Scientific Prediction in Nicholas Rescher’s Conception: Philosophico-Methodological Analysis

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DECLARES that the PhD/Doctoral Dissertation entitled "Scientific Prediction in Nicholas Rescher's Conception: Philosophico-Methodological Analysis" was prepared by Amanda Guillán under my supervision. Her research fits quite well into the characteristics of a Doctoral Thesis and, specifically, it meets all the criteria and requirements of an "International Doctor" (*Doctor internacional*) established in the Spanish legislation (RD 99/2011) as well as in the rules given by the University of A Coruña regarding the doctoral studies (*Reglamento de Estudios de Doctorado*, 17.7.2012).

Amanda Guillán has developed her PhD research at the University of A Coruña as well as at the University of Pittsburgh, where she has spent two research stays in order to fulfill the requirements of an "International Doctor" and to discuss details with the philosopher studied in this Doctoral Dissertation.

Ferrol, 2 June 2015

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Scientific Prediction in Nicholas Rescher's conception: Philosophico-Methodological analysis

Abstract

Scientific prediction is a central problem in philosophy and methodology of science. This topic has been particularly relevant in Nicholas Rescher's philosophy. On the one hand, scientific prediction appears as a key concept within his philosophical proposal, which is a system of pragmatic idealism; on the other, a number of his publications are devoted to the study of scientific prediction from different angles. *De facto*, he offers a rigorous and detailed conception of prediction in science.

Within this context, this Ph.D. research has two main objectives, which are interrelated. First, the analysis of the philosophico-methodological characters of scientific prediction in Rescher's conception is the focus of the attention. To do this, the research deals with different thematic realms: semantic, logical, epistemological, methodological, ontological, axiological, and ethical. These are grounded in the different components of science (language, structure, knowledge, processes, activity, ends, and values).

Second, the critical reconstruction of Rescher's philosophy of science is searched. His approach is a pragmatic idealism that is open to some important realist elements. This second line of research is developed in parallel with the first one, because his *system* of pragmatic idealism modulates the characters of scientific prediction.

La predicción científica en la concepción de Nicholas Rescher: Análisis filosófico-metodológico

Resumen

El problema de la predicción científica es un tema central para la Filosofía y Metodología de la Ciencia. Se trata de un tema especialmente relevante en la Filosofía de Nicholas Rescher. Por un lado, la predicción científica aparece como un concepto clave dentro de su propuesta filosófica, que es un sistema de idealismo pragmático. Por otro lado, tiene trabajos en los que analiza la predicción científica desde diversos ángulos. *De facto*, ofrece una concepción rigurosa y detallada de la predicción.

Dentro de este marco, la presente Tesis Doctoral tiene dos objetivos fundamentales, que están interrelacionados. En primer lugar, el estudio se orienta a analizar los caracteres filosófico-metodológicos de la predicción científica en la concepción de Rescher. A tal efecto, la investigación se enfoca desde diversos ámbitos temáticos: semántico, lógico, epistemológico, metodológico, ontológico, axiológico y ético. Estos ámbitos temáticos se fundamentan en los diversos componentes de la Ciencia (lenguaje, estructura, conocimiento, procesos, actividad, fines y valores).

En segundo término, la investigación se orienta a reconstruir críticamente la Filosofía de la Ciencia de Rescher. Su propuesta es un idealismo pragmático que está abierto a importantes elementos de realismo. Esta segunda línea se desarrolla de manera paralela a la primera, porque su *sistema* de idealismo pragmático modula los caracteres de la predicción científica.

A PREDICIÓN CIENTÍFICA NA CONCEPCIÓN DE NICHOLAS RESCHER: ANÁLISE FILOSÓFICA-METODOLÓXICA

RESUMO

O problema da predición científica é un tema central para a Filosofía e Metodoloxía da Ciencia. Trátase dun tema especialmente relevante na Filosofía de Nicholas Rescher. Por un lado, a predición científica aparece como un concepto clave dentro da súa proposta filosófica, que é un sistema de idealismo pragmático. Por outro lado, ten traballos nos que analiza a predición científica desde diversos ángulos. *De facto*, ofrece unha concepción rigorosa da predicción, onde acada un gran nivel de detalle.

Dentro deste marco, a presente Tese de Doutoramento ten dous obxectivos fundamentais, que están interrelacionados. En primeiro lugar, o estudo oriéntase a analizar os caracteres filosófico-metodolóxicos da predición científica na concepción de Rescher. A tal efecto, a investigación enfócase desde diversos ámbitos temáticos: semántico, lóxico, epistemolóxico, metodolóxico, ontolóxico, axiolóxico e ético. Estes ámbitos temáticos fundaméntanse nos diversos compoñentes da Ciencia (linguaxe, estrutura, coñecemento, procesos, actividade, fins e valores).

En segundo termo, a investigación oriéntase a reconstruir críticamente a Filosofía da Ciencia de Rescher. A súa proposta é un idealismo pragmático que está aberto a importantes elementos de realismo. Esta segunda liña de análise desenvólvese en paralelo á primeira, porque o seu *sistema* de idealismo pragmático modula os caracteres da predición científica.

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PART II

Predictive Knowledge and Predictive Processes in Rescher's Methodological Pragmatism

INTRODUCTION

The problem of scientific prediction is undoubtedly a central topic for the philosophy and methodology of science. This is because of its importance for scientific practice in the different empirical sciences (natural, social, and artificial), where prediction has several crucial roles. Thus, prediction can be a test for the scientific character of hypotheses and theories (basic science). It precedes the prescription oriented towards the solution of concrete problems (applied science), and it serves as a support for decision-making in practical contexts of acting (application of science).

Furthermore, when the goals of scientific research are considered, it is usual to highlight two of these goals: the explanation of past phenomena and events and the prediction of future phenomena and happenings. However, the attention directed towards scientific prediction is, certainly, very little in comparison to the effort devoted to the study of scientific explanation. This feature can be seen in the number of publications in this regard, which is clearly higher in the case of scientific explanation. But it is also the case that prediction frequently appears as a key concept in the research into other issues of the philosophy and methodology of science, such as scientific progress, complexity, or the limits of science.

I. Thematic Context of the Research

Certainly, Nicholas Rescher's contribution to the philosophical reflection on the problem of prediction must be highlighted. Thus, on the one hand, scientific prediction appears as a key concept within his philosophy and methodology of science. In effect, his pragmatic idealism emphasizes the importance of scientific prediction as a topic of analysis in the philosophy of science. On the other hand, several of his publications are devoted to the study of scientific prediction from different angles (above all, from the epistemological and methodological perspectives). In this way, he offers a rigorous conception of prediction, where the analysis achieves a great level of detail.

These reflections highlight the pertinence of developing a philosophico-methodological analysis of “scientific prediction” in Nicholas Rescher’s approach, since he is one of the authors who made the most contributions to the study of this topic, which is crucial for science and has been little considered in the philosophy of science (at least, in comparison with other problems, such as scientific explanation). This research is focused on the philosophy of science, where Rescher has developed his own proposal: a system of pragmatic idealism. Moreover, some of his contributions to philosophy, in general, receive attention to the extent that they are connected with his philosophy of science and can be relevant for the study of scientific prediction.

Nicholas Rescher was born in Germany in 1928. He settled in the United States when he was nine years old, and has produced an important philosophical contribution, where his analysis of scientific prediction can be emphasized. These contributions have been both theoretical — regarding a large number of problems — and practical, because he was one of the designers of the predictive procedure called Delphi. Within his theoretical contributions, his paper “On Prediction and Explanation” (1958) should be mentioned. In this paper, he calls into question the logical symmetry between prediction and explanation, which was the dominant thesis in that moment. His book *Predicting the Future* must be also highlighted, where a systematic philosophico-methodological analysis of scientific prediction is offered for the first time. This analysis is made from different relevant perspectives (especially, the epistemological, methodological, and ontological ones).

Besides the attention to the problem of scientific prediction in its different dimensions, Rescher has offered a *system of thought*; that is, he has provided his own conception of philosophy, in general, and philosophy of science, in particular. His proposal — pragmatic idealism — encompasses very influential contemporary elements, such as pragmatism, but his idealistic approach involves very different characteristics from naturalism, which has been frequent over the last decades. Very often, his approach has original features.

Within this framework — a key philosophico-methodological topic in an influential contemporary philosopher — this Ph.D. research has two main objectives. Firstly, the study is oriented towards the analysis of the philosophico-methodological characteristics of scientific prediction in Rescher's conception. To do this, the research is focused on different thematic realms: semantic, logical, epistemological, methodological, ontological, axiological, and ethical. These thematic realms of the analysis of scientific prediction are grounded in the different components of science (language, structure, knowledge, processes, activity, ends, and values), which can be oriented towards the future, so they are relevant for prediction.

Secondly, the investigation is oriented towards offering a critical reconstruction of Rescher's philosophy of science, which can be characterized as a pragmatic idealism that is open to some realist elements. This second line is developed in parallel with the first one, the philosophico-methodological features of scientific prediction, since in his approach the pragmatic idealism modulates the characters of prediction. In effect, his philosophy of science is related to a *system*, so the thematic realms of the analysis of scientific prediction are interrelated within a system of thought.

In order to develop those two axes of the investigation — the critical reconstruction of Rescher's concept of "prediction" and his system of pragmatic idealism — in a way that the relations between them can be noticed, the Ph.D. research is organized in three parts, according to a thematic criterion. These three parts are organized according to thematic criteria: I) General Coordinates, Semantic Features, and Logical Components of Scientific Prediction; II) Predictive Knowledge and Predictive Processes in Rescher's Methodological Pragmatism; and III) From Reality to Values: Ontological Features, Axiological Elements, and Ethical Aspects of Scientific Prediction.

As far as possible, each chapter has "autonomy" to some extent, since the angles of analysis are different (semantic, logical, epistemological, methodological, ontological, axiological, and ethical). However, the chapters are interconnected in two regards: the study of scientific prediction and the critical analysis of Rescher's system of thought. Thus, in principle, each chapter seeks to provide all the keys in order to address the problems, although this feature can involve some repetitions, which are thought as a way of facilitating the unifying thread of the present research.

II. From the Problems to the Philosophico-Methodological Analysis

The first part of the research is devoted to three issues. First, the general framework offered by Rescher for the study of scientific prediction is analyzed. Second, the research in scientific prediction is developed from the perspective of the semantics of science. Third, the investigation is carried through from the logic of science. In the second part, the research in prediction is centered on the epistemology and the methodology of science, which are the realms where Rescher made most of his contributions to the analysis of scientific prediction. Finally, in the third part, the attention goes to the ontology of science and the realm of values, where scientific prediction is studied from the axiology of research and the ethics of science.

Chapter 1 serves as a framework for the following chapters. Thus, on the one hand, the chapter tries to clarify the general coordinates of Rescher's system of pragmatic idealism; and, on the other, it seeks to offer a characterization of the philosophico-methodological elements of scientific prediction. I.e., it addresses the problem of the constituent factors of "scientific prediction." This involves developing a study that has two dimensions: a historic component and a thematic perspective. Regarding the historic component, the relevance of Rescher's academic training and career is considered, both for the articulation of his system of thought and for the development of his unequivocal interest regarding the problem of prediction.

After this historical framework, the thematic perspective, which is Rescher's pragmatic idealism, is researched. Two main aspects are considered in this regard: a) the role that he attributes to concepts in the articulation of knowledge, and b) his proposal about scientific progress, which is directly connected with the notion of "prediction." This leads to completing the framework through the attention to the philosophico-methodological characters of prediction (which are developed in the following chapters) and the problems posed by them. Finally, the place of Rescher's pragmatic idealism within the current context is analyzed.

In chapter 2 the investigation into scientific prediction is addressed from the perspective of language, so the problem of how scientific prediction should be conceived from language is considered. This perspective leads to the reflection on the features of Rescher's proposal about language, which is of a pragmatic character. In his approach to meaning, he considers that the use conditions have primacy over truth conditions. In this regard, the research in the repercussions that a pragmatic approach to language might have on the notion of "scientific prediction" is required

It is possible then to go more deeply into the language of "prediction." This path leads to addressing the problem of the concept of "scientific prediction" and its demarcation with respect to the notion of "non-scientific prediction." Regarding this issue, the aim is to achieve a higher level of rigor in the language used for prediction. This involves considering other distinctions as well, such as generic prediction and specific prediction, quantitative prediction and qualitative prediction, and the different possible types of scientific predictions according to their reliability or other characteristics. This issue is connected to the limits of prediction regarding the language, so the reflection on the duality “not-predictability” and “unpredictability” is also possible.

After the research from the semantic perspective, in chapter 3 the analysis of scientific prediction is developed in the realm of the logic of science. This viewpoint involves addressing the problem of the logical relations between scientific explanation and prediction. Thus, the theses that have been maintained regarding this problem are taking into account: (i) the thesis of the logical symmetry between explanation and prediction; and (ii) the thesis of the logical asymmetry, which Rescher favors. The study of both theses leads to emphasizing the temporality factor, which poses other questions of a logical character. In this regard, the reflection on the notion of “retrodiction” is required, as well as its possible logical equivalence with respect to scientific explanation, firstly, and scientific prediction, secondly.

There are other two problems that are especially important to consider in order to clarify the logical features of scientific prediction. The first one has to do with the nexus with induction, while the second one deals with the role of deductive logic. Regarding the first problem, the research considers two different (although connected) questions: a) the characterization of induction and b) the justification of induction. On this basis, the problem of the importance of induction for scientific prediction is considered, where its role in the context of discovery and the context of justification can be addressed. This leads to the second problem, which has to do with the role of deduction. On this issue, the possible limits of deductivism for scientific prediction are discussed.

Chapter 4 is oriented towards the investigation into the epistemological factors of scientific prediction in Rescher's approach, so the research goes to the kind of *cognitive content* offered by prediction and the related problems. To do this, his epistemology can be related to his theory of rationality, where he gives primacy to practice. From this perspective, the research in scientific prediction can be undertaken according to the types of rationality that he expressly considers: cognitive rationality, practical rationality, and evaluative rationality.

One crucial problem regarding the knowledge provided by predictions has to do with the reliability of the predictive statements. This focus of study leads to go more deeply into the fallibilism and its repercussions for prediction in basic science, applied science, and the application of science. The reliability of predictive knowledge is related to the epistemological limits to predictability. In this way, the attention goes also to problems such as uncertainty, which affects the kind of knowledge that can be achieved through prediction and has incidence in issues like risk management.

Chapters 5 and 6 analyze in detail the methodological aspects of scientific prediction. The research into the methodology of prediction requires two chapters in this Ph.D. research, because it is the realm where many of Rescher's contributions (and some of the most influential ones) to the problem of scientific prediction can be placed. Thus, chapter 5 has a more general orientation, so the research is devoted to clarifying the conceptual framework of Rescher's methodology of scientific prediction.

Insofar as Rescher addresses the problems from the primacy of practice, the study of his approach to methodological pragmatism is firstly developed. This leads the research to go more deeply in the roles of scientific prediction in the different types of scientific research (basic, applied, or of application) and in the empirical sciences (natural, social, or artificial).

Secondly, the research considers the preconditions for rational prediction, which are the necessary conditions for the predictive processes.

Within the methodological characters of scientific prediction, the focus of research in chapter 6 has a more concrete character. The analysis of the different predictive procedures and methods and their scientific import is developed here. In this regard, the processes of prediction are researched from the framework offered by Rescher. There are differences between estimative procedures of prediction and discursive or formalized processes of prediction, which can be either elementary processes or scientific methods. In turn, this path leads the research to considering the reliability and characteristics of the predictive procedures and methods, within an approach that assumes *de facto* a methodological pluralism regarding prediction.

The third part of the research starts with the investigation into the issues related with the ontological features of scientific prediction. From the ontology of science, the problem of prediction connects with the reality of the phenomena. This feature involves research into the specific characteristics that phenomena of different realms of the reality (natural, social, or artificial) might have. From this perspective, the attention goes to the repercussions (above all, epistemological and methodological) of the reality of phenomena on scientific prediction. Besides the realms of reality — in its triple empirical dimension — there is the problem of the characterization of future phenomena, which is connected with the time horizon of prediction and the possibility of control over phenomena.

Also from the ontology of science it is possible to research the ontological obstacles of scientific prediction. This is an especially important issue in Rescher’s approach. In this regard, the relevant varieties and modes of complexity are researched, which lead to emphasize the notion of *historicity*. Thus, the reflection on complexity is developed from the perspective of historicity, which is especially important for the social sciences and the sciences of the artificial.

Then, in chapter 8, the problems related to the axiological elements of scientific prediction are considered. This perspective leads to analyzing, firstly, Rescher's proposal regarding the axiology of research, in order to see how he modulates the axiological features of prediction. This involves considering the values as a system, where there is a double perspective of analysis: internal and external. The internal perspective sees science as activity by itself, while the external viewpoint deals with the relations of science with the context. In Rescher's axiology, which is preferentially structural, the internal component of analysis has primacy, where the epistemological and methodological values are emphasized.

Secondly, the axiological characters of prediction are investigated. To do this, on the one hand, the research in prediction as a value of science is addressed; and, on the other, the values which accompany prediction are analyzed. Regarding these problems, there are two dimensions of analysis: the structural perspective and the dynamic component. Rescher's proposal is preferentially structural. In this way, it is possible to broaden his proposal through the attention to the dynamic component. Thus, the study considers how prediction and the connected values modulate the aims, processes, and results of the scientific research (basic, applied, or of application), both from an internal perspective and from an external viewpoint.

Finally, in chapter 9, the research in scientific prediction is developed from the ethics of science. To do this, two perspectives of analysis are considered: a) the endogenous ethics, which is oriented towards scientific activity by itself; and b) the exogenous ethics, which analyses science as an activity connected with other activities (social, cultural, political, economic, ecological, etc.). The starting point of this chapter is the study of Rescher's ethics of science, which gives primacy to the internal perspective. This leads to go more deeply into the exogenous perspective, which is also important for the problem of prediction.

After that, the research is oriented towards reflection about the problems posed by the relation between scientific prediction and ethical values. Firstly, the repercussions on scientific prediction of the ethical limits of science are considered. Secondly, the study of the ethical values of scientific prediction is developed from the dynamic viewpoint, which deals with the evaluation of the aims, processes, and results of the research. To do this, the differences between basic science, applied science, and the application of science must be taken into account.

III. Acknowledgments

In order to finish the introduction of the Ph.D. research, I want to express my gratitude to the different persons and institutions that, one way or another, have contributed to make this work possible. In this regard, I must recognize the importance of Wenceslao J. Gonzalez, Professor of Logic and Philosophy of Science at the University of A Coruña and Supervisor of this Doctoral research. Firstly, I want to recognize his excellent work as a professor and researcher, which was decisive in my interest in the philosophy and methodology of science, in general, and in the problem of scientific prediction, in particular. Secondly, I want to thank him for his work as Supervisor of this Doctoral research, both for the time that he has spent in this task and for the quality of his remarks. Furthermore, I have benefited from his research on scientific prediction, which has been crucial in the development of the present research, as can be seen in the bibliographical section.

I also want to thank Nicholas Rescher, who showed a great interest in this project from the beginning. I have had the opportunity to work with him in two research stays at the University of Pittsburgh. I appreciate his support in order to make those stays possible, as well as kindness and the time he devoted to this research. The conversations I had with him have been decisive for this Ph.D. research. I have had the opportunity to clarify with him aspects of his conception. Moreover, I must emphasize in this regard that he was well disposed to solve all the questions I posed. Furthermore, I am grateful for his comments on previous versions of the chapters of the Ph.D. thesis, which have been really helpful.

It should be mentioned that this research was developed in the framework of the Program FPU of the Spanish Ministry of Education, Culture, and Sport. Also this program of the Ministry has supported the stays of research at the University of Pittsburgh. As FPU researcher, I have made this Ph.D. research at the University of A Coruña, to which I am really grateful; especially, to the staff of the *Vicerrectorado de Investigación y Transferencia*, due to their effective advice on many operative issues during these years. Also I would like to express my recognition to Antonio Bereijo, Associate professor at the Faculty of Humanities and Information Science (*Facultad de Humanidades y Documentación*) at the UDC and my colleague in the Research Group, who was always willing to help me.

Finally, I want to thank my family; especially, my parents, Luis and Ara, my sister Araceli, and my fiancé Fran. Without his love and support I hardly would have begun this project, and without the confidence they always gave me I would not have finished it.

PART I

General Coordinates, Semantic Features, and Logical Components of Scientific Prediction

CHAPTER 1

SCIENTIFIC PREDICTION IN A SYSTEM OF PRAGMATIC IDEALISM

Undoubtedly, Nicholas Rescher is one of the most productive contemporary philosophers. Besides his large list of publications, his intellectual trajectory has covered a variety of realms. Certainly, his academic production encompasses very different issues. Thus, he has addressed all the areas of the philosophy and methodology of science: semantics of science, logic of science, epistemology, methodology of science, ontology of science, axiology of scientific research, and ethics of science. Additionally, he has dealt with other philosophical realms, such as logic, metaphysics, history of philosophy, and theory of knowledge.[1]

Through that thematic extent and variety of analyses, Rescher has come to develop his own philosophical system. He is probably the contemporary philosopher that has addressed the most philosophical fields. In this regard, when he deals with the problem of scientific prediction, prediction does not appear as something isolated, but as an element that is part of a whole.[2] This means that, in order to analyze the concept of scientific prediction in Rescher's work, it is necessary to clarify the general coordinates

[1] The extent of Rescher's work can be noticed in the bibliography, which is current to the year 2009, that is included in the book of JACQUETTE, D. (ed.), *Reason, Method, and Value: A Reader on the Philosophy of Nicholas Rescher*, Ontos Verlag, Frankfurtt, 2009, pp. 633-643. An updated list of Rescher's publications can be seen in his web page: http://www.pitt.edu/~rescher/, (access on 14.12.2014).

His influence in the contemporary philosophy of science can be seen in the books devoted to his though. Besides the book of Jacquette, already quoted, some others can be highlighted: SOSA, E. (ed.), *The Philosophy of Nicholas Rescher. Discussions and Replies*, Reidel, Dordrecht, 1979; ALMEDER, R. (ed.), *Praxis and Reason: Studies in the Philosophy of Nicholas Rescher*, University Press of America, Washington, D.C., 1982; and ALMEDER, R. (ed.), *Rescher Studies. A Collection of Essays on the Philosophical Work of Nicholas Rescher*, Ontos Verlag, Heusenstamm, 2008,

[2] Cf. GONZALEZ, W. J., *La predicción científica. Concepciones filosófico-metodológicas desde H. Reichenbach a N. Rescher*, Montesinos, Barcelona, 2010, chap. 8, pp. 253-281; especially, pp. 253-259.

of his philosophical proposal, which is configured as a system of "pragmatic idealism."[3]

Within this framework, this chapter seeks to offer the philosophico-methodological coordinates for the analysis of scientific prediction in Rescher's thought, which has the idea of a system as a backdrop. In this regard, there is, in the first place, a reconstruction of his academic and intellectual trajectory. Through his philosophical work, Rescher came to articulate a system of thought that is supported by two mainstays: the theory of knowledge of Immanuel Kant and the pragmatism of Charles Sanders Peirce.

In the second place, the *historical* framework of his trajectory is followed by an analysis of his thematic frame, which is the conception of pragmatic idealism. In this approach, the concepts are particularly relevant to the articulation of knowledge, and his proposal of scientific progress is of pragmatic character. Both aspects are related to prediction. Next, the main philosophico-methodological characters of scientific prediction are addressed. This involves paying attention to the semantic, logical, epistemological, methodological, ontological, axiological, and ethical features of prediction, that in Rescher's approach are closely related. Finally, his system of pragmatic idealism is analyzed within the contemporary context.

1.1. Nicholas Rescher's Philosophy: General Coordinates

There are some background coordinates that modulate Rescher's thought. Following them it seems to me that his philosophical production, which is characterized by its amplitude and thematic diversity, has coherence

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[3] This is developed by Rescher in an explicit way in his three volumes on a system of pragmatic idealism: RESCHER, N., *A System of Pragmatic Idealism.* Vol. I: *Human Knowledge in Idealistic Perspective*, Princeton University Press, Princeton, NJ, 1992; RESCHER, N., *A System of Pragmatic Idealism.* Vol. II: *The Validity of Values: Human Values in Pragmatic Perspective,* Princeton University Press, Princeton, NJ, 1993; and RESCHER, N., *A System of Pragmatic Idealism.* Vol. III: *Metaphilosophical Inquires,* Princeton University Press, Princeton, NJ, 1994.

and systematicity. In this regard, the reflections that he made in his intellectual autobiography on his academic and research trajectory can be emphasized.[4] His main effort, which is directed to clarify the philosophico-methodological framework where his contributions are placed, is also relevant. This effort can be seen in his three volumes on *A System of Pragmatic Idealism*.[5]

In order to properly understand his proposal for scientific prediction, the first step consists of the reconstruction of his intellectual and academic trajectory. In this regard, the years when Rescher worked as a mathematician in the RAND Corporation are especially relevant. This is because at RAND he developed — together with Olaf Helmer and Norman Dalkey — the predictive procedure called Delphi[6]. As a second step, an inquiry into his system of pragmatic idealism will be conduced, since it is the framework where Rescher's approach to scientific prediction is placed.

1.1.1. Academic Training and Career

Nicholas Rescher was born on July 15th, 1928 in Hagen, a German city in the region of Westphalia. Faced with the troubles of the rise of Nazism, his family decided to emigrate to the United States of America. Erwin Hans Rescher was the first that crossed the Atlantic, followed a year after by his

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[4] This autobiography has had several editions. In this research the edition used is RESCHER, N., *Enlightening Journey. The Autobiography of an American Scholar*, Lexington Books, Lanham, MD, 2002.

[5] These are the previously quoted volumes: *A System of Pragmatic Idealism.* Vol. I: *Human Knowledge in Idealistic Perspective*; *A System of Pragmatic Idealism.* Vol. II: *The Validity of Values: Human Values in Pragmatic Perspective*; and *A System of Pragmatic Idealism.* Vol. III: *Metaphilosophical Inquires*.

[6] On the Delphi procedure of prediction, see LINSTONE, H. A. and TUROFF, M., *The Delphi Method. Techniques and Applications*. Electronic version is available in *http://is.njit.edu/pubs/delphibook/delphibook.pdf*, (access on 3.7.2013); RESCHER, N., *Predicting the Future. An Introduction to the Theory of Forecasting*, State University of N. York Press, N. York, 1998, pp. 91-96; ROWE, G. and WRIGHT, G., "Expert Opinions in Forecasting: The Role of the Delphi Technique," in ARMSTRONG, J. S. (ed.), *Principles of Forecasting: A Handbook for Researchers and Practitioners,* Kluwer, Boston, 2001, pp. 125-144; AYYUB, B. M., *Elicitation of Expert Opinions for Uncertainty and Risks*, CRC Press, Boca Ratón, FL, 2001, pp. 99-105; and BELL, W., *Foundations of Futures Studies. History, Purposes, and Knowledge*, *Human Science for a New Era, Vol. 1*, Transaction Publishers, Piscataway, NJ, 2003 (5th reimp. 2009; 1st ed. 1997), pp. 261-272.

wife, Meta Anna, and his son, Klaus Helmut Erwin Rescher, who was named Nicholas Rescher after his arrival to the United States. On July 8th, 1938 Rescher and his mother embarked on the *USS President Roosvelt* for North America, where they arrived in the morning of July 16th 1938.

At an early age, Rescher was interested in mathematics and philosophy.[7] He took a degree in Mathematics at *Queens College* in Flushing, New York, between 1946 and 1949; although he also attended some philosophy lessons. Herbert G. Bohnert (who was a student of Carnap) and Carl Gustav Hempel, one of the main representatives of the Berlin School (lead by Hans Reichenbach) were among his teachers in those years. Once Rescher got his degree, he received offers from the departments of Mathematics and Philosophy of Harvard, Yale, and Princeton. Rescher chose Princeton, where he was a PhD student from 1949 and 1951.

He attended the courses of Logic of Alonzo Church at Princeton. He was of an special relevance in Rescher's career, because Church decisively contributed to increase the interest of Rescher in Logic. In 1950 he earned his Master's degree, and started to teach at the university. By this time, he collaborated with Paul Oppenheim. In 1951 he earned his Ph.D. with a dissertation on "Leibniz's Cosmology: A Study of the Relations between Leibniz's Work in Physics and his Philosophy." By doing this, he became at the age of 22 in the youngest student who obtained a Ph.D, at the Department of Philosophy in Princeton.

Between 1952 and 1954 he served in the United States Marine Corps. This meant a break in his academic career. In 1954 he was offered a job in the Mathematics Division of RAND Corporation, which was then directed by John D. Williams. Rescher accepted the offer, and he moved to Santa Monica, where he stayed until 1956. During these years working at RAND

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[7] In his autobiography, Rescher links his interest on philosophy with the reading of the *History of Philosophy* by Will Durant. Cf. RESCHER, N., *Enlightening Journey. The Autobiography of an American Scholar*, p. 50.

Corporation, Rescher started to be interested in the problem of scientific prediction.

This aspect is relevant insofar as RAND Corporation (*Research and Development*) is a good example of what has been labeled a *think tank* (an organized group to provide ideas): it is a research institution that offers ideas and advice on political, trade or military interests. RAND Corporation was created in the first place to offer research support to the US Armed Forces. This was its main role when Rescher joined the Corporation as a researcher.

When he started his work at the RAND Corporation, Rescher was interested in issues related to game theory. After that, he collaborated with Fred Thompson in economic issues related to air war. After a second project, where he collaborated again with Fred Thompson and Frederick B. Moore, Rescher started to work in a project that he designed at the beginning of 1955. It was "a speculative assessment of how, given current intelligence assessments of then-extant Russian military capabilities, a preemptive nuclear 'counterforce' attack against U.S. retaliatory potential might be designed."[8]

RAND Corporation came to develop a great interest on prediction as a relevant part of its research support to the US Air Force. According to Rescher, "predicting enemy intentions has always been a key task of military intelligence, but in the modern technological world forecasting the development and deployment of weapons systems became no less crucial a mission. Acondingly the issue of identifying and validating prediction methods evolved as an area of RAND interest."[9]

Within the RAND Corporation, the set of investigations related to prediction were known with the code name "Delphi Project." The judgmental predictive procedure that Rescher developed together with Olaf Helmer and

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[8] RESCHER, N., *Enlightening Journey. The Autobiography of an American Scholar*, p. 90.
[9] *Enlightening Journey. The Autobiography of an American Scholar*, p. 92.

Norman Dalkey was named "Delphi Method."[10] Helmer was the most influential person for Rescher during the years he worked at RAND Corporation. Both of them shared a common interest on the theoretical aspects of scientific prediction, so they decided to meet once a week for work sessions to go more deeply into some aspects related with Delphi procedure.

Delphi procedure is a predictive procedure based on the interaction among a group of predictors, who are experts on the issue that prediction is about. Predictors do not confront each other. Instead, they answer a series of questionnaires in an individual and anonymous way. These questionnaires are presented to them in several successive rounds. After each round is finished, the predictors can know the group results, so that they can review their own initial answers. The final goal is to achieve an "aggregate prediction" that is supported by all the experts.[11]

The study of this predictive procedure was divided in two successive levels: on the one hand, Rescher collaborated with Helmer on the theoretical analysis of Delphi procedure; and, on the other, Helmer collaborated with Dalkey — and thereafter with Bernice Brown and Theodore Gordon — in the study of concrete cases. The first of these levels concerns basically the epistemology of prediction. One of the first papers that Rescher published on prediction (with the collaboration of Helmer) was about this issue: "On the Epistemology of the Inexact Sciences."[12]

In 1957, after he left the RAND Corporation, Rescher started his academic career at the University of Lehigh, in Bethlehem, Pennsylvania.

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[10] Rescher takes into account two mayor methodological approaches: (i) judgmental procedures, which are based on the estimation of experts who use a kind of unformalized reasoning; and (ii) discursive or scientific methods, which are based on the correcteness of inferential principles. Cf. RESCHER, N., *Predicting the Future. An Introduction to the Theory of Forecasting*, State University of N. York Press, N. York, 1998, p. 87. This idea appears in one of his first papers on prediction. Cf. RESCHER, "The Future as an Object of Research," *RAND Corporation Research Paper* P-3593, 1967.

[11] Cf. RESCHER, N., *Predicting the Future. An Introduction to the Theory of Forecasting*, p. 92.

[12] Cf. RESCHER, N. and HELMER, O., "On the Epistemology of the Inexact Sciences," *Management Sciences*, v. 6, (1959), pp. 25-52.

There, he teaches philosophy lessons to undergraduate students until 1961. In this period, he met Adolf Grünbaum, who was also in the Department of Philosophy at the University of Lehigh. It is quite remarkable that Rescher's philosophical interests were at this moment very diverse, among them his research on Arabic logic can be highlighted. Moreover, his philosophical publications in this period are about this topic.[13]

Following Grünbaum's suggestions, who has accepted a position at the University of Pittsburgh and recommended Rescher, he was named Professor of Philosophy at the University of Pittsburgh in 1961. Since then, he has been in Pittsburgh, where he is a Distinguished University Professor since 1970. He started then a prestigious and prolific career as professor and researcher, that lead him to be named Honoris Causa by eight universities: the University of Loyola, Chicago (1970); *Universidad Nacional* of Córdoba, Argentina (1992); University of Lehigh (1993); University of Konstanz (1996); *Queens College* (1999); University of Hagen (2001); University of Helsinki (2006); and University of Cleveland (2007).

Besides these Honoris Causa, Rescher has also received many prestigious awards. Among them, the Alexander von Humboldt Humanities Prize (1983); the Medal of Merit for Distinguished Scholarship, University of Helsinki (1990); the Chancellor's Distinguished Research Award, University of Pittsburgh (1990); and the Medal of Merit of the Federal Republic of Germany (*Bundesdienstkreuz erster Klasse*), 2011. It should be highlighted that in 2010 the University of Pittsburgh established the biennial Nicholas Rescher Prize for Contributions to Systematic Philosophy.

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[13] See, for instance, RESCHER, N., "Some Technical Terms of Arabic Logic," *Journal of the American Oriental Society*, v. 82, (1962), pp. 203-204; RESCHER, N., "Al-Farabi on Logical Tradition," *The Journal of the History of Ideas*, v. 24, (1963) pp. 127-132; and RESCHER, N., "Avicenna on the Logic of 'Conditional' Propositions," *Notre Dame Journal of Formal Logic*, v. 4, (1963), pp. 48-58. A complete list of his publications in the sixties can be found in his web page: *http://www.pitt.edu/~rescher/*, (access on 15.12.2014).

Another recognition of his academic and researcher career is his participation as president of numerous associations: *Charles Sanders Peirce Society* (1983-1986); *G. W. Leibniz Society of America* (1983-1986); *American Philosophical Association, Eastern Division* (1989-1990); *American Catholic Philosophical Association* (2003-2004); and *American Metaphysical Society* (2004-2005). He is also an elected member of many Academies, among which are the *Institut International de Philosophie,* the *Academie Internationale de Philosophie des Sciences*, the *European Academy of Arts and Sciences*, the *Royal Society of Canada*, and the *American Academy of Arts and Sciences*.

Reshcer has also been the editor of several journals, including *American Philosophical Quarterly* (1964-1994), *History of Philosophy Quarterly* (1983-1992), and *Public Affairs Quarterly* (1986-1991). In addition, he is co-editor of the *Pittsburgh Series in Philosophy and History of Science*, of the *University of California Press*, since 1980, and of *C.P.S. Publications in Philosophy of Science*, at the *University of America Press*, since 1982. He is in the editorial committee of many scientific journals, including *Epistemologia, Mind and Society*, *Journal of the Philosophy of Management, History of Philosophy and Logical Analysis, Idealistic Studies*, and *Philosophisches Jahrbuch*.

Rescher himself acknowledges a key feature of this fruitful and long academic trajectory: "I was unwilling or unable to settle down to one particular specialty."[14] Nevertheless, he came to articulate his own system of thought, which has some well-defined coordinates, so his philosophical contributions form part of that system. In this regard, the contact with some important thinkers of the neopositivism and logical empiricism is relevant. Rescher himself, in a paper entitled "The Berlin School of Logical Empiricism and its Legacy," says that he is part of the "younger generation" of the Berlin

[14] RESCHER, N., *Enlightening Journey. The Autobiography of an American Scholar*, p. 115.

School insofar as he was a student of Hempel.[15] This is especially relevant to his studies on prediction, because Rescher considers that they are "in the wake of [Hans] Reichenbach's work."[16]

Nevertheless, his system of though is not in tune with empiricism. Moreover, he is in a quite different approach: he endorses a "pragmatic idealism." This system that Rescher proposes has its roots in his own conception of the task of a philosopher: "A good philosopher, it seems to me, must be many-sided because the impetus to philosophizing is ultimately a search for systematic principles underlying the jumbled profusion of phenomena."[17] Regarding this issue, he acknowledges the Leibnizian influence: "The inspiration of Leibniz is clearly present in some of my books (e.g., *The Coherence Theory of Truth*) and is discernible in my general approach to the conduct of philosophical work."[18]

However, Immanuel Kant and Charles Sanders Peirce are, undoubtedly, the philosophers who have influenced most of Rescher's proposals. *De facto*, there is in his work an explicit concern to elaborate a system of thought where the idealism is compatible with the pragmatism: "I have gradually acquired the vision of a system of philosophy geared to the idealistic tradition from Leibniz and Berkeley through Kant to Hegel and Peirce, with the German idealists on the left side, the English Hegelians on the right, and the American pragmatists to the front."[19] It is a philosophical system of pragmatic idealism built on the basis of two mainstays: Kant's theory of knowledge and Peirce's pragmatism.

1.1.2. A Kantian Pragmatism: The Primacy of Practice

[15] Cf. RESCHER, N., "The Berlin School of Logical Empiricism and its Legacy," *Erkenntnis*, v. 64, (2006), pp. 281-304.
[16] RESCHER, N., "The Berlin School of Logical Empiricism and its Legacy," p. 298.
[17] RESCHER, N., *Enlightening Journey. The Autobiography of an American Scholar*, p. 174.
[18] RESCHER, N., *Autobiography*, Ontos Verlag, Heusenstamm, 2010, p. 69.
[19] RESCHER, N., *Enlightening Journey. The Autobiography of an American Scholar*, p. 174.

By means of a large number of publications, Rescher has configured his own philosophy. It is a "'Kantian pragmatism' open to realist contributions."[20] In effect, in the three volumes entitled *A System of Pragmatic Idealism*,[21] he sees human knowledge from an idealistic perspective, according to which our categories and concepts have a decisive role to characterize reality. But Rescher's idealism admits realist notions, such as "fact" or "objectivity." Thus, Kantism is open to realist contributions.[22] This is possible because "realism is compatible with a pragmatism in the style of that proposed by Charles S. Peirce."[23]

Within this framework of a Kantian pragmatism, Rescher offers an approach to human rationality that moves away from maximization,[24] which is the favorite conception of rationality in neoclassical approaches to economics. In this regard, his proposal on rationality is a pragmatic one, insofar as rational agent is that who "proceeds on the basis of the grounds that are available to him (which may well also be imperfect)."[25] Thus, he takes into account the limitations of the knowing subject, as well as the information limitations to which the subject can be exposed.

Due to these limitations, Rescher maintains that rationality demands an "optimization" with regard to the circumstances, which in not maximization in

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[20] GONZALEZ, W. J., *La predicción científica. Concepciones filosófico-metodológicas desde H. Reichenbach a N. Rescher*, p. 254.

[21] These are the three volumes published by Princeton University Press: *A System of Pragmatic Idealism.* Vol. I: *Human Knowledge in Idealistic Perspective*; *A System of Pragmatic Idealism.* Vol. II: *The Validity of Values: Human Values in Pragmatic Perspective*; and *A System of Pragmatic Idealism.* Vol. III: *Metaphilosophical Inquires.*

[22] Certainly, he rejects the naïve realism, which claims that it is easy to access reality (and also considers that it is easy to identify true statements). On the varieties of realism related to science, cf. GONZALEZ, W. J., "El realismo y sus variedades: El debate actual sobre las bases filosóficas de la Ciencia," in CARRERAS, A. (ed.), *Conocimiento, Ciencia y Realidad*, Seminario Interdisciplinar de la Universidad de Zaragoza-Ediciones Mira, Zaragoza, 1993, pp. 11-58.

[23] GONZALEZ, W. J., *La predicción científica*, p. 256.

[24] Cf. RESCHER, N., *Rationality. A Philosophical Inquiry into the Nature and the Rationale of Reason*, Clarendon Press, Oxford, 1988.

On the notion of "rationality" in Rescher's work, it can be see MOUTAFAKIS, N. J., *Rescher on Rationality, Values, and Social Responsibility. A Philosophical Portrait*, Ontos Verlag, Heusenstamm, 2007; especially, cap. 1, pp. 21-61.

[25] RESCHER, N., *Rationality. A Philosophical Inquiry into the Nature and the Rationale of Reason*, p. 7.

the strict sense.[26] He raises the issue from the primacy of practice: "Being rational consists in the disposition to make good reasons constitute the motives for what one does. Since this is something we can achieve only within limits, one must regard perfect rationality as an idealization and acknowledge that we humans are 'rational animals' because of our *capacity* for reason, and certainly not because of our achievement of perfected rationality."[27]

Based on rationality as something limited, Rescher suggests a holistic conception of rationality, where the role of values is fundamental. Thus, there are — in his judgment — three kinds of rationality, depending on the object of rational deliberation: "Philosophical tradition since Kant sees three major contexts of choice, those of *belief*, of accepting or endorsing theses or claims, of *action*, of what overt acts to perform, and of *evaluation*, of what to value or disvalue. These [contexts] represent the spheres of cognitive, practical, and evaluative reason, respectively."[28]

The pragmatic and Kantian influence that characterizes his philosophy is noticeable. On the one hand, Rescher gives priority to practice in his approach to human rationality, in general, and to scientific rationality, in particular.[29] This leads him to insist on the role of economic rationality, which refers to the instrumental component of rationality. In effect, Rescher thinks that both actions and beliefs should be evaluated in accordance to their effectiveness and efficiency to achieve ends. Thus, in order to achieve a

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[26] Cf. RESCHER, N., "Maximization, Optimization, and Rationality. On Reasons why Rationality is not Necessarily a Matter of Maximization," in RESCHER, N., *Ethical Idealism. An Inquiry into the Nature and Function of Ideals*, University of California Press, Berkeley and Los Angeles, 1987, pp. 55-84; especially, pp. 71-79.

[27] RESCHER, N., *Rationality*, p. 10.

[28] RESCHER, N., *Rationality,* pp. 2-3. This involves a holistic view of rationality according to which "cognitive, pragmatic, and evaluative rationality constitute a unified and indissoluble whole in which all three of these resources are inseparably co-present. Good reasons for believing, for evaluating, and for acting go together to make up a seamless and indivisible whole," RESCHER, N., *Rationality*, p. vii.

[29] Cf. MARSONET, M., *The Primacy of Practical Reason. An Essay on Nicholas Rescher's Philosophy*, University Press of America, Lanham, MD, 1996.

goal, "a rational creature will prefer whatever method process or procedure will, other things equal, facilitate goal realization in the most effective, efficient, and economical way."[30]

But, on the other hand, Rescher thinks that "a really thorough pragmatism must dig more deeply."[31] Thus, he considers that practice — the rational human activity — requires the selection of the best means in accordance with rational beliefs, appropriate values, and valid goals. Therefore, human rationality is not — in his judgment — merely an instrumental rationality, which only selects the means according to given ends. Whereas, the realm of rationality is certainly wider, since there is a rationality of ends or *evaluative* rationality that leads to select the appropriate ends.

In this regard, Rescher defends the existence of a clear nexus between rationality, science, and human values. He sets this nexus in an explicit way on the basis of two fundamental proposals: "1) that rationality includes not only correct reasoning (*razonamiento correcto*), but also adequate evaluation; and 2) that *praxis* — the effective implementation of practice into action — is ultimately the criterion of evaluation."[32]

Certainly, there is in his work an explicit criticism to those approaches to rationality understood as a merely instrumental rationality (i.e., a rationality centered only on the process that does not take into account the issue of the

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[30] RESCHER, N., "Pragmatism and Practical Rationality," *Contemporary Pragmatism*, vol. 1, n. 1, (2004), p. 44.

[31] RESCHER, N., *Realistic Pragmatism*, p. 168. In this regard, Rescher distinguishes two types of pragmatism: a) practicalism and b) funcionalism. Practicalism sees theory and theorizing as secondary in importance, so it gives a more important role to praxis. Meanwhile, funtionalism subordinates theory to praxis not in importance, but rather in fundamentally (that is, the justification of human beliefs, ends, and actions is always relative to the realm of action). Thus, theory is something crucial in importance, but the criterion of successful theorizing is success in matters of practical implementation. So Rescher's pragmatism is in the line of what he calls functionalism. See RESCHER, N., "Pragmatism and Practical Rationality," pp. 43-60; especially, pp. 43-44.

[32] RESCHER, N., *Razón y valores en la Era científico-tecnológica*, Paidós, Barcelona, 1999, p. 48.

value of the result).[33] It happens that Rescher thinks of science as an activity oriented towards *ends*. From this perspective, "values play a crucial role in science, and (...) this role is not something arbitrary or added, but it is inherent to the goal structure that defines science as a rational search."[34]

He maintains then that it is not good enough to evaluate diverse courses of action with regard to given ends. Instead, the election of ends should be evaluated as well and this should be done from a pragmatic perspective. Thus, an "axiology of purposes" is required, which he sees as "a normative methodology for assessing the legitimacy and appropriateness of the purposes we espouse"[35]. According to this "axiology of purposes," the assessing of the ends is a pragmatic assessing, that evaluates the appropriateness of the concrete ends with regard to the human needs and interests.[36]

Together with the Kantian and pragmatic influences — that can be seen in his approach to rationality, there are also realist elements in Rescher's philosophical proposal. In this regard, *objectivity* of values is a key feature. On the one hand, he insists on science as *our* science, since it is indebted to the conceptual categories of human beings.[37] And, on the other hand, it is a human activity of a teleological character that is modulated by values. Thus, both the ends sought by the research and the means oriented towards those ends should be selected in accordance with valid values. The validity of

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[33] Rescher criticizes the purely instrumentalist approaches to rationality. This can be seen in Herbert Simon's proposal, insofar as he does not accept a rationality of ends but only a rationality of means. Cf. RESCHER, N., *Rationality,* p. viii. An analysis of the notion of "rationality" in Simon and a comparison with Rescher's account is in GONZALEZ, W. J., "Racionalidad y Economía: De la racionalidad de la Economía como Ciencia a la racionalidad de los agentes económicos," in GONZALEZ, W. J. (ed.), *Racionalidad, historicidad y predicción en Herbert A. Simon*, Netbiblo, A Coruña, 2003, pp. 65-96.

[34] RESCHER, N., *Razón y valores en la Era científico-tecnológica*, p. 95.

[35] RESCHER, N., "Pragmatism and Practical Rationality," p. 45.

[36] Cf. "Pragmatism and Practical Rationality," pp. 44-47.

[37] Cf. RESCHER, N., "Our Science as *our* Science," in RESCHER, N., *A System of Pragmatic Idealism*. Vol. I: *Human Knowledge in Idealistic Perspective*, pp. 110-125; and RESCHER, N., "Nuestra Ciencia en tanto que *nuestra*," *Daimon, Revista de Filosofía*, n. 6, (1993), pp. 1-9.

values has an objective basis, which lead to an ontological component: it is rooted in the human needs that are of an universal character.

This leads Rescher to maintain that there is a *plurality of values* that should modulate both the ends and the means of the scientific research. These values can be internal (cognitive, methodological, …) or external (social, cultural, ecological, economic, etc.). Among them, Rescher gives priority to the values that are internal to scientific activity (above all, the epistemological and methodological values). This highlights his Kantism, "insofar as the content of science is more important than the socio-historical milieu."[38]

Despite this primacy of the internal component, Rescher's axiological approach — which connects to his proposal on scientific rationality — leads to a holism of values.[39] Thus, although it is certainly possible to make distinctions among values — there are internal values and external values, a complete separation of them is not possible. The reason for this criterion is a pragmatic one: in practice, the set of values is linked to human needs that are of a universal kind.[40] Nevertheless, as long as the values shape a system, it is possible to establish a hierarchy or scale of preferences. Consequently, the principal values, which modulate the ends and means of the research, are — for Rescher— the internal values to scientific activities.

1.2. A Systematic Conception of Science and Philosophy

The idea of a *system* has a clear presence in Rescher's work. In effect, he thinks that the aim of his task as a philosopher "is to become clear about

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[38] GONZALEZ, W. J., *La predicción científica,* p. 269.
[39] Cf. RESCHER, N., "How Wide is the Gap between Facts and Values?," in RESCHER, N., *A System of Pragmatic Idealism.* Vol II: *The Validity of Values*, pp. 65-92; and RESCHER, N., "Values in the Face of Natural Science," in RESCHER, N., *A System of Pragmatic Idealism.* Vol II: *The Validity of Values*, pp. 93-110.
[40] Cf. GONZALEZ, W. J., "Racionalidad científica y actividad humana. Ciencia y valores en la Filosofía de Nicholas Rescher," in RESCHER, N., *Razón y valores en la Era científico-tecnológica*, pp. 11-44; especially, p. 22.

the import and the credentials of various sorts of human knowledge—above all in the sciences, in everyday life, and in philosophical reflection itself. The adequate comprehension of the character of these various realms of inquiry—especially of the mutual interrelationships—is the formative purpose of the enterprise."[41]

This system is supported by two fundamental mainstays: Kantism and pragmatism. Thus, on the one hand, Rescher thinks that human knowledge is modulated by concepts and ideas, so that "science is indebted to the conceptual categories of the human beings and it is different from [the kind of science] that would be made by other agents with other conceptual configuration."[42] In this regard, the Kantian influence of his thought has primacy. And, on the other hand, when he focuses on the progress in science, the pragmatic dimension of his thought is highlighted. The nexus between scientific progress and technological innovation is then emphasized; and, furthermore, he highlights the link between scientific progress and prediction.

1.2.1. The Role of Concepts in the Development of Knowledge

Pragmatism modulates the idealistic proposal of Rescher. Thus, he discards a strong idealism and opts for "a middle-of-the-road idealism that makes significan concessions to realism."[43] In his judgment, the complexity of the discussion between idealism and realism is rooted in the wide variety of realisms and idealisms that have been defended during the history of philosophy.[44] This leads him to think that the solution cannot be found in the imposition of one of these philosophical doctrines, because realism and

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[41] RESCHER, N., *Enlightening Journey. The Autobiography of an American Scholar*, p. 174.
[42] GONZALEZ, W. J., *La predicción científica*, p. 254.
[43] RESCHER, N., *A System of Pragmatic Idealism.* Vol. I: *Human Knowledge in Idealistic Perspective*, p. xiv.
[44] Cf. RESCHER, N., "Realism and Idealism," in RESCHER, N., *A System of Pragmatic Idealism.* Vol. I: *Human Knowledge in Idealistic Perspective*, pp. 304-306.

idealism are not necessarily exclusive. On the contrary, "the sensible move is to opt for the middle ground and to combine a plausible version of realism with a plausible version of idealism."[45]

In his approach, this view does not involve that he takes an eclectic posture or a simple hybrid or combination of stances. As a Kantian philosopher, the concepts gain relevance to the articulation of knowledge. Categories and concepts in general allow us to articulate the reality. Therefore, science is a human product, which is above all of an intellectual kind and related with certain practices. The scientific view of the world is not absolute in cognitive terms, because science is "our" science. This means that it is the result of the interaction between the researcher and the environment (in principle, natural), according to our conceptual scheme.[46]

Rescher's acceptance of elements of ontological realism is based in pragmatic reasons. They encompass our notions of truth, communication, fact, or research, insofar as they require to *presuppose* the notion of *reality*.[47] At the same time, he defends a conceptual idealism: we know reality through our mental categories, our concepts to characterize real things. Knowledge of reality can only be reached through the resources that human beings have: "our only access to information about what the real is through the mediation of mind."[48]

By this way, Rescher establishes a distinction between reality *as such* and reality *as it presents itself to us*.[49] This involves that "the range of *fact* is

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[45] RESCHER, N., "Realism and Idealism," in RESCHER, N., *A System of Pragmatic Idealism. Vol. I: Human Knowledge in Idealistic Perspective*, p. 324.
[46] Cf. RESCHER, N., "Our Science as O-U-R Science," in RESCHER, N., *A Useful Inheritance. Evolutionary Aspects of the Theory of Knowledge*, Rowman and Littlefield, Savage, 1990, pp. 77-104.
[47] Cf. RESCHER, N., "Pragmatic Idealism and Metaphysical Realism," in SHOOK, J. R. and MARGOLIS, J., A. (eds.), *Companion to Pragmatism*, B. Blackwell, Oxford, 2006, pp. 386-397; especially pp. 388-393.
[48] RESCHER, N., "Realism and Idealism," in RESCHER, N., *A System of Pragmatic Idealism. Vol. I: Human Knowledge in Idealistic Perspective*, p. 324.
[49] Cf. RESCHER, N., "Our Science as O-U-R Science," in RESCHER, N., *A Useful Inheritance. Evolutionary Aspects of the Theory of Knowledge*, p. 77.

always broader than that of *knowledge*."[50] Certainly, he does not call into question the existence of a reality that is independent of the knowing subject.[51] Thus, he accepts the notion of objectivity, which he associates with impartiality. He does this by pragmatic reasons, because objectivity is — in his judgment — a "functionally useful instrumentality"[52] to guide research.

In his thought, the acceptation of an objective reality has to do with its utility. Thus, he takes into account six reasons by which it is required the notion of a *mind-independent reality*: "1) to preserve the distinction between true and false with respect to factual matters and to operate the idea of thuth as agreement with reality; 2) to preserve the distinction between appearance and reality, between our picture of reality and reality itself; 3) to serve as a basis for intersubjective communication; 4) to furnish the basis for a shared project of communal inquiry; 5) to provide for the fallibilistic view of human knowledge; and 6) to sustain the causal mode of learning and inquiry and to serve as basis for the objectivity of experience."[53]

Consequently, Rescher accepts the existence of a reality that is independent of the subjects that try to know that reality. But the knowledge of reality is always mediated by the categories and concepts of human beings, in such a way that it "represents information about an inquiry-relative *empirical* reality."[54] In his approach, the acceptation of an objective reality and a fallibilistic view of knowledge go hand-in-hand, since human being articulates reality through an imperfect conceptual scheme.[55]

This approach involves a view of science as a human product, where agents prevail as producers of science and recipients of the things achieved.

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[50] RESCHER, N., "Our Science as O-U-R Science," p. 79. This idea is developed by Rescher in his book *Scientific Realism*, Reidel, Dordrecht, 1987.
[51] Cf. RESCHER, N., "Nuestra Ciencia en tanto que *nuestra*," p. 2.
[52] RESCHER, N., "Pragmatic Idealism and Metaphysical Realism," in SHOOK, J. R. and MARGOLIS, J., A. (eds.), *Companion to Pragmatism*, p. 388.
[53] "Pragmatic Idealism and Metaphysical Realism," pp. 390-391.
[54] RESCHER, N., "Our Science as O-U-R Science," p. 80.
[55] Cf. RESCHER, N., "Pragmatic Idealism and Metaphysical Realism," p. 390.

In this way, Rescher maintains that “the limits of our experience set limits to our science.”[56] From this perspective, the ideal of a perfect science can be ruled out; i.e., the possibility of a fully completed science is rejected.[57] That is way in his approach the characterization of science as *our* science leads to a view of scientific knowledge as imperfect and incomplete.[58]

There is a clear connection between this issue of “perfect science” and the problem of the limits of scientific research. With regard to the limits of science, there is initially two different sides: the limits as “barriers” (*Schranken*) — what separates science from non-science — and the limits as “confines” (*Grenzen*), which deal with the final frontiers of the scientific research.[59]

Usually, when Rescher analyzes the limits of science, his attention is focused on the second side of the problem: the possible “confines” or the ceiling for scientific activity. His effort leads him to insist on the fact that we cannot know now the science that we will have in the future.[60] In addition, insofar as he sees science as a system, it is implicit in his view that there are also “barriers,” which separate science from other human activities.[61]

With regard to the confines, the perspective of a systems highlights the distinction between the “internal” obstacles — those that are due to scientific activity itself — and the “external” obstacles, which are those that come from

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[56] RESCHER, N., *The Limits of Science*, revised edition, University of Pittsburgh Press, Pittsburgh, 1999, p. 216

[57] RESCHER, N., *The Limits of Science*, revised edition, pp. 145-176.

[58] Cf. RESCHER, N., “The Imperfectibility of Science,” in RESCHER, N., *A System of Pragmatic Idealism.* Vol. I: *Human Knowledge in Idealistic Perspective*, pp. 77-95.

[59] Cf. RADNITZKY, G, “The Boundaries of Science and Technology,” in: *The Search for Absolute Values in a Changing World*. *Proceedings of the VIth International Conference on the Unity of Sciences*, vol. II, International Cultural Foundation Press, N. York, 1978, pp. 1007-1036.

An analysis of the limits of science as a matter that involves these two dimensions (the “barriers” and the “confines”) is in GONZALEZ, W. J., “Rethinking the Limits of Science: From the Difficulties for the Frontiers to the Concern on the Confines,” in GONZALEZ, W. J. (ed.), *The Limits of Science: An Analysis from “Barriers” to “Confines,”* forthcoming.

[60] Cf. RESCHER, N., “The Problem of Future Knowledge,” *Mind and Society*, v. 11, n. 2, (2012), pp. 149-163.

[61] The existence of some kind of “barriers” follows from his acceptance that science cannot cover the full field of human knowledge and specific human activities. See, in this regard, RESCHER, N., *Razón y valores en la Era científico-tecnológica*, pp. 99-121.

the environment. Usually, Rescher is focused on the internal obstacles to scientific activity, which he analyzes in accordance with the distinction between limits *in the weak sense* — the current difficulties to solve a problem — and limits *in the strong sense* (the unsolvable problems of science).[62] In this regard, there are internal limits to science that are rooted in its constitutive elements, so we can find obstacles due to the language of science, its structure, its knowledge, its processes, its activity, and its values (among then, ethical values).[63]

But there are also external limits to science that have to do with the relations between science and the environment (natural, social, or artificial). These limits have to do with the complexity that hinders scientific knowledge and that — in Rescher's proposal — has a strong impact on prediction.[64] Thus, when the future we try to predict is developmentary open, it can become unpredictable for us (or, at least, "not predictable".) This is what happens with future knowledge, which is not accessible to our current categories of knowledge, above all when the future is in the long run and we try to predict in a very detailed way.[65]

Regarding the barriers — what separates science from pseudoscience or other legitimate ways of knowledge — Rescher points out that science is also a limited endeavor, since scientific knowledge is just one human good among others.[66] He takes into account other ways of knowledge, so science

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[62] Cf. RESCHER, N., "On Learned Ignorance and the Limits of Knowledge," in RESCHER, N., *Cognitive Pragmatism. The Theory of Knowledge in Cognitive Perspective*, University of Pittsburgh Press, Pittsburgh, PA, 2001, pp. 63-80; especially, pp. 73-75.

[63] Cf. GONZALEZ, W. J., *La predicción científica*, pp. 275-276; and GONZALEZ, W. J., "Rethinking the Limits of Science: From the Difficulties for the Frontiers to the Concern on the Confines," in GONZALEZ, W. J. (ed.), *The Limits of Science: An Analysis from "Barriers" to "Confines,"* forthcoming.

On the constitutive elements of science, see GONZALEZ, W. J., "The Philosophical Approach to Science, Technology and Society," in GONZALEZ, W. J. (ed.), *Science, Technology and Society: A Philosophical Perspective*, Netbiblo, A Coruña, 2005, pp. 3-49; especially, pp. 10-11.

[64] Cf. RESCHER, N., *Predicting the Future*, chap. 8, pp. 133-156.

[65] Cf. RESCHER, N., "The Problem of Future Knowledge," pp. 149-163.

[66] Cf. RESCHER, N., *Razón y valores en la Era científico-tecnológica*, pp. 103-105.

is only one possible way of knowing. Nevertheless, scientific knowledge is — in his judgment — an especially important good due to its high instrumental value. Thus, from a pragmatic point of view, the pursuit of knowledge as a good "in no way hinders the cultivation of other legitimate goods; on the contrary, it aids and facilitates their pursuit, thereby acquiring an *instrumental* value in addition to its value as an absolute good in its own right."[67]

Thus, Rescher acknowledges that can be legitimate knowledge outside the science that has to do with philosophy and humanistic disciplines[68]. However, he does not use to take into account the historicity of knowledge. In particular, regardless his objections to Strawson related to the processes,[69] *historicity* is not adequately stressed in his view.[70] Above all, the lack of attention to the notion of "historicity" can be seen when he characterizes scientific change, which he connects to the idea of "progress." In this regard, his approach is in terms of "process," instead of being an approach focused on historicity.

1.2.2. Scientific Progress

Undoubtedly, scientific progress is one of the topics that receive more attention in the contemporary philosophy and methodology. Since 1978, Rescher has published several monographs where he analyzes scientific progress. Usually, he sees progress from a perspective focused on the economic dimension, so that he offers an approach to scientific progress where the analysis in terms of costs and benefits is especially relevant.[71]

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[67] RESCHER, N., *The Limits of Science*, revised edition, p. 243.
[68] Cf. RESCHER, N., *Razón y valores en la Era científico-tecnológica*, pp.106-113.
[69] Cf. RESCHER, N., *Process Metaphysics. An Introduction to Process Philosophy*, State University of N. York Press, Albany, NY, 1996, pp. 60-64.
[70] On the role of historicity in scientific change, cf. GONZALEZ, W. J., "El enfoque cognitivo en la Ciencia y el problema de la historicidad: Caracterización desde los conceptos," *Letras*, n. 114, n. 79, (2008), pp. 51-80.
[71] His interest in the economic aspects of scientific progress can be seen, fundamentally, in five of his monographs: RESCHER, N., *Peirce's Philosophy of Science*, University of Notre Dame Press, Notre Dame, 1978; RESCHER, N., *Scientific Progress. A Philosophical Essay on*

Generally speaking, it is possible to claim that the term "'progress' is a normative or goal-relative — rather than a purely descriptive — term."[72] So when it is claimed that, in fact, there has been "scientific progress," it is assumed that the new things achieved are an *improvement* in comparison with the old things; that is, there has been a scientific change and that change has a positive character (at least in epistemological terms).[73] Thus, the ends are closer than they were before the change had taken place.

In this regard, Ilkka Niiniluoto maintains that "'progress' can be contrasted with such neutral terms as 'development', and a philosophical analysis of scientific progress is tantamount to a specification of the *aims* of science."[74]. That is, if we want to be able to recognize the progress, the aims sought must also be recognizable. Rescher's notion of "scientific progress" goes in the same way, because — in his judgment — scientific progress is relative to the ends of science.[75] For him these ends are basically four: description, explanation, prediction, and control over nature.[76]

There are several aspects that characterize Rescher's notion of "scientific progress": 1. Scientific progress is potentially unlimited, since it is impossible for us to achieve a perfect science (that is, a completed science),

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the Economics of the Natural Science, B. Blackwell, Oxford, 1978; RESCHER, N., *Cognitive Economy. The Economic Dimension of the Theory of Knowledge*, University of Pittsburgh Press, Pittsburgh, 1989; RESCHER, N., *Priceless Knowledge? Natural Science in Economic Perspective*, Rowman and Littlefield, N. York, 1996; and RESCHER, N., *Epistemetrics*, Cambridge University Press, N. York, 2006.

For a synthesis of the content of this books, see WIBLE, J. R., "How is Scientific Knowledge Economically Possible?: Nicholas Rescher's Contributions to an Economic Understanding of Science," in ALMEDER, R. (ed.), *Rescher Studies. A Collection of Essays on the Philosophical Work of Nicholas Rescher*, pp. 445-476.

[72] NIINILUOTO, I., "Scientific Progress," *Synthese*, n. 45, (1980), p. 427.

[73] On the notion of "scientific progress", see GONZALEZ, W. J., "Progreso científico, autonomía de la Ciencia y realismo," *Arbor*, v. 135, n. 532, (1990), pp. 91-109; and GONZALEZ, W. J., "Progreso científico e innovación tecnológica: La 'Tecnociencia' y el problema de las relaciones entre Filosofía de la Ciencia y Filosofía de la Tecnología," *Arbor*, v. 157, n. 620, (1997), pp. 261-283.

[74] NIINILUOTO, I., "Scientific Progress," p. 428.

[75] Cf. RESCHER, N., *The Limits of Science*, revised edition, chapter 10, pp. 145-165.

[76] Cf. RESCHER, N., *Razón y valores en la Era científico-tecnológica*, p. 138. This highlights that his approach is principally oriented toward the sciences of nature.

so that it is always possible to enlarge or improve the available knowledge.[77] 2. Regarding the limits that hinder scientific progress, economic limits are especially important. They involve that there is a deceleration of scientific progress as its costs increase.[78] 3. Scientific progress has basically a conceptual character, although the practical dimension of scientific research should be stressed to assess progress: above all, the improvements with regard the ability of prediction and control over nature.[79]

1. On the first feature — scientific progress as potentially unlimited or endless — Rescher thinks that science is always open to future developments. In this regard, there is a relevant difference between two different senses of limits: the limits *in the weak sense* and the limits *in the strong sense*. There are limits *in the weak sense* when we are not able now to answer questions, because we do not have the knowledge required to answer them. Meanwhile, there are limits *in the strong sense* when we think that there are questions that we will not answer in the future, even in the long run.[80]

When Rescher compares the limits in the weak sense to the limits in the strong sense, he considers that the later are more problematic than the former. Limits in the strong sense are associated with *insolubilia* (the unsolvable problems of science). In this regard, when we accept that science is subject to limitations in the strong sense, it is accepted that there is now or there will be in the future significant questions that never will be answered.

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[77] Cf. RESCHER, N., *The Limits of Science*, revised edition, pp. 5-18; and RESCHER, N., *Scientific Progress. A Philosophical Essay on the Economics of the Natural Science*, pp. 38-53.

[78] Cf. RESCHER, N., *Scientific Progress. A Philosophical Essay on the Economics of the Natural Science*, pp. 79-94.

[79] Cf. RESCHER, N., *Methodological Pragmatism. A Systems-Theoretic Approach to the Theory of Knowledge*, B. Blackwell, Oxford, 1977.

[80] Cf. RESCHER, N., "On Learned Ignorance and the Limits of Knowledge," in RESCHER, N., *Cognitive Pragmatism. The Theory of Knowledge in Cognitive Perspective*, pp. 63-80; especially, pp. 73-75.

They are questions whose solution is beyond the limits of science — as a human activity; this is also the case in the long run.

However, Rescher points out that "there is no reason to think, on the basis of general principles, that any issues within the domain of natural science lie beyond its capabilities."[81] From this point of view, limits that affect science are always limits in the weak sense. In this case, this proposal — that science is subject to limits in the weak sense — is compatible with the claim that whatever be the question posed in a concrete moment of scientific research, we should think that we will be able to answer it, at least in the future.

But, on the basis of the *unpredictability* of the future science, it cannot be claimed that all the questions posed by science will be eventually answered.[82] Thus, Rescher accepts, in principle, the possibility that there are limits in the strong sense, so that they can be unsolvable problems in scientific research. However, he points out that these are two different theses: (i) that there could be unsolvable problems, and (ii) that those unsolvable problems can be identified. The later thesis — that we can identify now the questions that science will never be able to solve — is called "hyperlimitation" by Rescher.[83]

Certainly, this topic has to be seen in connection to the difficulties to predict the future knowledge. As Rescher states this problem, it is possible to

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[81] RESCHER, N., *The Limits of Science*, revised edition, p. 3.
[82] There is an important distinction between "unpredictable" and "not predictable." "Unpredictability" involves the complete impossibility of predicting. It is mainly due to the presence of anarchic phenomena. Meanwhile, "not predictability" is related to the current impossibility of achieving a prediction, which is usually due to the instability of the phenomena. This distinction is in GONZALEZ, W. J., *La predicción científica. Concepciones filosófico-metodológicas desde H. Reichenbach a N. Rescher*, p. 289; and GONZALEZ, W. J., *Philosophico-Methodological Analysis of Prediction and its Role in Economics*, Springer, Dordrecht, 2015, p. 56. See also EAGLE, A., "Randomness Is Unpredictability," *British Journal for the Philosophy of Science*, v. 56, (2005), pp. 749-790.
[83] Cf. RESCHER, N., *The Limits of Science*, revised edition, p. 113.

claim that there are difficulties to identify the *insolubilia*,[84] insofar as there are also difficulties to predict how the future science will be.[85] In fact, he points out that "the prospect of present knowledge about future discoveries is deeply problematic since the future of knowledge is fundamentally unpredictable. The details of the cognitive future are hidden in an impenetrable fog."[86]

This issue is connected with the Kant's *principle of question propagation*, which — in Rescher's judgment — has two main consequences for science: a) the unpredictability of future science, and b) the impossibility of achieving a perfect science. Thus, in the first place, on the basis of current knowledge, Kant's principle of question propagation involves the impossibility of predicting the questions we will ask in the future and, certainly, we do not know now the answers to these questions. For this reason, we cannot identify the *insolubilia* or assure their existence (that is, not as a current incapability that will be overcome in the future).

Obviously, the advancement of science can be seen as a wide cognitive process based on a "Kantian inspiration," because it can be seen as a process of questions and answers, where each new answer influences the question that can be posed. In this regard, Rescher points out different ways by which new knowledge can affect the questions that we consider: I) it can give new answers to old questions; II) it can generate new questions; and III) it can show that old questions are improper or illegitimate.[87]

Therefore, Rescher considers that we cannot predict now with accuracy the content of future knowledge. In consequence, we cannot predict what *questions* we will consider in the future. In addition, we do not know (and cannot know) if all the questions we have not answer yet are legitimate.

[84] Cf. RESCHER, N., *Predicting the Future*, pp. 186-188; and RESCHER, N., *The Limits of Science*, revised edition, chapter 8, pp. 111-127.
[85] Cf. RESCHER, N., *Predicting the Future*, pp. 177-183.
[86] RESCHER, N., "On Learned Ignorance and the Limits of Knowledge," p. 64.
[87] Cf. RESCHER, N., *The Limits of Science*, revised edition, p. 12.

Thus, "the task of specifying the limits of scientific capability in the production of knowledge is itself one that transcends the limits of our cognitive powers."[88] In this way, it also transcends our capabilities the task of identifying what the *insolubilia* problems of science are, although we can assume that those problems exist.

It should be pointed out that Kant's principle of question propagation involves the impossibility of the completeness of science. Rescher relates this issue to the existence of limits in the weak sense. Thus, scientific knowledge is open to the future, and this means that perfect science is an unfeasible ideal; that is, he does not accept the possibility of a completed science.[89] This is because each scientific improvement will generate new questions that require an answer, and so on. In this way, science is developed through a question-answering process, insofar as it overcomes the limits that hinder its advancement.

The distinction between limits *in the weak sense* and limits *in the strong sense* — where *hyperlimitation* can be included — has major implications for scientific progress. Rescher's proposal is clear: "the distinction between these various types of limits thus carries the important lesson—already drawn by Kant—that even the resolution of all *our* scientific problems would not necessarily mean that science as such is finite or completable."[90]

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[88] RESCHER, N., *Unknowability. An Inquiry into the Limits of Knowledge*, Lexington Books, Lanham, MD, 2009. p. 18.

[89] Rescher calls into question the possibility of achieving a perfect science form theoretical and practical viewpoints. His starting point is in the goals of science, which in his judgment are four: description, explanation, prediction, and control. Then, he identifies four conditions that a scientific discipline should meet in order to be considered completed: erotetic completeness, predictive completeness, pragmatic completeness, and temporal finality (the omega-condition). He considers that the first three are problematic from a theoretical point of view and unfeasible form a pragmatic viewpoint. Meanwhile, the temporal finality is unfeasible if we take into account the internal dynamics of the connection between scientific progress and technological innovation. Cf. RESCHER, N., *The Limits of Science*, revised edition, pp. 145-176.

[90] RESCHER, N., "On Learned Ignorance and the Limits of Knowledge," p. 74.

Thereby, he maintains an approach to scientific progress as unlimited, insofar as it is always open to the future.[91]

On the one hand, Rescher sees science as subject to limits *in the weak sense*. They are *current* limits that can be found in each historical stage of scientific development and will affect science also in the future. But they are obstacles that can be overcome through scientific development itself. In his own words: "to maintain (…) the essential limitlessness of science on the side of terminating limits—the feasibility of unending scientific progress—is not to deny the prospect of problems whose solution lies beyond the physical and/or economic limits of man's investigative capacities. The existence of actually unanswerable questions in science—problems whose solution lies forever on the inaccessible side of a technologically imposed data-barrier—would not mean an eventual end to scientific progress."[92]

Accordingly, Rescher thinks that, *de facto*, there will be always limits that hinder scientific progress; but, at the same time, he considers that scientific progress is always possible to the extent that those limits can be eventually overcome. Concurrently, he calls into question that there are, strictly speaking, limits *in the strong sense*. This is because, in the first place, when we consider that a question is in principle beyond the powers of science, it is difficult to maintain that this question is a legitimate scientific one (i.e., that it belongs to the scientific domain); and, in the second place, even if those limitations exist, it is impossible for us to identify them.[93] Following such way, it is questionable whether there is now or will be in the future a "ceiling" of scientific research, even when we must acknowledge the present existence of limits to scientific progress.

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[91] Cf. RESCHER, N., *Scientific Progress. A Philosophical Essay on the Economics of the Natural Science*, *passim*.
[92] RESCHER, N., "Some Issues Regarding the Completeness of Science and the Limits of Scientific Knowledge," p. 32.
[93] Cf. RESCHER, N., "On Learned Ignorance and the Limits of Knowledge," p. 75.

2. When Rescher considers the limits in the weak sense (that is, those limitations that affect science in each concrete stage), the second feature of his characterization of scientific progress appears: the relevance of the economic limits. In effect, "Rescher's approach on scientific progress is frequently based on the language of cost and benefit, because — for him — cost-effectiveness is a salient aspect of rationality, where the benefits of knowledge can be theoretical (or purely cognitive) or practical (or applied)."[94]

In this regard, it can be pointed out that "on the one hand, among the *internal benefits* of sciences is the increasing capacity that a science has to provide explanation and prediction, which also contribute explicitly to the human worldview as well as the solution of many practical problems of everyday life. On the other hand, there are growing *external costs*, mainly in the natural sciences and in the sciences of the artificial, which are due to the enlarging complexity of the phenomena studied as well as the greater difficulty in learning and mastery."[95]

Therefore, with regard to the economic limits to scientific progress, the analysis of the external costs is a fundamental issue. Regarding this problem, Rescher pays attention to the relations between science (above all, natural sciences) and technology. He thinks that science and technology are like "two legs of the same body,"[96] since each of them needs the other and contributes to its development. Again, his pragmatic component is clear: they are endeavors interrelated.

Because Rescher's analysis is focused on the natural sciences, he maintains that technologies for observation, experimentation, and de subsequent data-processing have a key role in scientific progress. In this

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[94] GONZALEZ, W. J., "Economic Values in the Configuration of Science," in AGAZZI, E., ECHEVERRÍA, J. and GÓMEZ, A. (eds.), *Epistemology and the Social*, Poznan Studies in the Philosophy of the Sciences and the Humanities, Rodopi, Amsterdam, 2008, p. 92.
[95] GONZALEZ, W. J., "Economic Values in the Configuration of Science," in AGAZZI, E., ECHEVERRÍA, J. and GÓMEZ, A. (eds.), *Epistemology and the Social*, p. 92.
[96] RESCHER, N., *Razón y valores en la Era científico-tecnológica,* p. 100

way, scientific progress and technological innovation are two notions that go together in his approach.[97] As J. F. Wible points out, in Rescher's proposal "scientific progress depends on scientific observation and it in turn depends both on the availability and types of resources required for scientific observation."[98]

In effect, Rescher thinks that there cannot be scientific progress without technology. "On the one hand, the transforming resources of technology use and exploit our scientific understanding of the world's processes. But, on the other hand, it turns out that science cannot progress without technology, because we can only obtain information about reality by interacting with it. We can only theorize about nature in an effective way to the extent that we can detect its processes (by 'observation') and manipulate its phenomena (by 'experimentation')."[99]

On the other hand, this relation of inter-dependence between science and the available technology involves a major limitation to scientific progress, since there are increasing costs related to data acquisition and management technologies as science advances. On the other hand, technological innovation enlarges complexity, because each solution given to the problems related to information processing and the control of the processes generates new problems of complexity.[100]

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[97] "Although scientific progress is always possible in principle (…) the achievement of this permanent possibility demands a continuous improvement of the technological capability of data extraction and exploitation," RESCHER, N., *Razón y valores en la Era científico-tecnológica,* p. 126.

[98] WIBLE, J. R., "How is Scientific Knowledge Economically Possible?: Nicholas Rescher's Contributions to an Economic Understanding of Science," in ALMEDER, R. (ed.), *Rescher Studies. A Collection of Essays on the Philosophical Work of Nicholas Rescher*, p. 446.

[99] RESCHER, N., *Razón y valores en la Era científico-tecnológica*, p. 100. Rescher calls this "thesis of the technological dependency," which maintains that "*progress in the theoretical superstructure of natural science hinges crucially upon improvements in the technological basis of data-acquisition and processing*," RESCHER, N., *Scientific Progress*, p.142.

[100] Cf. RESCHER, N., *Razón y valores en la Era científico-tecnológica*, pp. 118-121. On scientific creativity and technological innovation in the context of complexity, cf. GONZALEZ, W. J., "The Roles of Scientific Creativity and Technological Innovation in the Context of Complexity of Science," in GONZALEZ, W. J. (ed.), *Creativity, Innovation, and Complexity in Science*, Netbiblo, A Coruña, 2013, pp. 11-40.

In Rescher's judgment, "Kant's principle of question-propagation" is also present in the technological realm, and it is related to complexity. In his words, "throughout the progress of science, technology, and human artifice generally, complexity is self-potentiating because it engenders complications on the side of problems that can only be addressed adequately through further complication on the side of process and procedure. The increase in technical sophistication confronts us with a dynamic feedback interaction between problems and solutions that ultimately transforms each successive solution into a generator of new problems."[101]

This problem involves that there is — or can be in principle — a deceleration in scientific progress due to economic elements. Thus, the costs related to scientific progress increase at the same time that the benefits decrease, since "each successive order-of-magnitude step involves a massive cost for lesser progress; each successive fixed-size investment of effort yields a substantially diminished return."[102] From this point of view, the major limits to scientific progress are practical limits that rest basically on the physical-economic limitations to data acquisition and processing.[103]

3. The third basic feature that characterizes Rescher's proposal on scientific progress — which goes with its potentially unlimited character and the relevance of the economic limits — has a double side: on the one hand, he emphasizes that science progresses, fundamentally, through conceptual change; and, on the other hand, he considers that scientific prediction and control over nature are the best criteria at our disposal to assess scientific progress. Thus, he thinks of scientific progress as a *process* where changes occur and these changes are basically related to concepts.[104]

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[101] RESCHER, N., *Razón y valores en la Era científico-tecnológica*, p. 120.
[102] Cf. RESCHER, N., *The Limits of Science*, revised edition, p. 59.
[103] Cf. RESCHER, N., *Scientific Progress*, p. 236.
[104] Conceptual progress form the point of view of processes is not the same as *conceptual historicity* as the driving force of scientific change. Cf. THAGARD, P., *Conceptual revolutions*,

In effect, Rescher points out in an explicit way that "scientific change (…) is not just a matter of marginal revisions of opinion within a fixed and stable framework of concepts; the crucial developments involve a change in the conceptual apparatus itself."[105] This leads to a view of scientific progress as "a process of *conceptual* innovation that always places certain developments outside the cognitive horizons of earlier workers because the very concepts operative in their characterization become available only in the course of scientific discovery itself."[106]

But, at the same time, Rescher thinks that it is problematic to *assess scientific progress* on the basis of conceptual change. This is because, in his judgment, "when the 'external' element of *control over nature* is given its due prominence, the substantiation of imputations of scientific *progress* becomes a more manageable project than it could ever possibly be on a 'internal,' context-oriented basis."[107]

This approach is — in my judgment — problematic if we consider the framework of thought that Rescher offers. Clearly, he acknowledges that concepts can have an *objective content*. So it could be possible to assess, on the basis of the objectivity of the concepts, scientific progress in connection with conceptual changes, where historicity (of science, the agents and the researched reality itself) is compatible with objectivity.[108] Instead of doing that, Rescher claim is different: "the progress of science will be taken to center on its pragmatic aspect—the increasing success of applications in problem solving and control."[109]

Princeton University Press, Princeton, 1992; and GONZALEZ, W. J. (ed.), *Conceptual Revolutions: From Cognitive Science to Medicine*, Netbiblo, A Coruña, 2011.

[105] RESCHER, N., *The Limits of Science*, revised edition, p. 39.

[106] RESCHER, N., "The Problem of Future Knowledge," p. 151.

[107] RESCHER, N., *Methodological Pragmatism*, p. 188.

[108] On an analysis of conceptual change from the notion of "historicity," see GONZALEZ, W. J., "Conceptual Changes and Scientific Diversity: The Role of Historicity," in GONZALEZ, W. J. (ed.), *Conceptual Revolutions: From Cognitive Science to Medicine*, Netbiblo, A Coruña, 2011, pp. 39-62.

[109] RESCHER, N., *Methodological Pragmatism*, p. 185.

Ilkka Niiniluoto, among other authors, has criticized this proposal of Rescher. In his judgment, Rescher's insistence on prediction and the ability of control as criteria to assess the verisimilitude of theories results in a biased view of scientific progress. From this perspective, *pragmatic success* would be at most a criterion to evaluate *cognitive success*, but it is neither the only criterion nor the most important.[110] So Niiniluoto considers that there are a wide variety of reliable criteria. They are "cognitive factors such as truth, information, explanatory power, predictive capacity, precision, and simplicity."[111]

Regarding Niiniluoto's criticism, I need to point out that Rescher does not maintain, strictly speaking, that predictive success is, by itself, a criterion to assess the verisimilitude of scientific theories. What Rescher actually thinks is that "only a complex, reciprocally interactive gearing of explanation, prediction, and control can in the final analysis provide a satisfactory standard of scientific adequacy."[112] Nevertheless, he thinks that its role as a criterion to assess scientific progress is fundamental. Thus, "predictive efficacy is the best available token for the explanatory adequacy of our theories."[113]

1.3. The Main Philosophico-Methodological Elements of Prediction

Certainly, the problem of scientific prediction is among the most representative and discussed topics of the philosophy and methodology of science in the 20th century and the beginning of 21th century. From different philosophical approaches, it has been highlighted the relevance that the

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[110] Cf. NIINILUOTO, I., "Límites de la Tecnología," in GONZALEZ, W. J. (ed.), *Progreso científico e innovación tecnológica*, *Arbor*, v. 157, n. 620, (1997), p. 402.
[111] NIINILUOTO, I., "Límites de la Tecnología," p. 402.
[112] RESCHER, N., *Predicting the Future*, p. 165.
[113] *Predicting the Future*, p. 164. It seems odd to maintain that "predictive efficacy" is key for "explanatory adequacy," above all if we take into account that Rescher supports the asymmetry between explanation and prediction.

notion of “prediction” has to scientific activity.[114] In effect, prediction has several relevant roles in science: (i) it is an important aim of scientific research; (ii) in basic science prediction is usually used as a test of theories; (iii) it precedes the prescriptive task of applied sciences;[115] and (iv) it can be a starting point for decision making in the realm of the application of science.[116]

These considerations are based on the fact that the different components of science (language, structure, knowledge, method, activity, ends, and values)[117] can be oriented towards the future. Consequently, scientific prediction can be analyzed from a variety of realms that concern the aforementioned components. Thus, the study of scientific prediction has been addressed from the semantic, logical, epistemological, methodological, ontological, axiological, and ethical realms.[118]

Within Rescher’s philosophical conception, the problem of scientific prediction is placed in a prominent position. It should be highlighted his monograph devoted to scientific prediction, where he offers many elements to the analysis of prediction from the perspective of the diverse constituents of science: language, structure, knowledge, method, activity, ends, and

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[114] However, when it is compared with scientific explanation, the problem of prediction has undoubtedly received less attention in the contemporary philosophy and methodology of science: “Despite the fact that most philosophers acknowledge the general importance of prediction for science, the vast majority of the intellectual focus between the two goals rests on explanation. Prediction is rarely a topic in its own right, appearing mainly in discussions of confirmation, realism, and other topics. It has been this way for over 40 years,” DOUGLAS, H. E., “Reintroducing Prediction to Explanation,” *Philosophy of Science*, v. 76, n. 4, (2009), p, 445.
[115] Cf. GONZALEZ, W. J., *La predicción científica*, p. 11.
[116] Cf. GONZALEZ, W. J., “The Roles of Scientific Creativity and Technological Innovation in the Context of Complexity of Science,” in GONZALEZ, W. J., *Creativity, Innovation, and Complexity in Science*, pp. 11-40; especially, pp. 17-18.
[117] On the constitutive elements of science, see GONZALEZ, W. J., “The Philosophical Approach to Science, Technology and Society,” in GONZALEZ, W. J. (ed.), *Science, Technology and Society: A Philosophical Perspective*, pp. 3-49.
[118] On the roles of prediction and the diversity philosophical analyses regarding its different realms, see GONZALEZ, W. J., *La predicción científica*, passim. These realms of philosophical analyses have a direct repercussion in sciences such as economics. See GONZALEZ, W. J., *Philosophico-Methodological Analysis of Prediction and its Role in Economics*, passim.

values.[119] As he explicitly states, the book seeks "to provide a *theory of prediction*."[120] These components considered are interrelated within his proposal — that is a pragmatic idealism — since he is interested on a *system*.

Therefore, they are a set of interdependent elements in his conception, so "each factor can be distinguished from the others, but it cannot be properly separated: it is a part of a whole."[121] In fact, to a greater or lesser extent, Rescher deals with the semantic, logical, epistemological, methodological, ontological, axiological, and ethical components of scientific prediction. His goal is to offer a systematic conception of prediction; where the different levels are related giving rise to an interdependence network. *De facto*, he reaches the proposed aim: to provide a theory of prediction, which is analyzed here.

1.3.1. Semantic and Logical Features of Prediction

From a semantic viewpoint, prediction is about a future (something that is not yet). Thus, its referent is, in principle, something potential rather than actual. In this way, the sense and referent of a predictive statement belong to the realm of what is expected.[122] In this regard, Rescher's proposal is not, strictly speaking, a semantic approach to prediction. It is rather a *pragmatic* conception of prediction. In effect, his accounts of scientific language, in general, and the language of prediction, in particular, follow the pragmatic view of language. Thus, he sees meaning from use conditions, instead of considered that truth conditions are more important for the meaning.[123]

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[119] See RESCHER, N., *Predicting the Future*, passim.
[120] RESCHER, N., *Predicting the Future*, p. 1.
[121] GONZALEZ, W. J., *La predicción científica*, p. 259.
[122] Cf. *La predicción científica*, p. 284. See also BENTON, M. A. and TURRI, J., "Iffy Predictions and Proper Expectations," *Synthese*, v. 191, (2014), pp. 1857-1866.
[123] Rescher's approach to language is developed in RESCHER, N., *Communicative Pragmatism and Other Philosophical Essays on Language*, Rowman and Littlefield, Lanham, MD, 1998.

Within this framework, the pragmatic vision of meaning — as use — connects to pragmatism, since to predict is — in Rescher's judgment — an *activity* oriented towards the achievement of meaningful statements about future events and phenomena. To predict is "to endeavor to provide warranted answers to detailed substantive questions about the world's future developments."[124] For this reason, it also has an instrumental component: "Prediction (…) is our instrument for resolving our meaningful questions about the future, or at least of *endeavoring* to resolve them in a rationally cogent manner."[125]

From the point of view of language, Rescher accepts the Israel Scheffler's idea of scientific prediction as a *statement* that is about the future.[126] Thus, there is a clear difference between prediction and explanation, because the latter can be an argument.[127] This difference will be developed here from a logical viewpoint. In addition, in contrast to authors such as Milton Friedman[128] or Stephen Toulmin[129], Rescher does not accept a "prediction about the past."[130] Prediction is oriented towards the future and, consequently, "the semantics of prediction allows a predictive language

[124] RESCHER, N., *Predicting the Future*, pp. 37-38.
[125] *Predicting the Future*, p. 39.
[126] Cf. SCHEFFLER, I., "Explanation, Prediction, and Abstraction," *British Journal for the Philosophy of Science*, v. 7, (1957), pp. 293-309.
[127] Cf. GONZALEZ, W. J., *La predicción científica*, p. 260. On explanation as argument, see SINTONEN, M., *The Pragmatics of Scientific Explanation*, *Acta Philosophica Fennica*, v. 37, Helsinki, 1984, pp. 8, 10, 89-90, and 112.
[128] Cf. FRIEDMAN, M., "The Methodology of Positive Economics," in FRIEDMAN, M., *Economics*, The University of Chicago Press, Chicago, 1953, p. 9.
[129] The conception of Toulmin with regard to the possibility of obtaining predictions of past is in TOULMIN, S., *Foresight and Understanding*, Indiana University Press, Bloomington, 1961, pp. 26-27.
[130] According to Rescher, prediction is always future oriented, so pure statements about the past cannot be considered as a prediction. However, there can be "hybrid statements" that combine past features and future happenings. For example, "Columbus discovered America in 1492" is a statement about the past, but "If you go to the 'Archivo de Indias,' you will find records about the discovery of America" is future oriented statement (a prediction) which contains also information about the past. Rescher, N., *Personal Communication*, 12.5.2015.

about the future whose status of being true or false might not be specified on the basis of the knowledge available."[131]

Logically, a major problem regarding prediction is related to the logical similarities or differences between prediction and explanation. In this regard, it has been widely discussed whether prediction and explanation are symmetrical or asymmetrical processes. It is a controversy which started in 1948, when Carl Gustav Hempel and Paul Oppenheim published their well-known paper on "Studies in the Logic of Explanation."[132] For these philosophers, the difference between explanation and prediction would be just a temporal anisotropy: explanation deals with past phenomena, whereas prediction is oriented toward the future.

During the years when the symmetry thesis was widely accepted, Rescher suggested an analysis that went further than the mere temporal anisotropy. He clearly saw that explanation and prediction were different logical processes. In his judgment, "it cannot be maintained that explanation and prediction are identical from the standpoint of their logical structure, the sole point of difference between them being one of content, in that the hypothesis of a prediction concerns the future, while explanations concern the past."[133] Many years later, in *Predicting the Future*, he criticizes again the symmetry thesis. He does so in four successive levels: (i) logical, (ii) epistemological; (iii) methodological; and (iv) ontological.[134]

Generally, scientific explanation has more credibility than scientific prediction, insofar as it is possible to maintain with high probability the truth of

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[131] GONZALEZ, W. J., *Philosophico-Methodological Analysis of Prediction and its Role in Economics*, p. 15.
[132] Cf. HEMPEL, C. and OPPENHEIM, P., "Studies in the Logic of Explanation," *Philosophy of Science*, v.15, (1948), pp. 135-175.
[133] RESCHER, N., "On Prediction and Explanation," *British Journal for the Philosophy of Science*, v. 8, n. 32, (1958), p. 289. Rescher's criticism of the symmetry thesis can be seen also in RESCHER, N., *Scientific Explanation*, The Free Press, New York, 1970, pp. 30-37; especially pp. 32-34.
[134] Cf. GONZALEZ, W. J., *La predicción científica*, p. 264. See, in this regard, RESCHER, N., *Predicting the Future*, pp. 165-166.

the conclusion in an explicative argument. Meanwhile, a predictive statement is usually associated much lower degrees of probability.[135] In addition, the relation between informativeness and security is different in both cases. This leads Rescher to state the existence of a significant disanalogy between explanation and prediction.[136] Thus, the more specific and detailed an explanation is the more secure it is. Nevertheless, the more exact and informative a prediction is, the less confidence we can have in it.

Explanation and prediction are, therefore, two different processes, so it cannot be claimed that they are logically equivalent. However, insofar as — for Resche r— science is a *system*, both processes are coordinated. In this way, in contrast to the symmetry thesis, he suggests the "harmony thesis" between explanation and prediction, which maintains that both are closely related.[137] For this reason, Rescher thinks that "theories that do not yield predictions are sterile, and predictions—however successful—that lack a theoretical backing are for that very reason cognitively unsatisfactory."[138] This leads to the problem of predictivism, which has been widely discussed.

Furthermore, when prediction is analyzed from the logic of science, it appears problem of the "well-structured" theories oriented toward prediction. In this regard, a question is whether a "well-structured" theory can have an inductive structure (for example, the hypothetical-inductive[139]) or, on the contrary, the deductive structure (especially, the hypothetical-deductive) is the only valid structure. This leads us to considering several problems that affect prediction: a) how to characterize (and justify) the inductive inference, b) what is the role of induction regarding scientific prediction, and c) what are

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[135] RESCHER, N., *Predicting the Future*, p. 166.
[136] Cf. *Predicting the Future*, p. 257, nota 90.
[137] RESCHER, N., *Predicting the Future*, pp. 167-169. The "harmony thesis" is outlined in his book *Scientific Explanation*: "The key thing in scientific understanding is the capacity to exploit a *knowledge of laws* to structure our understanding of the past and to guide our expectations for the future," RESCHER, N., *Scientific Explanation*, p. 135.
[138] RESCHER, N., *Predicting the Future*, p. 167.
[139] Cf. NIINILUOTO, I. and TUOMELA, R., *Theoretical Concepts and Hypothetico-Inductive Inference*, Reidel, Dordrecht, 1973.

the possible limits to deductivism for scientific prediction.

1.3.2. Prediction in the Epistemological and Methodological Realms

Epistemologically, scientific prediction connects with the need to obtain a high degree of control of the variables in order to achieve a reliable knowledge about the future. Consequently, two major issues arise: on the one hand, the possibility of detecting the *patterns* that affect the changes of the variable that is studied; and, on the other, the availability of means to know *other variables* that interact with the studied variable.[140] This allows us to understand why very often we can only obtain conditional predictions instead of categorical predictions.[141]

From this perspective, it is assumed that scientific prediction must be supported by reasons. For Rescher, predictions which do not rest on reasons are in rigor *prophecies*. Prophecies, unlike scientific predictions, do not have credibility for the scientific endeavor. Thus, he rejects the thesis of D. H. Mellor according to which "predictions don't need reasons,"[142] since those predictions without reasons are actually prophecies without practical utility for science. Consequently, scientific predictions are characterized by being reasoned predictions.[143]

This issue connects the epistemological realm of prediction with the general field of human rationality and, then, with the specific field of scientific rationality. Thus, following Wenceslao J. Gonzalez,[144] it is possible to connect

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[140] Cf. GONZALEZ, W. J., *La predicción científica*, p. 285.
[141] Cf. *La predicción científica*, p. 286.
[142] MELLOR, D. H., "The Possibility of Prediction," *Proceedings of the British Academy*, v.65, (1975), p. 221.
[143] "Any prediction worth bothering about must rest on some evidential basis. Some rational substantiation must be at hand because serious cognitive interest attaches not to predictions as such but *rational* predictions—those that are credible in the sense that there is good reason to accept them as correct then and there, before the fact," RESCHER, N., *Predicting the Future*, p. 38.
[144] Cf. GONZALEZ, W. J., *La predicción científica*, pp. 264-265.

Rescher's epistemology of prediction with his theory of rationality.[145] On the basis of this nexus, it can be seen that Rescher suggests an approach to human rationality, in general, and scientific rationality, in particular, which is characterized by its *broad* nature. Because, in his judgment, rationality concerns three successive levels: a) beliefs, b) actions, and c) ends.[146] Each one of them has repercussions on scientific rationality.

According to this basis, Rescher develops a normative theory of rationality. This theory gives primacy to practical reason over theoretical reason. This feature affects scientific prediction. His conception highlights the pragmatic dimension of prediction, insofar as it is the result of a rational activity. Thus, he conceives prediction as an instrument: "Prediction (…) is our instrument for resolving our meaningful questions about the future, or at least of *endeavoring* to resolve them in a rationally cogent manner."[147]

Within a pragmatic context, it happens that we have important questions on future developments and we need answers to those questions. This is not, for Rescher, a simple issue of curiosity, but a matter of survival. Every human action needs to some extent information about the future, so he considers that "to act, to plan, to survive, we must anticipate the future, and the past is the only guide to it that we have."[148] This epistemological element is linked with the logical component, since practical rationality gives us a justification of the kind of *inductive inference* that allows us to obtain statements of future form the available data about the past-and-present experience.

These coordinates are placed in a fallibilistic epistemological

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[145] Rescher has devoted a large number of his publications to human rationality, in general, and scientific rationality, in particular. Besides the first two volumes already quoted on "a system of pragmatic idealism," there are his books *Rationality*, published in 1988, and *Razón y valores en la Era científico-tecnológica*, published in 1999.

[146] Cf. RESCHER, N., *Rationality. A Philosophical Inquiry into the Nature and the Rationale of Reason*, passim.

[147] RESCHER, N., *Predicting the Future*, p. 39.

[148] *Predicting the Future*, p. 65.

framework. Thus, for Rescher, scientific knowledge is always revisable, so it is possible to improve what we have now.[149] This issue connects with the problem of the limits of science. Among them, he highlights the epistemological and ontological limits.[150] Epistemological limits (such as uncertainty, inferential incapacity, etc.) are especially important for scientific prediction, since it is a knowledge that, because of its very nature, cannot be tested in the present.[151] Meanwhile, ontological limits have to do with the complexity of phenomena, where can be chaos, chance, etc. In short, he maintains that "our predictions are in principle always fallible."[152]

However, the epistemology of prediction in Rescher — which is fallibilistic — has also elements of realism, among them that predictive knowledge must rest on objective basis. It is possible then to obtain true knowledge about the future (or at least close to truth). In this regard, his approach is — in my judgment — correct, because he rejects a naïve version of realism and opts for "a realism which, while acknowledging our limitations in this regard, nevertheless persists in using the resources of reason to doing the best we can in the recognition that while overall this is going to prove to be quite a lot, it will never be nearly as much as we would ideally like."[153]

Methodologically, a systematic account of scientific prediction should take into account a diversity of issues, which can be analyzed according to different methodological levels. In effect, there are at least two different levels in methodology of science: (i) the general methodology of science; and (ii)

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[149] Rescher himself characterizes his epistemology in terms of fallibilism in RESCHER, N., *The Limits of Science*, revised edition, especially in chapter 3, pp. 29-42.

[150] Cf. GUILLAN, A., "Límites del conocimiento y Ciencias de la Complejidad: Factores epistemológicos y ontológicos como obstáculos a la predicción científica", in GONZALEZ, W. J. (ed.), *Las Ciencias de la Complejidad: Vertiente dinámica de las Ciencias de Diseño y sobriedad de factores*, pp. 181-204.

[151] "Epistemological limits on prediction exist insofar as the future is *cognitively inaccessible*—either because we cannot secure the needed data, or because it is impossible for us to discover the operative laws, or even possibly because the requisite inferences and/or calculations involve complexities that outrun the reach of our capabilities," RESCHER, N., *Predicting the Future*, p. 134.

[152] RESCHER, N., *Predicting the Future*, p. 66.

[153] *Predicting the Future*, p. 222.

the special methodology of science.[154] Within the later, two realms can be approached: a) the broad scope, which is concerned to the nexus between a discipline and methodological problems of the general realm; and b) the restricted scope, which takes into account the specific features of each science.[155] In this regard, Rescher is mainly focused on the natural sciences, although he also addresses some specific problems of the social sciences (he is not expressly concerned to the sciences of the artificial).

Moreover, there is the question of the roles of prediction in scientific practice, which can be different in basic science, in applied science, and in the application of science.[156] Thus, scientific prediction plays different roles:[157] 1) in basic research (both in sciences of nature and in social sciences), prediction can be used as a *test* for the hypothesis and theories. 2) In the case of applied science (pharmacology, medicine, economics, etc.) prediction is usually a guide (i.e., a previous step to prescription), since the anticipation of the possible future is needed to suggest the patterns oriented toward the solution of concrete problems. 3) When the application of science is considered, prediction has also a relevant role as the basis for the decision-making.

With regard to the methodology of scientific prediction, Rescher's account is *de facto* within a framework of methodological pragmatism. It is an approach which maintains that scientific theses and theories should be evaluated according to methodological criteria, where the ability to obtain successful predictions is basic.[158] Within these coordinates, his contributions

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[154] Cf. GONZALEZ, W. J., "Marco teórico, trayectoria y situación actual de la Filosofía y Metodología de la Economía," *Argumentos de Razón Técnica*, v. 3, (2000), pp. 13-59.
[155] Cf. GONZALEZ, W. J., *La predicción científica*, p. 286.
[156] Cf. NIINILUOTO, I., "The Aim and Structure of Applied Research," *Erkenntnis*, v. 38, n. 1, (1993), pp. 1-21; NIINILUOTO, I., "Approximation in Applied Science," *Poznan Studies in the Philosophy of Sciences and the Humanities*, (1995), pp. 127-139; and GONZALEZ, W. J., "The Philosophical Approach to Science, Technology and Society," in GONZALEZ, W. J. (ed.), *Science, Technology and Society: A Philosophical Perspective*, pp. 3-49.
[157] Cf. GONZALEZ, W. J., *La predicción científica*, p. 11.
[158] Cf. RESCHER, N., *Methodological Pragmatism*, chapter 5, pp. 66-80.

regarding the methodological features of scientific prediction follow two major steps: (i) the preconditions for rational prediction, and (ii) the typology of the predictive processes that can be used in scientific activity.

On the former step, Rescher seeks to explicitly state the preconditions for rational prediction. Thus, he seeks the necessary conditions for achieving reliable predictions.[159] On the later issue, he accepts a plurality of processes that are oriented towards predicting the possible future. Rescher's acknowledgement of a methodological pluralism basically respond to the diversity of the predicted phenomena (natural, social or artificial) and the kind of question posed about those phenomena.[160] Consequently, there is a clear nexus between the methodological realm and the epistemological and ontological fields.

1.3.3. Ontological Features of Prediction and the Realm of Values

Ontologically, there are several issues at stake regarding prediction. On the one hand, it is possible to think that the kind of predictions we can achieve (with regard to their reliability, accuracy, etc.) depends on the *type of reality* prediction is about. In this regard, it should be considered the distinction between the natural reality, the social realm, and the field of the artificial. From this distinction, the specific problems which affect prediction in these realms (natural, social or artificial) could be considered. This can be made according to the kind of reality that is researched.

On the other hand, there is the ontological status of the future. If prediction is — for Rescher — a statement that deals with future phenomena, there is the problem of how to characterize the future, which is something that does not exist yet. In this regard, he considers that the future has several features: a) it does not exist yet, by definition; b) it unavoidably will be (i.e.,

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[159] Cf. RESCHER, N., *Predicting the Future*, p. 86.
[160] Cf. RESCHER, N., *Personal Communication*, 15.7.2014.

the future will come in one way or another); c) we can only have incomplete information about its nature; and d) the control we can exert over future phenomena is very limited.[161]

These features of the reality of future (natural, social or artificial) lead to acknowledge the ontological limits to prediction, which rests on the complexity of phenomena. In this regard, Rescher admits that “ontological limits exist insofar as the future of the domain at issue is *developmentally open*—causally undetermined or underdetermined by the existing realities of the present and open to the development of wholly unprecedented patterns owing to the contingencies of choice, chance, and chaos.”[162]

Within the ontological obstacles, some could be highlighted now: (i) anarchy and volatility; (ii) chance, chaos, and arbitrary choice; and (iii) creativity. In my judgment, the problem of the ontological limits to creativity can be seen from the point of view of complexity, which involves taking into account historicity (of science, agents, and the reality itself that is research).[163] Because the reality (natural, social or artificial) that is predicted might be complex, so its complexity has repercussions both on the very possibility of predicting and the kind of prediction achievable (with regard to its reliability, accuracy, precision, etc.).

Axiologically, the problem of scientific prediction is initially twofold in his approach: on the one hand, there is the issue of the role of *prediction as a value* of science; and, on the other hand, it can be considered the problem of the *values of prediction*, that is, what are the desirable characteristics that predictive statements should have in order to be worthy. Both dimensions are closely interrelated in Rescher’s account, since the value of prediction for

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[161] Cf. RESCHER, N., *Predicting the Future*, p. 2. The second feature cannot be understood in a deterministic way.
[162] *Predicting the Future*, p. 134.
[163] On historicity as a feature of science in the three levels mentioned before, see GONZALEZ, W. J., “Conceptual Changes and Scientific Diversity: The Role of Historicity,” in GONZALEZ, W. J. (ed.), *Conceptual Revolutions: From Cognitive Science to Medicine*, pp. 39-62.

science depends on the kind of values it has (accuracy, precision, etc.).[164]

Rescher's axiology of scientific research, likewise his philosophy of science in general, falls within the coordinates of a system of pragmatic idealism that admits elements of realism.[165] He considers that science as activity is modulated by a plurality of values. Among those values, he gives primacy to the internal values of scientific activity, which are those that goes with the constitutive elements of science (language, structure, knowledge, method, activity, ends, and values). He gives them priority over the values that modulates sciences as an activity connected with other human activity (such as social, political, economic or ecological values).

When the focus is on scientific prediction, it seems clear that prediction appears to be an important aim of science *among others.* Thus, Rescher considers that science has a goal-structure that "encompasses the traditional quartet of description, explanation, prediction, and control."[166] Nevertheless, it has an especially valuable role, since in his judgment "prediction is the very touchstone of science in that it affords our best and most effective test for the adequacy of our scientific endeavors."[167]

With regard to the values that should be with scientific prediction, Rescher gives primacy to the internal values, above all, he emphasizes the epistemological and methodological values. He does this from a structural perspective that takes into account two successive levels: a) predictive

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[164] Certainly, it is usual to think of prediction as connected with values such as accuracy and precision. This can lead to highlight the value of prediction as an aim of scientific research. In this regard, Thomas S. Kuhn claimed that prediction is related with the most assumed values of science, above all, when it is a quantitative prediction. Cf. KUHN, TH. S., "Postscript—1969," in KUHN, TH. S., *The Structure of Scientific Revolutions*, The University of Chicago Press, Chicago, 2nd ed., 1970, p. 185. On Kuhn approach to prediction, see GONZALEZ, W. J., *La predicción científica*, chapter 4, pp. 127-159.

[165] On Rescher's axiology of research, see GONZALEZ, W. J., "Racionalidad científica y actividad humana. Ciencia y valores en la Filosofía de N. Rescher," in RESCHER, N., *Razón y valores en la Era científico-tecnológica*, pp. 11-44; and GONZALEZ, W. J., "Economic Values in the Configuration of Science," pp. 85-112.

[166] RESCHER, N., *Epistemology*. *An Introduction to the Theory of Knowledge*, State University of New York Press, Albany, NY, 2003, p. 258.

[167] RESCHER, N., *Predicting the Future*, p. 161.

questions, and b) predictive answers of statements about the future (that is, the predictions).[168] In his conception, he adopts a structural perspective, because — in his judgment — prediction is mainly a cognitive content with methodological relevance. So the structural factors have primacy.

But, together with the structural dimension, there is a *dynamic* trait in the axiology of science, which has to do with the teleological character of scientific research. This character is modulated by different factors. Initially, this activity involves taking into account the aims, processes, and results (where there is also the problem of the consequences that could have those results)[169]. In turn, the aims, processes, and results — and the connected values — vary in the context of basic science, applied science, and the application of science.[170]

The ethical components that modulate scientific prediction can also be considered here. In this regard, it has been noticed that prediction connects with the ethics of science "through the presence of prediction in the *research activity*, mainly when the ethical limits of science are discussed."[171] This involves taking into account the differences between basic science, applied science, and the application of science, both from an endogenous perspective — that has to do with the aims, processes, and results — and form the exogenous component, which is oriented towards the relations with the environment (social, cultural, political, economic, ecological, etc.), which

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[168] Cf. *Predicting the Future*, pp. 113-125.

[169] Cf. GONZALEZ, W. J., "Value Ladenness and the Value-Free Ideal in Scientific Research," in LÜTGE, CH. (ed.), *Handbook of the Philosophical Foundations of Business Ethics*, Springer, Dordrecht, 2013, pp. 1503-1521.

[170] On the differences between basic science and applied science with regard to the aims, processes, and results, cf. GONZALEZ, W. J., "Ciencia y valores éticos: De la posibilidad de la Ética de la Ciencia al problema de la valoración ética de la Ciencia Básica," in GONZALEZ, W. J. (ed.), *Ciencia y valores éticos*, *Arbor,* v. 162, n. 638, (1999), pp. 139-171; especially, pp. 158-159.

On the distinction between applied science and application of science, see NIINILUOTO, I., "The Aim and Structure of Applied Research," pp. 1-21; and GONZALEZ, W. J., "The Roles of Scientific Creativity and Technological Innovation in the Context of Complexity of Science," pp. 11-40; especially, pp. 17-18.

[171] GONZALEZ, W. J., *Philosophico-Methodological Analysis of Prediction and its Role in Economics*, p. 20.

is changeable. It is an approach that highlights the historicity of scientific activity, which is a feature that Rescher rarely takes into account.

1.4. Pragmatic Idealism in the Contemporary Context

When Rescher deals with scientific prediction, each one of the aforementioned philophico-methodological angles of analysis (semantic, logical, epistemological, methodological, ontological, axiological, and ethical) is placed in the framework of his own philosophical proposal, which can be characterized as a pragmatic idealism open to elements of realism. This involves that the philosophico-methodological study of his concept of prediction must take into account the coordinates a system of thought, which is supported by two major mainstays: idealism and pragmatism. But, at the same time, his view is open to realism with regard to relevant philosophical aspects.

1.4.1. A System Open to Realism without Eclecticism

It happens that each one of these philosophical traditions (realism, idealism, and pragmatism) is characterized by having a heterogeneous character. In effect, there is a wide variety of realistic, idealistic, and pragmatic approaches within contemporary philosophy, in general, and contemporary philosophy and methodology of science, in particular. Thus, within the same philosophical tradition, each thinker can defend very diverse approaches regarding relevant points. This philosophical diversity leads to the existence of proposals that are, in principle, antagonistic (such as, for instance, realism and idealism). But, concerning some aspect, there might be some convergent points between them.

Regarding this issue of a possible convergence, it should be pointed out that Rescher's system of thought seeks such combination of different conceptions. His view of pragmatic idealism open to realistic elements is not conceived as an eclectic proposal. Instead of that, he articulates his own philosophical system, where he chosses versions of idealism and pragmatism that are compatible with realistic elements. They also belong to a system, understood as a coherent philosophico-methodological conception about science.

In order to avoid inconsistency, Rescher claims that realism and idealism "need not be contradictory; indeed, both contain a substantial element of truth"[172]. Thus, in order to avoid the contradictory elements, it is required — in his judgment — "to opt for the middle ground and to combine a plausible version of realism with a plausible version of idealism. The issue is not one of the dichotomous choice of either realism or idealism but rather one of a compromising synthesis in the interests of a fruitful collaboration between these historically warring positions."[173]

Due to his pragmatic view, Rescher accepts some realistic notions, such as "fact" or "objectivity." His position seeks to integrate them in a pragmatic idealistic proposal. Thus, his approach involves — as it happens in some pragmatic conceptions — the acceptation of an ontological variety of realism that acknowledges the existence of a reality that is independent to the mind of the knowing subject. In addition, he thinks that reality has its own properties that are accessible to the subjects that want to know that reality, within some limits. In effect, in Rescher's proposal, human capacity to know the reality is *limited*, so that "we cannot justifiably equate reality with what can, in principle, be known by us, nor equate reality with what can, in principle, be expressed by our language."[174]

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[172] RESCHER, N., "Realism and Idealism," en RESCHER, N., *A System of Pragmatic Idealism.* Vol. I: *Human Knowledge in Idealistic Perspective*, p. 304.
[173] RESCHER, N., "Realism and Idealism," in RESCHER, N., *A System of Pragmatic Idealism.* Vol. I: *Human Knowledge in Idealistic Perspective*, p. 324.
[174] RESCHER, N., "Cognitive Limits," in RESCHER, N., *A System of Pragmatic Idealism.* Vol. I: *Human Knowledge in Idealistic Perspective*, p. 253.

Following a pragmatic vision, Rescher dismisses a naïve version of realism, which is incompatible with his epistemological proposal (that is fallibilistic). At the same time, he manifestly rejects the scientific realism. This position is characterized by him as the philosophical doctrine that maintains that science provides us, in fact, *true knowledge* about the reality. Thus, in his judgment, scientific realism involves equating *reality as such* with *reality as we know it* through science. Consequently, “what decisively impedes the tenability of scientific realism is the fundamentally epistemological consideration that the world will doubtless eventuate as being very different from the way our best scientific theories currently represent it to be.”[175]

From this perspective, Rescher reduces scientific realism to a version of naïve realism, which is incompatible with a fallibilistic approach to scientific knowledge. Thereby, he does not take into account other versions of scientific realism that are certainly more sophisticated.[176] Thus, he opts for a version of “metaphysical realism” that he describes as “the doctrine that the world exists in a way that is substantially independent of the thinking beings that inquire into it, and that its nature—its having whatever characteristics it does actually have—is also comparably thought independent.”[177]

This characterization is an approach that in its development goes beyond the “classical” metaphysical realism.[178] It is also different from the

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[175] RESCHER, N., “Scientific Realism,” in RESCHER, N., *A System of Pragmatic Idealism.* Vol. I: *Human Knowledge in Idealistic Perspective*, p. 277.

[176] In this regard, it can be highlighted the critical scientific realism of the Finnish School, which has been developed by authors such us R. Tuomela or I. Niiniluoto. Cf. GONZALEZ, W. J., “El realismo y sus variedades: El debate actual sobre las bases filosóficas de la Ciencia,” in CARRERAS, A. (ed.), *Conocimiento, Ciencia y realidad*, pp. 47-50. In addition, Rescher does not analyze the recent debates on scientific realism, such as the “structural realism” proposed by John Worrall. Cf. GONZALEZ, W. J., “Novelty and Continuity in Philosophy and Methodology of Science,” in GONZÁLEZ, W. J. and ALCOLEA, J. (eds.), *Contemporary Perspectives in Philosophy and Methodology of Science*, Netbiblo, A Coruña, 2006, pp. 1-27.

[177] RESCHER, N., “Metaphysical Realism,” in RESCHER, N., *A System of Pragmatic Idealism.* Vol. I: *Human Knowledge in Idealistic Perspective*, p. 255.

[178] On the characterization of metaphysical realism, see GONZALEZ, W. J., “El realismo y sus variedades: El debate actual sobre las bases filosóficas de la Ciencia,” pp. 40-41 and 44-46. A criticism to metaphysical realism can be found in the “internal realism” proposed by H.

"metaphysical realism" defended by K. R. Popper.[179] This is so because, in Rescher's thought, the acceptance of an ontological realism is connected with an epistemological conception of conceptual idealism, which gives primacy to Kantism regarding cognitive matters.

However, Rescher's epistemological approach involves elements of realism, such as the possibility of obtaining objective knowledge of the extramental reality. This is the case due to his acceptance that ontological dimension of realism — the existence of a reality independent of the knowing subjects — is something inseparable from the epistemological dimension that involves the possibility of achieving to some extent adequate information about that mind independent reality. Even more, he thinks that the epistemological dimension presupposes the acceptance of the ontological component.[180]

Consequently, Rescher considers that it is required to clarify which bases are needed to accept the existence of a mind independent reality. In this regard, he clearly acknowledges the Kantian influence, which is modulated by a pragmatic conception in the line of Charles S. Peirce. Thus, Rescher thinks that "objectivity represents a postulation made on functional (rather than evidential) grounds: we endorse it in order to be in a position to learn by experience at all. As Kant clearly saw, objective experience is possible only if the existence of such a real, objective world is *presupposed* from the outset rather than being seen as a matter of ex post facto discovery about the nature of things."[181]

Therefore, for Rescher, the independence of the extramental reality is

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Putnam. See PUTNAM, H., "A Defense of Internal Realism," in PUTNAM, H., *Realism with a Human Face*, Harvard University Press, Cambridge, 1990, pp. 30-42.

[179] Cf. POPPER, P., "Intellectual Autobiography," in SCHILPP, P. A. (ed.), *The Philosophy of Karl Popper*, Open Court, La Salle (Illinois), 1974, vol. I, pp. 3-181.

[180] Cf. RESCHER, N., "Metaphysical Realism," in RESCHER, N., *A System of Pragmatic Idealism.* Vol. I: *Human Knowledge in Idealistic Perspective*, p. 256.

[181] "Metaphysical Realism," in RESCHER, N., *A System of Pragmatic Idealism.* Vol. I: *Human Knowledge in Idealistic Perspective*, p. 257.

something that we must accept *a priori*, on the basis of its practical utility, insofar as it makes it possible from the beginning the intersubjective communication and the communal inquiry. This is because "only in subscribing to such a fundamental postulate of reality can we take the sort of view of experience, inquiry, and communication that we in fact have. Without it, the entire conceptual framework of our thinking about the world and our place within it would come crashing down."[182] It is present here one of the main concerns of Rescher: the rejection of skepticism, which calls into question the very possibility of achieving a true or verisimilar knowledge about reality.[183]

In order to reject a skeptic approach, Rescher maintains that it is not good enough to appeal to the existence of a reality independent of the knowing subjects as a necessary condition for scientific practice. What he asks for is a "retrojustification" on the basis of the results of the scientific research.[184] This "retrojustification" has a pragmatic dimension and a cognitive component. Thus, "on the *pragmatic* side we find that we obtain a world picture on whose basis we can opérate effectively (pragmatic revalidation); on the *cognitive* side we find that we arrive at a picture of the world that provides an explanation of how it is that we are encouraged to get things (roughly) right—that we are in fact justified in using our phenomenal data as data of objective fact (explanatory revalidation). Accordingly, the success at issue is twofold—both in terms of understanding (cognition) and in terms of application (praxis). And it is this ultimate success that justifies and

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[182] RESCHER, N., "Metaphysical Realism," in RESCHER, N., *A System of Pragmatic Idealism.* Vol. I: *Human Knowledge in Idealistic Perspective*, p. 266.
[183] On this regard, see RESCHER, N., *Skepticism*, Blackwell, Oxford, 1980; and RESCHER, N., "Skepticism and Its Deficits," in RESCHER, N., *Epistemology. An Introduction to the Theory of Knowledge*, pp. 37-70.
[184] Cf. "Metaphysical Realism," in RESCHER, N., *A System of Pragmatic Idealism.* Vol. I: *Human Knowledge in Idealistic Perspective*, pp. 266-270.

rationalizes, retrospectively, our evidential proceedings."[185]

On the basis of these considerations, the "metaphysical realism" of Rescher — understood as a version of realism that admits a mind independent reality and the accessibility of that extramental reality to the knowing subjects, within some limits — is supported by an epistemological idealism, which in turn is connected with a pragmatism of the primacy of practice. He emphasizes that "the sort of realism contemplated here is accordingly one that pivots on the fact that we *think* of reals in a certain sort of way, and that in fact the very conception of the real is something we employ because doing so merits our ends and purposes."[186] Thus, for him, reality and concepts are eventually seen from the perspective of human practice.

1.4.2. An Idealism with Distinctive Features

Rescher offers a type of idealism with distinctive features, since he develops a view of idealism that is compatible with some realist elements in his philosophical conception. In this regard, he distinguishes two major types of idealism: ontological idealism and epistemic idealism. In turn, each one of these types of realism can take different varieties of idealism. Within ontological idealism, Rescher distinguishes two varieties: (i) *causal idealism* and (ii) *supervenience idealism*. Both types of ontological idealism have in common that they consider that everything there is, apart from minds themselves, arises from the operations of minds, either causally or in a supervenient way.[187] Rescher rejects both kinds of ontological idealism, so his idealist proposal is within the coordinates of an epistemic idealism.

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[185] RESCHER, N., "Metaphysical Realism," in RESCHER, N., *A System of Pragmatic Idealism.* Vol. I: *Human Knowledge in Idealistic Perspective*, p. 268.
[186] "Metaphysical Realism," in RESCHER, N., *A System of Pragmatic Idealism.* Vol. I: *Human Knowledge in Idealistic Perspective*, p. 270.
[187] Cf. RESCHER, N., "Realism and Idealism," in RESCHER, N., *A System of Pragmatic Idealism.* Vol. I: *Human Knowledge in Idealistic Perspective*, p. 324.

Within the framework of epistemic idealism, there are also several options: a) *fact idealism*, which maintains that to be as a fact is to be a language-formable fact —that is, a truth; b) *cognitive idealism*, which considers that to be as a truth is to be knowable; c) *strong substantival idealism*, which is the option according to with to be as a thing or entity is to be actually discerned by some knower; d) *weak substantival idealism*, which states that to be as a thing or entity is to be discernible; e) *explanatory idealism*, which maintains that an adequate explanation of the material reality requires some recourse to mental characteristics or operations; and f) *conceptual idealism*, which is the version of idealism that maintains that whatever is real is in principle knowable and the knowledge of reality involves conceptualization.[188]

Conceptual idealism is the version of idealism that modulates Rescher's system of pragmatic idealism. In order to deal with concepts, his proposal is based on two types of dependences between mind and matter (the extramental reality), which follow different directions. Thus, on the one hand, he maintains that "mind is *causally* dependent upon (i. e., causally requires) matter, in that mental process demands causally or productively the physical workings of matter"; and, on the other hand, "matter (conceived of in the standard manner of material substance subject to physical law) is *explicatively* dependent upon (i.e., conceptually requires) mind, in that the conception of material processes involves hermeneutically or semantically the mentalistic workings of mind."[189]

Therefore, Rescher thinks that our knowledge of the extramental reality is always mediated by our concepts and categories, so it is not possible to

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[188] Cf. "Realism and Idealism," in RESCHER, N., *A System of Pragmatic Idealism.* Vol. I: *Human Knowledge in Idealistic Perspective*, p. 305.
[189] RESCHER, N., "Realism and Idealism," in RESCHER, N., *A System of Pragmatic Idealism.* Vol. I: *Human Knowledge in Idealistic Perspective*, p. 318.

equate, in principle, *reality as such* and *reality as we know it*.[190] On this basis, he rejects scientific realism, which he sees as the thesis that science, in fact, describes now reality in an adequate way.[191] Because, in his judgment, "the world *that we describe* in science is one thing, the world *as we describe it* in science is another, and they would coincide only if our descriptions were totally correct—something that we are certainly not in a position to claim."[192]

Although Rescher criticizes scientific realism — that, in his conception, is reduced to a version of naïve realism — he do not accept an instrumentalist approach to science.[193] The reason is that his pragmatism is out of tune with instrumentalism, insofar as he admits realist elements in the worldview. Thus, he admits that the aims of science are in tune with realism, since science actively seeks an objective knowledge of reality. But those aims are only achievable within some limits, so real science — *our* science — must be distinguished from ideal or perfect science.[194]

Consequently, Rescher maintains that it should be accepted that "the cognitive enterprise is governed by ideals—in particular, those of knowledge/truth and of science/system. But in a community of *rational* agents, even ideals must pay their way by proving themselves to be efficient and effective in conducting to full realization of the goals and values in whose name they are instituted."[195] This attention to efficacy and efficiency in goal realization lead to the pragmatic dimension of his thought, which is clearly influenced by Charles S. Peirce.

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[190] To go more deeply in Rescher's conceptual idealism, see RESCHER, N., *Conceptual Idealism*, Blackwell, Oxford, 1973.

[191] Cf. RESCHER, N., "Scientific Realism," in RESCHER, N., *A System of Pragmatic Idealism.* Vol. I: *Human Knowledge in Idealistic Perspective*, pp. 275-295.

[192] "Scientific Realism," in RESCHER, N., *A System of Pragmatic Idealism.* Vol. I: *Human Knowledge in Idealistic Perspective*, p. 279.

[193] Cf. RESCHER, N., "Scientific Realism," in RESCHER, N., *A System of Pragmatic Idealism.* Vol. I: *Human Knowledge in Idealistic Perspective*, pp. 286-289.

[194] Cf. RESCHER, N., "Science and Idealization," in RESCHER, N., *A System of Pragmatic Idealism.* Vol. I: *Human Knowledge in Idealistic Perspective*, pp. 206-303.

[195] RESCHER, N., "Science and Idealization," in RESCHER, N., *A System of Pragmatic Idealism.* Vol. I: *Human Knowledge in Idealistic Perspective*, p. 300.

In effect, together with an ontological conception, which is mainly realist in the central tenets, and a epistemology, which gives clearly primacy to a conceptual idealism, the pragmatic dimension has eventually primacy in his methodological account. This feature is especially important in order to understand his contributions to the semantic, logical, axiological, and ethical realms. So, when Rescher develops his methodological pragmatism, he explicitly declares that it is a return to the Peircean roots of pragmatic tradition.[196] In this regard, the Peircean influence leads him to reject explicitly other versions of pragmatism, such as the subjective pragmatism of W. James, pragmatism as social and cultural construction of J. Dewey, and the relativistic proposals by F. Schiller and R. Rorty.[197]

The differences between the version of pragmatism that Rescher subscribes and other proposals of pragmatism — subjective, of social and cultural construction, and relativistic — can be seen in the realist elements of his system of pragmatic idealism. They are differences between such conceptions regarding notions such as "truth," "fact," "objectivity," and "value." Thus, Rescher develops a realist account of those notions that is, in fact, compatible with a pragmatic approach to the rationality of the human beliefs, actions, choices, and evaluations.

To sum up, in my judgment, Rescher manages to coordinate in a coherent way nuanced philosophical positions from traditions such as idealism and pragmatism that are, in principle, very diverse. In addition, he accepts central tenets of realism insofar as they are in tune with pragmatism. He does this in a way that allows him to avoid a merely eclectic approach. Instead of that, he seeks to combine idealism and pragmatism with realist elements in such a way that they could be mutually compatible. Thus, he

[196] On Rescher's methodological pragmatism there is a more detailed treatment in the chapter 5 of this Ph.D. research.
[197] Cf. RESCHER, N., *Realistic Pragmatism*, chapter 1, pp. 1-56; especially, pp. 15-31 and 44-47; and chapter 2, pp. 57-80.

configures his own system of thought, which is the framework of his conception regarding scientific prediction. In effect, the different realms of analysis of prediction (semantic, logical, epistemological, methodological, ontological, axiological, and ethical) are interrelated in Rescher's thought, which is oriented toward a system of pragmatic idealism that is open to realist elements.

CHAPTER 2
ANALYSIS OF SCIENTIFIC PREDICTION FROM LANGUAGE

When Rescher analyses prediction from language, his starting point is a pragmatic conception that gives primacy to the use of language when the meaning is considered.[198] This trait affects prediction, in general, and scientific prediction, in particular. Because, in the first place, he is interested in the process of communication, so he stresses the features that makes it possible in that process the exchange and understanding of informative messages. Only in the second place there are other elements related to meaning, such as reference.[199] Thus, considered from a pragmatic approach to meaning, scientific prediction is then the result of an activity that seeks to obtain justified answers to meaningful questions about future occurrences.[200]

This chapter seeks to offer an analysis of Rescher's proposal on the features of scientific prediction from the viewpoint of language. In order to do this, several steps are followed: 1) the general coordinates of his approach to scientific language — where pragmatics has primacy over semantics — are considered. 2) Within the option that considers meaning as use, the features that he assigns to scientific prediction are addressed. 3) His characterization of prediction is analyzed and the distinction between qualitative prediction and quantitative prediction is addressed.

4) Also Rescher's contribution to the analysis of scientific prediction as a statement is analyzed. In order to do this, in the first place, the difference between "prediction" and "retrodiction" is addressed. In the second place, the

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[198] Cf. RESCHER, N., *Communicative Pragmatism and other Philosophical Essays on Language*, Rowman and Littlefield, Lanham, MD, 1998.

[199] On the differences between the semantic and pragmatic approaches to reference, see GONZALEZ, W. J., *La Teoría de la Referencia. Strawson y la Filosofía Analítica*, Ediciones Universidad de Salamanca and Publicaciones de la Universidad de Murcia, Salamanca-Murcia, 1986.

[200] Cf. RESCHER, N., *Predicting the Future*, pp. 37-39.

distinction between "prediction," "foresight," "forecasting," and "planning" is considered. It is a distinction established on the basis of the degree of control of the relevant variables. 5) The demarcation problem is contemplated with regard to scientific prediction. This includes the debate about the role of prediction to assess the scientific plausibility of a theory or a discipline. 6) The limits of language are seen with regard to prediction, where the distinction between "not predictability" and "unpredictability" is highlighted.

2.1. Characteristic Features of Meaning in Rescher

Concerning meaning — both human, in general, and scientific, in particular — Rescher takes a pragmatic perspective. So he suggests a view of meaning as use when he underlines an approach to language as communication. *Communicative Pragmatism* — the title of this main work devoted to language, which is the only one on this topic that he has written so far — is indicative of his proposal on meaning.[201] His view of language goes with his approach to knowledge. Thus, as a pragmatist philosopher, he highlights the realm of *human activity*; and, as a Kantian author, he insists that *human knowledge* is modulated by our mental categories and concepts. On the one hand, the emphasis on the use prevails in his view of meaning; and, on the other, the role of the ideas — which he considers as decisive in the characterization of reality — is highlighted regarding knowledge.

2.1.1. Communication as Activity and Meaning with Cognitive Content

This emphasis on communication as human activity involves an instrumental account of language, since language appears as an "instrument" for human communication, instead of being mainly a way to represent

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[201] Cf. RESCHER, N., *Communicative Pragmatism and other Philosophical Essays on Language*, *passim*.

reality.[202] Thus, for Rescher, communication is the process that allows us to *share* what we know about the world through the use of language: "our knowledge regarding the world's things is always developed within a linguistic-systematic system of reference."[203]

However, this pragmatic account of Rescher's idealism admits some elements of realism.[204] In his approach to meaning, the notion of "objectivity" has an important role. In effect, this notion of objectivity — that influences the realist view of "fact" — appears as a necessary condition for communication: "Human cognition as we understand it would be impossible without communal inquiry into and interpersonal communication about an objective order of reality. And without a presupposition of ontological objectivity the very idea of investigating a shared world would become inoperable."[205] This is important because M. Dummett maintains that objectivity is the key to semantic realism.

In his paper "Pragmatic Idealism and Metaphysical Realism," Rescher insists on this idea of ontological objectivity as a support for human communication. He maintains in his paper that the existence of an objective reality that is independent of the knowing subject is "a postulate whose justification pivots—in the first instance—on its functional utility in enabling us to operate as we do with respect to inquiry and deliberation."[206]

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[202] These two different usages of language appear in different authors, among them Michael Dummett. Within his large intellectual production on philosophy of language, it could be highlighted DUMMETT, M., *Frege: Philosophy of Language*, Duckworth, London, 2nd ed. 1981.

[203] RESCHER, N., *Razón y valores en la Era científico-tecnológica*, p. 54.

[204] On realism and meaning two papers of M. Dummett can be highlighted. Cf. DUMMETT, M., "Realism" (I), conference in the *Oxford University Philosophical Society* on March 8th 1963. Reprinted in DUMMETT, M., *Truth and Other Enigmas*, Duckworth, London, 1978, pp. 145-164; and DUMMETT, M., "Realism" (II), *Synthese*, v. 52, n. 1, (1982), pp. 55-112. However, Dummets' personal philosophy endorses a semantic anti-realism.

[205] RESCHER, N, "Obtectivity and Comunication. How Ordinary Discouse is Committed to Objectivity," in RESCHER, N., *Communicative Pragmatism and other Philosophical Essays on Language*, p. 94.

[206] RESCHER, N., "Pragmatic Idealism and Metaphysical Realism," p. 386.

The opening of his thought to realist contributions can be seen in his approach to meaning, where the notion of objectivy is crucial as content of communication with an ontological basis. He considers that the acceptation of an objective reality is "*presupposed* from the outset rather than being seen as a matter of ex post facto discovery about the nature of things."[207] He also maintains that it is a necessary condition for communication.

In his judgment, commitment with objectivity is an instrument that makes it possible to carry through any cognitive venture, since meaning itself involves a cognitive content. In this way, the concept of "objective reality" is justified on *functional basis*, instead of inferential basis: "We require this postulate to operate our conceptual scheme, and its validation accordingly lies in its utility. We could not form our existing conceptions of truth, fact, inquiry, and communication without presupposing the independent reality of an external world."[208]

Therefore, the pragmatic approach to meaning does not lead Rescher to see communication in relativistic terms. Because he points out that language has cognitive content. Thus, our access to the extramental reality is modulated by our categories and concepts. Although human knowledge is always fallible, it is possible to achieve objective knowledge. In this way, true statements are those that describe reality as it is.[209] As Wenceslao J. Gonzalez points out, Rescher accepts P. F. Strawson idea that "facts are what statements (when true) state."[210] Thus, he distinguishes the notions of "truth" and "fact." Because "thuth" is, for Rescher, a linguistic notion: "it is the representation of a fact through its statement (*enunciación*) in some real

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[207] RESCHER, N., "Metaphysical Realism", in RESCHER, N., *A System of Pragmatic Idealism.* Vol. I: *Human Knowledge in Idealistic Perspective*, p. 257.
[208] RESCHER, N., "Communicative Pragmatism," in RESCHER, N., *Communicative Pragmatism and other Philosophical Essays on Language*, p. 36.
[209] Cf. RESCHER, N., "Cognitive Limits," in RESCHER, N., *A System of Pragmatic Idealism.* Vol. I: *Human Knowledge in Idealistic Perspective,* pp. 243-254; especially, pp. 243-244.
[210] STRAWSON, P. F., "Truth" (II), *Proceedings of the Aristotelian Society*, v. sup. 24, (1950), p. 136. This paper is quoted in GONZALEZ, W. J., *La predicción científica,* p. 256.

language. Any correct statement in some real language formulates a truth."[211] Meanwhile, a "fact" is a real circumstance that exists in an objective way and, therefore, it exceeds the limits of language and knowledge.

Nonetheless, we can distinguish between truth in language as such (truthfulness); truth in knowledge, which is expressed through the adequacy of statements and transmits objectivity regarding reality; and truth in the real things, which is made explicit in terms of authenticity. The first is, in rigor, the "semantic" truth, in the sense of the language as the expression of an actual content. The second is a cognitive (or epistemic) truth, since it transmits an agreement between the statement and the described fact. The third is an ontological truth, where the real thing itself is what is true. Usually Rescher deals with the cognitive and ontological analysis of truth.

Even when Rescher admits truth in science, the process of information acquisition involves cooperation and communication. Thus, it is "a process of *conceptual* innovation that always places certain facts completely outside the cognitive range of the researches in any concrete period."[212] For this reason, he insists that reality as such cannot be equated with the things we know and can express through language. Reality exceeds the descriptive resources of language and those resources are in debt to our cognitive mechanisms for conceptualization. Reality is potentially emergent to language, but it should be first integrated in our conceptual scheme.[213] In this regard, it can be considered that ontological truth is broader than epistemic truth.

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[211] RESCHER, N., *Razón y valores en la Era científico-tecnológica*, p. 54.
[212] *Razón y valores en la Era científico-tecnológica*, p. 54.
[213] On this regard, Rescher writes that "blood circulated in the human body well before Harvey; substances containing uranium were radioactive before Becquerel. The emergence at issue relates to our cognitive mechanisms of conceptualization, not to the objects of our consideration in and of themselves. Real-world objects must be conceived of as antecedent to any cognitive interaction — as being there right along, 'pregiven' as Edmund Husserl put it. Any cognitive changes or innovations are to be conceptualized as something that occurs on our side of the cognitive transaction, not on the side of the objects with which we deal," RESCHER, N., "Cognitive Limits," in RESCHER, N., *A System of Pragmatic Idealism.* Vol. I: *Human Knowledge in Idealistic Perspective*, p. 247.

But it happens that meaning, knowledge, and reality are actually interrelated. In fact, Rescher considers that human beings dump his knowledge of the world on the language. In this way, language reflects a conceptual system, at the same time that it is limited by that very system. It is an imperfect resource, but language can carry an *objective content*. Thus, in his account, meaning is not reduced to a mere intersubjective use of language, because he admits objective bases in it.

2.1.2. The Primacy of the Pragmatic Dimension

Rescher gives primacy to the pragmatic dimension, since he thinks that language is mainly an instrument that makes it possible the communication. On this basis, he is fundamentally interested in two matters: (i) what are the conditions that provide an effective communication, and (ii) what are the conditions that allow us to carry through in an optimal way the effective communication.[214] Within this framework, he seeks to clarify the normative issues that regulate communication; that is, he investigates the general principles that make it possible (and also efficient) the communicative practice.

Although his account of meaning involves a cognitive content and he also admits an objectivity with ontological basis, Rescher's approach to meaning is not, properly speaking, a semantic approach. He acknowledges the distinction between semantics and pragmatics. This distinction leads him to admit that there are differences between the *use conditions* and the *truth conditions* of a statement.[215] Use conditions encompass a series of operational criteria that allow us to express properly a statement in a

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[214] Cf. RESCHER, N., "Communicative Pragmatism," in RESCHER, N., *Communicative Pragmatism and other Philosophical Essays on Language*, pp. 3-4.

[215] On the differences between use conditions and truth conditions, as well as on the primacy that Rescher gives to the former over the later, see RESCHER, N., "Truth Conditions versus Use Conditions (a Study on the Utility of Pragmatics)," in RESCHER, N., *Communicative Pragmatism and other Philosophical Essays on Language*, pp. 61-75.

concrete language. Truth conditions are those objective circumstances that make it possible to claim that a statement is true. Therefore, use conditions are oriented towards the users of a language, while truth conditions are oriented towards the reality of what is expressed.

According to Rescher, "for while truth conditions deal with the objective facts, use conditions deal with the linguistic properties."[216] In this regard, he sees use conditions as more important to communication than truth conditions; although he admits that both of them should be taken into account in any account of language. For Rescher, "meaning is a comprehensive concept that embraces both semantical and pragmatic issues. (…) Any exclusivistic doctrine along the lines of meaning is use, or meaning is a matter of truth conditions, is one-sided, dogmatic, *and* inappropriate in its claim to exclusiveness."[217]

Rescher insists that both of them (truth conditions and use conditions) are required. Because "the fact that both are inextricably interrelated in matters of meaning—that meaning analysis has a formal (semantic) and an informal (pragmatic) dimension that are inseparably interrelated—means that there is a symbiotic interconnection here that permits neither side to claim unconditional priority over the other."[218] Therefore, he acknowledges the relevance of both types of conditions in the analysis of meaning. Nevertheless, his account is mostly focused on the *use conditions*.[219] Because, even when he expressly claims that both are equally important, he

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[216] RESCHER, N., "Truth Conditions versus Use Conditions (a Study on the Utility of Pragmatics)," p. 62.
[217] "Truth Conditions versus Use Conditions (a Study on the Utility of Pragmatics)," p. 67.
[218] RESCHER, N., "Truth Conditions versus Use Conditions (a Study on the Utility of Pragmatics)," p. 74.
[219] On the primacy of the pragmatic approach in his philosophical proposal on language, see RESCHER, N., "Communicative Pragmatism," pp. 1-48.

considers that an approach to meaning from use conditions has advantages over an analysis focused on truth conditions.[220]

When Rescher notices that truth conditions of a statement are about "objective facts," it can be claimed that he is in tune with semantic realism.[221] A conception of truth as "agreement" with reality underlies this issue.[222] Thus, the truth of a statement depends on the agreement of its content with the objective facts. To preserve this notion of truth implies, therefore, presupposing the existence of a reality that is independent of the knowing subject. In the same way, intersubjective communication and research as a community task are only possible if we all can access the same objective reality.

However, if we accept that truth conditions are about "objective facts," this involves — in Rescher judgment — that the concept of "truth" is not applicable in certain contexts and, then, it remains in the background with regard to meaning.[223] This happens when the meaning of a question, an order or a counterfactual conditional is analyzed, insofar as they are linguistic forms that do not refer to an objective reality.[224] Here, the issues of "correctness" or "appropriateness" — that are oriented towards the practice of using the language — supersede the notion of truth in the analysis of meaning.[225]

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[220] Cf. RESCHER, N., "Linguistic Pragmatism," in RESCHER, N., *Epistemic Pragmatism and Other Studies in the Theory of Knowledge*, Ontos Verlag, Heusenstamm, 2008, pp. 13-21.

[221] Cf. RESCHER, N., "Truth Conditions versus Use Conditions (a Study on the Utility of Pragmatics)," p. 62.

[222] In fact, he maintains that one of the reasons to accept the assumption that there is an objective and mind-independent reality is "to preserve the distinction between true and false with respect to factual matters and to operate the idea of truth as agreement with reality," RESCHER, N., "Pragmatic Idealism and Metaphysical Realism," p. 390.

[223] Cf. RESCHER, N., "Truth Conditions versus Use Conditions (a Study on the Utility of Pragmatics)," p. 62.

[224] Cf. RESCHER, N., "Truth Conditions versus Use Conditions (a Study on the Utility of Pragmatics)," pp. 72-74. When he analyses prediction from language, his approach is also pragmatic, since predictive statements do not usually refer to an objective existing reality, but they has to do with the possible future.

[225] Cf. "Truth Conditions versus Use Conditions (a Study on the Utility of Pragmatics)," p. 72.

On the basis of the advantages that Rescher sees in pragmatics over semantics, he offers a conception of meaning as use and an account of language as an instrument that facilitates communication. He is especially interested in the communicative use of language, so that he is focused on the principles that regulate communication. Then, his pragmatic perspective appears with an economic inspiration. Thus, he understands communication as a process that follows an economic rationality in terms of costs and benefits. A sender and a receiver intervene in this process, which should be ruled by economic values such as effectiveness and efficiency.[226]

But language is a means to transmit some content, so that language is an instrument that makes it possible the transmission of information. This concerns both ordinary language ("a general-purpose instrument") and scientific language ("a specialized [instrument].")[227] The use of language makes it possible the transmission of information through the communication performed by a sender and a receiver. Economic principles are important in this process because "effective communication is throughout a matter of maintaining proper cost-benefit coordination."[228]

There are a close connection in Rescher between is account of language and his approach to rationality. This nexus is rooted in his view of language as linked to communication and his account of knowledge as a human need. He sees rationality as "a means to adaptive efficiency, enabling

[226] On the economic features of communication, cf. RESCHER, N., *Cognitive Economy. The Economic Dimension of the Theory of Knowledge*; especially, chapter 2, "Economic Aspects of Communication," pp. 47-68.
[227] RESCHER, N., "Communicative Pragmatism," p. 8. For a discussion on the conditions of possibility of the ordinary language, see CEREZO, M., "La Teoría de la Expresión en el *Tractatus*. Consideraciones en torno a la explicación wittgensteiniana del lenguaje ordinario," in FLÓREZ, A., HOLGUÍN, M., and MELÉNDEZ, R. (eds.), *Del espejo a las herramientas. Ensayos sobre el pensamiento de Wittgenstein*, Siglo del Hombre Editores, Pontificia Universidad Javeriana and Universidad Nacional de Colombia, Bogotá, 2002, pp. 51-68.
[228] "Communicative Pragmatism," p. 7.

us—sometimes at least—to adjust our environment to our needs and wants rather than the reverse."[229]

On the one hand, language makes it possible human communication; and, on the other hand, that human beings meet their need of obtaining information is something that depends on effective communication. Thus, he considers that "gived our need for information to orient us in the world (on both pure and practical grounds), the value of creating a community of communicators is enormous. We are rationally well advised to extend ourselves to keep the channels of communications to our fellows open, and it is well worth expending much for the realization of this end."[230]

Thus, Rescher sees communication as a rational process that is oriented towards an aim. From the point of view of the sender, the aim is to transmit information to the receiver. For the receiver, the aim is to obtain information from the sender.[231] In the case of science, communication is especially important, since the production of scientific knowledge is a community process.[232] Both the sender and the receiver are interested in exchanging information in an effective and efficient way, since they obtain a benefit from this process.

In economic terms, to share information is the rational option: "It is far easier, cheaper, and more convenient for people to get information by sharing than by themselves having to undertake the often laborious inquiries and researches needed to develop it *de novo*."[233] For Rescher, communication is a human activity whose aims, processes, and result should be evaluated in economic terms (i.e., criteria based on economic values).

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229 RESCHER, N., *Rationality*, p. 2.
230 RESCHER, N., "Economic Aspects of Communication," in RESCHER, N., *Cognitive Economy. The Economic Dimension of the Theory of Knowledge*, p. 53.
231 Cf. RESCHER, N., "Communicative Pragmatism," p. 15.
232 Cf. "Communicative Pragmatism," p. 15.
233 RESCHER, N., "Economic Aspects of Communication," in RESCHER, N., *Cognitive Economy*. *The Economic Dimension of the Theory of Knowledge*, pp. 47-48.

In his judgment, communication is not costless, since it involves costs in terms of time and effort. To carry through the practice of using the language in an effective and efficient way is a question that depends of the acceptation of a series of assumptions, which allow us to minimize the costs that are inherent to the communication process. These assumptions are independent of the special features of the discourse. They are inserted in the general context of communication: "They are forthcoming not from the specific content of the message at issue but from the contextually indicated presuppositions we make on our own responsibility."[234] Therefore, there are general principles in communication of normative character such as credibility, reliance, clarity, and contextualization.[235]

Nevertheless, since language is an "imperfect resource,"[236] it is not always possible to express oneself in a clear and explicit manner. Even more, a statement can be susceptible of several interpretations, at least in some cases. Hence, a proper interpretation of a statement involves knowing the communication context. For Rescher, "it is fair to say that *in interpretation context is not just important, it is everything*."[237] Thus, he notices that a text transmits an informative message in two different ways: (1) the substance of what it says; that is, the information it conveys *directly* through its explicit meaning; and (2) the message it conveys *obliquely* by saying what it says in a particular way.[238]

When a statement is taken with independence of the context, it can admit different interpretations. Besides the aim sought by communication, two aspects intervene in the processes of communication: on the one hand,

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[234] RESCHER, N., "Communicative Pragmatism," p. 6.
[235] Cf. "Communicative Pragmatism," pp. 7-8. On reliance and cooperation as principles that make it possible to minimize the costs of research and communication see RESCHER, N., "The Economics of Trust and Cooperation," in RESCHER, N., *Cognitive Economy. Cognitive Economy. The Economic Dimension of the Theory of Knowledge*, pp. 33-46.
[236] Cf. RESCHER, N., "Communicative Pragmatism," p.8.
[237] "Communicative Pragmatism," p. 9.
[238] RESCHER, N., "Communicative Pragmatism," p. 9.

the explicit content of what is stated; and, on the other, the context in which that content is send. In this way, the message obtained is the result of the interpretation of the context in relation to the context of discourse. Thus, the receiver must carry through a process of interpretation, in order to select one of the many alternative constructions that a statement or a set of statements can admit. For this reason, the suitable transmission of information depends on the correct interpretation of the content in relation to the context.

Besides the context, Rescher highlight the role of reliance and credibility in communication.[239] The sender must strive to have credibility and the receiver must trust in the sender. A high cost comes from a systematic critical position on the statements of other people. To proceed always (not only in case we have good reasons) under the assumption that we cannot trust in the sender has a high cost; because a complete skeptical attitude would deprive us of any possibility to obtain information.

In accordance with his pragmatism with economic components, Rescher sees the rational behavior as that that leads us to obtain information in an efficient and effective way. To achieve this goal, credibility is really important: "We adopt an epistemic policy of credence in the first instance because it is the most promising avenue toward our goals, and then persist in it because we subsequently find, not that it is unfailingly successful, but that it is highly cost-effective."[240]

Considered this issue from an economic viewpoint, an effective activity of communication requires conventions such as: a) the sender expresses what he or she understands that is the truth (truthfulness in language); and b) the sender expresses himself or herself in an accurate and not misleading

[239] Cf. RESCHER, N., "The Economics of Trust and Cooperation," in RESCHER, N., *Cognitive Economy. The Economic Dimension of the Theory of Knowledge,* pp. 33-46.
[240] RESCHER, N., "Communicative Pragmatism," p. 16.

way (which involves truth as agreement).[241] These conventions are justified on economic grounds, since they are "practices that represent the most efficient and economical way to accomplish our communicative work."[242] The issue is to obtain the highest benefit from the information transmitted, minimizing the inherent costs to the process of information acquisition and transmission. It is possible to think that there is profitability in stressing the truth in language.

Consequently, the pragmatic dimension has primacy in Rescher's account of language. He deals with language as an "instrument" for communication and with those conditions that make it possible to exchange message with informative content in the communicative practice. The most important thing is, then, to achieve effectiveness and efficiency in the process. Although he acknowledges that language is an imperfect resource, he also admits that it can carry an *objective content*. In this way, even when he gives primacy to the pragmatic dimension, meaning is not reduced to a mere intersubjective use of language as long as he admits objective bases in its content.

2.2. Scientific Prediction in a Theory of Meaning

From the point of view of language, scientific prediction is about a possible future.[243] Wenceslao J. Gonzalez writes that "its sense — the content expressed — and the referent towards which it is oriented belong to the realm of what is expected."[244] When Rescher considers the referent of prediction, he thinks that it does not agree with an available reality — something that has already happened or that is happening now—, but with a

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[241] Cf. "Communicative Pragmatism," p. 8. This is especially important in the case of scientific prediction, because it is not possible to determine *now* if what the predictive statement says is true or not.
[242] RESCHER, N., "Communicative Pragmatism," p. 8.
[243] Cf. GONZALEZ, W. J., *La predicción científica*, p. 284.
[244] *La predicción científica,* p. 284. What is expected can be in an ontological, epistemological, or heuristic sense.

possible future. For this reason, in his approach, truth conditions of a predictive statement are in the background. Even more, when he analyses scientific prediction from the viewpoint of language, his account is principally "pragmatic." It is not, strictly speaking, a "semantic" account.

In addition, Rescher places prediction in an active context.[245] To predict is, in his judgment, an activity whose aim is to achieve meaningful claims with regard to future occurrences. In order to predict, we have to endeavor "to provide warranted answers to detailed substantive questions about the world's future developments."[246] So, faced with a question about a future occurrence, prediction seeks to offer an answer on the basis of the available knowledge. Additionally, he gives prediction an instrumental component: "prediction, in sum, is our instrument for resolving our meaningful questions about the future, or at least of *endeavoring* to resolve them in a rationally cogent manner."[247]

2.2.1. Context of Use

As it happens in the case of language in the general level, language of prediction cannot be analyzed without taking into account the context of use. As an intellectual activity, prediction is carried through in a communicative context — in every kind of language — and a research context (in scientific language). In this way, to a large extent, the *value* that Rescher confers to prediction is due to its practical utility. Because he considers that, in the realm of the daily life, to obtain information about the future events is a human need.

We have meaningful questions about future developments, and we need answers to those questions. This is not, for Rescher, just a matter of curiosity, but a matter of survival. Every human action needs to some extent

[245] Cf. GONZALEZ, W. J., *La predicción científica,* p. 260.
[246] RESCHER, N., *Predicting the Future*, pp. 37-38.
[247] *Predicting the Future*, p. 39.

information about the future, and practical reasoning is basic in this regard. He considers that “to act, to plan, to survive, we must anticipate the future, and the past is the only guide to it that we have.”[248] But this is not entirely accurate, because there is human creativity (and history shows that the future can be different from what was thought of in a historical moment). Rescher considers that practical rationality is what gives a justification for the inductive inference, which allows us to obtain statements about the future on the basis of the past experience.

He also values prediction according to its *utility* in the scientific realm. He thinks that scientific prediction can be used mainly in two directions “as a test of the acceptability of theories and as a guide to discovery.”[249] In the first case, the referent of the prediction is usually something that do not happen yet, so prediction deals with an ontological novelty (for example, in the prediction of an eclipse or the climate change). Meanwhile, in the second case, the novelty is epistemological, so the prediction allows us to discover a reality that has not been observed yet.

From his pragmatic viewpoint, to predict is an activity oriented towards an aim — “to provide warranted answers to detailed substantive questions about the world’s future developments,”[250] and that aim is basically justified with regard to its utility. For this reason, Rescher considers that predictive knowledge is itself valuable. However, he highlights that “the fact that virtually all *action* is in some way future oriented endows our predictive knowledge with special practical potency.”[251]

Prediction is an aim of science, but it is an aim *among others*, since the structure of ends of scientific activity is also oriented towards description,

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[248] RESCHER, N., *Predicting the Future*, p. 65.
[249] *Predicting the Future*, p. 160.
[250] RESCHER, N., *Predicting the Future*, pp. 37-38.
[251] *Predicting the Future*, p. 12.

explanation, and control over nature.[252] But prediction is an especially important aim, because it can be used as a guide for prescription in applied science and its role as a test in basic science allows us to evaluate de comparative theoretical adequacy of scientific theories.[253] In this way, the meaning of the prediction is seen from the perspective of the use. Therefore, it is possible to claim that scientific prediction is one of the realms where — in Rescher's judgment — an analysis of meaning focused on use conditions has advantages over an analysis centered on truth conditions.

2.2.2. Statement about Novel Facts

As a statement about the future or claim about novel facts, a predictive statement can be truth — if what prediction claims happen in the future — but we cannot say that a prediction is true before the predicted phenomenon or development does happen. For this reason, Rescher maintains that "correctness" is more important than "truth" to prediction.[254] It is said that a prediction is "correct" when, on the basis of the available information, it is possible to claim that it adapts well to what we know about how the future facts could be. But we have to wait that those facts happen in order to assess if the prediction is actually true.

For Rescher, what makes that a statement about the future has, in fact, predictive character is not something linked to its sense and reference, but something that has to do with the nexus between language and action. So he accepts that there can be meaning without referent. In that case, scientific prediction can be meaningful even when we cannot confirm now if its sense is related with a real referent. Then, the reaction of receiver of the prediction is more important that prediction itself (its sense), insofar as the receiver

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[252] Cf. RESCHER, N., *Razón y valores en la Era científico-tecnológica*, p. 138.
[253] Cf. RESCHER, N., *Predicting the Future*, p. 161.
[254] Cf. *Predicting the Future*, p. 70.

attributes to the stament the condition of predictive assertion and he has to decide on its correctness.[255]

Correctness and credibility must go together —in Rescher's judgment— in a successful prediction. To be *credible* a prediction must have a plausible grounding. Instead of *correctness*, "it is credibility that is the cardinal predictive virtue,"[256] because it can be determined at the present time. Credibility is based on evidence and probability that support the predictive statement, which are the rational support for the prediction. In this way, practical utility of a predictive statement rests on its credibility, since only those predictions that are credible will be used as test for theories and as a guide for action.

Although it is commonly easier to achieve a successful prediction when it is not much informative (i.e., when it is general or without many details), science seeks informative definiteness. Scientific language seeks accuracy and precision, but — in Rescher's judgment — this involves taking risks. This is because, in principle, the more informative a prediction is — that is, the more accurate, precise, detailed, etc. — the less secure it is. Security is determined on the basis of its probability or its degree of acceptability.[257]

It happens that generic predictive statements are generally the most accepted, since they are, in principle, more credible with regard to their eventual correctness. However, credibility cannot be obtained by diminishing informativeness, which is an "indispensable criterion for a good prediction."[258] This means that predictions should be seek that are both epistemic secure and informative. To achieve an optimal equilibrium between informativeness and credibility is, therefore, one of the main aims of prediction; but it is also one of the main difficulties it must tackle.

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[255] Cf. RESCHER, N., *Predicting the Future*, pp. 38-39.
[256] *Predicting the Future*, p. 122.
[257] Cf. RESCHER, N., "Communicative Pragmatism," pp. 19-24.
[258] RESCHER, N., *Predicting the Future*, p. 120.

There are — according to Rescher — two ways to establish the credibility of a prediction: the evidential and the authoritative.[259] These two options are related with the procedures and methods that are used to predict. He divides the predictive processes into two groups: judgmental or estimative procedures — where prediction is rooted in the personal estimation of the experts — and the formal or discursive methods that follow processes that are explicitly detailed.[260] On this basis, a prediction is credible is one of these possibilities is available: a) it is considered that it has an evidential basis that supports the statement, or b) it is thought that the predictor is a reliable source.[261]

Every predictive statement can be seen as content or as a result. It is revisable, but it should be evaluated in terms of objectivity and truth (or, at least, correctness). This is possible if the scientific prediction is, in effect, a rational prediction ascribe to it values such as objectivity and truth. Therefore, even when he adopts a clearly pragmatic approach, it is important to highlight that Rescher's account does not reduce prediction to the mere use of language. He accepts, in effect, the objectivity of the knowledge about the future, so it could be true. This is because scientific prediction is a statement that we obtain as a result of a rational process supported by evidence (either theoretical or empirical). It deals with "novel facts" in some relevant sense (ontological, epistemological or heuristic).

2.3. The Language of "Prediction"

When "prediction," in general, is considered, it is understood that prediction encompasses a series of features. Thus, to offer a characterization of the concept of "prediction," Rescher suggests four main features: a) it is

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[259] Cf. *Predicting the Future*, p. 123.
[260] Cf. RESCHER, N., *Predicting the Future*, pp. 85-112.
[261] From this perspective, it seems that Rescher considers that the methodological dimension is more relevant than the language when the demarcation between scientific and non-scientific prediction is at stake.

future-oriented; b) it is correct or incorrect; c) it is meaningful; and d) it is informative.[262] In my judgment, it is possible to enlarge this characterization if it is stressed that prediction has to do with *something expected*. A predictive statement involves that something is expected in the future. This linkage with something expected involves *novelty*, so prediction is connected with the notion of "novel facts," since prediction is about not observed or now unobservable things. Moreover, these general features can be diversified in two directions: quantitative prediction and qualitative prediction.

2.3.1. The Concept of "Prediction"

When Rescher suggests the concept of "prediction," he places it within a framework with regard to language where the pragmatic dimension has primacy. As a statement,[263] scientific prediction is a content oriented towards the future, and it can be correct or incorrect; because it involves a meaning with an informative content.[264] As a statement oriented towards the future, prediction should be supported by rational bases. It is the result of an inference made from the data available regarding the facts of the past and the present.[265] It is not possible, in Rescher's judgment, to predict without reasons,[266] because to predict — either scientifically or on the basis of the everyday experience — is, *eo ipso*, a rational activity.

It happens that, even when scientific prediction is oriented towards a potential future —the first feature pointed out—, its content can be objective, since it is the result of a rational process. In my judgment, the acknowledgement that scientific prediction is supported by reasons — theoretical or empirical bases that justify an anticipation of the possible

[262] Cf. RESCHER, N., *Predicting the Future*, pp. 54-55.
[263] This involves a difference between prediction and scientific explanation, which can be understood as an argument. Cf. GONZALEZ, W. J., *La predicción científica,* p. 260.
[264] Cf. RESCHER, N., *Predicting the Future*, pp. 54-55.
[265] Cf. RESCHER, N., *Predicting the Future*, p. 86.
[266] In this way, Rescher rejects D. H. Mellor's thesis according to which "prediction don't need reasons," MELLOR, D. H., "The Possibility of Prediction," p. 221.

future— is especially important. Because both the use of prediction as a test for the validity of the theories and its use as a guide for policy-making in applied sciences can only be justified if the prediction has, in effect, rational bases. In addition, these rational bases could be corrigible and this involves that it is possible to obtain more or better information about the future in order to predict.

Another feature —besides the orientation towards the future— that Rescher attributes to scientific prediction is it can be correct or incorrect. They are conditions of the use of language, so that truth conditions remain in the background. Because, in his judgment, the meaningful character of a predictive statement has to do with the *possibility* that it turns out to be true, instead of being related with its actual truth. In that case, what makes the prediction meaningful is the possibility to prove, in the future, that it is true or false. Prediction establishes that something will happen instead of something else, and it makes this on rational basis that demarcate the predictive statement from the simple prophecy. In this way, successful prediction "is a matter of conjoining correctness and credibility."[267]

As usual, Rescher gives priority to the epistemological dimension. The credibility that is attributed to a prediction rests on its rational basis. This rational basis leads us to think that the statement is *correct*: rationality is the cement for the correctness of the prediction. In Rescher's judgment, "predictions are not (or should not be) categorized as being true / false but rather as correct / incorrect."[268] This is because he is considering a notion of truth as correspondence. Thus, insofar as prediction is about future occurrences, the truth of a statement about the future cannot be established in the present. In effect, it only can be judged once the fact predicted by the statement has happened. So, that a prediction is true is something that

[267] RESCHER, N., *Predicting the Future*, p. 56.
[268] *Predicting the Future*, p. 70.

depends on what the *future facts* will be, whereas its correctness depend on what we know about how those facts could be.

Therefore, the predictive statement should be made on the basis of reasons that make it credible before the fact or development predicted happens. In this way, it is also possible to attribute correctness to it. In Rescher's account, *credibility* has more weight than truth when prediction is analyzed from the point of view of language. A prophecy can be true; but it cannot serve as a guide for human action because it does not have an inferential basis that allows us to think that it is credible and correct. As a consequence of this, the meaningful character of a prediction — the third feature pointed out above — rests (in Rescher's judgment) on use conditions instead of truth conditions. Because meaningfulness — in his approach — derives form the activity of communication and, in that case, is contextual.

In addition to the features that have been pointed out, scientific prediction must be informative. This means that it should meet several requirements, such as definiteness, exactness, detail, precision, etc.[269] It is difficult to obtain a very informative prediction, because of the problem of achieving an optimal equilibrium between predictive security and informativeness. The relation between these requirements responds to the following principle: "*the more informative a forecast is, the less secure it is, and conversely, the less informative, the more secure it is*."[270] Thus, to achieve when of these requirements in a high degree generally involves to diminish considerable the other. However, it is possible to achieve both requirements in a moderate degree. Rescher situates there the optimal point of equilibrium, which is the point where prediction is more effective as a guide for human action, in general, and scientific action, in particular.

[269] Cf. RESCHER, N., *Predicting the Future*, p. 62.
[270] RESCHER, N., *Predicting the Future*, p. 62.

In my judgment, there is another feature that might be added to the characterization offered by Rescher: prediction deals with something *expected*, so it is related with novelty. As a statement that, on rational basis, is oriented towards the future, scientific prediction belongs to the realm of the things expected.[271] It is about not observed (or now unobservable) phenomena and it is therefore linked to the notion of "novel facts,"[272] which involve novelty.

Prediction is different from the mere expectation, since it asserts something more than a reasonable possibility. Thus, prediction says that something will happen (given some conditions) and it does this on the basis of the regularities detected in the past and present facts. In this way, he has a cognitive content: it is linked to an objective basis and then it cannot be reduced to the mere use of the language. Prediction not only anticipates a future fact, but it also asserts that we might expect that it will happen.

2.3.2. Quantitative Prediction and Qualitative Prediction

Rescher does not take into account expressly the distinction between quantitative prediction and qualitative prediction. It is a question that is implicit when he addresses scientific prediction from a methodological viewpoint. However, the distinction between "qualitative predictions" and "quantitative prediction" is an especially important issue when prediction is seen from the point of view of language, since it conditions diverse approaches to scientific research. In addition, it is an issue that has clear

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[271] Cf. GONZALEZ, W. J., *La predicción científica,* p. 284.

[272] Prediction involves some kind of novelty. In fact, it is possible to claim that it is a "research on novel facts," GONZALEZ, W. J., *La predicción científica,* p. 11.

The philosopher who gives more importance to the notion of "novel facts" was Imre Lakatos. Cf. LAKATOS, I., *The Methodology of Scientific Research Programmes. Philosophical Papers, vol. 1*, Cambridge University Press, Cambridge, 1978. On the notion of "novel facts" in Lakatos' conception, see GONZALEZ, W. J., "Lakatos's Approach on Prediction and Novel Facts," *Theoria*, v. 16, n. 3, (2001), pp. 505-508; GONZALEZ, W. J., *La predicción científica,* pp. 179-184; and GONZÁLEZ, W. J., "The Evolution of Lakatos's Repercussion on the Methodology of Economics," *HOPOS: The Journal of the International Society for the History of Philosophy of Science*, v. 4, n. 1, (2014), pp. 1-25.

epistemological and methodological repercussions. Therefore, the concepts of "qualitative prediction" and "quantitative prediction" should be clarified.

Basically, *qualitative predictions* have the following features. (i) They do not follow expressly defined rules, but we achieve them through an intuitive procedure, since it seeks to grasp tendencies, rhythms or patterns in phenomena to anticipate their behavior in the future. (ii) Since they are not obtained through a formal process, subjects who make the prediction are fundamental. In this way, the resulting prediction is based to a large extent on the expertise of the predictors. (iii) Usually, all the available information used for the prediction is not detailed.[273]

Insofar as they are qualitative, interpretation has more weight; so different predictions might disagree. For this reason, it is possible that different experts achieve different predictions, even when they have the same information.[274] Rescher addresses this problem in terms of "predictive scatter," which is related to uncertainty and adds difficulty to prediction. Thus, when we deal with a limited body of information, competing theories can arise that will lead to contradictory predictions. Consequently, "the prospect of conflicting predictions has to be accepted as a pervasively recurrent phenomenon."[275] This can happen in the sciences of nature and, to a larger extent, in the social sciences.

In contrast to qualitative predictions, *quantitative predictions* have the following features: a) they are supported by models that can include some kind of law and, in some cases, they have a clear mathematical expression; b) the role of the agent who makes the prediction is mostly in the background, since the important thing is the model itself; and c) the variables used for the prediction are well specified, because the model must offer the

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[273] Cf. GONZALEZ, W. J., *Philosophico-Methodological Analysis of Prediction and its Role in Economics*, p. 58.
[274] This has been analyzed by B. G. Malkiel in the case of financial and stock markets. Cf. MALKIEL, B. G., *A Random Walk Down Wall Street,* W. W. Norton, N. York, 1973.
[275] RESCHER, N., *Predicting the Future*, pp. 135-136.

information that is relevant for its validity.[276] Quantitative prediction has advantages over qualitative prediction, since its evaluation has fewer difficulties. Firstly, its quantitative character makes it possible to test in a more detailed way its accuracy in the future. Secondly, if prediction is supported by models that might involve laws —instead of being made on the basis of the knowledge of the experts— there will be a higher level of objectivity. Thirdly, it is possible to clearly assess to what extent the relevant important are taken into account.

Rescher's framework to address this distinction between qualitative and quantitative prediction is methodological, instead of being a semantic framework. This is because when he addresses the different types of scientific prediction, his attention goes to the *process* that has been followed to obtain the prediction. Thus, he divides the processes of prediction in two groups: the judgmental procedures and the formalized or inferential methods.[277] It is possible to maintain that, above all, judgmental procedures lead to qualitative predictions. Meanwhile, predictions obtained as a result of the use of formalized processes can be either qualitative or quantitative. But Rescher normally uses the "scientific" term when the methods have an important mathematical component.

Usually, the features of the qualitative predictions can be seen in those predictions that, from a methodological viewpoint, Rescher calls "judgmental."[278] In this kind of prediction, the credibility and correction of the prediction depend directly on the confidence in the experts, because predictor's expertise is basic in a judgmental prediction. Thus, it is possible to claim that qualitative prediction is supported by "their intuitive awareness of

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[276] Cf. GONZALEZ, W. J., *Philosophico-Methodological Analysis of Prediction and its Role in Economics*, pp. 60-63.
[277] Cf. RESCHER, N., *Predicting the Future*, p. 88.
[278] The main features of this predictive procedure, which is developed on the basis of predictor's expertise, already appear in one of the first papers on prediction by Rescher. Cf. RESCHER, N., "The Future as an Object of Research," *RAND Corporation Research Paper* P-3593, 1967; especially, pp. 6-7.

detectable patterns in the phenomena."[279] In this case, there is not a formal process, and the information used or the inference made is not generally shown in an explicit way.

In my judgment, Rescher has contributed effectively to this type of prediction; because he contributed together with Olaf Helmer and Norman Dalkey to the creation of the predictive procedure Delphi during the period he worked as a mathematician at the RAND Corporation (from 1954 to 1956).[280] Delphi procedure is a predictive process where a group of experts intervene, but there is no interaction among them. Through successive questionnaires, the aim is to obtain answers of the experts in order to achieve eventually an "aggregate prediction."

What allows these kinds of predictions is the capability of the agents to anticipate the possible future. For this reason, the epistemological obstacles to prediction affect these kinds of predictions to a great extent. In this way, Rescher considers that in this realm —where the predictions are usually qualitative— "the usual shortcoming of a reliance on experts—bias, speculative opinionizing, justifactory opacity, and the like—all come into play once more."[281] However, he thinks that this kind of predictive procedures have a great value, because it makes it possible to predict phenomena that are not possible to predict by formal processes.

For Rescher, unformalized methods should be valued to the extent that their usage "extends our predictive range by dispensing with the need for detailed theories and/or models to provide the theoretical underpinning of prediction."[282] However, this predictions are little valued from a scientific point of view.[283] In fact, his methodological conception places them out of science,

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[279] RESCHER, N., *Predicting the Future*, p. 89.
[280] Cf. *Predicting the Future*, p. 110.
[281] RESCHER, N., *Predicting the Future*, p. 97.
[282] *Predicting the Future,* p. 110.
[283] For example, in economics qualitative prediction has been seen as *complementary* to quantitative prediction: "En general, podemos decir que el único procedimiento de predicción

because in his approach only the predictions that are the result of a formal process (on the basis of models open to laws and mathematical regularities) can be called “scientific.”

With certain redundancy, it is possible to say that, in Rescher’s judgment, those methods of prediction that “proceeds on the basis of scientific principles”[284] are “scientific methods,” and they usually have a mathematical component. In this case, he considers as scientific those predictions that are the result of processes that are mainly based on laws and models. He thinks that law-based predictions have a high value: “our most sophisticated predictive method is that of *inference form formalized laws* (generally in mathematical form), which govern the functioning of a system.”[285]

Certainly, Rescher shows a certain preference for the methods that he calls “scientific.” Consequently, he is inclined to see quantitative predictions as more valuable than qualitative predictions. To a large extent, this is because he stresses accuracy and precision as the values that should characterize scientific prediction. However, this preference is more implicit than explicit in Rescher, and it is not as noticeably as in other authors. Kuhn, for example, emphasized to a greater extent the importance of the quantitative predictions in comparison with qualitative predictions.[286] Thus, he maintained that “probably the most deeply held values concern predictions: they should be accurate; quantitative predictions are preferable to qualitative

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que se presta a ser analizado y evaluado de acuerdo con unos criterios científicos es el de los modelos econométricos. Sin embargo, estos procedimientos coexisten con una pléyade de instrumentos subjetivos, paneles de opinión, encuestas, valoraciones de expertos, etc., que muchas veces complementan o son complementados por los resultados de las predicciones basadas en modelos,” FERNÁNDEZ VALBUENA, S., “Predicción y Economía,” in GONZALEZ, W. J., (ed.), *Aspectos metodológicos de la investigación científica*, 2nd ed., Ediciones Universidad Autónoma de Madrid and Publicaciones Universidad de Murcia, Madrid-Murcia, 1990, p. 386.

[284] RESCHER, N., *Predicting the Future,* p. 106.

[285] *Predicting the Future,* p. 106.

[286] On Kuhn’s approach to prediction, cf. GONZALEZ, W. J., *La predicción científica*, chap. 4, pp. 127-159.

ones; whatever the margin of permissible error, it should be consistently satisfied in a given field; and so on."[287]

In this regard Rescher's position is more qualified than Kuhn's viewpoint. In my judgment, the key is that Rescher is in some sense more pluralistic. He notices that predictions that are the result of "scientific" processes — that can be associated with quantitative predictions due to the usage of models that have a mathematical expression — are the predictions that provide more "rational comfort."[288] Moreover, he considers that "it is fortunate that the use of experts is no tour only predictive resource."[289] Concurrently, he insists that every prediction is, in principle, fallible. So the most important thing is to acknowledge the limits that affect prediction and try to overcome them.

From this perspective of predictive pluralism, qualitative predictions are valuable, since they may extend our predictive range.[290] In this way, qualitative predictions are something more than a simple complement to quantitative prediction, because they allow us to anticipate phenomena that are not predictable on the basis of formalized methods of prediction. However, Rescher's approach has several ambiguities: 1) he does not delimit in a clear way the differences and relations between quantitative and qualitative predictions; 2) he admits that there are, *de facto*, predictive procedures and predictive methods, and thinks that the later are more reliable; and 3) he does not characterize what are the thematic realms that can obtain some benefit form qualitative predictions, even when it seems that social sciences and the sciences of the artificial are the greater beneficiaries of the existence of qualitative predictions.

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[287] KUHN, TH. S., "Postscript— 1969," in KUHN, TH. S., *The Structure of Scientific Revolutions*, 2nd ed., p. 185.
[288] Cf. RESCHER, N., *Predicting the Future,* p. 110.
[289] *Predicting the Future,* p. 97.
[290] RESCHER, N., *Predicting the Future,* p. 110.

2.4. Characterization of the Predictive Statements

Although Rescher's main interest is not the scientific language, his view of scientific prediction as a statement that is oriented towards the future should be emphasized. Thus, from a pragmatic perspective — the use of language, he rejects that we can have a genuine "retrodiction" or "prediction of past:" prediction involves the cognitive anticipation of a possible future and retrodiction is, in principle, oriented towards the past.[291] Moreover, when prediction is seen as a statement, it is advisable to distinguish among different kinds of scientific predictions. Thus, it is possible to differentiate several predictive notions: foresight, prediction, forecasting, and planning, according to the degree of control of the variables.[292]

2.4.1. Prediction and Retrodiction

Rescher insists on prediction as a statement oriented towards the future. This temporal feature leads him to reject, *de facto*, that there can be a genuine "retrodiction."[293] In this sense, he does not accept that it is possible to predict with regard to past events. This thesis of the "prediction of past" has been maintained by Milton Friedman, among other authors. In his well-known text on the methodology of positive economics, Friedman stresses that prediction must not necessarily deal with future phenomena, but it can

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[291] However, according to A. Grünbaum, Hempel defends the possibility that "retrodiction" and "prediction" can be equivalent. This would be the case when a prediction is made from subsequent conditions, so the retrodiction would be oriented towards the future. Cf. GRÜNBAUM, A., "Temporally-Asymmetric Principles, Parity between Explanation and Prediction, and Mechanism versus Teleology", *Philosophy of Science*, v. 29, n. 2, (1962), pp. 146-170.

This possibility has been analyzed by Wesley C. Salmon. Cf. SALMON, W. C., "On the Alleged Temporal Anisotropy of Explanation. A Letter to Professor Adolf Grünbaum form his Friend and Colleague", in EARMAN, J., JANIS, A., MASSEY, G. and RESCHER, N. (eds.), *Philosophical Problems of the Internal and External Worlds. Essays on the Philosophy of Adolf Grünbaum*, University of Pittsburgh Press, Pirttsburgh, PA, 1993, pp. 229-248; especially, p. 235.

[292] Cf. GONZALEZ, W. J., *Philosophico-Methodological Analysis of Prediction and its Role in Economics*, pp. 68-72.

[293] The differences between "prediction" and "retrodiction" are addressed from a logical perspective in the chapter 3 of the present PhD research

be about past events.[294] The possibility of predicting with regard to the past was also defended by Stephen Toulmin in his book *Foresight and Understanding.*[295]

Friedman considers that "the 'predictions' by which the validity of a hypothesis is tested need not be about phenomena that have not yet occurred, that is, need not be a forecast of future events; they may be about phenomena that have occurred but observations on which have not yet been made or are not known to the person making the prediction."[296] Toulmin not only admits the "prediction of past," but also a "prediction of present." He thinks of prediction as an "assertion about the occurrence of a particular sort of event—whether in the past, present, or future."[297]

However, Rescher does not subscribe a possible "prediction of past." He also rejects a "prediction of present," because prediction is about future events or developments. In his judgment, the acceptation of a "prediction of past," which has been maintained by authors such as Milton Friedman and Stephen Toulmin, is the result of a failure in the distinction between *an event as such* and *people's stance towards an event*. So we can predict future reactions to past events, but never something that has already happened.[298]

In my judgment, Rescher criticism is right. Nevertheless, the notion of "novel facts" should be emphasized when this problem is considered, because prediction deals with not observed or now unobservable things. In this way, prediction connects to the notion of "novel facts." Thus, it seems to me that this notion and its relation to scientific prediction is a basic issue, both to clarify the concept of "prediction" and to call into question the possibility of a genuine "retrodiction." The notion of "novel facts" can be seen,

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[294] Cf. FRIEDMAN, M., "The Methodology of Positive Economics," in FRIEDMAN, M., *Economics*, p. 9.

[295] Cf. TOULMIN, S., *Foresight and Understanding. An Inquiry into the Aims of Science,* pp. 26-27.

[296] FRIEDMAN, M., "The Methodology of Positive Economics," p. 9.

[297] TOULMIN, S., *Foresight and Understanding*, p. 31.

[298] Cf. RESCHER, N., *Predicting the Future*, p. 254, n. 66.

at least, in three different senses: (i) ontological, which deals with a future event, temporal in the strict sense; (ii) epistemological, which has to do with a phenomenon that exists from an ontological point of view, but that is unknown; and (iii) heuristic, whose novelty rests on being a fact that is novel for the theory.[299]

When prediction involves a novelty in the ontological sense, the anticipation of the possible future is clear; for example, a prediction about the winner of some election or an event in a time that is posterior to the present moment. When the novelty is in the epistemological sense, the inference made from the available data leads to conclude that it is expected that something exists or that a concrete entity will be discovered (for example, the prediction about the existence of the neutrino).[300] So together with the strictly temporal factor, prediction is also related to something expected. In this way, prediction is oriented towards the future and claims that it may be expected that something happens.

Usually, Rescher highlights the temporal factor. He distinguishes between a statement about the past and a prediction — a statement about the future, on the basis of claiming that only a prediction can be falsified by the future development of the events or phenomena. In effect, "only statements that reach beyond the facts of the past-&-present—statements that could, in principle, be falsified by yet unrealized developments—can qualify as genuinely predictive."[301] Thus, with regard to the language, scientific prediction is a statement about the future, so it is not possible to have neither a prediction of past (a "retrodiction") nor a prediction of present.

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[299] On the different senses of the notion of "novel facts," cf. GONZALEZ, W. J., "Lakatos's Approach on Prediction and Novel Facts," pp. 505-508.

[300] This feature is connected with the role of prediction as a guide for discovery, which is one of the roles of prediction that Rescher points out. Cf. RESCHER, N., *Predicting the Future*, p. 160.

[301] RESCHER, N., *Predicting the Future*, p. 46.

2.4.2. Foresight, Prediction, Forecasting, and Planning

From the point of view of the content, although every prediction we can obtain appears always as fallible, there are differences between them. They are differences that depend on the degree of control of the variables. It seems clear that there are different types of predictions, depending on the phenomenon studied, the problem discussed, and the methodology that is used. They are questions closely related to the degree of control of the variables that are important for the prediction. Consequently, it is possible to propose specific terms to refer to each type of prediction.

In a generic way, Rescher admits these differences with regard to variations in predictive reliability. It is an issue that, in his approach, is addressed from a methodological point of view. This is because — in his judgment — the predictions in natural sciences are usually different from predictions in social sciences. Thus, he thinks that predictions in astronomy, for example, are "virtually certain;"[302] and that their predictive security is higher than the level of certainty that we often have when the prediction is in the social sciences.[303]

Within the social realm, the inherent complexity to the studied systems is the main problem that affects prediction. In effect "in any system whose workings are subject to a very large number of intricately interacting factors, there is going to be a great sensitivity to parameter determination, so that even a small variation on input values will amplify into substantial variations in output values."[304]

However, this higher complexity does not make it impossible the predictive task of the social sciences. Nevertheless, it does affect the processes that should be followed and the prediction that we obtain

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[302] RESCHER, N., "On Prediction and Explanation," p. 286.
[303] Cf. RESCHER, N. and HELMER, O., "On the Epistemology of the Inexact Sciences," pp. 37-38; and RESCHER, N., *Predicting the Future*, pp. 191-208.
[304] RESCHER, N., *Predicting the Future*, p. 197.

eventually as a result. Its characteristics — in Rescher's judgment — would be different from the features of prediction in the realm of the sciences of nature. Fundamentally, he addresses this issue in relation to economics, where he considers that it is possible to claim that "economics cannot succeed with prediction at the level of exact quantitative detail regarding specifics, but can only succeed at the leel of generalities, tendencies, and probabilities.[305] Therefore, Rescher accepts several distinctions. On the one hand, he distinguishes between quantitative and qualitative prediction; and, on the other hand, he notices the distinction between the generic and the specific prediction.

But, to be more rigorous, it is possible to establish more distinctions. Moreover, this issue should not be only contemplated with regard to the differences between the predictions of different sciences or groups of sciences. It is also advisable to distinguish *within each discipline* the possible types of predictions. A quadruple distinction has been proposed in economics among "foresight," "prediction," "forecasting," and "planning."[306] In my judgment, this distinction makes the philosophical discussion on prediction more rigorous form the point of view of language.

To be sure, Rescher does not characterize the possible types of scientific prediction, and he uses the terms "prediction," "foresight," and "forecast" as synonymous. However, he can see in his approach a concern about assigning a specific term to each type of prediction.[307] But this is an issue that he does not develop, because, in his judgment, "the actual albeit regrettable fact is that English does not afford us this terminological luxury."[308] It seems to me that this claim is questionable.

[305] *Predicting the Future*, p. 198.
[306] Cf. FERNÁNDEZ VALBUENA, S., "Predicción y Economía," in GONZALEZ, W. J. (ed.), *Aspectos metodológicos de la investigación científica*, 2nd edition, pp. 385-405.
[307] Cf. RESCHER, N., *Predicting the Future*, pp. 53-56.
[308] *Predicting the Future*, p. 55.

In effect, several distinctions are accepted in economics. Thus, it is possible to differentiate between "foresight," "prediction," and "forecasting," according to the degree of control of the variables that they achieve. *Foresight* is the most secure kind of prediction: "it is a presentation about the state of a variable within a period of time, when the variable is directly or indirectly under our control."[309] Then, a foresight provides knowledge oriented towards the future about a variable that can be controlled (for example, the VAT). For this reason, it is the most secure type of prediction, since — in principle — there will not be changes in the variables that affect the foresight success.

Sensu stricto, *prediction* is a specific type of statement about the future. Thus, unlike foresight, it does not involve the complete control of the variables that are relevant to the statement. In this case, there are factors of the variable that are not under the control of the predictor, but they are subjected to variations, which can be due either to their endogenous behavior or to exogenous factors (for example, inflation or unemployment). For this reason, the reliability of the prediction — in this strict sense — is lower than in the case of a foresight.

Different from foresight and prediction, a *forecasting* has a margin of error associated with it. In this way, instead of provide a concrete number; the forecast establishes a margin where the forecasted phenomenon is expected to be placed (for example, a forecast about the unemployment rate). If we attend to Rescher's proposal, we have that, according to the relation between predictive security and informativeness, it is possible to think that, in principle, he seems to consider the forecast as more secure than the prediction, because the former is less precise and detailed than the latter.

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[309] FERNÁNDEZ VALBUENA, S., "Predicción y Economía," p. 388.

Now then, the difference between the prediction and the forecast can be in the model used. Because, in the case of economics, "that a particular presentation could be a prediction or a forecast depends on—almost always—the procedure used to make it. Thus, a determinist model (where there are no random variables) makes predictions, whereas a stochastic model (which includes random variables) makes forecastings."[310] However, there is no unanimity in the terms within this discipline, where habitually "prediction" and "forecast" are used as they were interchangeable notions.[311]

Finally, it can be stressed that "foresight," "prediction," and "forecast" are different form "planning." *Planning* is made on the basis of the different statements about the future and it seeks to provide patterns for action in the realm of applied science and technology.[312] So it encompasses a teleological approach, since it is oriented towards problem solving. In this way, within applied science it is possible to see prediction as the previous step to prescription and this eventually serves the tasks of planning.

Rescher does distinguish between "prediction" and "planning." He associates planning to an intentional realm of the direction of action. It can be "positive," when the aim is make that something happens; or "negative," when it tries to avoid that something happens.[313] He assumes the importance of planning in economics: "*policy guidance* is one of the main aims of the macroeconomic enterprise."[314] In his judgment, although economics does not achieve the desirable level of predictive success, it can indeed have success in policy guidance. Because he considers that "effective operation [of policy guidance] does indeed *not* demand categorical predictions, since even

[310] FERNÁNDEZ VALBUENA, S., "Predicción y Economía," p. 389. Quoted in GONZALEZ, W. J., *Philosophico-Methodological Analysis of Prediction and its Role in Economics*, p. 69.
[311] Cf. GONZALEZ, W. J., *La predicción científica*, p. 262n.
[312] Cf. *La predicción científica*, pp. 261-263.
[313] Cf. RESCHER, N., *Predicting the Future*, pp. 235-236.
[314] *Predicting the Future*, p. 198.

merely probabilistic considerations can provide serviceable and perfectly cogent guidance to action."[315]

So Rescher distinguishes "prediction" and "planning." But he uses without distinction the terms "prediction," "foresight," and "forecast." However, sometimes he uses the term "forecast" to refer to a "specific sort of prediction which foretells the occurrence or nonoccurrence of a particular concrete eventuation at a particular definite time."[316] Therefore, it is a type of prediction that can be tested in a clearer way than in the case of less specific predictions. In my judgment, this only distinction is not good enough in philosophico-methodological terms.

To be more rigorous with regard to the language, a distinction between the diverse types of predictions is required. Regarding this point, Rescher's account is — in my judgment — revisable according to a more sophisticated analysis of language. It is possible to distinguish a qualitative prediction from a quantitative prediction, as well as differentiate a generic prediction from a specific prediction. But it is also possible to establish differences between types of prediction such as "foresight," "prediction," "forecasting," and "planning." It should be emphasized that several distinctions are already accepted with regard to scientific explanation,[317] and it seems advisable to achieve a typological variety in the realm of scientific prediction.

2.5. Scientific Prediction and the Problem of Demarcation

In some disciplines, such as economics, many authors have seen prediction as a criterion to demarcate science from non-science (and also from pseudo-science). The use of prediction as a scientific test is a widely discussed issue, whose repercussions have been especially important in

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[315] RESCHER, N., *Predicting the Future*, p. 198.
[316] *Predicting the Future*, p. 42.
[317] Cf. SALMON, W. C., *Four Decades of Scientific Explanation*, University of Minnesota Press, Minneapolis, 1990; and GONZALEZ, W. J. (ed.), *Diversidad de la explicación científica*, Ariel, Barcelona, 2002.

economics. This has been the case mainly in mainstream economics. This is because predictive success has been considered as the main epistemological and methodological evidence to assess the scientific character of economics.[318] But, to use prediction as a scientific test for a discipline, the demarcation between scientific and non-scientific predictions should be also clarified.

2.5.1. Accommodation and Scientific Prediction

For Rescher, scientific prediction is different from the mere "precognition" or "clairvoyance."[319] Although he does not stress the problem of demarcation between scientific and non-scientific prediction, he does admit differences with regard to the language. Thus, there are "*unreasoned* predictions" that are different from scientific predictions.[320] Unreasoned predictions lack rational basis, so it is not possible to determine if they are credible or not. These unreasoned predictions are also called by Rescher "prophecies;" and he sees them as mere conjectures that do not have practical utility. In effect, from a scientific perspective, "predictions whose merits can be recognized only after the fact with the wisdom of retrospective hindsight are effectively useless."[321]

In contrast with a meaningful prediction — and, therefore, a prediction with cognitive content — a prophecy is "useless." In effect, it is not credible and, consequently, we cannot assign it the value of correctness. Rational basis is what gives credibility to a prediction, which is supported by the knowledge about past and present facts. In this way, Rescher demands a

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[318] Cf. GONZALEZ, W. J., "Prediction as Scientific Test of Economics," in GONZALEZ, W. J. and ALCOLEA, J. (eds.), *Contemporary Perspectives in Philosophy and Methodology of Science*, Netbiblo, A Coruña, 2006, pp. 83-112.
[319] Cf. RESCHER, N., *Predicting the Future*, pp. 53-56.
[320] RESCHER, N. and HELMER, O., "On the Epistemology of the Inexact Sciences," p. 32.
[321] RESCHER, N., *Predicting the Future*, p. 55.

"realistic foresight."[322] Consequently, he criticizes D. H. Mellor's proposal, according to which "predictions don't need reasons."[323]

Certainly, without reasons that justify an inference oriented towards the future, prediction lacks credibility: "Outside the context of grammatical examples and imaginative fictions, neither statements nor predictions have any serious interest for us in the absence of reasons for seeing them as credible."[324] This feature has direct repercussions in order to consider that a prediction is a genuine "scientific prediction."

The problem of the unrealistic assumptions has been widely discussed in economics. This question arises with the publication in 1953 of Milton Friedman's work "The Methodology of Positive Economics." In this text, Friedman proposes a methodological instrumentalism, in the sense of subordinate scientific methods to the aim of predicting. He claims that "the only relevant test of the validity of a hypothesis is comparison of its predictions with experience."[325] Thus, in his judgment, an economic model cannot be assessed on the basis of realistic assumptions, but through its predictive capability, which is understood as correctness in the results.

Rescher disagrees with this account of methodological instrumentalism, and he considers that the defense of predictive models with unrealistic assumptions is infeasible. In fact, he explicitly criticizes Friedman's theses in this regard.[326] Rescher maintains that "'models' that do not acutally *model*—that is, do not isomorphically reflect the real world's arrangements in their own makeup—will for this very reason fail to parallel the real world's *modus operandi* and accordingly prove predictively failure prone."[327] This leads him to maintain that the criterion of demarcation between scientific prediction and

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[322] Cf. *Predicting the Future*, p. 40
[323] MELLOR, D. H., "The Possibility of Prediction," p. 221.
[324] RESCHER, N., *Predicting the Future*, p. 256, n. 81.
[325] FRIEDMAN, M., "The Methodology of Positive Economics," pp. 8-9.
[326] Cf. RESCHER, N., *Predicting the Future*, pp. 109 and 194-196.
[327] *Predicting the Future*, p. 109.

non-scientific prediction is the realism of the assumption. Thus, a model that does not adequately reflect the reality it seeks to predict is not a scientific model.

Reichenbach's proposal about the clairvoyant can be also criticized. For Rescher, what distinguish a prophecy of a clairvoyant and an astronomer's prediction is precisely the realistic assumptions of the later in contrast to the former. Thus, scientific prediction is a prediction whose realism can be determined in advanced. This makes prediction credible before the predicted developments take place eventually. In this way, prediction provides knowledge useful to action and from a pragmatic conception of language this also makes prediction a meaningful statement.

But the realism of the assumption is not — in Rescher's proposal — a sufficient criterion to demarcate scientific prediction from non-scientific prediction. However, it is a sufficient criterion to distinguish between rational and non-rational prediction. Thus, in his judgment, not every rational prediction is a scientific prediction. He admits two kinds of *rational predictions*: those that are based on everyday experience and scientific predictions.[328] Scientific predictions are the result of using scientific methods and knowledge; and, in this sense, they are superior to non-scientific prediction. He thinks that scientific predictions are superior as *science*, but not necessarily as *prediction*, because "the fact that all genuine prediction is oriented toward the open and (as yet) observationally inaccesible future means that our predictions are in principle always fallible."[329]

In this regard, it seems to me that the language can have a role when the issue is to distinguish between scientific prediction and non-scientific prediction. It is an issue that Rescher does not develop, because — in his judgment — the differences between scientific and non-scientific predictions

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[328] Cf. RESCHER, N., *Predicting the Future*, p. 57.
[329] *Predicting the Future*, p. 57.

are basically of a methodological character.[330] In my judgment, to distinguish a scientific prediction from a non-scientific one, the rigor of the language used should be also considered (for example, the accuracy and precision in the sense and reference of the terms used).

Moreover, when the scientific character of a prediction is only assessed from a methodological viewpoint, this can lead to instrumentalist approaches (which are proposals that Rescher tries to avoid). Within this discussion, there have been authors — such as M. Friedman or H. Reichenbach — who maintained that predictive success is a necessary condition for science. This predictivist position involves that only those theories which are oriented towards prediction are scientific; and, consequently, only those disciplines which have theories that successfully predict novel facts are scientific disciplines. From this perspective, predictive success is the main criterion to demarcate science from non-science.

These accounts connect with the debate about the methodological weight of prediction of novel facts in comparison to accommodation to already available facts.[331] Thus, from the predictivist view (that is axiological, epistemological, and, above all, methodological), prediction is given more weight than accommodation. In effect, generally speaking, predictivism is the view according to which "correctly predicting data confers greater confirmation than successfully accommodating data."[332]

Rescher does not take part explicitly in this controversy between prediction and accommodation, although some of the features that configure his approach to scientific prediction allow us to place his conception within a

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[330] Cf. Rescher, N., *Personal Communication*, 15.7.2014.

[331] On this discussion, see HITCHCOCK, CH. and SOBER, E., "Prediction versus Accommodation and the Risk of Overfitting," *British Journal of Philosophy of Science*, v. 55, (2004), pp. 1-34; and GONZALEZ, W. J., *La predicción científica*, pp. 288-292.

[332] HARKER, D., "On the Predilections for Predictions," *British Journal for the Philosophy of Science*, v. 59, (2008), p. 429.

moderate version of predictivism.[333] On the one hand, he considers that prediction has more methodological weight than accommodation; and, on the other, he thinks that to predict is more difficult than to explain already known facts.[334] Thus, he maintains that prediction is our best test for the validity of the scientific theories. Moreover, he considers that prediction is — together with the advancements regarding the control over nature — the best indicator we have in order to assess scientific progress.

When Rescher thinks of his work about prediction, he points out that they are "in the wake of [Hans] Reichenbach's work."[335] The author of *Experience and Prediction* considers that prediction is the main aim of the scientific endeavor.[336] This emphasis on prediction as the principal aim of science allows us to place him within the predictivist tradiction, where there have been philosophers such as Francis Bacon. After him, predictivism appears again in authors like W. Whewell, Imre Lakatos, and — with the required qualifications — Rescher. However, Reichenbach and Rescher differ on their approaches to prediction as an aim of science. This have repercussions on their methodological proposals and, subsequently, on their views about the role of scientific prediction in the demarcation problem.

According to Reichenbach, prediction is the main aim of science and he considers that the inductive inference is an "instrument of prediction so devised that it must lead to success if success is attainable."[337] Thus, scientific method must be oriented towards prediction, which is inferred by

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[333] On the different versions of predictivism, cf. HARKER, D., "On the Predilections for Predictions," pp. 429-453.

[334] That Rescher considers that it is more difficult to predict the future than to explain the past can be seen in accordance with the reasons he offers for a defense of the thesis of the logical asymmetry between explanation and prediction. Cf. RESCHER, N., *Predicting the Future*, pp. 165-166. The problem of the symmetry or asymmetry between explanation and prediction is addressed in the chapter 3 of this PhD research.

[335] RESCHER, N., "The Berlin School of Logical Empiricism and its Legacy," p. 23.

[336] Cf. REICHENBACH, H., *Experience and Prediction. An Analysis of the Foundations and the Structure of Knowledge,* The University of Chicago Press, Chicago, 1938, reprinted in 1949.

[337] REICHENBACH, H., *The Theory of Probability, An Inquiry into the Logical and Mathematical Foundations of the Calculus of Probability,* University of California Press, Berkeley, 1949, p. viii.

means of induction (that is related to probability theory). In his own words, "the theory of probability supplies the instrument of predictive knowledge as well as the form of the laws of nature; its subject is the very nerve of scientific method."[338] By linking method with prediction, predictive capability is configured as the *test* that determines the scientific character of a discipline. Consequently, a theory that does not predict is a theory that does not achieve the main aim of scientific research and, thereafter, it does not meet the requirements to be a "scientific" theory.

In this way, Reichenbach adopts "an instrumentalist perspective: prediction is an aim in itself and the improvement of the methods of prediction could be made without knowing whether prediction as such is possible *de facto*."[339] In other words, he proposes a methodological instrumentalism insofar as he subordinates scientific method to the aim of predicting. But also an instrumentalist interpretation of the aim of predicting itself is possibly. This interpretation follows from a metaphor that he uses in various of his works: "every inductive prediction is like casting a net into the ocean of the happenings of nature; we do not know whether we shall have a good catch, but we try, at least, and try by the help of the best means available."[340]

Meanwhile, Rescher insists in science as an activity that involves a wide field, "because it encompasses the traditional quartet composed of description, explanation, prediction, and control. In this way, we have two areas to address: the theoretical [description and explanation] and the practical [prediction and control over nature]."[341] However, he gives priority to prediction and control in his approach. This is because, for Rescher, "the

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[338] REICHENBACH, H., "Predictive Knowledge," in REICHENBACH, H., *The Rise of Scientific Philosophy*, University of California Press, Berkeley, 1951 (reprinted in 1966), p. 233.
[339] GONZALEZ, W. J., "Reichenbach's Concept of Prediction," *International Studies in the Philosophy of Science*, v. 9, n. 1, (1995), p. 47.
[340] REICHENBACH, H., "Predictive Knowledge," in REICHENBACH, H., *The Rise of Scientific Philosophy*, p. 246. See also REICHENBACH, H., *Experience and Prediction*, pp. 362-363.
[341] RESCHER, N., *Razón y valores en la Era científico-tecnológica*, p. 138.

former [the theoretical area] is related to what science allows us *to say*, whereas the later [the practical area] is related to what science allows us *to do*."[342]

In Reichenbach's approach, prediction is a strong demarcator, since — in his judgment — it is the main aim of scientific activity. It is then a necessary condition to establish that something is scientific. An instrumentalist methodology underlies this proposal, because he thinks that the scientific processes are the means required to achieve the aim of predicting.[343] Meanwhile, for Rescher, prediction is not a test in a demonstrative sense, but merely evidential. "In this domain [the science] even our best confirmed theories are no more than reasonable but also provisional *estimates* of truth."[344]

But, although Rescher avoids adopting a position of instrumentalist predictivism, it seems advisable to go deeper in the distinction between scientific prediction and non-scientific prediction, where language can have an important role. This is an issue that Rescher does not develop — in my judgment — in a satisfactory way. Son when the issue is to address the role of prediction as a criterion to demarcate science from non-science (or from pseudo-science), it seems to me that the demarcation between scientific prediction and non-scientific prediction should be also analyzed.

2.5.2. The Pragmatic Alternative

As a pragmatic philosopher, Rescher offers an alternative to instrumentalism. Thus, he highlights the realm of human activity and,

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[342] *Razón y valores en la Era científico-tecnológica*, p. 138.
[343] Cf. GONZALEZ, W. J., "Prediction as Scientific Test of Economics," in GONZALEZ, W. J. and ALCOLEA, J. (eds.), *Contemporary Perspectives in Philosophy and Methodology of Science*, p. 85. Reichenbach's ideas on prediction as an aim and a test for science are to some extent similar to those maintained by Milton Friedman, insofar as he sees prediction as the main aim of economics and as the most relevant criterion to establish its scientific adequacy. Cf. GONZALEZ, W. J., "Prediction as Scientific Test of Economics," pp. 85-86.
[344] RESCHER, N., *Predicting the Future*, p. 171.

consequently, he gives prediction a high value as an aim of science. Moreover, he considers that prediction can be used in two different directions: “as a test of the acceptability of theories and as a guide to discovery.”[345] The first direction is epistemological-methodological, while the second option is clearly heuristic. In this way, he sees scientific prediction as the main criterion to evaluate the comparative theoretical adequacy of scientific theories, although he admits that “*both* theoretical *and* applicative/experimental achievements must be allowed to count in assessing the success and viability of research programs.”[346] This is because, for him, the explanation of phenomena is the characteristic cognitive task of science.[347]

However, by emphasizing the practical dimension of science, Rescher stresses prediction as an aim of science which has priority and its role as a test for the acceptability of theories. Thus, he maintains that “theories that do not yield predictions are sterile.”[348] It is, in my judgment, a claim that can be called into question. One of the reasons for that is of a historical character: it happens than some of our best supported theories, such as the theory of evolution, do not make, strictly speaking, predictions.

This possibility is an objection that Rescher seems to take into account. In this regard, he establishes a distinction between “predictive inference” and “predictive import.” He points out that although the theory of evolution does not make predictions, it provides a content that allows us to make predictive inferences.[349] Thus, there are theories oriented only towards past developments that do not make *predictive inference*. However, they do have

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[345] *Predicting the Future*, p. 160.
[346] RESCHER, N., *Methodological Pragmatism*, p. 186.
[347] Cf. RESCHER, N., *Razón y valores en la Era científico-tecnológica*, p. 111.
[348] RESCHER, N., *Predicting the Future*, p. 167.
[349] Cf. *Predicting the Future*, p. 161.

predictive import, insofar as their content serves as a support to achieve statements about the future.[350]

Through the pragmatic alternative, predictive language is emphasized. Thus, even when Rescher claims that his work is in tune with Reichenbach's, there are important differences between them, especially when the role of prediction as a test for scientific theories is addressed. According to Reichenbach, prediction is the main aim of science. This leads him to think that scientific method should be oriented towards achieve that aim. For this reason, he considers that every scientific research should be subordinated to the aim of prediction. Meanwhile, Rescher sees prediction as an important aim *among others*. Thus, his approach can be characterized as *predictivist* (due to the high value he gives to prediction); but certainly it is not *instrumentalist* (because scientific methods should not be subordinated to the aim of achieving predictions).

In this way, Rescher's predictivism is *moderate*. This is because, even when he stresses the role of prediction as the best test for scientific theories[351] — which is its usual role in basic science — he rejects a methodological instrumentalism and insists on explanation as an important aim of scientific research. He thinks that instrumentalist authors go too far, because there are other important aims of science — such as explanation, so scientific theories cannot be considered as mere predictive instruments.[352]

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[350] On this issue, Wenceslao J. Gonzalez points out that this distinction that Rescher establish between "predictive inference" and "predictive import" is similar to that maintained by W. C. Salmon between "predictive import" and "predictive content," cf. GONZALEZ, W. J., *La predicción científica*, p. 266. Salmon distinction is in SALMON, W. C., "Rational Prediction," *British Journal for the Philosophy of Science*, v. 32, (1981), pp. 115-125. (Reprinted in GRÜNBAUM, A. and SALMON, W. C. (eds.), *The Limitations of Deductivism*, University of California Press, Berkeley, 1988, pp. 47-60.)

Due to its "predictive import," some authors have defended the predictive capacity of evolutionary theory. Cf. WINTHER, R. G., "Prediction in Selectionist Evolutionary Theory," *Philosophy of Science*, v. 76, n. 5, (2009), pp. 889-901.

[351] Cf. RESCHER, N., *Predicting the Future*, p. 265.

[352] Cf. *Predicting the Future*, p. 164.

Thus, Rescher introduces a series of nuances in his philosophical approach that separates his proposal from predictivist positions, such as those maintained by Hans Reichenbach or Milton Friedman. *De facto*, he maintains a moderate version of predictivism, which is the proposal according to which "theories from which it is possible to make successful predictions are better supported by total evidence than those scientific theories that merely accommodate existing facts."[353]

Moreover, he is especially interested in the relation between prediction and control. Thus, he thinks that it is possible to differentiate two modes of prediction: passive predictions and predictions related to control. A prediction about an eclipse or a weather forecast, for example, are passive predictions, oriented towards providing information about the world, so we can align our expectations with those predictions. But there is another kind of predictions which are related to our try to control the world. In this case, we not only expect things happen in one way or another, but we try to make it happen in one way or another. In his judgment, these active predictions or related to control are more important and critical in testing scientific theories and in running experiments than the predictions of the passive or expecting kind.[354]

Certainly, in his pragmatic alternative to instrumentalism, prediction would not be the *requirement* of science. Then it neither is a necessary condition — language, structure, etc. — to establish what science is. However, prediction in Rescher's account may be seen as an epistemological and methodological criterion to distinguish the scientific character of a discipline. Therefore, it might be a demarcator in the weak sense; that is, a sufficient condition to determine what science is. It is a weak demarcator — in my judgment — as an important aim of scientific research

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[353] GONZALEZ, W. J., *La predicción científica,* p. 292.
[354] RESCHER, N., *Personal Communication*, 12.5.2015

and as a test for theories, besides its role as a guide to orientate scientific prescriptions.

Rescher's claim that "theories that do not yield predictions are sterile"[355] can be interpreted from a pragmatic viewpoint. Because — in his judgment — prediction is the best scientific test we have and it is also crucial as a guide to orientate human action. He considers that "to act, to plan, to survive, we must anticipate the future."[356] Therefore, he sees prediction as the previous step to prescription, both in the realm of human action, in general, and in the case of scientific prescription, in particular. He gives them primacy to prediction over explanation, due to its clearer nexus with the realm of *human activity* (the practical dimension).

Concurrently, Rescher insists on prediction as an important aim of science among others. Science — above all, basic science — does not only seek to predict novel facts. It also deals with explanation and description of already available facts and control over nature. Therefore, from a methodological viewpoint, prediction is not the only test for scientific theories; but it is possible to see it as the best available test (as Rescher does), since it has a high confirmation value.

It would be, in this case, a test that — within basic science — guarantees the scientific character of a discipline, with a limited value when the issue is to establish that a theory is not scientific. In effect, on the one hand, it is not indispensable to achieve predictions in order to have science; and, on the other, it might be maintained as scientific a theory that does not have success in prediction (in this sense, it is possible to find "good theories that make bad predictions").[357] This considerations are taken into account by

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[355] RESCHER, N., *Predicting the Future*, p. 167.

[356] *Predicting the Future*, p. 65.

[357] "As we shall see later, with chaotic systems found in the domains of some of our most successful theories (e.g., classical mechanics and electrodynamics), these theories are guaranteed to be predictively inadequate and, as a result, unacceptable after all! What this philosophically uncomfortable situation demands is an approach to theory validation capable

Rescher when he claims that predictive success is a test in an evidential sense, rather than being demonstrative.[358]

To consider prediction as a strong demarcator involves — in my judgment — an overrating of the role played by prediction in science. Prediction is a criterion of demarcation that allows us to separate scientific theories form non-scientific ones; but it is only a demarcator in the weak sense. A theory with predictive success might be considered as scientific. But, in this case, it would be a sufficient condition (not a necessary condition) to establish its scientific character; because we should not link every science to an instrumental subordination to prediction. If prediction is understood as a demarcator in the strong sense (as an indispensable condition in order to have science) then we would place outside science disciplines such as genetics or history that are mainly oriented towards explanation.

Therefore, it seems that prediction is not, in principle, a necessary condition to accept as scientific a theory or a discipline (for example, economics).[359] In basic science, it can be a test — even the best test we have — to establish the scientific value of theories. Meanwhile, in applied science, prediction have a direct link to prescription, because it provides the information required in order to solve concrete problems.

Even when Rescher does not develop predictive language to a large extent — he does not offer especial details for the characterization of the semantic predictive content —, his approach allows us to see, in my

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of accommodating situations in which *good theories make bad predictions*, i.e., when disagreements between predictions and experimental data are *not* indicative of any theoretical or experimental defects," BATITSKY, V. and DOMOTOR, Z., "When Good Theories Make Bad Predictions," *Synthese*, v. 157, n. 1, (2007), p. 82.

[358] Cf. RESCHER, N., *Predicting the Future*, p. 171.

[359] In effect, this issue has been especially important in economics, where its usage to determine the scientific character of the discipline has been widely discussed. Wencesalo J. Gonzalez has analyzed this problem according to the proposals of four Nobel Prize winners: Milton Friedman (1976), John Hicks (1972), James Buchanan (1986), and Herbert Simon (1978). Cf. GONZALEZ, W. J., "Prediction as Scientific Test of Economics"; especially, pp. 84-92; and GONZALEZ, W. J., "A Economía en canto Ciencia: Enfoque desde a complexidade," *Revista Galega de Economía*, v. 21, n. 1, (2012), pp.183-212.

judgment, that prediction has a high value as an aim of science. It is also stressed due to its uses as a test for theories (in the realm of basic science) and as a previous step to prescription (in applied science). However, to the extent that science is oriented towards a variety of goals, prediction is not necessarily required in order to have science. As a scientific test, its value is limited; and, in principle, prediction is only a sufficient condition to establish the scientific validity of theories.

2.6. Limits of Language and Prediction: "Not Predictable" and "Unpredictable"

Within his pragmatic orientation (which sees language from a pragmatic perspective), Rescher is interested in the limits of science. In fact, he is one of the authors who have paid more attention to the problem of the limits of knowledge. In his approach, science is a human product where agents prevail, because categories — and, in general, concepts — allow us to articulate the reality (categories and concepts are expressed through language). To the extent that the scientific vision of the world is a human product, it is not cognitively absolute, because science is "our" science. It is the result that arises from the interaction between the researcher and her context. For this reason, Rescher maintains that "the limits of our experience set limits to our science."[360]

Above all, Rescher insists in the limits derived from agents' capabilities (mainly cognitive), although he also points out the obstacles that arise from the complexity of the phenomena that are researched.[361] Epistemological and ontological limits affect scientific knowledge, in general, and knowledge about the future, in particular. When he addresses the limits that affect prediction, he pays especial attention to the natural science, although he also

[360] RESCHER, N., *The Limits of Science*, revised edition, p. 216.
[361] Rescher also addresses the ethical limitations to scientific activity and technological endeavor. Cf. RESCHER, N., *Razón y valores en la Era científico-tecnológica*, pp. 151-203.

addresses the problem in relation to the social sciences, with attention to phenomena of economics and sociology.[362]

According to Rescher, there are two main types of limits to prediction: epistemological and ontological. Epistemological limits are those limits that affect prediction insofar as it is made by agents with limited cognitive abilities.[363] However, the first limit is in the language: it is difficult to know something we cannot state. There are also ontological limits to predictability insofar as it deals with future phenomena, which have not happened yet and, therefore, they are still open.

Now then, it should be acknowledged that the limits of science are not only epistemological and ontological. This can be clearly seen when it is considered the distinction between the limits due to the agents and the limits of scientific activity itself.[364] The limits due to the agents are related with the capabilities of scientists as subjects with bounded rationality, who are faced with a varied context (cultural, social, etc.) in the knowledge of reality. Meanwhile, the limits of scientific activity itself are those limits involved in the scientific endeavor: they are rooted in its constitutive elements. They are obstacles present in the diverse realms of science: semantic, logical, epistemological, methodological, ontological, axiological, and ethical.[365]

In other words, we can find obstacles due to the language of science, its structure, knowledge, processes, activity, and values (among them, ethical values). In this way, there are not only obstacles in the agents, but also in the activity itself developed by science. In Rescher's approach, to the extent that science is *our* science, the barriers between the limits due to the agents and

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[362] Cf. RESCHER, N., *Predicting the Future*, chapter 11, pp. 101-208; especially, pp. 193-202.

[363] According to Rescher, epistemological limits affect prediction "insofar as the future is *cognitively inaccessible* — either because we cannot secure the needed data, or because it is impossible for us to discover the operative laws, or even possibly because the requisite inferences and/or calculations involve complexities that outrun the reach of our capabilities," *Predicting the Future*, p. 134.

[364] Cf. GONZALEZ, W. J., *La predicción científica*, pp. 275-276.

[365] Cf. *La predicción científica*, pp. 277-281.

the limits due to scientific activity itself tend to fade.[366] Thus, he insists on the limits due to the limited capabilities of the agents and, besides the epistemological and methodological realms, he pays much less attention to the obstacles present in the diverse realms of science.

Within this framework, it is important to analyze prediction from language: if words do not involve sense and reference, it is really difficult the advancement of science. Thus, it can be addressed the issue of the semantic limits to prediction. Strictly speaking, semantic obstacles to prediction are related to "the difficulties to identify new phenomena —their sense and reference."[367] This gets complicated insofar as Rescher's approach to language is not properly a semantic approach, but a pragmatic one. His interest is not in the content of meaning, but rather in the nexus between two forms of impossibility of prediction: "not predictability" and "unpredictability."[368]

"Unpredictability" involves the full impossibility of prediction for human beings. It is mainly due to the presence of phenomena characterized by anarchy or lack of laws.[369] Meanwhile, "not predictability" refers to the current impossibility of stating a prediction, usually due to the instability of the

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[366] Cf. GONZALEZ, W. J., *La predicción científica*, p. 277.
[367] *La predicción científica*, p. 275.
[368] In fact, Rescher uses the notions of "unpredictability" and "impredictability." In his judgment, "an important difference is neatly marked in English usage by the difference between *unpredictable* and *impredictable*, the former being geared to volatility, the latter to intractability. In London weather conditions are unpredictable in March: one minute it can be clear and sunny and ten minutes later there may be clouds and rain. Here instability is at work. On the other hand, the future of the American poetry is impredictable: we simply have no grip on any laws or regularities that provide for rational prediction. Both cases alike frustrate the project of prediction," RESCHER, N., *Predicting the Future*, p. 137.

It seems to me that the terms used by Rescher can lead to confusion. For this reason, the notions chosen in this PhD research are different, in order to distinguish something that we cannot predict now from something that will never be predicted. "Not predictability" is used here instead of what Rescher calls "unpredictability." Thus, a phenomenon is not predictable when there is a current impossibility of predicting it (either through a generic prediction or through a specific prediction). Meanwhile, "unpredictability" is used instead of "impredictability," when there is a complete impossibility of predicting a phenomenon or event (either in the short, middle, or long run). See GONZALEZ, W. J., *Philosophico-Methodological Analysis of Prediction and its Role in Economics*, p. 56.
[369] Cf. RESCHER, N., *Predicting the Future*, pp. 136-138.

phenomena that we want to predict.[370] The former is focused on the intractability of phenomena and the latter is oriented towards the volatility of the events.

When a phenomenon lacks regularity, there is no possibility of predicting its future behavior. Its “intractability” makes it impossible any attempt of prediction. Anarchy prevails, which Rescher distinguishes from chaos. Chaos corresponds to extreme instability, and not with the complete lack of order.[371] Meanwhile, anarchy involves unpredictability. It is not possible to predict about an anarchic phenomenon or system, since there is no relation between its behavior in the past and its development in the future. In this case, the impossibility of prediction is inherent to the phenomenon at issue, and not to the current inability to predict it.

Meanwhile, *not predictability* is related to volatility, which has to do with the behavior of the processes over time. It is linked to the temporal projection of the prediction. Thus, commonly, processes are more stable in the short run than in the long run. But the volatility of phenomena is always a clear obstacle to prediction. In effect, stable processes are more predictable than those characterized by being volatile or unstable. In turn, when a phenomenon is stable, this makes it easier to clarify what elements give this continuity and contribute to a better projection into the future.[372]

But, even when Rescher admits this distinction between what is completely “unpredictable” and what is merely “not predictable” according to the available information and knowledge, he is not always rigorous in the

[370] Cf. *Predicting the Future*, pp. 79-82. On the notion of “unpredictability,” see EAGLE, A., “Randomness Is Unpredictability,” pp. 749-790.
[371] On chaos as an obstacle to scientific prediction, see WERNDL, CH., “What are the New Implications of Chaos for Unpredictability?,” *British Journal for the Philosophy of Science*, v. 60, (2009), pp. 195-220.
[372] This can be seen in the case of economics, where stable elements are sought in order to overcome the obstacles to predictability, such as human rationality in decision-making. Cf. GONZALEZ, W. J., “Racionalidad y Economía: De la racionalidad de la Economía como Ciencia a la racionalidad de los agentes económicos,” in GONZALEZ, W. J. (ed.), *Racionalidad, historicidad y predicción en Herbert A. Simon*, pp. 65-96.

usage of both notions.[373] In my judgment, this is because he uses to think of this issue in terms of "not predictability." Thus, according to him, there are no reasons to think that science cannot answer any question that arises in its domain (if not now, at least in the future).[374] In this way, it is problematic to claim that something is "unpredictable" in the strict sense.[375]

This can be seen with regard to the nexus he establishes between two aspects: on the one hand, the notions "not predictability" and "unpredictability;" and, on the other, the limits of science *in the weak sense* and *in the strong sense*.[376] Thus, science is clearly subject to limits in the weak sense. It seems clear that we have questions that we cannot answer now, because nowadays we do not have knowledge enough to solve them. Meanwhile, when the limits are in the strong sense, we can establish now that there are questions that we cannot answer in the future, even in the long run.

With regard to the limits in the strong sense, Rescher notices that "there is no reason to think, on the basis of general principles, that any issues within the domain of natural science lie beyond its capabilities."[377] It can be considered that there are difficulties to identify the "insolubilia" problems of science,[378] because there are also — to a greater or lesser extern — difficulties to predict how future science will be.[379] It happens that new

[373] Cf. RESCHER, N., *Predicting the Future*, pp.138-140, and 146-148.
[374] Cf. RESCHER, N., *The Limits of Science*, revised edition, p. 3.
[375] Moreover, the possibility of predicting the future depends on both epistemological and ontological issues. Regarding what we can predict or not in science, Rescher thinks that the best source of information we have comes from science itself: it is not an external issue. Moreover, only science itself can inform us about the achievable degree of precision for scientific prediction. This depends on circumstances such as the scope — short, medium or long run —, the available technology, etc. Additionally, it also depends on the question we want to ask. In principle, the more concrete the question is, the more complicated it will be to answer it accurately. Rescher, N., *Personal communication*, 17.6.2014.
[376] Cf. GONZALEZ, W. J., *La predicción científica*, pp. 274-275.
[377] RESCHER, N., *The Limits of Science*, revised edition, p. 3.
[378] Cf. RESCHER, N., *Predicting the Future*, pp. 186-188, and RESCHER, N., *The Limits of Science*, revised edition, chapter 8, pp. 111-127.
[379] Cf. RESCHER, N., *Predicting the Future*, pp. 177-183. On this issue, see also JACQUETTE, D. (ed.), *Reason, Method, and Value: A Reader on the Philosophy of Nicholas Rescher*, part

knowledge that we achieve leads us to new questions. This generates a "principle of question propagation," where the solutions given to the posed problems raise, in turn, new questions.[380]

If we cannot identify the unsolvable problems of science, because we do not know now what we will know in the future, then there are also difficulties to identify the unpredictable phenomena. That is, there are clear difficulties to establish what problems are intrinsically unsolvable by human science, and not merely not-predictable in accordance with current limitations. However, we can claim that it is an unachievable goal the complete predictability of phenomena.

In this case, it is assumed that science is subject to predictive incompleteness,[381] not merely in descriptive terms but also in prescriptive ones. This means that we do not just reflect a factual situation — description in the current moment — but also prescription is ruled out — the *ought to be* of science in the future — with regard to the possibility of achieving predictive completeness. Because, in order to achieve predictive completeness, there are not only problems of language (limits to identify all the affected elements of reality), but also epistemological and methodological problems.

Consequently, in order to be completed with regard to prediction, science has to achieve the goal of accurately predicting all things that, in principle, science itself considers predictable.[382] But, both with regard scientific knowledge, in general, and predictive knowledge, in particular, the fallibilistic position should be assumed. Therefore, he considers that all knowledge we accept is revisable, because it can turn to be false.[383]

III, sec. 3 ("The Unpredictability of Future Science") and 6 ("Unrealizability of Perfected Science").

380 In addition, Rescher considers that only science can inform us about its own limits, and this is always with regard to each particular moment. Cf. RESCHER, N., *Personal Communication*, 17.6.2014.

381 Cf. RESCHER, N., "The Problem of Future Knowledge," pp. 149-163.

382 Cf. RESCHER, N., *The Limits of Science*, revised edition, p. 146.

383 Rescher's characterization of his own episteomology in terms of fallibilism can be seen in

Together with prediction there is the metaprediction. In that case, Rescher thinks that scientific activity itself is an unpredictable endeavor.[384] "Kant's principle of question propagation" is also valid in the case of prediction: new predictive answers lead to new predictive questions that, in turn, require an answer. This leads Rescher to state that natural sciences are subject to predictive incompleteness;[385] an approach which can be extended to the social sciences and the sciences of the artificial.

However, Rescher thinks that natural sciences are "our best predictive tool."[386] But they are an imperfect tool, since they are unpredictable with regard to aspects of their very possible future (at least, with the desired level of accuracy and precision).[387] This fact does not lead him to a skeptic position regarding the possibility of prediction, but to a realist approach. Thus, in his judgment, "the inescapable imperfection of this instrument means that the predictive project too is imperfectable and that our aspirations in this direction must be kept within realistic bounds"[388].

Therefore, Rescher accepts predictive and metapredictive limitations of science; that is, he admits that scientific theories involve limits to prediction and that we cannot predict future developments of the current sciences. Thus, he assumes that the complete predictability is a goal that cannot be achieved by means of "our" science. In his proposal, he insists on the limits that hinders the predictive task of science. He address this issue mainly in epistemological and ontological terms, although there are obstacles in the different realms of science, starting with the language. This is because we

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RESCHER, N., *The Limits of Science*, revised edition; especially, chapter 3, "The Instability of Science," pp. 29-42.

[384] Cf. RESCHER, N., "The Unpredictability of Future Science," in COHEN, R. S. ET AL. (eds.), *Physics, Philosophy and Psychoanalysis*, Reidel, Dordrecht, 1983, pp. 153-168.

[385] Cf. RESCHER, N., *Predicting the Future*, pp. 183-186.

[386] *Predicting the Future*, p. 187.

[387] See RESCHER, N., "The Problem of Future Knowledge," pp. 149-163.

[388] RESCHER, N., *Predicting the Future*, p. 188.

cannot identify always all the elements at stake in a prediction (relevant variables, etc.).

According to the present analysis, it can be suggested that, besides the epistemological and ontological realms, the problem of the limits has to do also with the semantic, logical, methodological, axiological, and ethical fields. Certainly, they involve two types of impossibility of prediction: “not predictability” and “unpredictability,” although it is not always easy to provide examples of this conceptual distinction.

On the one hand, there are “not predictable” phenomena due to the existence of current limitations; and, on the other, there are “unpredictable” developments, because there are things that we cannot predict neither now nor in the future. Although Rescher conceptually assumes this distinction, it is not really important in his approach. In addition, it is not clear enough insofar as one thing is not being able to offer now an accurate and precise prediction and another different is to be “not predictable.” Furthermore, in his proposal, we cannot establish the final limits of scientific knowledge. Consequently, claiming that there are phenomena that will *never* be predicted is also problematic.

CHAPTER 3

LOGICAL FEATURES OF SCIENTIFIC PREDICTION

Logically, scientific prediction is related to a series of problems that have to do with the internal articulation of the scientific theories, whether they are conceived as isolated theories (in the Popperian way, for example) or they are considered as series of interrelated theories (for example, in the Lakatosian way or in other view that articulates theoretical frameworks and historicity). In this regard, it should be highlighted that, form a logical perspective, "the existence of well-structured scientific theories does not imply, in principle, that they should be predictive."[389]

De facto, the nature of scientific theories can be diverse with regard to its configuration: a) explicative; b) explicative and predictive; and c) predictive.[390] Thus, the internal structure of scientific theories can be oriented towards explanation, prediction or both. For this reason, an important issue is that related to the possible structural similarities or differences between explanation and prediction, which includes its symmetry or its asymmetry.

This topic of the logical features of explanation and prediction became relevant for the status of scientific prediction.[391] In this regard, this chapter is oriented, firstly, toward the analysis of the controversy among those who were in favor of the symmetry thesis of explanation and prediction and those were not. Secondly, within the framework of the asymmetry thesis between explanation and prediction, the account of Rescher regarding their relations is studied. Thirdly, this question is related to the factor of temporality and the

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[389] GONZALEZ, W. J., *Philosophico-Methodological Analysis of Prediction and its Role in Economics*, p. 15.
[390] Cf. *Philosophico-Methodological Analysis of Prediction and its Role in Economics*, p. 15.
[391] See in this regard BARNES, E. C., *The Paradox of Predictivism*, Cambridge University Press, Cambridge, 2008; and DOUGLAS, H. E., "Reintroducing Prediction to Explanation," pp. 444-463.

On the approaches to scientific explanation, see GONZALEZ, W. J., "Caracterización de la 'explicación científica' y tipos de explicaciones científicas," in GONZALEZ, W. J. (ed.), *Diversidad de la explicación científica*, pp. 13-49.

relevance it has for the logic of prediction. On the factor of temporality two problems are considered: (i) there is a mere temporal anisotropy between explanation and prediction?; and (ii) are retrodiction and prediction equal from a philosophical perspective?

Furthermore, when prediction is seen from the logic of science, it should be considered the debate on the "well-structured" theories oriented toward prediction. Then a question is whether they can have an inductive structure (for example, the hypothetical-inductive[392]) or, on the contrary, the only valid structure is the deductive one, especially, the hypothetical-deductive structure. This leads to consider the problem of induction in two successive dimensions: 1) the characterization and justification of induction; and 2) the role of induction regarding scientific prediction. Finally, the possible limits of deductivism for scientific prediction are considered.

3.1. From Logical Symmetry to Asymmetry between Explanation and Prediction

When prediction is seen from a logical point of view, a major problem is the issue of the similarities or differences with respect to scientific explanation. In this regard, the thesis of the *logical symmetry* between explanation and prediction has been widely discussed. According to this thesis, to explain and to predict are equal processes from a logical perspective. It is a thesis that, after its initial formulation by Carl Gustav Hempel and Paul Oppenheim,[393] had a considerable influence on other authors, such as Adolf Grünbaum.[394] Against this logical account there is the thesis of the asymmetry, which maintains that explanation and prediction are not equal from a structural or logical viewpoint.

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[392] Cf. NIINILUOTO, I. and TUOMELA, R., *Theoretical Concepts and Hypothetico-Inductive Inference*, *passim*.

[393] Cf. HEMPEL, C. and OPPENHEIM, P., "Studies in the Logic of Explanation," pp. 135-175.

[394] Cf. GRÜNBAUM, A., "Temporally-Asymmetric Principles, Parity between Explanation and Prediction, and Mechanism versus Teleology," pp. 146-170.

Rescher actively participated in this controversy very early. He did it as a critic of the symmetry thesis and a defender of the logical asymmetry between explanation and prediction. In order to do this, he developed a proposal that combines logical, epistemological, methodological, and ontological elements of scientific explanation and prediction. Through these elements, he maintains that there is a "significant disanalogy" between both scientific processes.[395] Within this framework, he suggests his own alternative to the Hempel and Oppenheim's thesis: the *harmony thesis*. It has a pragmatic orientation, since it takes into account the nexus between the processes of explanation and prediction in scientific practice.[396]

3.1.1. A Significant "Disanalogy": Explanation of Past and Prediction of Future

Within the logical features of scientific prediction, a major problem has to do with the debate on the logical symmetry or asymmetry between "explanation" and "prediction." This controversy starts in the year 1948, when Carl Gustav Hempel and Paul Oppenheim published their well-known paper on "Studies in the Logic of Explanation."[397] In this paper they propose the thesis of the logical symmetry between explanation and prediction, which maintains that "to explain" and "to predict" are symmetrical processes. This involves that they are logically equal, mainly due to the use of scientific laws, since they are valid both for the past and for the future.

This philosophers think of scientific explanation according to a deductive-nomological model, where explanation is made on the basis of

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[395] Rescher's criticism appeared for the first time in a paper published in 1958: RESCHER, N., "On Prediction and Explanation," pp. 281-290. One year later, he defends again the logical asymmetry between explanation and prediction. He does this in a paper published with O. Helmer. Cf. RESCHER, N. and HELMER, O., "On the Epistemology of the Inexact Sciences," pp. 25-52.

[396] See RESCHER, N., *Predicting the Future*, pp. 167-169.

[397] Cf. HEMPEL, C. and OPPENHEIM, P., "Studies in the Logic of Explanation," pp. 135-175. It is in the framework of the logical empiricism that was dominant in the philosophy of science of the United States in that time.

laws and is supported by a deductive logical structure. In their judgment, the deductive-nomological patterns of explanation involve a logical symmetry between explanation and prediction.[398] Thus, Hempel and Oppenheim expressly maintain that "wathever will be said in this article concerning the logical characteristics of explanation or prediction will be applicable to either, even if only one of them should be mentioned."[399]

From this perspective, the different between explaining and predicting is of temporal nature with a pragmatic dimension: explanation deals with past phenomena, whereas prediction is oriented towards phenomena that have not happened yet. This enunciation of prediction expressly involves that prediction is prior in time to the predicted phenomena. But it is also possible to think of predictions of phenomena that already exist in the present but that we do not know yet. Thus, to differentiate between explanation and prediction, they emphasize the temporal factor: "If E is given, i.e. if es we know that the phenomenon described by E has occurred, and a suitable set of statements C_1, C_2 , … , C_k, L_1 , L_2 , … L_r, is provided afterwards, we speak of an explanation of the phenomenon in question. If the latter statements are given and E is derived prior to the occurrence of the phenomenon it describes, we speak of a prediction."[400]

On this logical basis, which has methodological projection, the symmetry thesis involves that every scientific explanation can serve as prediction. Even more, for Hempel and Oppenheim, "is this potential

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[398] Later Hempel will develop the inductive-statistical model of explanation. Cf. HEMPEL, C. G., "Deductive-Nomological vs. Statistical Explanation," in FEIGL, H. and MAXWELL, G. (eds.), *Minnesota Studies in the Philosophy of Science*, vol. 3, *Scientific Explanation, Space, and Time*, University of Minnesota Press, Minneapolis, 1962, pp. 98-169.

In this case there is — for Hempel — a logical symmetry between the inductive-statistical model of scientific explanation and the probabilistic prediction, cf. SALMON, W. C., "On the Alleged Temporal Anisotropy of Explanation. A Letter to Professor Adolf Grünbaum form his Friend and Colleague," in EARMAN, J., JANIS, A., MASSEY, G. and RESCHER, N. (eds.), *Philosophical Problems of the Internal and External Worlds. Essays on the Philosophy of Adolf Grünbaum*, University of Pittsburgh Press, Pirttsburgh, 1993, pp. 231-232.

[399] Cf. HEMPEL, C. G. and OPPENHEIM, P., "Studies in the Logic of Explanation," 138.

[400] Cf. "Studies in the Logic of Explanation," p. 138.

predictive force which gives scientific explanation its importance: only to the extent that we are able to explain empirical facts can we attain the major objective of scientific research, namely not merely to record the phenomena of our experience, but to learn from them, by bassing upon them theoretical generalizations which enable us to anticipate new occurrences and to control, at least to some extent, the changes in our environment."[401]

But, according to Hempel and Oppenheim, every scientific prediction can serve as scientific explanation (either within a deductive-nomological model or an inductive-statistical one) under suitable circumstances.[402] For Salmon, this part is the most problematic aspect of this conception. He considers that scientific prediction is an statement about the future.[403] Thus, "as such, a prediction could not be an explanation, for an explanation, according to Peter [Hempel], is an argument. The most that could be maintained is that legitimate scientific predictions are *the conclusions of* arguments that conform to the schemas of D-N or I-S explanation."[404]

This logical-methodological position on the structural symmetry between "explanation" and "prediction" was influential for several authors. Among them, Adolf Grünbaum should be highlighted. However, as Wesley C. Salmon notices, Hempel and Oppenheim's paper was practically unnoticed for a decade.[405] Thus, in the late fifties, Rescher was one of the first authors who criticized the symmetry thesis.[406] Later on, in 1998, he gave shape to his own alternative to the proposal of Hempel and Oppenheim. In that time, he

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[401] HEMPEL, C. and OPPENHEIM, P., "Studies in the Logic of Explanation," p. 138.
[402] Cf. GONZALEZ, W. J., *La predicción científica*, p. 216.
[403] This idea was proposed in SCHEFFLER, I., "Explanation, Prediction, and Abstraction," pp. 293-309.
[404] SALMON, W. C., "On the Alleged Temporal Anisotropy of Explanation. A Letter to Professor Adolf Grünbaum form his Friend and Colleague," in EARMAN, J., JANIS, A., MASSEY, G. and RESCHER, N. (eds.), *Philosophical Problems of the Internal and External Worlds. Essays on the Philosophy of Adolf Grünbaum*, p. 232.
[405] Cf. SALMON, W. C., *Causality and Explanation*, Oxford University Press, N. York, 1998, p. 68.
[406] See RESCHER, N., "On Prediction and Explanation," pp. 281-290.

proposes the harmony thesis between "explanation" and "prediction."[407]

It should be emphasized that, in 1958, when the symmetry thesis was widely accepted, Rescher's account is critic to it: he goes further than the option in favor of a simple temporal difference between explanation and prediction. He emphatically claims that ""it cannot be maintained that explanation and prediction are identical from the standpoint of their logical structure."[408] In his judgment, "rather than being the single point of minor difference between explanation and prediction, this temporal asymmetry is of far-reaching and fundamental import."[409] In fact, for him, the different temporal orientation of explanation and prediction leads to important differences between them with regard to their logical structure.

It happens that, in scientific explanation, conclusion is firmly supported by premises. Meanwhile, the degree of probability associated to prediction is usually much lower.[410] In the paper of 1959 that Rescher published together with O. Helmer, he insists on this asymmetry between explanation and prediction: "An explanation must *establish* its conclusion, showing that there is a strong warrant why the fact to be explained—rather than some possible alternative—obtains. On the other hand, the conclusion of a (reasoned) prediction need not be well established in this sense; it suffices that it be rendered *more tenable than comparable alternatives*. Here then is an important distinction in logical strength between explanations and predictions: An explanation, though it need not logically rule out alternatives altogether, must beyond reasonable doubt establish its hypothesis as *more credible than its negation*. Of a prediction, on the other hand, we need to require only that it

[407] Cf. RESCHER, N., *Predicting the Future*, pp. 167-169.
[408] RESCHER, N., "On Prediction and Explanation," p. 289. Rescher's criticism to the symmetry thesis can be also seen in RESCHER, N., *Scientific Explanation*, pp. 30-37; especially, pp. 32-34. On this issue, see also VAN FRAASSEN, B. C., "Rescher on Explanation and Prediction," in ALMEDER, R. (ed.), *Rescher Studies: A Collection of Essays on the Philosophical Work of Nicholas Rescher Presented to him on the Occasion of his 80th* Birthday, Ontos Verlag, Berlin, 2009, pp. 339-361.
[409] RESCHER, N., "On Prediction and Explanation," p. 286.
[410] Cf. RESCHER, N., *Predicting the Future*, p. 166.

establish its hypothesis simply as *more credible than any comparable alternative*."[411]

Once this logical basis is established, Rescher maintains that there is not a mere temporal asymmetry between explanation and prediction, but a significant disanalogy between them. The "disanalogy" is based in the underlying difference between explaining and predicting, which is of an ontological kind. Because explanation is about phenomena or events that have already happened, whereas prediction is oriented towards phenomena of events that we expect in the future. This leads to acknowledge that the relation between informativeness and security is different in both cases. Thus, the more detailed the explanation is, the more secure it usually is; whereas in principle prediction is less secure as its informative content increases.[412]

Nevertheless, besides this logical basis for the distinction, Rescher considers that there are also epistemological, methodological, and ontological differences between explanation and prediction. (i) Epistemologically, explanation has a causal linkage that is clearer than in the case of prediction, for which there can be, in principle, alternatives. (ii) Methodologically, prediction and explanation are also different, since there are processes that we can explain, but we cannot predict them. (iii) Ontologically, past facts are different form future developments, which are still open.[413]

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[411] RESCHER, N. and HELMER, O., "On the Epistemology of the Inexact Sciences," p. 32. Rescher and acknowledge that there are exceptions to this common pattern: "Of course prediction may, as in astronomy, be as firmly based in fact and as tightly articulated in reasoning as any explanation. But this is not a general requirement to which predictions *must* conform. A doctor's prognosis, for example, does not have astronomical certitude, yet practical considerations render it immensely useful as a guide in our conduct because it is far superior to reliance on guesswork or on pure chance alone as a decision making device," RESCHER, N. and HELMER, O., "On the Epistemology of the Inexact Sciences," p. 32.

[412] Cf. RESCHER, N., *Predicting the Future*, p. 257, n. 90. "Informative content" or "informativeness" is understood here as the level of detail achieved by the prediction; that is, its precision.

[413] Cf. *Predicting the Future*, pp. 165-166.

Consequently, his criticism of the symmetry thesis combines logical, epistemological, methodological, and ontological elements.[414] This is something that it suggests initially in 1958, so he was one of the first philosophers who rejects the proposal — that was dominant then — on the logical symmetry between explanation and prediction. But, besides the criticism to the characterization of this thesis by Hempel and Oppenheim, Rescher came to develop his own alternative to the symmetry thesis. He calls it *harmony thesis* between explanation and prediction, since it emphasizes the idea of complementarity. The epistemological and, above all, methodological nexus between scientific explanations and predictions are highlighted in this harmony thesis.[415]

3.1.2. Rescher's Proposal on the Nexus between Explanation and Prediction

After rejecting the symmetry thesis — that had a great influence on the Received View, Rescher considers what the relations between scientific explanation and prediction are. He thinks that they are different processes form a logical point of view. In addition, he offers epistemological, methodological, and ontological reasons that support the asymmetry between explanation and prediction. He develops his own proposal from the acknowledgement of the logical asymmetry between them. Thus, the "harmony thesis between explanation and prediction" maintains that, even when to explain and to predict are asymmetrical processes, they are closely interrelated.[416]

However, this proposal of Rescher is not, strictly speaking, a properly

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[414] Cf. GONZALEZ, W. J., *La predicción científica*, p. 264.
[415] The "harmony thesis" is already outlined in his book on scientific explanation: "The key thing in scientific understanding is the capacity to exploit a *knowledge of laws* to structure our understanding of the past and to guide our expectations for the future," RESCHER, N., *Scientific Explanation*, p. 135.
[416] Cf. RESCHER, N., *Predicting the Future*, pp. 167-169.

logical account of the relations between explanation and prediction. It is of a preferentially *methodological* character, insofar as it sees the problem in terms of the advancement of knowledge. In effect, Rescher's starting point is the following question: "Yet what is to be said about the relative priority of prediction versus explanation in science once one abandons the supposed equivalence at issue in the Hempel-Oppenheim thesis of logical symmetry?"[417] This means that, after considering the debate on the logical symmetry or asymmetry between explanation and prediction, Rescher deals with the problem in new terms, which are oriented towards the methodological relevance of prediction and explanation.

From this perspective, the debate on the logical symmetry or asymmetry between prediction and explanation connects with the controversy about which one has more relevance to evaluate scientific contents: the accommodation to what is already known or the prediction about novel facts.[418] In this regard, Rescher's approach is certainly predictivist to the extent that he considers that "prediction is the very touchstone of science in that it affords our best and most effective test for the adequacy of our scientific endeavors"[419]. It is, however, a *weak* or *moderate predictivism*.[420] In effect, he explicitly criticizes the *instrumentalist* approaches to prediction,[421] according to which "prediction is *all* that matters and thereby constitutes the alpha and omega of science."[422]

Within the framework of his pragmatic conception, where the advancement of knowledge is oriented towards aims, Rescher thinks that to

[417] *Predicting the Future*, p. 167.
[418] On this methodological controversy, see GONZALEZ, W. J., *La predicción científica*, pp. 288-292; and GONZALEZ, W. J., *Philosophico-Methodological Analysis of Prediction and its Role in Economics*, pp. 50-53.
[419] RESCHER, N., *Predicting the Future*, p. 161.
[420] On the distinction between the strong versions of predictivism and the weak predictivism, see HITCHCOCK, CH. and SOBER, E., "Prediction versus Accommodation and the Risk of Overfitting," pp. 1-34; and BARNES, E. C., *The Paradox of Predictivism*, *passim*.
[421] In this regard, his criticism to the predictivist thesis of Milton Friedman can be highlighted. See RESCHER, N., *Predicting the Future*, pp. 109 and 194-196.
[422] RESCHER, N., *Predicting the Future*, p. 164.

explain and to predict are not symmetrical or equivalent processes. He sees them as a part of a whole, so they are processes that should be *coordinated*, within a systemic approach to science.[423] For this Reason, there cannot be — in his judgment — an absolute instrumental priority of prediction with regard to explanation. Thus, he considers that "theories that do not yield predictions are sterile, and predictions—however successful—that lack a theoretical backing are for that very reason cognitively unsatisfactory."[424]

After acknowledging a methodological difference, with preference for prediction, Rescher suggest the "harmony thesis" between explanation and prediction. It involves a functional complementarity: "scientific adequacy […] involves a complex negotiation in which *both* prediction *and* explanation play a symbiotic and mutually supportive role."[425] He summarizes this thesis in three principles: "1. To qualify as well established, our explanatory theories must have a track record of contributing to predictive success. 2. To qualify as credible, our predictions must be based upon theories that militate for these particular predictions over against other possibilities. 3. Our explanatory theories should be embedded in a wider explanatory framework that makes it possible to understand why they enjoy their predictive successes"[426].

According to this perspective, an adequate scientific *understanding* of phenomena involves the capacity to explain and predict those phenomena, at

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[423] Cf. *Predicting the Future*, pp. 167-169.

[424] Cf. RESCHER, N., *Predicting the Future*, p. 167. The first part of this proposal should be qualified, because there are examples of scientific theories that are really influential and that are not oriented towards prediction. Thus, Charles Darwin did not orient his theory of evolution towards the elaboration of predictions, but his theory was not sterile regarding the phenomena at stake. Certainly, the Darwinian evolutionary approach might generate predictions of new species, but there is no evidence that this was the aim of the author of *The Origin of Species*.

[425] RESCHER, N., *Predicting the Future*, p. 167.

[426] *Predicting the Future*, p. 168. Even when Rescher's proposal certainly makes sense, it could be qualified. It is possible to think in explicative theories of historical character that do not aim to make predictive contributions, at least in a direct way. There can also be considered predictive theories with correct predictions that do not have yet a well-developed explicative theory.

least in principle. Thus, on the one hand, scientific theories oriented towards explanation should — in Rescher's judgment — yield predictions. This fits with his methodological pragmatism, whose final goal is say how to evaluate the truth or verisimilitude of scientific knowledge.[427] Faced with this goal of the scientific activity, the capacity of theories to yield successful predictions prevails.[428] Even more, he maintains that "explanatory theories that yield no predictive advantages are […] deficient. For in the final analysis only their role in providing for correct predictions can validate theories as adequate."[429]

And, on the other hand, scientific prediction should be made on the basis of reasons: science is not interested on predictive success without rational basis.[430] Así, "with any *cogent* prediction […] one should be able to provide a validating rationale as to why that prediction is acceptable (a rationale that need not necessarily qualify as an explanation of the phenomenon being predicted)"[431]. As predictive success can be not good enough for science, he manifestly rejects the methodological instrumentalism. In this way, it is required to give the reasons that support a prediction in order to consider it as a *scientific* prediction. In this regard, Rescher thinks that "explanatory theories are best situated to yield effective predictions in a systematic and reliable manner."[432]

Thus, Rescher clearly rejects that explanation and prediction are symmetrical or equivalent processes. In addition, he does this on the basis of

[427] Methodological pragmatism is developed by Rescher in some of his publications. Among them, the following could be highlighted: RESCHER, N., *Methodological Pragmatism. A Systems-Theoretic Approach to the Theory of Knowledge*, *passim*; RESCHER, N., *Realistic Pragmatism. An Introduction to Pragmatic Philosophy*, *passim*; and RESCHER, N., "Pragmatism at the Crossroads," in RESCHER, N., *Pragmatism. The Restoration of its Scientific Roots*, Transaction Publishers, N. Brunswick, NJ, 2012, pp. 1-19.
[428] "Prediction is the very touchstone of science in that it affords our best and most effective test for the adequacy of our scientific endeavors," RESCHER, N., *Predicting the Future*, p. 168.
[429] RESCHER, N., *Predicting the Future*, p. 167.
[430] For example, an astrologer may predict successfully, but he does not offer genuine scientific knowledge.
[431] RESCHER, N., *Predicting the Future*, p. 167.
[432] *Predicting the Future*, p. 167.

reasons that show their asymmetry in diverse realms: semantic[433], logical, epistemological, methodological, and ontological. However, he thinks that they are coordinated process, so science must aim to achieve a harmony between explanation and prediction. In this way, he also rejects the instrumentalist predictivism and opts for a moderate version of predictivismo, which is — in my judgment — a position more adequate to scientific practice.

3.2. The Temporality Factor

Wesley C. Salmon offers a quite interesting review of the symmetry thesis, where the logical elements have more weight than in the case of Rescher.[434] In fact, Salmon directly objects Grünbaum's approach to symmetry, which gives an especial relevance to the logical dimension of the problem from a characterization of the scientific laws. Thus, the temporality factor — the temporal anisotropy between explanation and prediction — is emphasized.[435]

This issue of temporality connects with the problems posed by the notion "retrodiction." In effect, two logical issues can be considered here. On the one hand, there is the problem of the possible equivalence of "retrodiction" and scientific explanation, which arises when the possibility of explaining on the basis of subsequent conditions to *explicandum* (the fact

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[433] Semantic reasons are not explicitly in Rescher's criticism to the symmetry thesis. But it is implicit that there are differences between explanation and prediction from the point of view of language to the extent that he characterizes scientific prediction as a *statement*. It seems clear that the referent of a statement about the future can be different from what exists now or what existed in the past (that is the realm of explanation). The sematic differences have logical repercussions with regard to the problem of the symmetry.

However, this view of prediction as a statement is not clear in the whole set of Rescher's publications on this issue. Thus, in a paper of 1963, he characterizes prediction as an *argument*: "A *potential prediction* of the supposed fact that a system *will* exhibit the characteristic *Q* at time *t* is an argument whose conclusion is the statement that the system exhibits *Q* at *t*," RESCHER, N., "Discrete State Systems, Markov Chains, and Problems in the Theory of Scientific Explanation and Prediction," *Philosophy of Science*, v. 30, n. 4, (1963), p. 329.

[434] Cf. SALMON, W. C., "On the Alleged Temporal Anisotropy of Explanation," pp. 229-248.

[435] Cf. GRÜNBAUM, A., "Temporally-Asymmetric Principles, Parity between Explanation and Prediction, and Mechanism versus Teleology," pp. 146-170.

that is explained) is accepted. And, on the other hand, there is the question of the logical equivalence between prediction and "explanation," which is usually linked with the acceptation of a genuine "prediction of past."

3.2.1. Is There Just and Anisotropy between Explanation and Prediction?

Following the thread of the logical-methodological proposal of Adolf Grünbaum this question is posed as a key for solving this problem. Grünbaum has been one of the major defenders of the symmetry thesis between explanation and prediction. In his judgment, many of the objections to this thesis (among them, those by Rescher) are due to an inadequate understanding of Hempel's proposal on this matter.[436] For this reason, he considers that the first step is to shed light on the symmetry thesis as it was formulated by Hempel and Oppenheim in his well-known paper of 1948.[437]

According to Grünbaum interpretation of the symmetry thesis, we have this position: "For Hempel, the particular conditions C_i (i = 1, 2, ... n) which, in conjunction with the relevant laws, account for the *explanandum*-event, *E*, may be *earlier* than *E* in *both* explanation *and* prediction or the C_i may be *later* than *E* in *both* explanation and prediction. Thus, a case of *prediction* in which the C_i would be *later* than *E* would be one in astronomy, for example, in which a future *E* is accounted for by reference to C_i which are still further in the future than *E*. These assertions hold, since Hempel's criterion for an explanation as opposed to a prediction is that *E* belong to the scientist's *past* when he offers his account of it, and his criterion for a corresponding prediction is that *E* belong to the scientist's future when it is made."[438]

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[436] Cf. GRÜNBAUM, A., "Temporally-Asymmetric Principles, Parity between Explanation and Prediction, and Mechanism versus Teleology," pp. 146-170.
[437] Cf. HEMPEL, C. and OPPENHEIM, P., "Studies in the Logic of Explanation," pp. 135-175.
[438] GRÜNBAUM, A., "Temporally-Asymmetric Principles, Parity between Explanation and Prediction, and Mechanism versus Teleology," p. 156.

In effect, the difference between prediction and explanation is, for Hempel and Oppenheim, a *temporal anisotropy* with regard to the subject who explains or predicts the concrete fact. Thus, in scientific explanation, the fact has already happened, whereas in prediction the fact has not yet occurred.[439] Consequently, the temporal difference with regard to the particular conditions (Ci) does not allow us to distinguish between explanation and prediction, but they lead to de distinction between prediction and retrodiction.

Following this argumental line, we have — as Grünbaum noticed — that "in the retrodiction-prediction antithesis, a *retrodiction* is characterized by the fact that the C_i are *later* than *E*, while the C_i are *earlier* than *E* in the kind of *prediction* which is antithetical to retrodiction but *not* identical with Hempelian prediction."[440] When the problem is seen in this way, there are two aspects: "Firstly, a retrodiction as well as a prediction can be an H-prediction, and a prediction as well as a retrodiction can be an H-explanation. Secondly, being an H-prediction rather than an H-explanation or conversely depends on the transient homocentric 'now,' but there is no such 'now'-dependence in the case of being a retrodiction instead of a prediction, or conversely."[441]

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[439] Cf. HEMPEL, C. and OPPENHEIM, P., "Studies in the Logic of Explanation," p. 138.

[440] GRÜNBAUM, A., "Temporally-Asymmetric Principles, Parity between Explanation and Prediction, and Mechanism versus Teleology," p. 156.

[441] GRÜNBAUM, A., "Temporally-Asymmetric Principles, Parity between Explanation and Prediction, and Mechanism versus Teleology," p. 156. An example of how a H-prediction could be a retrodiction is provided by Salmon: "If, for example, the Astronomer Royal had, in 1917, established the state that the sun-moonearth system would assume in 1921, and had (still in 1917) derived the occurrence of the 1919 eclipse from the 1921 conditions, his inference would have been both a retrodiction and a H-prediction," SALMON, W. C., "On the Alleged Temporal Anisotropy of Explanation," p. 235.

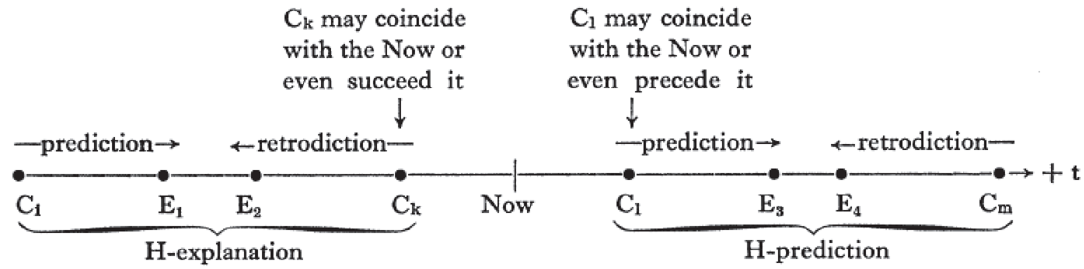

Fig. 1 Reproduced from GRÜNBAUM, A., "Temporally-Asymmetric Principles, Parity between Explanation and Prediction, and Mechanism versus Teleology," *Philosophy of Science*, v. 29, n. 2, (1962), pp. 156.

On the basis of this characterization, Grünbaum answers the objections that Rescher points out with regard to the symmetry thesis. In his judgment, two different types of asymmetries between explanation and prediction should be distinguished: (i) epistemological asymmetry, and (ii) logical asymmetry. "We shall refer to the *first* asymmetry as pertaining to the '*assertibility*' of the *explanandum* while speaking of the second as an asymmetry in the '*inferability*' or '*why*' of the *explanandum.* In the light of this distinction, we shall be able to show that the existence of an epistemological asymmetry in regard to the assertibility of the *explanandum cannot* serve to impugn the Hempelian thesis of symmetry, which pertains to only the *why* of the *explanandum.*"[442] In this way, Grünbaum thinks that, on the basis of the epistemological asymmetry between explanation and prediction, it is not possible to maintain that there is also a logical asymmetry between them.

Certainly, Rescher's criticism to the symmetry thesis takes into account several aspects, and the epistemological asymmetry between explanation and prediction is one among them. Because, in his approach, science is a *system*, so the diverse elements that conforms science are interrelated. Consequently, besides the logical features, there are semantic, epistemological, methodological, and ontological aspects that support the

[442] GRÜNBAUM, A., "Temporally-Asymmetric Principles, Parity between Explanation and Prediction, and Mechanism versus Teleology," p. 159.

asymmetry between explanation and prediction.[443] From this perspective, it seems to me that Grünbaum is right when he claims that, in Rescher's criticism to symmetry thesis, the logical elements are in the background; whereas — for Hempel and Grünbaum — it is a proposal on the *logical* relations between scientific explanations and predictions.

But — in my judgment — Grünbaum is wrong when he claims that Rescher rejects the symmetry thesis on the basis of the epistemological asymmetry between explanation and prediction. Rather, there is a broader approach at stake: Rescher shows that there are several asymmetries between both processes. They are basically differences that have to do with the logical, epistemological, methodological, and ontological realms (where it is possible to add the semantic field). In this way, he offers a broad view of the relations between explanation and prediction. In addition, he gives reasons that lead to reject the symmetry between them in the different realms that can be considered.

It should be highlighted that Wesley Salmon directly criticizes Hempel's symmetry thesis on the basis of the structural elements. He does this in a book in honor of Grünbaum and, due to their friendship, Salmon writes his paper as a letter and includes kind remarks on him. Certainly, Grünbaum is one of the major defenders of the symmetry thesis.[444] Salmon is well aware of that and his starting point is the analysis of the two parts of Hempel's symmetry thesis: (i) every scientific explanation can, under suitable circumstances, serve as a prediction; and (ii) every scientific prediction can, under suitable circumstances, serve as an explanation.[445]

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[443] Cf. RESCHER, N., *Predicting the Future*, p. 165-166.

[444] Cf. SALMON, W. C., "On the Alleged Temporal Anisotropy of Explanation. A Letter to Professor Adolf Grünbaum form his Friend and Colleague," pp. 229-248.

[445] An analysis of Salmon criticism of Hempel's proposal is in GONZALEZ, W. J., "Caracterización de la 'explicación científica' y tipos de explicaciones científicas," pp. 13-49; especially, pp. 18-19. See also GONZALEZ, W. J., *La predicción científica*, pp. 216-217; and GONZALEZ, W. J., *Philosophico-Methodological Analysis of Prediction and its Role in Economics*, pp. 48-50.

On the first part of the argument, Salmon considers that it "*seems* clearly hold for D-N explanations."[446] In this way, he notices that, within a deductive-nomological model of scientific explanation, an argument that provides an explanation of a past event might also serve to anticipate it in the future (for example, the knowledge used to explain a solar eclipse can also serve to predict it). Thus, "if the explanatory facts had been at our disposal before the occurrence of the fact to be explained (the explanadum) we would have been able to predict that fact, for we would have been in possession of true premises from which it follows deductively."[447]

Meanwhile, the second part of the Hempelian argument is more problematic, as Peter Achinstein admits.[448] Because there is a logical difference: Salmon sees scientific prediction as a *statement*, whereas for Hempel scientific explanation is an *argument*. From this perspective, prediction cannot be an explanation, but it has its own characteristics. Then, the most that can be maintained is that a prediction can be the conclusion of an argument that conforms to either a deductive-nomological model of explanation or a inductive-probabilistic model.[449] In addition, Salmon

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[446] SALMON, W. C., "On the Alleged Temporal Anisotropy of Explanation," p. 231.

[447] "On the Alleged Temporal Anisotropy of Explanation," p. 231.

[448] "This part of the symmetry thesis is usually thought to be more dubious of the two. To begin with, it might be said, a prediction is simply a statement that something will occur (or perhaps that something has occurred that has not been verified)," ACHINSTEIN, P., "The Symmetry Thesis," in FETZER, J. H. (ed.), *Science, Explanation, and Rationality. The Philosophy of Carl G. Hempel*, Oxford University Press, Oxford, 2000, p. 168.

[449] SALMON, W. C., "On the Alleged Temporal Anisotropy of Explanation," p. 232.

However, for Achinstein, to acknowledge that prediction is a statement does not involve an objection to this part of the symmetry thesis; because "Hempel is concerned not just with predictive statements (ones that say something will occur), but with predictive *arguments* or *inferences*, that is, with cases in which some prediction is made from, or on the basis of, something," ACHINSTEIN, P., "The Symmetry Thesis," in FETZER, J. H. (ed.), *Science, Explanation, and Rationality. The Philosophy of Carl G. Hempel*, pp. 168-169.

Achinstein considers that a more fair objection is provided by the following example: "Suppose a drug company tests a drug on one thousand patients with symptoms *S* and discovers that in eight hundred cases the symptoms are relieved, while no one in a control group not taking the drug had relief. This might provide a very sound scientific basis for the prediction that the drug will be effective approximately 80 percent of the time. Yet the explanation for the drug's general effectiveness is not that it was effective in the test cases," ACHINSTEIN, P., "The Symmetry Thesis," p. 169.

considers that this is the position adopted by Grünbaum in his defense of the symmetry thesis.[450]

It also happens that — in Grünbaum's judgment — Hempel's symmetry thesis has consequences for the notion of retrodiction. Because, to the extent that the temporal anisotropy is with regard to the subject who explains or predicts, he considers that it has no relevance whether the initial conditions are antecedents conditions (previous to the fact that we want to explain) or subsequent conditions (later that the fact that we want to explain). In this way, "a retrodiction as well as a prediction can be an H-prediction, and a prediction as well as a retrodiction can be an H-explanation."[451]

Because Salmon is focused on examples from physics, a central problem in this regard has to do with the reversibility or irreversibility fo the processes of nature and their relation with causal processes. On this issue, Salmon points out a series of considerations: 1) Objectively, the universe possesses a temporal anisotropy based on irreversible physical processes. 2) The fundamental laws of nature are symmetric from a temporal point of view. 3) The temporal anisotropy of the universe is something *de facto* not *de jure*; that is, it is based on matters of fact, not on temporally asymmetric physical laws. 4) Although many laws of nature are temporally symmetric, there are *de facto* in nature processes that are irreversible.[452]

These are considerations that Salmon attributes to Hans Reichenbach, and he thinks that his colleague Grünbaum would agree with them.[453] Thus, Salmon analyses the consequences of these claims about the "direction of time" for the problem of the logical symmetry between explanation and prediction. In his judgment, the temporal anisotropy applies to reversible physical systems and to irreversible ones: "We distinguish, consequently,

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[450] SALMON, W. C., "On the Alleged Temporal Anisotropy of Explanation," p. 232.

[451] GRÜNBAUM, A., "Temporally-Asymmetric Principles, Parity between Explanation and Prediction, and Mechanism versus Teleology," p. 156.

[452] Cf. SALMON, W. C., "On the Alleged Temporal Anisotropy of Explanation," pp. 241-242.

[453] Cf. "On the Alleged Temporal Anisotropy of Explanation," p. 241.

earlier and later where lunar and planetary motions are concerned just as we do with regard to ice cubes melting in glasses of ginger ale."[454]

This leads to three *anisotropies* that go together: (i) the anisotropy of time, (ii) the anisotropy of causation, and (iii) the anisotropy of scientific explanation.[455] Because, on the one hand, causes normally precede the effects; and, on the other, if we want to explain a phenomenon or event it is not good enough to know its effects — subsequent to the phenomenon, but we have to consider the causes that are, in principle, prior to the phenomenon or event that we want to explain.[456] In this way, Salmon rejects two logical-methodological symmetries that Grünbaum accepts: a) the symmetry between prediction and explanation; and b) the symmetry between retrodiction and explanation.

3.2.2. Are Retrodiction and Prediction Logically Equivalent?

According to Grünbaum's interpretation of Hempel and Oppenheim's symmetry thesis, "in the retrodiction-prediction antithesis, a *retrodiction* is characterized by the fact that the C_i are *later* than *E*, while the C_i are *earlier* than *E* in the kind of *prediction* which is antithetical to retrodiction but *not* identical with Hempelian prediction."[457] For Grünbaum, as it could be seen in the figure exposed above, a retrodiction can be about past or future phenomena, so it could be equivalent to H-explanation or to H-prediction, respectively. The difference is that, in a retrodiction, information used to make the inference is *subsequent* to the explained or predicted phenomenon; that

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[454] SALMON, W. C., "On the Alleged Temporal Anisotropy of Explanation," p. 242.
[455] Cf. GONZALEZ, W. J., *La predicción científica*, p. 217.
[456] The temporal precedence of the cause with regard to the effect is something clear in Salmon's approach: "Time and causality go hand in hand. The anisotropy of time is deeply connected to the anisotropy of causality. Causes come before their effects, not after them. Now, if one agrees that causality is an indispensable component of scientific explanations of *particular events*, it is natural to suppose that the anisotropy of time and causality would be reflected in an anisotropy of scientific explanation," SALMON, W. C., "On the Alleged Temporal Anisotropy of Explanation," pp. 242-243.
[457] GRÜNBAUM, A., "Temporally-Asymmetric Principles, Parity between Explanation and Prediction, and Mechanism versus Teleology," p. 156.

is, the conditions used are *subsequent* conditions instead of *antecedent* conditions.[458]

Salmon gives an example in which a prediction in the sense of Hempel (H-prediction) can be a retrodiction: "If, for example, the Astronomer Royal had, in 1917, established the state that the sun-moon-earth system would assume in 1921, and had (still in 1917) derived the occurrence of the 1919 eclipse from the 1921 conditions, his inference would have been both a retrodiction and an H-prediction."[459] This notion of "retrodiction" as equivalent to "prediction" is not especially problematic, since the information used deals with events of the past or the present and is about eclipses, which have a well-known regularity.

On this issue, Rescher's account is the following: "any sort of rational prediction (…) will accordingly require informative input material that indicates that three conditions are satisfied: 1. that relevant information about the past-&-present can be obtained in an adequately timely, accurate, and reliable way, 2. that this body of data exhibits discernible patterns, and 3. that the patterns so exhibited are stable, so that this structural feature manifests a consistency that also continues into the future."[460]

It could be considered that, in Salmon's example exposed above, these preconditions of rational prediction pointed out by Rescher are met in both cases: first, in the prediction about the state of the solar system in 1921; and, second, in the prediction of the eclipse of 1919 using a prediction made previously (the state of the solar system in a more distant future). However, this is certainly not the usual curse of action in scientific practice.

In effect, as Salmon points it out, this usage of the term *retrodiction* "may seem a bit odd form the standpoint of the ordinary usage."[461] Because,

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[458] See fig. 1 of Grünbaum, p. 139.
[459] SALMON, W. C., "On the Alleged Temporal Anisotropy of Explanation," p. 235.
[460] RESCHER, N., *Predicting the Future*, p. 86.
[461] SALMON, W. C., "On the Alleged Temporal Anisotropy of Explanation," p. 235.

frequently, “retrodiction” is understood as a “prediction of past” (for example, an inference in the realm of archeology), instead of being a “prediction of future” made on the basis of subsequent conditions to the predicted event (for example, to anticipate in 1917 an eclipse that will occur in 1919 on the basis of the knowledge about the solar system’s state in 1921).

Another piece of information that can clarify this discussion is the notion of “retrodiction” as “prediction of past,” which appears in authors such as Stephen Toulmin. Because he thinks, in effect, that *prediction* is an “assertion about the occurrence of a particular sort of event—whether in the past, present, or future.”[462] In this regard, Wenceslao J. Gonzalez points out that prediction has a vague meaning in Toulmin “as a consequence of the sense of prediction as ‘testable implication’ whose reference could be in the past, present or future.”[463]

It should be emphasized that, faced with this option with regard to temporality, Rescher does not accept this possible usage of the term “retrodiction” as prediction of past. Expressly, he claims that “a *potential prediction* of the supposed fact that a system *will* exhibit the characteristic *Q* at time *t* is an argument whose conclusion is the statement that the system exhibits *Q* at *t*.”[464] Meanwhile, “a *potential retrodiction* of the purported fact that a system has exhibited the characteristic *Q* at time *t* is an argument whose conclusion is the statement that the system exhibits *Q* at *t*.”[465]

Thus, on the basis of the language used, there is a clear difference between a prediction and a retrodiction. This is because, in Rescher’s judgment, scientific prediction has a content that is always oriented towards the future; whereas retrodiction is oriented towards the facts of the past. This

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[462] TOULMIN, S. E., *Foresight and Understanding*, p. 31.
[463] GONZALEZ, W. J., “Scientific Prediction in the Beginning of the ‘Historical Turn:’ Stephen Toulmin and Thomas Kuhn,” *Open Journal of Philosophy,* v. 3, (2013), p. 355.
[464] RESCHER, N., “Discrete State Systems, Markov Chains, and Problems in the Theory of Scientific Explanation and Prediction,” p. 329.
[465] “Discrete State Systems, Markov Chains, and Problems in the Theory of Scientific Explanation and Prediction,” p. 329.

involves that, on the one hand, there cannot be an authentic "retrodiction" understood as "prediction of past," insofar as — in his approach — prediction deals with a possible future. And, on the other hand, insofar as Rescher characterizes retrodiction as a statement that deals with something past, it cannot be equivalent to a prediction made from subsequent conditions, which is one of the senses of "retrodiction" that Grünbaum attributes to Hempel.[466]

Another possibility about this problem is offered by the term "postdiction." After the publication of *Experience and Prediction*, it has been claimed that the major innovation of Hans Reichenbach regarding the problem of prediction was the introduction of the term "postdictability" as opposed to "predictability."[467] With this notion of "postdictability" the temporal factor is emphasized, so what is "pre-dicted" is something previous to the phenomenon at issue; whereas what is "post-dicted" occurs once the phenomenon has happened. However, "prediction" and "retrodiction" are, in my judgment, different notions.[468] The differences between them can be clearly seen in Reichenbach's proposal on "postdictability."

After Reichenbach, Imre Lakatos also used the term "postdiction," but he does this in a way that "prediction" also encompasses post-diction: "I use 'prediction' in a wide sense that includes 'postdiction',"[469] which in his approach is a sort of "retrodiction." Thus, for Lakatos, prediction can be about

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[466] "A retrodiction as well as a prediction can be an H-prediction, and a prediction as well as a retrodiction can be an H-explanation," GRÜNBAUM, A., "Temporally-Asymmetric Principles, Parity between Explanation and Prediction, and Mechanism versus Teleology," p. 156.
[467] Cf. GONZALEZ, W. J., *La predicción científica*, pp. 48-49. The notion of "postictability" appears for the first time in the book *Philosophical Foundations of Quantum Mechanics*. Cf. REICHENBACH, H., *Philosophical Foundations of Quantum Mechanics*, University of California Press, Berkeley, 1944, p. 13.
[468] Cf. GONZALEZ, W. J., "Reichenbach's Concept of Prediction," pp. 37-58; especially, pp. 53-54.
[469] LAKATOS, I., "Falsification and the Methodology of Scientific Research Programes," in LAKATOS, I. and MUSGRAVE, A. (eds.), *Criticism and the Growth of Knowledge*, Cambridge University Press, Cambridge, 1970, pp. 91-196. Reprinted in LAKATOS, I., *The Methodology of Scientific Research Programmes. Philosophical Papers*, vol. 1, p. 32, note.

past occurrences, instead of being always oriented towards the future.[470] But it happens again that there are reasons for the differences between prediction and retrodiction, both in basic science and in applied science.[471]

Because the anticipation of the possible future is not the same that the enunciation of a past, which is something that has already happened and therefore will not change. Human future is open, whereas the past is already closed (at least, with regard to the existence of the phenomena). This can be seen in the normal scientific practice, above all, when it is applied research (as well as in the subsequent phase of application of science). Because in applied science prediction is related to prescription. Thus, prediction offers knowledge about the possible future that is needed to solve the concrete problem posed. It is a role that cannot encompass "retrodiction," "insofar a statement about the past does not offer us, in principle, any relevant information about the future whose problems we try to solve by means of the prescription."[472]

Now then, Lakatos' focus of attention is in the methodologically positive character of prediction. Reichenbach, however, was not interested in the controversy about the logical symmetry or asymmetry between explanation and prediction. Nevertheless, Hempel and Oppenheim used Reichenbach's proposal as a source that supports the symmetry thesis. In their judgment, "the logical similarity of explanation and prediction, and the fact that one is directed towards past occurrences, the other towards future ones, is well expressed in the terms 'post-dictability' and 'predictability' used by

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[470] Cf. GONZALEZ, W. J., "Lakatos's Approach on Prediction and Novel Facts," pp. 499-518; and GONZALEZ, W. J., "The Evolution of Lakatos's Repercussion on the Methodology of Economics," pp. 1-25.

[471] Cf. GONZALEZ, W. J., "Prediction and Prescription in Biological Systems: The Role of Technology for Measurement and Transformation," in BERTOLASO, M. (ed.), *The Future of Scientific Practice: "Bio-Techno-Logos*," Pickering and Chatto, London, 2015, pp. 133-146 and 209-213.

[472] GONZALEZ, W. J., "Prediction and Prescription in Biological Systems," in BERTOLASO, M. (ed.), *The Future of Scientific Practice: "Bio-Techno-Logos*," p. 139.

Reichenbach."[473]

But it is possible to think that Hempel and Oppenheim fail in their interpretation of Reichenbach's proposal. They do this — in my judgment — in two different senses: a) insofar as they consider that "post-diction" can be equivalent to "explanation;" and b) when they consider that Reichenbach lay the foundations of the defense of the logical symmetry between "explanation" and "prediction." It seems to me that, when the most notable features of Reichenbach's conception of prediction are analyzed, this interpretation by Hempel and Oppenheim has problems.

The key is that, for Reichenbach, the relation between the statements that deal with past phenomena and the statements about future depelopments does not rest on a possible logical symmetry, but on the probabilistic character of scientific knowledge. In his judgment, there is "a close connection between the weights of propositions concerning past events and predictions: their weights enter into the calculations of predictional values of future events which are in causal connection with the past event."[474]

Therefore, with the introduction of the term "postdictability," Reichenbach "is emphasazing the limits of science in accordance with his probabilistic view."[475] This is because, in his judgment, "the same limitation follows for the determination of past data in terms of given observations, and that we therefore must also speak of a limitation of *postdictability*."[476] So Reichenbach is emphasizing that — as it happens with regard to prediction — "all relations between observational data are restricted to statistical relations."[477]

In *The Direction of Time,* Reichenbach also deals with the problems of postdictability. He points out there that there is an important difference

[473] HEMPEL, C. and OPPENHEIM, P., "Studies in the Logic of Explanation," p. 138, note 2a.
[474] REICHENBACH, H., *Experience and Prediction.* p. 27.
[475] GONZALEZ, W. J., *La predicción científica*, p. 48.
[476] REICHENBACH, H., *Philosophical Foundations of Quantum Mechanics*, p. 13.
[477] *Philosophical Foundations of Quantum Mechanics*, p. 49.

between postdiction and prediction, which is due to the sort of information and knowledge required in each case: "*Predictions* require a knowledge of the total cause; *postdictions*, or statements about past events, can be based on partial effects, on records."[478] Thus, he highlights the divergent points between "predictability" and "postdictability," that basically has to do with the epistemological and methodological realms. So he goes further that the mere temporal anisotropy between them. On this basis, it is possible to maintain that — in his approach — there is not a logical equivalence between "postdiction" and "prediction."

3.3. The Role of Inductive Logic with Regard to Scientific Prediction

Habitually, the logical aspects of science are linked with deduction and induction, without rejecting a recent interest on abduction.[479] Certainly, logic has to with deduction and Popper insisted — as well as other rationalist philosophers — on the nexus between prediction and deduction. Meanwhile, other empiricist-inspired authors, such as Reichenbach or Salmon, put effort into associating prediction with induction. If it is accepted that deduction is demonstrative whereas induction is not, then there are clear repercussions in terms of the validation of predictions.

Rescher's approach to induction has its own characters, since he offers an account which gives priority to the epistemological realm and, later, to the methodological level. This is because he is interested in a specific view on induction as a kind of *ampliative reasoning*. Thus, even when he acknowledges the logical basis of induction — and he also establishes

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[478] REICHENBACH, H., *The Direction of Time*, edited by M. Reichenbach, University of California Press, Berkeley, 1956, p. 22.
[479] Cf. NEPOMUCENO, A., "Scientific Models of Abduction: The Role of Non Classical Logic," in GONZALEZ, W. J. (ed.), *Bas van Fraassen's Approach to Representation and Models in Science*, Springer, Dordrecht, 2014, pp. 121-141; and SINTONEN, M., "Reasoning to Hypotheses: Where do Questions Come?," *Foundation of Science*, v. 9, (2004), pp. 249-266.

several sorts of inductive inference — his attention is usually focused on the cognitive content provided by induction. He does this from a pragmatic approach, where the use of induction as a procedure to solve answers is highlighted.

Within this framework, Rescher addresses the two facets of the problem of induction: a) its characterization, which has incidence for the subsequent use of induction in *our* science; and b) its justification, since he researches the bases that support induction as a process. In this regard, there are two different dimensions, although they are intertwined. On the one hand, in his approach, induction can be characterized as a mode of reasoning and, consequently, as an issue that has to do with Logic. And, on the other hand, Rescher's justification of induction is pragmatic. Thus, the validity of an inductive argument is established on the basis of epistemological considerations (that is, with regard to the content of knowledge that it provides) and its methodological repercussions.[480]

When the focus is on the use of induction by science, then we have that Rescher acknowledges the role of induction with regard to scientific prediction. This is because induction can lead to achieve statements about the future, based on the available information about the development followed by phenomena in the past and present. This activity, which gives relevance to induction for scientific prediction, can be seen in two successive levels. These levels have to do with the context of discovery and the context of justification, respectively: (i) induction as a procedure to achieve predictive statements; and (ii) the role of induction in the justification of prediction.

3.3.1. The Problem of Induction as Scientific Procedure

[480] Cf. RESCHER, N., "A Pragmatic Justification of Induction," in RESCHER, N., *Pragmatism. The Restoration of its Scientific Roots*, Transaction Publishers, N. Brunswick, NJ, 2012, pp. 133-149.

Undoubtedly, the problem of induction is one of the most debated and controversial issues in philosophy and methodology of science, in general, and in the sphere of logic of science, in particular. According to Hempel's view of this topic, the so-called "problem of induction" can be divided, in principle, into two sub-problems.[481] One has to do with the *characterization* of induction (what is induction and which kind of rules does the inductive reasoning follow?). The other sub-problem, which depends on the solution to the previous one, deals with the *justification* of induction (that is, the possible validation of the inductive reasoning).[482]

When Rescher thinks of the *problem of induction*, he preferably takes into account the second sub-problem. Thus, in his book *Induction*, his focus of attention is on the problem of how to provide a pragmatic justification of induction. However, he also addresses the problem of the *characterization* (the first level of analysis). Nevertheless, his conception addresses a "broad" perspective on induction, instead of a "narrow" view. In his judgment, a "narrow" viewpoint of induction maintains that induction is a method for reasoning that allows us to achieve universal generalizations from supportive instances.[483]

In contrast to this characterization of induction, of a clear logical inspiration, Rescher suggest a broader characterization in order to overcome some problems. His idea is to include "all of our rational devices for reasoning from evidence in hand to objective facts about the world. Induction, thus understood, will encompass the whole of 'the scientific method' of

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[481] Cf. HILPINEN, R., "Hempel on the Problem of Induction," in FETZER, J. H. (ed.), *Science, Explanation, and Rationality. The Philosophy of Carl G. Hempel*, p. 91.

[482] Cf. HEMPEL, C. G., "Turns in the Evolution of the Problem of Induction," *Synthese*, v. 46, n. 3, (1981), pp. 389-404; especially, pp. 389-390.

[483] Cf. RESCHER, N., *Induction*, Basil Blackwell, Oxford, 1980, p. 2. As an example of the "narrow" viewpoint, Rescher mentions J. S. Mill's approach to induction, of Aristotelian inspiration, that sees induction as "the operation of discovering and proving general propositions," RESCHER, N., *Induction*, p. 2, n. 2.

reasoning, and in treating of the justification of induction we take in hand the validation of the processes of reasoning in the sciences."[484]

Within this "broad" perspective, it seems that Rescher assumes that, in principle, scientific procedures always encompasses an inductive element, insofar as they are based on the observation an experimentation of particular phenomena in order to achieve general statements. Thus, when the problem of the justification of induction is addressed, in his judgment, the validity of the typical mode of reasoning used in scientific praxis is also called into question.

In his later works, Rescher basically maintains his initial view of induction, as it appears in his monograph *Induction*. He holds that it is a kind of reasoning that allow us to obtain answers to question through an optimal use of the available information.[485] But, at the same time, he offers now additional elements for a more exhaustive characterization of induction. In this regard, he notices that "induction is a mode of reasoning that moves from premises that present presumably acceptable data to conclusions that make claims whose information extends above and beyond what those premises provide for."[486] Therefore, for him, the major characteristic of induction consists in its *ampliative character*.

Expressly, Rescher points out that he understands the "ampliative" character of inductive reasoning in the same way that C. S. Peirce did it: "For Peirce, 'ampliative' reasoning is synthetic in that its conclusion goes beyond ('trascends') the information stipulated in the given premises (i.e., cannot be derived from them by logical processes of deduction alone), so that it 'follows' from them only inconclusively."[487] The inductive character of induction (that

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484 RESCHER, N., *Induction*, p. 2.
485 *Induction*, pp. 19-20.
486 RESCHER, N., "Induction as a Pragmatic Resource," in RESCHER, N., *The Pragmatic Vision. Themes in Philosophical Pragmatism*, Rowman and Littlefield, Lanham, MD, 2014, p. 52.
487 RESCHER, N., *Induction*, p. 6.

is, that induction provides new knowledge that is not stipulated in the premises) involves a clear different with respect to deductive Logic.

This clear difference with deduction follows already known lines. Because Rescher claims that “we cannot pass by any sort of inference or cognitive calculation from the ‘premises’ of an inductive ‘argument’ to its ‘conclusion’ because (*ex hypothesi*) this would be a deductive *non sequitur*—the conclusion (in the very nature of the case) asserts something regarding which its premises are altogether silent. Clearly the paradigm mode of *inference*—of actually deriving a conclusion from the premises—is actual deduction, and this paradigm does not fit induction smoothly (…) With inductive reasoning there is always an epistemic (or conjectural) gap between the premises and the conclusion.”[488]

Regarding the comparison between kinds of inferences from a logical point of view, it is usual to notice that inductive inferences are *contingent*, whereas deductive inferences are *necessary*.[489] This has repercussions on scientific prediction. They affect its very possibility and reliability. This aspect can be seen with regard to one of the modes of inductive reasoning, which consists in the transition from the information about the past developments to the achievement of statements oriented towards the future. In this way, induction could be required to predict the possible future.[490]

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[488] RESCHER, N., “Induction as a Pragmatic Resource,” in RESCHER, N., *The Pragmatic Vision. Themes in Philosophical Pragmatism*, p. 56. In this regard, besides the Peicean influence, Rescher quotes William Whewhell with approval. For Whewhell, deduction “descends steadily and methodically, step by step: Induction mounts by a leap which is out of the reach of method [or, at any rate, mechanical routine]. She bounds to the top of the stairs at once…,” WHEWELL, W., *Novum Organon Renovatum*, J. W. Parker and Son, London, 1858, p. 114. Text quoted in RESCHER, N., “Induction as a Pragmatic Resource,” pp. 55-56.

[489] Cf. VICKERS, J., “The Problem of Induction,” in ZALTA, E. N. (ed.), *The Stanford Encyclopedia of Philosophy* (Fall edition of 2014), *http://plato.stanford.edu/archives/fall2014/entries/induction-problem/* (access on 10.12.2014).

[490] “Deductive inference can never support contingent judgments such as meteorological forecasts, nor can deduction alone explain the breakdown of one's car, discover the genotype of a new virus, or reconstruct fourteenth century trade routes,” VICKERS, J., “The Problem of Induction,” in ZALTA, E. N. (ed.), *The Stanford Encyclopedia of Philosophy* (access on 10.12.2014).

These considerations support Rescher's rejection to what he calls "narrow" view on induction, in the line of authors such as J. Stuart Mill and many others who insist on the logical perspective on induction.[491] Because, since inductive reasoning is ampliative — in contrast to deductive inference —, then it cannot be just a kind of inference that gets universal generalizations from particular cases. Thus, besides the reasoning that goes from the particular to the general, Rescher admits that there is a variety of modes of inductive reasoning: from the past to the future, from the sample to population, from the instance to the type, etc.[492]

So he combines two aspects in his characterization of induction. On the one hand, there is the logical basis, which has to do with induction as an ampliative mode of reasoning that can follow different ways (particular to general, past to future, etc.); and, on the other hand, there is the epistemological dimension, which has primacy in Rescher's approach. This is due to the ampliative character of inductive reasoning, which involves a cognitive gap, insofar as it goes further than the available information in order to provide new knowledge. In this way, he associates induction with its pragmatic usage, insofar as it is a procedure of question answering: "induction is at bottom an *erotetic* (question-answering) rather than an *inferential* (conclusion-deriving) procedure"[493].

3.3.2. Justification of Induction: The Pragmatic Preference

[491] Within the wide bibliography on this matter, it can be highlighted the relation beween inductive Logic and probability. See, for example, BLACK, M., "Inducción," Spanish version by Pascual Casañ, in BLACK, M., *Inducción y probabilidad*, Cátedra, Madrid, 1984, pp. 33-83; BLACK, M., "Probabilidad," Spanish version by Rafael Beneyto, in BLACK, M., *Inducción y probabilidad*, pp. 85-148; GALAVOTTI, M. C., "The Modern Epistemic Interpretations of Probability: Logicism and Subjectivism," in GABBAY, D. M., HARTMANN, S., WOODS, J., *Handbook of the History of Logic.* Vol. 10: *Inductive Logic*, Elsevier, Oxford, 2011, pp. 153-203; GILLIES, D., *Philosophical Theories of Probability*, Routledge, London, 2000; and HÁJEK, A. and HALL, A., "Induction and Probability," in MACHAMER, P. and SILBERSTEIN, M., *The Blackwell Guide to the Philosophy of Science*, Blackwell, Oxford, 2002, pp. 149-172,

[492] Cf. RESCHER, N., "Induction as a Pragmatic Resource," p. 52.

[493] "Induction as a Pragmatic Resource," p. 59.

Since inductive inferences are "ampliative" (i.e., they give a cognitive content that extends that provided by the available information), there is always certain risk of error.[494] This leads to the second aforementioned level of the problem of induction, which has to do with its *justification*. Because, in contrast to deduction, inductive reasoning can lead to false conclusions on the basis of true premises.[495] On this issue, David Hume's proposals have greatly influenced the philosophical reflection on the validation of the inductive inferences.[496]

This issue of the justification of induction can be addressed, in principle, from two different perspectives: the strictly logical perspective — in the sense of providing a proof of validity of an inductive conclusion — and the epistemological perspective, which appeals to the content of knowledge provided by the inductive reasoning. From the logical perspective, in the line of the Humean criticism of induction, it might be considered that it is impossible to justify the conclusion of the inductive reasoning as true. This means that induction is not demonstrative. So it is accepted that it is not possible to provide a proof in terms of truth as justification of an inductive inference.

Once the logical path is abandoned with regard to problem of the *justification* of induction, Rescher adopts a basically epistemological perspective (the second possibility aforementioned) with methodological repercussions. In his approach there is a clear pragmatic component. This is

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[494] Cf. VICKERS, J., "The Problem of Induction," section 1, (access on 10.12.2014).

[495] "In valid deduction we are in the fortunate position of having premises that provide *conclusive* grounds for our conclusions: we have situations of fully supportive pro-information. Induction effectively inverts this proceeding, resolving the questions we face correlatively with the minimum of contraindications. We seek to minimize the as-yet-visible risks in the inevitably risky venture of cognitive gap filling," RESCHER, N., "Induction as a Pragmatic Resource," p. 53.

[496] Cf. HUME, D., *A Treatise of Human Nature*, vol. 1, edited by D. F. Norton and Mary J. Norton, Oxford University Press, Oxford, 2007, book 1, part 3, section VI, pp. 61-65. In this regard, it can be seen LANGE, M., "Hume and the Problem of Induction," in GABBAY, D. M., HARTMANN, S., and WOODS, J. (eds.), *Handbook of the History of Logic.* Vol. 10: *Inductive Logic*, Elsevier, Oxford, 2011, pp. 43-91.

a solution which is coherent with his *characterization* of induction, where the epistemological dimension has primacy over the strictly logical considerations.[497] Moreover, he thinks that the problem of the justification of induction is in no case a matter which could be solved on the basis of Logic. For this reason, he is inclined to "search a validation of induction on the basis of practical considerations."[498]

Firstly, Rescher acknowledges the problem that is posed by the Humean account with regard to induction: "Hume may be taken to have shown, with all the lucidity that philosophical arguments admit of, that there simply can be no 'justification of induction' by way of a demonstrative proof."[499] He considers that the Scottish empiricist was right when he maintained that it is not possible to demonstrate that a conclusion of an inductive inference is true. Thus, he assumes the intrinsic difficult that has the achievement of generalization of universal character from experience, which is something temporal and episodic.[500]

But, secondly, Rescher notices that "it is senseless to make demands or impose conditions that cannot in the very nature of things be satisfied, and absurd to require a demonstration whose accomplishment is manifestly impracticable."[501] For this reason, Humean objection to induction does not lead Rescher to reject the validity of the inductive reasoning, since it is possible to provide a pragmatic justification of induction. Moreover, he accepts that it is possible to justify induction on the basis of epistemological reasons, which have methodological repercussions. Thus, the most important thing is not the inference oriented towards something general, but the ability

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[497] On his own approach to induction, Rescher writes that "it sees induction not as a characteristic mode of drawing conclusions, but *as an estimation technique*, a methodology for obtaining answers to our factual questions through optimal exploitation of the information at our disposal," RESCHER, N., *Induction*, p. 20.
[498] RESCHER, N., *Personal Communication*, 19.8.2014.
[499] RESCHER, N., *Predicting the Future*, p. 64.
[500] RESCHER, N., *Personal Communication*, 19.8.2014.
[501] RESCHER, N., *Predicting the Future*, p. 64.

of induction to solve questions in those contexts where the available information is limited or imperfect.[502]

This kind of pragmatic justification suggested by Rescher is — my judgment — coherent with his characterization of induction. This is because, to the extent that he maintains that "induction is not really a mode of *inference*, strictly speaking, but rather one of *estimation*,"[503] justification of induction cannot proceed on the basis of the rules of Logic.[504] In turn, he also avoids a strictly empiricist approach, which in principle decontextualizes inductive reasoning from the situation. Instead of that, Rescher maintains that we must take into account the context and purpose of inductive reasoning.[505]

From this epistemological-pragmatic perspective, the importance of induction for scientific prediction is emphasized. Insofar as Rescher understands induction as an enlargement of knowledge, this involves a clear nexus between induction and the anticipation of the future, at least at a general level: "It is undeniably possible to look upon an induction as an argument: a process of drawing a general conclusion of inherently future applicability from evidence regarding the past."[506] This is because "for to

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[502] RESCHER, N., *Personal Communication*, 19.8.23014.

[503] RESCHER, N., "Induction as a Pragmatic Resource," p. 63.

[504] In this regard, it is advisable to distinguish between "Logic," as the study of the inferential principles and rules with a well-defined rigor, and "logic," that can consist of processes of reasoning which seek an estimation oriented towards the truth. When Rescher thinks of "inductive logic," he has usually in mind the second sense of "logic" (as truth estimation), so he assumes that inductive logic does not have the rigor that deductive logical rules have.

The advisability of distinguishing Logic — as a rigorous formal science — form logic — understood as an approach that seeks general patterns without proving in a formal way that what is obtained is true — has been pointed out by W. J. Gonzalez in order to study the work of philosophers such as Karl Popper, who sometimes uses the first sense (when he appeals to formal logic as the basis of methodological approaches of general character), whereas in other occasions uses the second sense, which is wider (for example, in some approaches regarding the social sciences). These differences between the two possible senses can be seen in GONZALEZ, W. J., "La evolución del Pensamiento de Popper," in GONZALEZ, W. J. (ed.), *Karl Popper: Revisión de su legado*, Unión Editorial, Madrid, 2004, pp. 23-194.

[505] "Induction is, in the final analysis, a venture in practical/purposive rather than in strictly theoretical/illuminative reasoning," RESCHER, N., "Induction as a Pragmatic Resource," p. 63.

[506] RESCHER, N., "A Pragmatic Justification of Induction," p. 135. When Rescher analyses scientific prediction, he usually considers the realm of basic science, where inductive prediction can be a test for scientific theories. But the role of generic inductive prediction can be also addressed in the context of applied science (as the previous step to prescription) and

evidentiate our predictive claims about the future, we have no alternative but to look to the past-&-present."[507] This involves that, in order to predict the possible future, to use the mode of reasoning that goes from past to future can be an option (and it is a role that seems to be usual in certain time projections of available data).

3.4. Importance of Induction for Scientific Prediction

If induction is seen as a kind of reasoning from past to future, then there is an inductive component that goes with scientific prediction: "All modes of rational prediction call for scanning the data at hand in order to seek out established temporal patterns, and then set about projecting such patterns into the future in the most efficient way possible. For sensible prediction is always a matter of rational economy, of adapting our expectations of the future to the occurrence structures of the past in the most simple and economical way that the epistemic circumstances of the case admit."[508] This involves assuming the economics of research, which is part of the economics of science proposed by Rescher.

As a matter of fact, this pragmatist viewpoint based on the economics of research is central in Rescher's approach to induction. In his conception, inductive reasoning oriented to prediction has a crucial role. In effect, one of the modes of induction that he mentions and accepts is related to the transition from past to future. So inductive reasoning can have a predictive orientation. Furthermore, he thinks that "it is, of course, true, and *trivially* true, that any authentic *generalization* must apply to future cases."[509]

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in the case of the application of science (for example, in business, where it is usual to make prediction on the basis of the trends observed in the past.)

[507] RESCHER, N., *Predicting the Future*, p. 86.

[508] *Predicting the Future*, p. 86.

[509] RESCHER, N., "A Pragmatic Justification of Induction," in RESCHER, N., *Pragmatism. The Restoration of its Scientific Roots*, p. 135.

3.4.1. Role in the "Context of Discovery"

Two different levels can be distinguished when the importance of induction to scientific prediction is addressed. One has to do with the context of *discovery*, where induction can be seen as a process that allows us to achieve predictive statements; whereas the other falls within the context of *justification*, where its task has to do with the validation of the predictive processes and their results.[510] In turn, within this second level, two possible dimensions should be considered: a) justification of induction as a *process* to predict scientifically (that is, to what extent induction is a predictive "procedure" or a predictive "method")[511]; and b) the role of induction for the justification of the *results*, that is, the content of prediction as such or the predictive theories.

Rescher takes into account both the "context of discovery" and the "context of justification" when he develops his approach to induction. He is aware of the importance of induction to predict scientifically the possible future. In effect, he considers that "on the standard 'inductive' model of scientific method, the predictions of science are generated by logico-mathematical derivations that apply general theories to situation-specific facts so as to preindicate future observations."[512] Thus, inductive process can lead to the *discovery* of new predictions, insofar as it is possible to anticipate

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[510] Javier Echeverría has suggested enlarging the traditional distinction between "context of discovery" and "context of justification." In his approach four contexts of scientific activity can be distinguished: context of education, context of innovation, context of evaluation, and context of application. He addresses this with regard to the axiology of research. So he insists on the axiological features of each of these contexts. Cf. ECHEVERRÍA, J., "El pluralismo axiológico de la Ciencia," *Isegoría*, v. 12, (1995), pp. 44-79.

In this study, the relation between scientific prediction and induction is addressed from a logical-methodological perspective. So the main interest is in how induction can be a process to obtain scientific predictions (the "context of discovery") and how it is possible to validate predictive processes and results through induction (the "context of justification").

[511] On this distinction between "predictive procedures" and "predictive methods," see GONZALEZ, W. J., *Philosophico-Methodological Analysis of Prediction and its Role in Economics*, chapter 10, pp. 251-284.

[512] RESCHER, N., *Predicting the Future*, p. 161.

the possible future on the basis of the available information about the past and present occurrences.

Furthermore, Rescher generally maintains that prediction is the result of an inference from the information about the things that already happened. Thus, an argument oriented towards prediction fits usually in the type of reasoning that goes from the past to the future. This seems clear if the preconditions of rational prediction are considered. These conditions are the following: a) data availability; b) pattern discernability; and c) pattern stability, so the patterns observed continue into the future.[513] In this regard, induction can have a role with regard to the *goals* of scientific research when it seeks to predict the possible future.

However, the patterns can change. Consequently, the development of phenomena in the future can be different from the patters followed in the past. Thus, there is uncertainty with regard to the future, so we have to acknowledge the limits to inductive prediction. For this reason, Rescher thinks that we have to deal with Hume criticism of induction, which has clear consequences for the prediction obtained on the basis of the available information about something that has already happened. *De facto*, Rescher is mainly interested in the *justification* of the inductive process that is oriented toward question-answering regarding the possible future, which has repercussions on the problem of inductive predictions' reliability.

3.4.2. Task in the "Context of Justification"

As Rescher notices, "for Hume, the predictive aspect of all attempts to use *available* evidence to establish *general* conclusions calls for 'the transferring of past experience to the future,' a process he saw as predicated

[513] Cf. *Predicting the Future*, pp. 86-88. There is a deeper treatment on this topic in the chapter 5 of this Ph.D.

on the assumption 'that the future resembles the past.'"[514] In Hume's judgment, since experience is the only rational justification to admit this assumption, "there is no rational warrant for our inductive predictions. Its only basis lies in a habit-established psychological expectation."[515]

However, it seems clear that, contrary to what Hume maintained, Rescher does not think that inductive prediction requires the assumption that future invariably resembles the past. Instead of this position, he accepts that there can be changes in phenomena, because the predicted phenomena may be irregular. Even more, he explicitly recognizes that obstacles such as choice, chance or chaos are common. From this point of view, phenomena may follow unprecedented pattern, so there are clear limits to the predictions obtained through inductive reasoning.[516]

Thereby it is not possible to justify inductive prediction by merely accepting the *regularity* of phenomena, since the patterns can change. For this reason, even when Rescher accepts Hume's criticism of inductive reasoning, he thinks that a change of perspective is required to deal with the problem of the *validation* of induction. This change of perspective — which is coherent with his characterization of induction as a mode of reasoning oriented towards question-answering — consists of putting the strictly logical viewpoint aside and taking an epistemological approach, which has methodological repercussions. He sees the problem form a pragmatic viewpoint, which involves a contextual character.

In effect, Rescher addresses two problems related to the context of justification — the justification of induction as a *process* for predicting in a scientific way and its role for the justification of the *results* — within a

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[514] RESCHER, N., *Predicting the Future*, p. 64. According Hume, "there can be no *demonstrative* arguments to prove, *that those instances, of which we have had no experience, resemble those, of which we have had experience*," HUME, D., *A Treatise of Human Nature*, vol. 1, edited by D. F. Norton and Mary J. Norton, Oxford University Press, Oxford, 2007, book 1, part 3, section VI, p. 62.

[515] RESCHER, N., *Predicting the Future*, p. 64.

[516] Cf. *Predicting the Future*, p. 134.

framework that is clearly pragmatic. As a process used to predict the future, he thinks that there are two reasons to use induction in scientific practice: 1) utility, insofar as we know that induction may succeed as a predictive process; and 2) improvement, insofar as induction offers a better prospect of success than other alternatives.[517]

According to these reasons offered by Rescher, it seems to me that there are several issues at stake that he does not explicitly state. (i) Induction has a role in the context of discovery insofar as it allows us to obtain predictions. Thus, it is relevant with regard to the *aims* of the research, since the kind of inductive inference that goes from past to future leads us to obtain predictive hypotheses. (ii) Induction has also a role in the context of justification. It appears in two successive levels, which have to do with the processes and the results. a) Regarding the *processes*, there is the problem of the justification of the use of induction as a procedure for predicting the future in a scientific way. b) With regard to the *results*, justification deals with the statements about the future (the inductive predictions). This involves the problems related to the quantity and quality of the observations and experiments (to what extent they have evidential value with regard to the predictions obtained).

The solution that Rescher gives to the problems related to *justification* — that deal with the processes and the results — is contained, in my judgment, in his account of *methodological pragmatism*; because, in effect, "Rescher argues that a method of inquiry whose use systematically meets with success is to be seen as truth-indicative. False belief may sometimes lead to success, but it could hardly be supposed to do so on a routine basis."[518] According to this methodological pragmatism, we can "monitor tour

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[517] Cf. *Predicting the Future*, p. 64.
[518] SANKEY, H., "Why is it Rational to Believe Scientific Theories Are True?," in CHEYNE, C. and WORRALL, J. (eds.), *Rationality and Reality. Conversations with Alan Musgrave*, Springer, Dordrecht, 2006, p. 126.

acceptance of theses via the methods that substantiate them, and then validate these methods by pragmatic tests—specifically considerating how well we fare *in applying and implementing its professed claims in matters of prediction and control.*"[519]

Thus, in the first place, the validity of the predictive statements of inductive character is assessed on the basis the *methods* that substantiate those statements. Then, in the second place, the validity of the methods is evaluated with regard to their ability to give successful predictions (i.e., statements regarding the future). Therefore, according to Rescher, the justification of the results involves taking into account the processes that lead to those results. If those processes have been systematically successful with regard to prediction, then it could be said that the result is valid.

It seems clear that Rescher's methodological pragmatism involves itself an inductive element, since it is rooted in an inference that goes from past to the future. In effect, results are considered valid if the method used has achieved — in the past — a systematic success in matters related to prediction and the control of phenomena. Thus, on the basis of past experience, we conclude that the method at issue will also lead to reliable results in the future. From this perspective, the justification of induction — both with regard to processes and results — is a pragmatic issue, and the most important thing is the ability to have predictive success.

This pragmatic perspective leads Rescher to criticize in an explicit way Hans Reichenbach's approach to induction.[520] Because, for Reichenbach, the conclusion of an inductive reasoning can be accepted to the extent that it is our best posit or wager with regard to the future: "What we obtain is a wager; and it is the best wager we can lay because it corresponds to a procedure the applicability of which is the necessary condition of the

[519] RESCHER, N., *Realistic Pragmatism. An Introduction to Pragmatic Philosophy*, p. 96.
[520] Cf. RESCHER, N., *Predicting the Future*, p. 258, note 92.

possibility of predictions. To fulfill the conditions sufficient for the attainment of true predictions does not lie in our power; let us be glad that we are able to fulfill at least the conditions necessary for the realization of this intrinsic aim of science."[521]

Although there is no objection to accept, in principle, that "an absolute reliability of the predictions cannot be warranted"[522] there are reasons to reject that "it would be illusory to imagine that terms 'true' or 'false' ever expressed anything else than high or low probability values."[523] In effect, predictions' fallibility is a feature that Rescher and Reichenbach's accounts have in common; but Reichenbach's notion of "prediction" is a really weak characterization of scientific prediction, insofar as he associates the statements about the future with posits or wagers.

Expressly, Rescher objects the approach of Reichenbach to prediction in terms of a wager: "Hans Reichenbach (…) saw the matter [the problem of induction] not as one of establishing knowledge but rather as making a bet."[524] As opposed to the conception of the logical empiricists of the Berlin School, which associates prediction with induction and relates induction to the theory of probability in frequentist terms, Rescher insists on the epistemological component of induction, which he considers from a genuinely pragmatic perspective. Because, in his judgment, "the validation of an inductive knowledge of the future must in the end be founded on the non- or preinductive basis of essentially *practical* reasoning. What we have here is not a theoretical demonstration of a thesis but a pragmatic validation of a cognitive praxis."[525]

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[521] REICHENBACH, H., *Experience and Prediction,* p. 357.
[522] *Experience and Prediction*, p. 86.
[523] REICHENBACH, H., "Logistic Empiricism in Germany and the Present State of its Problems," *Journal of Philosophy*, v. 33, n. 6, (1936), p. 156.
[524] RESCHER, N., *Predicting the Future*, p. 258, n. 92.
[525] *Predicting the Future*, p. 65.

Therefore, the problem of induction is not a matter of making a "wager" — according to Reichenbach's expression. Instead of this path, we have to proceed in a rational way in science, according to the available information, which is usually imperfect. For Rescher, to predict is a rational activity, which is oriented towards answering in the best possible way the questions we have about the world's future developments. From this pragmatic perspective, which sees to problem solving, the justification of the use of induction as a predictive procedure is ultimately rooted in the capability of those procedures developed on the basis of induction to obtain successful predictions.

3.5. Possible Limits of Deductivism to Scientific Prediction

Karl R. Popper maintained a logical-methodological approach to scientific prediction of an expressly deductivist character.[526] In effect, the Viennese philosopher thought that he had found a solution to the problem of induction[527], which involved its complete rejection as a logical-methodological procedure.[528] This has clear consequences for prediction, since — in his judgment — the Logic of prediction is the deductive Logic: "Corroboration has no inductive aspect; and the logic of prediction consists, simply, in deducting predictions from hypotheses plus initial conditions. In other words, the logic of prediction is the ordinary deductive logic and nothing else."[529] From this

[526] On Popper's approach to scientific prediction, see GONZALEZ, W. J., "The Many Faces of Popper's Methodological Approach to Prediction," in CATTON, PH. and MACDONALD, G. (eds.), *Karl Popper: Critical appraisals*, Routledge, London, 2004, pp. 78-98; and GONZALEZ, W. J., *La predicción científica*, chapter 2, pp. 55-89. On the influence of falsificationism on prediction in economics, see GONZALEZ, W. J., *Philosophico-Methodological Analysis of Prediction and its Role in Economics*, chapter 3, pp. 79-101.

[527] "I think that I have solved a major philosophical problem: the problem of induction," POPPER, K. R., "Conjectural Knowledge: My Solution of the Problem of Induction," in POPPER, K. R., *Objective Knowledge. An Evolutionary Approach*, Clarendon Press, Oxford, 1972 (5th revised ed., 1979), p. 1.

[528] Nevertheless, Popper finally admits that we need a whit of induction to achieve general statements. Cf. POPPER, K. R., "Replies to my critics," in SCHILPP, P. A. (ed.), *The Philosophy of Karl Popper*, vol. 2, Open Court, La Salle, IL, 1974, p. 1193.

[529] POPPER, K. R., "Replies to my Critics," in SCHILPP, P. A. (ed.), *The Philosophy of Karl Popper*, vol. 2, p. 1030.

perspective, scientific prediction cannot be made on the basis of an inductive inference.

It is an approach that "assumes that, among the array of generalizations that are compatible with the available observational evidence, there is a *rational basis in favor of one unrefuted generalization* (conjecture, hypothesis, etc.) instead of others for use in a predictive argument."[530] Therefore, there are rational bases for the preference of a generalization instead of another one, where "corroboration" also has a role. In this regard, Popperian notion of *corroboration* involves that corroboration only allows us to judge past performance of a theory, but it is not possible to use it to predict future performance.[531]

Wesley Salmon made a valuable critique of this Popperian proposal. In his paper on rational prediction,[532] Salmon highlights the problems that may have a logical approach to prediction that is developed on purely deductive basis, such as the Popperian approach.[533] In this regard, he goes more deeply in something that Reichenbach had already made: Salmon seeks to analyze the limits of deductivism to the problem of scientific prediction.[534]

Within an approach that combines a defense of Logic as the basis of induction and probability as a key element for the philosophy of science, Reichenbach maintains that Popper fails when he discards the notion of

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530 GONZALEZ, W. J., *Philosophico-Methodological Analysis of Prediction and its Role in Economics*, p. 86.

531 Cf. POPPER, K. R., *Unended Quest*. *An Intellectual Autobiography*, Fontana/Collins, London, 1976 (enlarged edition, Routledge, London, 1992; reprinted in 2002), p. 103.

532 SALMON, W. C., "Rational Prediction," pp. 115-125. (Reprinted in GRÜNBAUM, A. and SALMON, W. C. (eds.), *The Limitations of Deductivism*, University of California Press, Berkeley, 1988, pp. 47-60.)

533 An analysis of Salmon's criticism to Popper's proposal is in GONZALEZ, W. J., *Philosophico-Methodological Analysis of Prediction and its Role in Economics*, pp. 85-87.

534 "I (…) unfortunately feel compelled to declare my opposition to the theses presented in Popper's book, for they appear to me to be completely untenable," REICHENBACH, H., "Über Induktion und Wahrscheinlichkeit. Bemerkungen zu Karl Poppers *Logik der Forschung*," *Erkenntnis*, v. 5, n. 4, (1935), pp. 267-284. Translated by E. Schneewind: "Induction and Probability. Remarks on Karl Popper's *The Logic of Scientific Discovery*," in REICHENBACH, H., *Selected Writings*, vol. 2, edited by M. Reichenbach and R. Cohen, Reidel, Dordrecht, 1978, p. 372.

probability: "Contrary to his claims: 1. The process of falsifying a theory contains the concept of probability. 2. The procedure for constructing a new theory contains the concept of probability."[535] This is an element that supports the need of induction, since according to Reichenbach the inductive inference allows us to obtain probability statements that, in turn, are the basis of the statements about the future.[536]

Salmon also criticizes the insufficiency of deductivism to give an adequate basis for rational prediction. However, he does this from a perspective that is different from that adopted by Reichenbach, where it is required to take into account the purpose of the prediction. For Salmon, there are at least three reasons that can lead us to predict. "First, we are sometimes curious about future happening, and we want to satisfy that curiosity (…) Second, we sometimes make predictions for the sake of testing a theory. (…) Third, we sometimes find ourselves in situations in which some practical action is required, and the choice of an optimal decision depends upon predicting future occurrences."[537]

Therefore, together with the future knowledge provided by prediction and its role as a test of scientific theories, Simon acknowledges the practical dimension, where prediction is linked with decision-making. Rescher also admits those roles of prediction.[538] However, these options do not exhaust the complete framework of the uses of prediction. Because in science, besides basic science — which seeks to explain and to predict, there is

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[535] REICHENBACH, H., "Induction and Probability. Remarks on Karl Popper's *The Logic of Scientific Discovery*," in REICHENBACH, H., *Selected Writings*, vol. 2, p. 373.

[536] "Probability propositions express relative frequencies of repeated events, that is, frequencies counted as a percentage of the total. They are derived from frequencies observed in the past and include the assumption that the same frequencies will hold approximately for the future. They are constructed by means of an inductive inference," REICHENBACH, H., "Predictive Knowledge," p. 236.

[537] SALMON, W. C., "Rational Prediction," pp. 115-116.

[538] Cf. RESCHER, N., *Predicting the Future*, passim. He has also related his approach to prediction with decision-making in RESCHER, N., "Predictive Incapacity and Rational Decision," *European Review*, v. 3, n. 4, (1995), pp. 327-332. Collected in RESCHER, N., *Sensible Decisions. Issues of Rational Decision in Personal Choice and Public Policy*, Rowman and Littlefield, Lanham, MD, 2003, pp. 39-47.

applied science — which relates prediction and prescription — and there is also the application of science, where predictions are required too.[539]

The proposal of Salmon has consequences for the choice between different generalizations that have not been refuted. Because in order to prefer a generalization instead of another one, it is required to take into account the purpose of the generalization. This involves that, on the basis of the different reasons to predict, the distinction between two kinds of preferences should be considered: the *theoretical preference* and the *practical preference*.[540] Thus, with regard to the practical preference, Salmon considers that Popper was wrong when he maintained that corroboration cannot be used to predict future performance.

In Popper's judgment, corroboration can *motivate* the preference of a theory, although it has not predictive import; but, for Salmon, the problem is how it is possible to *justify* this preference.[541] Because "in order to make a prediction, one must choose a conjecture which has predictive content to serve as a premise in a predictive argument. In order to make a *rational* prediction, it seems to me, one must make a *rational* choice of a premise for such an argument. But from our observational evidence and from the statements about the corroboration of a given conjecture, no predictive appraisal follows."[542]

Through his alternative to Popper's approach, Salmon combines the positive character of experience with the pragmatic component of decision-making and the reliability of predictions. Thus, we need to solve "how it could be rational to judge theories *for purposes of prediction* in terms of a criterion

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[539] See GONZALEZ, W. J., "The Roles of Scientific Creativity and Technological Innovation in the Context of Complexity of Science," pp. 11-40; especially, pp. 17-18. When Salmon criticizes Popper, he only thinks of basic sciences and the ordinary uses of prediction (curiosity and decision-making in daily life).
[540] Cf. SALMON, W. C., "Rational Prediction," p. 118.
[541] "Rational Prediction," p. 121.
[542] SALMON, W. C., "Rational Prediction," p. 119.

which is emphatically claimed to be lacking in predictive import."[543] Even more, in order to have an adequate conception of *rational prediction*, this problem of the *justification* of the choice between general statements must be solved.

For Salmon, the solution to this issue requires to distinguish between *predictive content* and *predictive import*. Because "statements whose consequences refer to future occurrences may be said to have predictive content; rules, imperatives, and directives are totally lacking in predictive content because they do not entail any statements at all. Nevertheless, an imperative—such as 'No smoking, please'—may have considerable predictive import, for it may effectively achieve the goal of preventing the occurrence of smoking in a particular room in the immediate future."[544]

With this distinction between *predictive content* and *predictive import*, Salmon highlights how corroboration statements can have *predictive import*, even when they are not about future happenings.[545] On this issue, Rescher position is clear: "*of course* past performance is a predictive indicator. (What could possibly serve better?) What past performance does *not* enable one to do is to predict with failproof accuracy"[546]. Thus, Rescher insists in the legitimacy of the use of induction, although the fallibility of the inductive prediction must be acknowledged.

Criticism of Popper's deductivist conception is especially important for Rescher, since his methodological pragmatism cannot be supported by

[543] "Rational Prediction," p. 122.
[544] SALMON, W. C., "Rational Prediction," p. 123.
[545] In *Predicting the Future* Rescher makes a distinction similar to Salmon's. It consists of distinguishing between "predictive import" and "predictive inference". Thus, on the one hand, there are theories which make *predictive inferences*; that is, they are theories which can provide statements about the future. And, on the other hand, there are theories which deal with the past and, consequently, they do not make predictions; but they can have *predictive import*, so they can provide the content required to make predictive inferences (for example, the theory of evolution), cf. RESCHER, N., *Predicting the Future*, p. 161. The similitudes between them have been noticed by Wenceslao J. Gonzalez, cf. GONZALEZ, W. J., *La predicción científica*, p. 266.
[546] RESCHER, N., *Predicting the Future*, p. 260, n. 112.

exclusively deductive bases. There is room for induction in Rescher's methodological pragmatism. Thus, a thesis can be justified methodologically. The procedure follows two successive steps.[547] In the first place, a thesis is methodologically justified through the application of a cognitive method for the validation or substantiation of factual claims.[548] In the second place, the adoption of this method is justified on the basis of practical criteria, which are preeminently two: "success in prediction and efficacy in control."[549]

This two steps procedure can be applied to the inductive practices. Instead of appealing to Logic, Rescher thinks that induction can be *methodologically* justified; that is, it can be supported assessing if the inductive practice of obtaining generalizations on the basis of the available evidence works.[550] To do this, experience must have a positive role in the substantiation of generalizations, so — for Rescher — falsification does not suffice in this regard.

The Popperian logical-methodological pairing of falsification-refutation is considered by Rescher as something marginal. Thus, "of course, an evidentially falsified or disconfirmed generalization must be ruled out, but this step does not take us far. The absence of evidential invalidation is no touchstone of truth—as any statician knows from curve-fitting problems; *mutually* incompatible generalizations may yet be compatible with all the evidence."[551]

Because Rescher explicitly considers that falsification — and, therefore, refutation — does not suffice, experience must have a *positive role* for the justification of a generalization. But it happens that we cannot establish that a generalization is true on the basis of the available evidence: "Where generalizations are concerned, finite evidence cannot go as far as to yield

[547] Cf. *Methodological Pragmatism*, p. 67.
[548] Cf. RESCHER, N., *Methodological Pragmatism*, p. 15.
[549] *Methodological Pragmatism*, p. 67.
[550] Cf. RESCHER, N., "A Pragmatic Justification of Induction," pp. 135-136.
[551] "A Pragmatic Justification of Induction," p. 136.

assured truth, and so the ‘it works’ at issue cannot mean success at providing correct (true) empirical generalizations.”[552] In this regard, his concern is the same that Salmon shows in his paper on rational prediction: how is it possible to choose *in a rational way* among several generalizations that are incompatible amongst each other, but are compatible with the available evidence.

On this issue, Rescher takes again a pragmatic criterion. Thus, for him, it is not an issue of “establishing an empirical generalization, but validating the rationality of a practice (an epistemic practice, to be sure, by which generalizations are supported).”[553] To do this, the purpose that is sought by the practice must be taken into account. This is because to establish the validity of an epistemic practice is a matter that directly depends on the efficacy and efficiency in the achievement of the aim sought, since epistemic practices are means than seek to achieve a certain aim.[554]

From this perspective, the methodological pragmatism suggested by Rescher requires to use the past performance of the methods (among them, inductive procedures) as an indicator of their predictive success in the future. But, “to be sure, its experiential support through evidence-in-hand regarding its record of success does not *prove* that a method will succeed in future applications. But the probative weight of experience cannot be altogether discounted: established success must be allowed to carry *some* weight.”[555]

Once again, Rescher notices that the impossibility of *proving* the truth of a generalization should not lead to reject the positive role of experience and the validity of the inductive reasoning. This is because, on the basis of pragmatic considerations, he thinks that the use of past performance as a predictive indicator to establish generalizations is a valid procedure. Thus,

[552] RESCHER, N., “A Pragmatic Justification of Induction,” p. 136.
[553] “A Pragmatic Justification of Induction,” p. 139.
[554] Cf. RESCHER, N., *Methodological Pragmatism*, *passim*.
[555] RESCHER, N., “A Pragmatic Justification of Induction,” p. 141.

through a different way, he achieves the same background conclusion that Salmon reached: deduction alones does not suffice for scientific prediction.

Therefore, when prediction is analyzed from the logic of science, which deals with the structural features of scientific theories, there are several questions at stake. Firstly, there are the problems that arise when prediction is compared with scientific explanation in terms of their logical structure. In this regard, it seems clear that there is a *logical asymmetry* between explanation and prediction, so a structural equivalence between both processes can be rejected. Secondly, the perspective of *temporality* gives more elements in favor of the asymmetry thesis, at the same time that it offers an adequate framework to address the analysis of the logical differences between prediction and retrodiction.

Thirdly, there is the problem of *induction*, which Rescher tries to solve in a positive way. Thus, he thinks that it is possible to justify the validity of the inductive reasoning for scientific prediction on the basis of pragmatic considerations. This involves a change of perspective, since the strictly logical perspective is rejected in favor of an epistemological approach to induction that has methodological repercussions. Finally, this leads to pose the problem of the limits of deductivism to prediction. In this regards, the elements offered by Rescher and Salmon's criticism emphasize the insufficiency of deductivism to solve the problems posed by scientific prediction.

Part II

Predictive Knowledge and Predictive Processes in Rescher’s Methodological Pragmatism

CHAPTER 4

EPISTEMOLOGICAL FACTORS OF SCIENTIFIC PREDICTION

Initially, scientific prediction can be characterized as a kind of prediction based on reasons. This feature connects the epistemological field of prediction with the general realm of human rationality, which leads to the specific realm of scientific rationality. In this regard, Nicholas Rescher's epistemology of scientific prediction has links with his approach to rationality.[556] He accepts a normative conception of rationality and gives primacy to practical reason, which, in turn, leads to an evaluative rationality. In his judgment, rationality is not a simple matter of adjustment of means to ends, because the very ends should be subjected to rational deliberation.[557] His approach is in terms of *practicable* rationality, which has similitudes with Herbert A. Simon's bounded rationality.[558]

Within this framework, the present chapter addresses Rescher's approach to rationality and the problems that arise due to its relation with predictive knowledge. Although he insists on the primacy of practice,[559]

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[556] Rescher has addressed the problem of rationality in many publications. But, among them, it can be highlighted RESCHER, N., *Rationality. A Philosophical Inquiry into the Nature and the Rationale of Reason*, *passim*. Among his papers devoted to this topic, some should be emphasized: RESCHER, N., "Pragmatism and Practical Rationality," pp. 43-60; RESCHER, N., "*Homo Optans*: On the Human Condition and the Burden of Choice," in RESCHER, N., *Studies in Philosophical Anthropology*, Ontos Verlag, Heusenstamm, 2006, pp. 1-7; and RESCHER, N., "Rationality and Moral Obligation," in RESCHER, N., *Studies in Philosophical Anthropology*, pp. 79-93.

[557] See, for example, RESCHER, N., *Razón y valores en la Era científico*-tecnológica, pp. 77-90.

[558] On the notion of *bounded rationality*, see the papers compiled in SIMON, H. A., *Models of Bounded Rationality.* Vol. 1: *Economic Analysis and Public Policy*, The MIT Press, Cambridge, MA, 1982; SIMON, H. A., *Models of Bounded Rationality.* Vol. 2: *Behavioral Economics and Business Organization*, The MIT Press, Cambridge, MA, 1982; and SIMON, H. A, *Models of Bounded Rationality.* Vol. 3: *Empirically Grounded Economic Reason*, The MIT Press, Cambridge, MA, 1997.

It might be considered that Rescher is in tune with Simon with regard to the *bounded* character of human rationality, in general, and scientific rationality, in particular. However, Rescher's approach to rationality is broader, to the extent that he accepts an evaluative rationality or rationality of ends. Meanwhile, for Simon, rationality is mainly instrumental (that is, it is a rationality of means).

[559] RESCHER, N., *The Primacy of Practice*, Basil Blackwell, Oxford, 1973. On this feature of Rescher's philosophy of science, see MARSONET, M., *The Primacy of Practical Reason. An*

knowledge is his starting point, so the cognitive realm is crucial in his conception of human rationality, in general, and scientific rationality, in particular. Thus, firstly, his theory of rational choice is analyzed. It is a holistic theory, according to which human being's abilities for reason are bounded. Secondly, the main types of rationality (cognitive, practical, and evaluative) are addressed. These types of rationality, as Rescher admits, can be detected in I. Kant.[560] In addition, their relation with scientific prediction is considered, insofar as prediction is — for Rescher — the result of a rational process.

Thirdly, the attention goes to the fallibilism that characterizes Rescher's epistemological approach, which is also related to predictive knowledge. Regarding this issue, two questions arise: a) the problem of determining the truth of the predictive statements, and b) the knowledge of the variables important for the prediction. Fourthly, the epistemological limits to predictability are analyzed, where the problem of uncertainty can be highlighted. Moreover, other problem considered is how these limits can affect the decisions made by using knowledge about the future. Finally, the problem of risk is analyzed in relation with cognitive rationality, as a framework for addressing the nexus between risk and scientific prediction.

4.1. A Holistic Theory of Rationality

Rescher suggests an approach to rationality that gives primacy to the practical dimension, so it is not a "pure reason."[561] Thus, he differentiates the realm of the intelligence from the field of rationality, where there a diversity of possibilities. Initially, rationality has two sectors: one theoretical and the other

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Essay on Nicholas Rescher's Philosophy, *passim*.

[560] Cf. RESCHER, N., *Rationality. A Philosophical Inquiry into the Nature and the Rationale of Reason*, pp. 2-3.

[561] On Rescher's proposal about scientific rationality, see GONZALEZ, W. J., "Racionalidad científica y actividad humana: Ciencia y valores en la Filosofía de Nicholas Rescher," in RESCHER, N., *Razón y valores en la Era científico-tecnológica*, pp. 11-44; especially, pp. 24-27.

practical. The latter has primacy in his approach, insofar as the pragmatic dimension prevails. But he admits that human rationality is subject to limits,[562] which are noticeable in the cognitive realm. Then, he rejects the notion of "maximization," which involves having the whole range of possibilities in a context, and suggests the concept of "optimization," which means the acknowledgement of limitations, so it is oriented towards the *best we can do* in each concrete context.[563]

His approach to rationality — above all, in the cognitive domain — has certain parallelism with Herbert A. Simon's proposal, insofar as he assumes *de facto* an approach of bounded rationality. But their philosophical roots are different: Simon is an empiricist. He learnt it from R. Carnap's positivism.[564] Furthermore, the notion of "optimization" in Rescher is different from the concept of "satisfaction" proposed by Simon.[565] The difference between both approaches is mainly rooted in two issues: I) the normative character of Rescher's proposal on rationality, in contrast to the preferential descriptive character of Simon's approach; and II) Rescher's attention to the evaluative realm of rational, which does not appear in Simon's proposal.

4.1.1. The Realm of Rationality: Knowledge, Actions, and Values

Because Rescher considers that the intellectual field is very important to address human matters, he sees intelligence and rationality as "two sides

[562] As rational activity, prediction is a task subjected to limits; among them, there are epistemological limits.

[563] Cf. RESCHER, N., "Maximization, Optimization, and Rationality. On Reasons why Rationality is not Necessarily a Matter of Maximization," in RESCHER, N., *Ethical Idealism. An Inquiry into the Nature and Function of Ideals*, pp. 55-84.

[564] Cf. SIMON, H. A., *Models of my Life*, Basic Books, N. York, NY, 1991 (reprinted in MIT Press, Cambridge, MA, 1996). Rudolf Carnap was one of his professors at the University of Chicago. On Simon's position, see GONZALEZ, W. J., "Herbert A. Simon: Filósofo de la Ciencia y economista (1916-2001)," in GONZALEZ, W. J., *Racionalidad, historicidad y predicción en Herbert A. Simon*, pp. 7-63.

[565] Cf. RESCHER, N., "Maximization, Optimization, and Rationality. On Reasons why Rationality is not Necessarily a Matter of Maximization," in RESCHER, N., *Ethical Idealism. An Inquiry into the Nature and Function of Ideals*, pp. 55-84.

of the same coin."[566] In his judgment, "the structure of rationality is a matter of system, not of sequence."[567] In this way, intelligence is an instrument of rationality. In effect, he considers that "to behave rationally is to make use of one's intelligence to figure out the best thing to do in the circumstances."[568] Thus, he uses the concept of "intelligence" in order to characterize what human rationality consists of.

But, sometimes, Rescher uses both notions interchangeably; for example, when he notices the difference between the ability to being rational and the exercise of that ability: "there is a crucial distinction between having the capacity for intelligent (rational) action and exercising this capacity intelligently (rationally)."[569] In effect, one thing is being able to do something in an intelligent way and another thing is achieving that exercise in the practical life. However, he admits that rationality is broader than the simple intelligence, since it encompasses several realms. Thus, when he characterizes rationality as the intelligent pursuit of the appropriate ends, he notices that "'intellligence' indicates cognition, 'pursuit' action, and 'appropriateness' evaluation"[570]. So rationality encompasses three different areas: cognition, action, and evaluation; while intelligence is mainly related to cognition.

The distinction between "intelligence" and "reason" seems clearer when Rescher addresses the faculties demanded by rationality. He notices that the rational subject must have five faculties: imagination, information-processing, evaluation, selection—informed choice, and agency.[571] Both informed choice

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[566] RESCHER, N., "The Light of Reason," in RESCHER, N., *A System of Pragmatic Idealism.* Vol. I: *Human Knowledge in Idealistic Perspective*, p. 4.
[567] RESCHER, N., *Rationality. A Philosophical Inquiry into the Nature and the Rationale of Reason*, p. 124.
[568] RESCHER, N., "The Light of Reason," in RESCHER, N., *A System of Pragmatic Idealism.* Vol. I: *Human Knowledge in Idealistic Perspective*, p. 4.
[569] "The Light of Reason," in RESCHER, N., *A System of Pragmatic Idealism.* Vol. I: *Human Knowledge in Idealistic Perspective*, p. 10.
[570] RESCHER, N., *Epistemology*. *An Introduction to the Theory of Knowledge*, p. 188.
[571] RESCHER, N., *Rationality*, p. 11.

and agency — that is defined by Rescher as the capacity to implement choices — indicate that rationality is not merely intellectual, since it involves the capacity to choice. Thus, free-will is required for rationality.[572]

Then, Rescher highlights that "intelligence" is different from "rationality." So, in his judgment, the capacity to implement choices "separates rational agency from mere intelligence as such, thus setting *persons* apart from mere *intelligences*."[573] This issue is related to the notion of "artificial intelligence," since an artificial device can solve given problems, but only persons can decide what problems they want to solve. Consequently, rationality requires intelligence ("the ability to acquire knowledge"[574]) and free will, which is "the capacity for decision and action in the light of evaluation on the basis of information."[575]

Consequently, for Rescher, intelligence is a necessary condition for rationality, which is developed in the different human domains, since the rational agent must be also an intelligent subject. But intelligence as such is not good enough for guarantying the rational behavior, because rationality "consists in the intelligent pursuit of appropriate objectives."[576] To the extent that it consists in a "pursuit," rationality is related to the realm of the human action. It is an "intelligent" pursuit, since is supported by knowledge about the issues that are important in order to achieve the goals of the action developed. Therefore, knowledge, action, and evaluation are the three realms that shape rationality.

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[572] On this issue, see RESCHER, N., "Free Will," in RESCHER, N., *Philosophical Explorations*, Ontos Verlag, Heusenstamm, 2011, pp. 61-77; and RESCHER, N., *Free Will: A Philosophical Reappraisal*, Transaction Publishers, New Brunswick, NJ, 2009.

[573] RESCHER, N., *Rationality*, p. 11.

[574] RESCHER, N., "The Light of Reason," in RESCHER, N., *A System of Pragmatic Idealism.* Vol. I: *Human Knowledge in Idealistic Perspective*, p. 10.

[575] "The Light of Reason," in RESCHER, N., *A System of Pragmatic Idealism.* Vol. I: *Human Knowledge in Idealistic Perspective*, p. 10.

[576] RESCHER, N., "Rationality and Moral Obligation," in RESCHER, N., *Studies in Philosophical Anthropology*, p. 79.

In contrast to "intelligence," which involves — in principle — immediacy, rationality involves certain mediation with a discursive component. Specifically, rationality encompasses deliberation, either in the field of knowledge, in the area of action, or in the realm of evaluation. Meanwhile, intelligence allows the grasp of something in the way of intuition. It is situated then in the realm of something "immediate;" while rationality belongs to the field of something "mediated." Thus, intelligence is related to the capacity to achieve knowledge, but the deliberation about the consistency and coherence of the knowledge achieved — theoretical, practical, or about ends — belongs to the realm of rationality.

Additionally, human rationality — with its different forms — can have a historical component. This feature is present in Rescher's approach when he notices that "the methods we use in cultivating rationality change in the light of the experience we have with them."[577] Thus, although he considers rationality itself as something stable — to the extent that it consists in the effective and efficient action in order to achieve valid ends — Rescher notices that rationality involves changes with regard to the circumstances and conditions of the subject. There is a component of variability in this adaptation to the context that — in my judgment — can become genuinely historical.

Within this framework, a salient point is that Rescher rejects an instrumental conception of rationality.[578] So, in his judgment, rationality is not a simple matter of adjustment of means to ends, but the very ends should be subjected to rational deliberation. Precisely, evaluative rationality makes his approach (that is *pragmatic*) different from an *instrumental* conception. Moreover, he maintains that rationality is holistic: "cognitive, pragmatic, and evaluative rationality constitute a unified and indissoluble whole in which all

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[577] RESCHER, N., *Rationality*, p. 14.

[578] In fact, he uses the notion "practical rationality," which is broader than the simple instrumental rationality.

three of these resources are inseparably co-present."[579] Usually, he gives primacy to practical reason over theoretical reason, because the justification both of the ends and the beliefs is always — in his judgment — related to the realm of action.[580] Thus, he considers that the rules of reason are "regulative principles" that guide human action on the basis of efficacy and efficiency. In this way, "reason is eminently practical—it wants what works (is efficient and effective)."[581]

On this basis, Rescher rejects the establishment of clear frontiers between the theoretical and practical realms of rationality. In effect, he considers that each one of the three realms of rational deliberation — theoretical, practical, and evaluative — is supported by others.[582] Then, rational deliberation has the character of a system: an interdependence network. His approach to rationality is holistic, insofar as he sees rationality as "a unified and indissoluble whole in which all three of these resources [cognitive, practical, and evaluative] are inseparably co-present. Good reasons for believing, for evaluating, and for acting go together to make up a seamless and indivisible whole."[583]

From the theroetical and practical reflection, rationality works in three realms, since it deliberates about knowledge, actions, and ends. But, in some sense, this is a conceptual distinction, because each one of those realms involves the others in the usual practice. When this approach is lead to scientific rationality, then scientific rationality is not a simple adjustment of means to ends, because the ends should be evaluated. In Rescher's approach, rational action leads us to the achievement of preferable ends in an effective and efficient way, on the basis of well-grounded knowledge and

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[579] RESCHER, N., *Rationality*, p. vii. On Rescher approach to rationality, see MOUTAFAKIS, N. J., *Rescher on Rationality, Values, and Social Responsibility. A Philosophical Portrait*, *passim*.
[580] Cf. RESCHER, N., "Pragmatism and Practical Rationality," pp. 43-60; especially, pp. 43-44.
[581] RESCHER, N., *Rationality,* p. 17.
[582] Cf. *Rationality*; especially, chap. 8, pp. 119-132.
[583] RESCHER, N., *Rationality,* p. vii.

valid values.

The acknowledgement of a rationality that deals with the ends of the human activity involves — in my judgment — an improvement with regard to narrower conceptions about human rational, in general, and scientific rationality, in particular; for example, the approaches that give primacy to substantive rationality (focused on results)[584] and the proposals of procedural rationality (focused on processes).[585] In effect, besides the results and the processes, Rescher takes into account expressly the rationality of the ends.

This approach has clear consequences for prediction, above all, from the epistemological, methodological, and axiological perspectives. *Epistemologically*, scientific prediction can be seen as cognitive content, insofar as it provides knowledge about the possible future. From this perspective, cognitive rationality has a role regarding the predictive knowledge. From a *methodological* point of view, prediction is the result of a rational process directed to predicting scientifically the possible future. Therefore, not only the result is important, but also the predictive models must meet some requirements, such as the realism of the assumptions.

But Rescher's conception is not reduced to an approach to scientific rationality as a procedural rationality, because the ends sought must be also rational. Thus, *axiologically*, his holistic view of rationality has also repercussions for scientific prediction. It involves that prediction has value, firstly, with regard to the aims on science; and, secondly, regarding the processes and the potential results. In this way, the holistic framework that he

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[584] When rationality is characterized as "substantive," then level of the results has primacy. It is the prevailing approach in the mainstream economics. Regarding scientific prediction, substantive rationality involves the primacy of the predictive success. Therefore, what matters is the result of the prediction — the predictive success, instead of the process. Cf. FRIEDMAN, M., "The Methodology of Positive Economics," pp. 3-43.

[585] Simon distinguishes his approach of "procedural rationality" (which is developed from psychology) from "substantive rationality," which has its origins in economics. Cf. SIMON, H. A., "From Substantive to Procedural Rationality," in LATSIS, S. (ed.), *Method and appraisal in economics*, Cambridge University Press, Cambridge, 1976, pp. 129-148. Cf. GONZALEZ, W. J., *Philosophico-Methodological Analysis of Prediction and its Role in Economics*, chapter 8, pp. 203-228.

proposes about human rationality, in general, and scientific rationality, in particular, is related to a broad approach to scientific prediction, where there are three levels at stake: the aims of scientific research, the processes oriented towards obtaining those aims, and the results eventually achieved.[586]

4.1.2. An Approach of Bounded Rationality

Rescher considers that human rational behavior is subjected to limits. *De facto*, he assumes a view of the human agent with bounded rationality: "Rationality does not make demands beyond the limits of what is genuinely possible for us—it does not require accomplishments beyond the limits of the possible."[587] This leads to relate this approach of pragmatic idealism to rationality with other two conceptions: on the one hand, the standard economic theory of rational choice;[588] and, on the other, Herbert A. Simon's proposal of bounded rationality.[589]

He criticizes both theories from several angles, but above all his criticism is made insofar as they do not take into account the evaluative dimension of rationality.[590] Regarding the standard theory of rational choice, he also opposes the notion of maximization of the expected subjective utility. Instead, he proposes the concept of "optimization,"[591] which has into account

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586 The aims, processes, and results are the three successive stages in the internal dynamics of scientific research. Cf. GONZALEZ, W. J., "Las Ciencias de Diseño en cuanto Ciencias de la Complejidad: Análisis de la Economía, Documentación y Comunicación," in GONZALEZ, W. J. (ed.), *Las Ciencias de la Complejidad: Vertiente dinámica de las Ciencias de Diseño y sobriedad de factores*, Netbiblo, A Coruña, 2012, pp. 7-30; especially, pp. 8-9.

587 RESCHER, N., *Rationality*, p. 8.

588 On the standard theory of rational choice, see HAUSMAN, D. M., *The Inexact and Separate Science of Economics*, Cambridge University Press, Cambridge, 1992 (2nd rep., 1996); especially, chapter 1, pp. 13-27.

589 Cf. SIMON, H. A., "Theories of Bounded Rationality," in MCGUIRE, C. B. and RADNER, R. (eds.), *Decision and organization*, North-Holland, Amsterdam, 1972, pp. 161-176. (Reprinted in SIMON, H. A., *Models of Bounded Rationality.* Vol. 2: *Behavioral Economics and Business Organization*, pp. 408-423).

590 Cf. RESCHER, N., *Rationality*, p. 95 y pp. 107-132.

591 Cf. RESCHER, N., "Maximization, Optimization, and Rationality. On Reasons why Rationality is not Necessarily a Matter of Maximization," in RESCHER, N., *Ethical Idealism. An Inquiry into the Nature and Function of Ideals*, pp. 55-84; especially, pp. 71-79.

the limits of the subjects and the importance of the context, so his approach has certain parallelism with Simon's "bounded rationality."

Like Simon, Rescher rejects the concept of "maximization" of the standard theory of rational choice; that is, the theory accepted by mainstream economics.[592] This theory has a normative character that is accepted in the realm of neoclassical microeconomics. In its standard formulation, theory seeks to characterize how rational agents should make their choices, in case they behavior as rational agents. In order to do this, agents must obey the axioms demanded by the theory: transitivity, completeness, context-independence, and continuity.[593] The axioms of the theory introduce a normative element, since they establish what the characteristics of the agents' preference orders are. If preferences are ordered in accordance with these requirements, a utility function can be elaborated with only one maximum. In this way, a rational agent is the agent who makes decisions by maximizing his utility function.

Since the middle of the 20th century, standard theory has to face criticism and alternative proposals, which have been suggested both with regard to the general level of human choices and to the specific realm of scientific choices. David Houghton, in his paper on "Reasonable Doubts about Rational Choice," offers a clear exposition of some of the problems of the standard theory. Among them, he highlights three: a) the impossibility of making perfectly informed decisions; b) the lack of empirical support to the conception of the rational subject as utility maximizer;[594] and c) the lack of attention to social norms or rules for acting.[595]

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[592] Cf. RESCHER, N., *Rationality*, pp. 107-132.

[593] Cf. HAUSMAN, D. M., *The Inexact and Separate Science of Economics*, pp. 15-19.

[594] In this regard, Hausman notices that "to argue that utility theory is a good theory of how people actually behave because it is also a theory of how they ought to behave seems like the argument that people do not cheat on their taxes because they morally ought not to do so," HAUSMAN, D. M., *The Inexact and Separate Science of Economics*, p. 218.

[595] Cf. HOUGHTON, D., "Reasonable Doubts about Rational Choice," *Philosophy*, v. 70, n. 271, (1995), pp. 53-68. Regarding the problems of the standard theory, see also SEN, A., "The

Rescher's criticism is focused on the first two points. Regarding the first point — the impossibility of making completely informed decisions — he considers that human beings generally do not have all the important information for decision-making. In this way, "the rational resolution of problems is context-sensitive to the information in hand."[596] For this reason, context is crucial for a conception of rationality with a practical component. In this way, he rejects the axiom of the standard theory about the context-independent preference order.

In effect, Rescher maintains that "rationality as such is something fixed—its nature is constant. But while rationality itself is something stable, the course of action it requires of us changes with circumstances and conditions."[597] Those circumstances and conditions involve that it is not always possible to make perfectly informed decisions. But it is possible to improve and increase the information at hand. Moreover, this is a demand of rationality.[598]

Regarding the second point (the idea of rational agent as utility maximizer), Rescher thinks that the notion of "utility" in rational choice theory is "a mere fiction—sometimes useful."[599] Since his starting point is a holistic conception of rationality, which has an evaluative dimension, he sees the notion of "maximization" as a narrow approach to rational choice. In fact, in his judgment, "rational choice is a matter not of one-dimensional *maximization*, but of the structurally diversified *optimization* that calls for

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Formulation of Rational Choice," *The American Economic Review*, v. 84, n. 2, (1994), pp. 385-390; and BOUDON, R., "Limitations of Rational Choice Theory," *The American Journal of Sociology*, v. 104, n. 3. (1998), pp. 817-828.

[596] RESCHER, N., *Rationality,* p. 22.

[597] *Rationality*, p. 15.

[598] In this regard, Rescher maintains that "rationality is not just a passive matter of making good use of the materials one has on hand —in cognitive matters, say, the evidence in view. It is also a matter of actively seeking to enhance these materials: in the cognitive case, by developing new evidential resources that enable one to amplify and to test one's conclusions," RESCHER, N., *Rationality,* p. 8.

[599] RESCHER, N., "Maximization, Optimization, and Rationality. On Reasons why Rationality is not Necessarily a Matter of Maximization," in RESCHER, N., *Ethical Idealism. An Inquiry into the Nature and Function of Ideals*, p. 64.

harmonizing a complex profile of diversified goods and goals."[600]

The conception of rationality in terms of "utility maximization" involves assuming that "utility" is measurable and that the rational agent seeks to maximize it. This feature means that the different values and ends of the human action can be evaluated on the basis of a common measure. In Rescher's judgment, this claim is problematic, because the realm of the human values is complex and varied.[601] Therefore, it is problematic to claim that the different choices of the agents can be characterized in terms of "potentiating utility." Rescher considers that, regarding this issue, "economists incline to proceed strictly in terms of preferences, since these seem to be a common denominator in people's choices."[602]

But, for Rescher, preferences are not good enough for characterizing rationality. What is important is not merely what is preferred, but *what is preferable*, according to valid values and ends. For this reason, "once the link between utility and value is broken, the link between utility maximization and rational choice is also severed."[603] Moreover, the very notion of "maximization" is problematic, since generally human beings cannot achieve what is the best, but what in principle can be seen as the *best possible* taking into account the context.

Consequently, Rescher does not think of human rationality as expected subjective utility maximization, but as an optimization. His approach at this point is *realistic*, since takes into account the limitations of the knowing subject, as well as the informational restrictions to which the agents can be subjected.[604] Therefore, rationality does not demand that the agents act

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[600] RESCHER, N., "Maximization, Optimization, and Rationality. On Reasons why Rationality is not Necessarily a Matter of Maximization," p. 55.
[601] Cf. "Maximization, Optimization, and Rationality. On Reasons why Rationality is not Necessarily a Matter of Maximization," p. 58.
[602] RESCHER, N., *Rationality*, p. 109.
[603] *Rationality*, p. 111.
[604] Rescher especially insistis in characterizing his own approach to rationality as a realist conception. Cf. RESCHER, N., *A System of Pragmatic Idealism.* Vol. I: *Human Knowledge in*

according to *the* rational decision form an ideal perspective, but according to *the best* decision, taking into account that neither our resources nor our capacities are unlimited.

Herbert A. Simon — who made a proposal on universal basis supported in the case of economics — has especially insisted on the limited character of human rationality.[605] In his judgment, “there is today a very strong tradition of *a priorism* in economics, or what might be called deductionism. There is a very strong tradition of accepting the utility maximization hypothesis and then seeing, often with the aid of very powerful and elegant mathematical tools, what kind of conclusions you can draw from those premises, preferably by mathematical means. And there are even some economists who think that the theory is analytic and not refutable. I find it a rather curious point of view that a theory which purports to be about the real world should, somehow or other, follow from unrefutable premises and therefore not be subject to empirical test.”[606]

Although Rescher’s main interest is not focused on the case of economics, a similar criticism to the “standard” conception in economics is in his work, but his reasons for the objections are different. Certainly, his proposal is also normative in origin, as it is the standard theory of rational choice. But his view is a normative theory with regard to the type of rationality that human beings, in fact, can achieve, and the justification of this type of rationality is — in his judgment — pragmatic. Thus, a rational agent is the agent who seeks the optimum understood as “the best available,” instead of being the “maximum.”

From different philosophical perspectives, Simon and Rescher offer

Idealistic Perspective, p. 6.

[605] Cf. GONZALEZ, W. J., “Configuración de las Ciencias de Diseño como Ciencias de lo Artificial: Papel de la Inteligencia Artificial y de la racionalidad limitada,” in GONZALEZ, W. J. (ed.), *Las Ciencias de Diseño. Racionalidad limitada, predicción y prescripción*, Netbiblo, A Coruña, 2007, pp. 41-69; especially, pp. 59-63.

[606] SIMON, H. A., “Why Economists Disagree,” in SIMON, H. A., *Models of Bounded Rationality.* Vol. 3: *Empirically Grounded Economic Reason*, p. 407.

alternative proposals to the standard theory of rational choice. Based on an empiricist support, Simon presents a realistic and psychological characterization of the limits to human rationality;[607] that is, he offers a description of human rationality "as 'bounded' and 'satisfacing' — instead of being unlimited and maximizing."[608] His thematic axis is an empiricist approach oriented towards the observation of human behavior.

Meanwhile, although Rescher develops a holistic approach to rationality, his framework is more pragmatic than Simon's. So, "a rational person proceeds on the basis of the grounds that are available to him (which may well also be imperfect)."[609] Thus, generally, maximization is not available. So in his approach rationality demands and "optimization" according to the circumstances, which is different from "maximization:"[610] it does not involve a possible maximum, but the best we can obtain. But "satisfaction" is neither good enough, because Rescher's normative approach to rationality involves the rational deliberation about the ends of human action, which transcends the mere "preferences."

4.1.3. Practicable Rationality

Our capacity to reason is limited and, for Rescher, we can only exercise it within the framework of *practicable rationality*. Practicable rationality is characterized as the rationality "geared to resolutions that are rationally appropriate with *everything* relevant taken into account that we can effectively manage to take account of in the prevailing circumstances—that are *optimal as best we can manage to tell*."[611] This practicable rationality is

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[607] Cf. SIMON, H. A., "From Substantive to Procedural Rationality," in LATSIS, S. J. (ed.), *Method and Appraisal in Economics*, p. 144.
[608] GONZALEZ, W. J., "Herbert A. Simon: Filósofo de la Ciencia y economista (1916-2001)," in GONZALEZ, W. J., *Racionalidad, historicidad y predicción en Herbert A. Simon*, p. 11.
[609] RESCHER, N., *Rationality*, p. 7.
[610] Cf. RESCHER, N., "Maximization, Optimization, and Rationality. On Reasons why Rationality is not Necessarily a Matter of Maximization," pp. 55-84; especially, pp. 71-79.
[611] RESCHER, N., *Rationality*, p. 28.

then different from an *ideal rationality*, "which is geared to resolutions that are rationally appropriate with (absolutely) *everything* relevant taken into account—that are *optimal pure and simple*."[612]

Rescher is concerned about the limits of rationality both in the theoretical real and in the practical dimension. His approach is in terms of practicable rationality, so he is aware that not always is possible to have all the information relevant and, in addition, the means at our disposal can be also limited. In this way, rationality only demands "that we do the best we can manage with the means in hand."[613] Thus, rational agent is required to use the limited resources he has in each concrete situation in order to guide his choices in the best possible way (that is, in an *optimal* way).

Then, the "predicament of reason" appears. It involves that human rationality (i) aims at the absolutely best; but (ii) it settles for the best that is available.[614] At this point, it is important to notice that "*rationality* is 'information-sensitive': exactly what qualifies as the most rational resolution of a particular problem of belief, action, or evaluation depends on the precise content of our data about the situation at issue. And this dependency so functions that a 'mere addition' to our information can transform the optimality situation radically."[615] Faced with those features, human beings are rational within a context: they only can do the best in the concrete circumstances of a certain context.

However, the acknowledgment of the inherent limitations of human rationality does not lead Rescher to reject a view of rationality as a matter of *idealization*. Thus, an idealization is possible a) because we justify possible courses of action, and b) because the rational solution that we can achieve is that which, under similar circumstances, any other human agent can identify

[612] *Rationality*, p. 28.
[613] RESCHER, N., *A System of Pragmatic Idealism.* Vol. I: *Human Knowledge in Idealistic Perspective*, p. 9.
[614] Cf. RESCHER, N., *Rationality*, p. 30.
[615] *Rationality*, p. 24.

as the rational solution.[616] In this way, his approach to human rationality is not only of a normative character, but it also encompasses a descriptive element. Thus, although the rational solution to every problem — theoretical or practical — is context-dependent, it is universal at the same time. So, given exactly the same circumstances, the rational choice is the same for every agent.

To the extent that they agree with the idea that rationality is with regard to real subjects, Simon and Rescher are close in their approaches, but there is an explicit pragmatic component in Rescher, who sees the problem from practice: "being rational consists in the disposition to make good reasons constitute the motives for what one does. Since this is something we can achieve only within limits, one must regard perfect rationality as an idealization and acknowledge we humans are 'rational animals' because of our *capacity* for reason, and certainly not because of our achievement of perfected rationality."[617]

Between Simon's and Rescher's proposals there are differences, at least, with regard to two crucial issues: (i) the normative character of Rescher's approach against the genuinely descriptive character of Simon's bounded rationality, and (ii) the explicit acknowledgement of the evaluative realm of rationality, which is only present in Rescher's account. This normative character of his account involves that "the key point is that the significance of rationality does not, ultimately, lie in its role as a *descriptive* characterization of human proceedings (in how people *do* function) but rather in its *normative* role, as an indication of how people should function in the best interests of their cognitive and practical concerns. (…) The norms of rationality—like those of morality—are in no way undermined or invalidated

[616] Cf. MARSONET, M., *The Primacy of Practical Reason. An Essay on Nicholas Rescher's Philosophy*, pp. 63-69.
[617] RESCHER, N., *Rationality*, p. 10.

by the fact that people violate them."[618]

For Rescher, the social scientists who, like Simon, suggest a merely descriptive theory of rationality, "are engaged in a futile venture and condemned from the very outset to an inappropriate view of the rational enterprise."[619] Rescher's proposal is fundamentally a normative one. But, in contrast to the standard theory of the rational choice, it is not inclined to an ideal type of rationality. Instead, it is oriented towards a "practicable" rationality, which is the rationality for which agents are in fact qualified. Moreover, it takes into account the fact that human beings sometimes behave in a non-rational way.[620]

There are five requisites that, in Rescher's judgment, are demanded by rationality in matters of belief, action, or evaluation: (i) *consistency* (to avoid self-contradiction); (ii) *uniformity* (to treat similar cases alike); (iii) *coherence* (to make sure that one's commitments hang together); (iv) *simplicity* (to avoid needless complications); and (v) *economy* (to be efficient in the cost-benefit relation).[621]

Those requirements give rationality a systemic character, insofar as they are "an organic (or systematic) unity of procedure, serving to make sure that everything fits together in an effective and mutually supportive way."[622] Moreover, those requirements are flexible to some extent, as it can be seen in Rescher's treatment of the problem of inconsistency in the case of cognitive rationality.[623] In his approach, they are ideals that should be sought, cultivated, and valued; but their absence would not collapse every rational endeavor from the beginning.

Besides the emphasis in the normative character of his approach, the

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618 *Rationality,* pp. 196-197.
619 RESCHER, N., *Rationality,* p. viii.
620 Cf. RESCHER, N., "*Homo Optans*: On the Human Condition and the Burden of Choice," in RESCHER, N., *Studies in Philosophical Anthropology*, pp. 1-7.
621 Cf. RESCHER, N., *Rationality,* p. 16.
622 RESCHER, N., *Rationality,* p. 16.
623 Cf. *Rationality,* pp. 73-91.

other important point that separates Rescher's approach from Simon's bounded rationality is the rationality of ends.[624] In effect, although Simon mentions the ends in some papers,[625] he does not contemplate in rigor the problem of the rationality of the ends chosen: there is not an evaluation of ends in his approach. He is only focused on the rationality of the beliefs of the agents and the means selected in order to achieve certain end, so the ends are assumed as "given." Meanwhile, for Rescher, "rational choice is a matter of opting not for what is preferred, but for what is preferable."[626] Thus, besides the evaluation of ends, he considers that rationality in terms of "satisfaction of preferences" — which is Simon's proposal — is the result of a biased approach to rationality. In his judgment, rationality is not about what people prefer, but about what *is preferable* in accordance with human interests and values.

This feature is — in my judgment — the main contribution of Rescher to the problem of rational choice and scientific rationality. Thus, by introducing the question of the rationality of ends (what is *preferable*) rationality broadens its realm to encompasses the evaluation of the ends according to values. In this way, the rational agent not only has to justify his beliefs, but also the preferability of his options. Thus, Rescher suggests a holistic view of rationality, according to which rationality not only deliberates about the processes (the selection of the best means), but also about the result, insofar

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[624] A comparison between both approaches is in GONZALEZ, W. J., "Racionalidad y Economía: De la racionalidad de la Economía como Ciencia a la racionalidad de los agentes económicos," in GONZALEZ, W. J. (ed.), *Racionalidad, historicidad y predicción en Herbert A. Simon*, pp. 65-96; especially, pp. 70-79.

The expressly acceptation of a rationality of ends can especially affect the sciences of design, since their activity is oriented towards concrete aims. This is a matter that Rescher does not develop, because he is mainly interested in the natural science and, sometimes, in the social sciences. Meanwhile, he does not expressly address the realm of the sciences of the artificial. On this matter, see GONZALEZ, W. J., "Rationality and Prediction in the Sciences of the Artificial," in GALAVOTTI, M. C., SCAZZIERI, R. and SUPPES, P. (eds.), *Reasoning, Rationality and Probability*, CSLI Publications, Stanford, 2008, pp. 165-186.

[625] SIMON, H. A., "Rationality in Political Behavior," *Political Psychology*, v. 16, (1995), pp. 45-63.

[626] RESCHER, N., *Rationality,* p. 112.

as it orientates the action towards the achievement of the best goals.[627]

4.2. Scientific Prediction and the Main Types of Rationality

In order to analyze the epistemological factors of prediction in Rescher, after the consideration of his holistic approach to rationality, the three types of rationality at stake must been taken into account. Thus, as he notices, "philosophical tradition since Kant sees three major contexts of choice, those of *belief*, of accepting or endorsing theses or claims, of *action*, of what overt acts to perform, and of *evaluation*, of what to value or disvalue. These [contexts] represent the spheres of cognitive, practical, and evaluative reason, respectively."[628]

From those realms, there are — in Rescher's judgment — three types of rationality according to the object of rational deliberation: (i) *cognitive rationality*, which addresses what should be believed or accepted in the realm of knowledge, either theoretical or empirical; (ii) *practical or instrumental rationality*, which is about what actions should be performed; and (iii) *evaluative rationality*, which is focused on what goals and ends should be preferred or valued.[629]

This approach to rationality suggested by Rescher is connected to his proposal about the epistemological factors of scientific prediction. In effect, in his judgment, to predict is a *rational activity*, so scientific predictions are characterized by being reasoned prediction. Thus, they are statements about the future which are supported by theoretical or empirical reasons that justify the anticipation of the possible future. On this basis, scientific prediction can be related to the three realms of rationality that Rescher contemplates: cognitive, practical, and evaluative.[630]

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[627] Cf. RESCHER, N., "Pragmatism and Practical Rationality," pp. 43-60.
[628] RESCHER, N., *Rationality*, pp. 2-3.
[629] Cf. *Rationality*, p. 3.
[630] Cf. GONZALEZ, W. J., *La predicción científica*, pp. 264-265.

4.2.1. Cognitive Rationality

Rescher considers that rationality involves a *cognitive* or *epistemic* dimension. Cognitive rationality deals with what should be accepted in the realm of knowledge and, therefore, what belongs to the theoretical realm of rationality. On the one hand, this cognitive rationality demands answers to questions posed about the world; and, on the other, it requires that those answers could be justified. Thus, cognitive rationality requires increasing the available information in order to increase and improve our knowledge about the world. In addition, it allows us to justify the beliefs accepted as valid. The justification of beliefs can be of two types: discursive or presumptive.[631]

A belief is justified *discursively* when the justification is obtained on the basis of another belief established previously. From this perspective, cognitive rationality seeks homogeneity in information-processing, since "there must be justified beliefs as inputs to arrive at justified beliefs as outputs."[632] Meanwhile, the *presumptive* justification does not proceed through other previously accepted beliefs, but in a direct way through a "presumption." Thus, a belief is justified in this way when "there is a *standing presumption* in its favour and no pre-established (rationally justified) reason that stands in the way of its acceptance."[633]

Rescher suggests a series of indicators that are "presumptions of reliability." On the basis of these "presumptions" a belief or beliefs can be justified *presumptively*. They are general principles such as the following: (i) believe the evidence provided by the senses; (ii) accept the declarations of other people (in the absence of any counter-indications); (iii) trust in the reliability of the cognitive aids and instruments used in the research (for example, telescopes or reference works); and (iv) accept, in principle, the

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[631] Cf. RESCHER, N., *Rationality*, pp. 49-50.
[632] *Rationality*, p. 49.
[633] RESCHER, N., *Rationality*, p. 50.

declarations of established experts.[634]

When prediction is at issue, scientific rationality (in its epistemic dimension) follows the same process. Thus, on the basis of the available knowledge, the aim is to obtain answers to substantive questions about future developments. Moreover, the answers given (that is, the predictions) must be justified. The presumptions of reliability are also relevant to prediction, since predictive statements are oriented towards a possible future and, therefore, it is not possible to test them now. Furthermore, prediction has also role for the justification of hypotheses and theories. This role is usual in basic science, where prediction can be used as test for theories.

Both with regard to scientific knowledge, in general, and predictive knowledge, in particular, the procedure of the cognitive rationality is supported by economic principles. Thus, in Rescher's approach, the practical dimension has primacy over the theoretical component, because — in his judgment — reason is eminently practical: "Be it in matters of belief, action, or evaluation, its mission centers about the deliberate endeavor to maximize benefits relative to expenditures."[635] Therefore, there is in science an *internal* economic dimension, which affects not only the actions, but also the cognitive content; because the cognitive dynamics of science is not cost-free. In this way, scientific rationality should be considered as connected to economic rationality.

Rescher suggests an economic-cognitive approach that demands an *epistemic optimization*: it seeks a positive balance between the required costs and the benefits eventually obtained with regard to an aim sought. Thus, he considers that the cognitive component of rationality involves an economic dimension. In effect, he maintains that "rationality and economy are inextricably interconnected. Rational inquiry is a matter of epistemic

[634] Cf. *Rationality*, p. 52.

[635] RESCHER, N., "Knowledge and Scepticism in Economic Perspective," in RESCHER, N., *Cognitive Economy*. *The Economic Dimension of the Theory of Knowledge,* p. 11.

optimization, of achieving the best overall balance of cognitive benefits relative to cognitive costs."[636]

On the one hand, the human process of knowing involves benefits, both theoretical (or cognitive) and practical (or applied);[637] and, on the other, it involves costs (in terms of complexity, difficulty, resources, etc.). This economic-cognitive approach has methodological repercussions, because the methods are above all oriented towards the increase of knowledge. For Rescher, in the process of knowing there is an economy of means: "Concern for answering our questions in the most straightforward, most cost-effective way is a crucial aspect of cognitive rationality in its economic dimension."[638]

This feature means that scientific rationality requires an epistemic optimization; that is, it is oriented towards an optimal use of the resources with regard to the potential benefits of the cognitive endeavor.[639] With this economic-cognitive approach, Rescher emphasizes the importance of the economic factors that are internal to the process of knowing. He insists on science as *human activity*, so scientific rationality is eminently pragmatic: "inquiry and the acquisition of information is itself a practical activity on the same footing with any other—a process that must be governed by the standard justificatory ground rules of practical reason."[640]

This claim — to some extent cryptic — emphasizes the primacy of practice; that is, problem-solving as a proof of cognitive validity. On this basis, scientific prediction can be seen also in practical terms, as a rational

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[636] "Knowledge and Scepticism in Economic Perspective," in RESCHER, N., *Cognitive Economy*. *The Economic Dimension of the Theory of Knowledge,* p. 13.
[637] Cf. GONZALEZ, W. J., "Racionalidad y Economía: De la racionalidad de la Economía como Ciencia a la racionalidad de los agentes económicos," in GONZALEZ, W. J. (ed.), *Racionalidad, historicidad y predicción en Herbert A. Simon*, p. 72.
[638] RESCHER, N., "Knowledge and Scepticism in Economic Perspective," in RESCHER, N., *Cognitive Economy*. *The Economic Dimension of the Theory of Knowledge,* p. 14. On the methodological repercussions of the "cognitive-economic" approach of Nicholas Rescher, see GONZALEZ, W. J., "Racionalidad y Economía: De la racionalidad de la Economía como Ciencia a la racionalidad de los agentes económicos," pp. 65-96; especially, pp. 72-74.
[639] Cf. RESCHER, N., *Priceless Knowledge? Natural Science in Economic Perspective*, p. 8.
[640] RESCHER, N., *Rationality*, p. 122.

procedure that involves an economic dimension, since prediction should be obtained in an effective and efficient way, so it could be possible an epistemic optimization in the process of predicting. Therefore, there is a nexus between cognitive rationality and scientific prediction, which emphasizes the presence of economic factors that are internal to prediction.

In effect, *cognitive rationality* intervenes in the predictive task of science, since prediction is supported by knowledge about the important variables, as well as by adequate inferences.[641] Certainly, it is not a free-cost task, since it requires a series of resources: experimentation techniques, observation means, procedures of data processing, etc. Thus, the minimization of costs should be sought in prediction.

In turn, this nexus between cognitive rationality and scientific prediction has repercussions for the problem of the epistemological limits of prediction. In effect, predictive knowledge is subjected to limits, insofar as the cognitive capacities of the human beings are *limited*. For example, the presence of informational restrictions for the subjects that make science is one of the factors that might limit the predictions. This kind of limits favors uncertainty, which accompanies the bounded rationality and has repercussions on scientific prediction. In effect, the capacity to compute the information is limited; and, in principle, the future has a number of different possibilities.

4.2.2. Practical Rationality

A general feature of Rescher's epistemological approach is that rationality is eminently practical; and, in certain sense, it is also contextual. Practical rationality deals with the realm of action, and is about the means that are used to achieve a certain goal. But, since he develops a holistic conception of reason, he has a critical attitude toward approaches such as Herbert Simon's view, because Simon does not assume in rigor a rationality

[641] Cf. GONZALEZ, W.J., *La predicción científica,* pp. 264-265.

of ends, but only of means.[642]

The practical dimension of rationality defended by Rescher requires the adjustment of means to ends; but the very ends must be adequate according to values that have an objective component.[643] Thus, there are two issues that are closely related: selecting the ends and having values in order to choose them. In contrast to Simon, he also claims that "in the broad scheme of things, the two aspects are needed: the ends without the requirement of the means are frustrating; the means without adequate ends are unproductive and useless."[644]

Thus, Rescher gives primacy to the practical reason in his approach to rationality. But it is not a simple rationality of means to given ends, so it is not a purely instrumental rationality. In his judgment, the rational character of an action cannot be assessed without an evaluation of the adequacy of the ends of action. In this way, "both matters—the efficacy of means and the validity of goals—are essential aspects of practical rationality."[645]

From a pragmatic perspective, there is a practical criterion of evaluation. For Rescher, actions and beliefs are evaluated according to their efficacy and efficiency in the achievement of the goals and aims. Then, rationality is associated to the achievement of goals or to meet a concrete need. In those cases, "a rational creature will prefer whatever method

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[642] On Herbert A. Simon's theory of rationality, see GONZALEZ, W. J., "Racionalidad y Economía: De la racionalidad de la Economía como Ciencia a la racionalidad de los agentes económicos," pp. 65-96; BEREIJO, A., "La racionalidad en las Ciencias de lo Artificial: El enfoque de la racionalidad limitada," in GONZALEZ, W. J. (ed.), *Racionalidad, historicidad y predicción en Herbert A. Simon*, pp. 131-146; and GONZALEZ, W. J., "Configuración de las Ciencias de Diseño como Ciencias de lo Artificial: Papel de la Inteligencia Artificial y de la racionalidad limitada," in GONZALEZ, W. J. (ed.), *Las Ciencias de Diseño. Racionalidad limitada, predicción y prescripción*, Netbiblo, A Coruña, 2007, pp. 41-69.

[643] Cf. RESCHER, N., "Pragmatism and Purpose," in RESCHER, N., *Pragmatism. The Restoration of its Scientific Roots*, pp. 21-47. On the objectivity of values in the axiological conception of Rescher, a more detailed treatment is offered in the chapter 8 of this Ph.D. research.

[644] RESCHER, N., *Razón y valores en la Era científico-tecnológica,* p. 82.

[645] RESCHER, N., *Rationality,* p. 93.

process or procedure will, other things equal, facilitate goal realization in the most effective, efficient, and economical way."[646]

Rescher insists that practical rationality is mainly of an economic kind. Thus, it seeks the optimization of the benefits obtained from rational behavior in relation to the costs of the recourses. The, the process — the search — prevails, instead of the product (the final result). This feature is related to approaches like the Aristotelian conception, where rationality is more the processes (the decision-making) than the result. Here, there is certain similitude with Simon, who also sees rationality more as a process than as a result.[647]

For Rescher, on the basis of the available information, we try to achieve the sought goal by selecting those means that allow us to achieve it in an efficient way. But this pragmatic feature not only has to do with the means. In effect, he considers that it is present in the three realms of rational deliberation: the field of the information (the cognitive realm), the area of the means (the practical component), and the realm of the ends (the evaluative aspect).

Since in Rescher's thought rationality is addressed from a pragmatic perspective, the very justification of the rational behavior is also of a pragmatic character: "Rationality has the perfectly rational justification that in failing to heed the dictates of reason we came up on the short end of the balance of benefits gained versus advantages foregone."[648] Thus, practical rationality, which has to do mainly with the processes, seeks that those

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[646] RESCHER, N., "Pragmatism and Practical Rationality," p. 44.
[647] Simon is more interested in what the disciplines of Aristotelian inspiration (logic, ethics, and psychology) say about rationality (where rationality is seen as a process) than in disciplines such as sociology or (mainstream) economics, where rationality is seen as result. In effect, against substantive rationality, Simon offers an approach to rationality that gives primacy to the procedural component. Cf. SIMON, H. A., "Bounded Rationality in Social Science: Today and Tomorrow," *Mind and Society,* v. 1, n. 1, (2000), pp. 25-39. Spanish translation: "La racionalidad limitada en Ciencias Sociales: Hoy y mañana," in GONZALEZ, W. J. (ed.), *Racionalidad, Historicidad y Predicción en Herbert A. Simon*, pp. 97-110.
[648] RESCHER, N., *Satisfying Reason. Studies in the Theory of Knowledge*, Kluwer, Dordrecht, 1995, p. 29.

processes are effective and efficient. In turn, this feature connects with the normative aspect of his approach, which is focused on the methods instead of the results, but that direct the processes towards what *ought to be*, which can have general validity.

Certainly, the process has primacy over the product, but Rescher seeks that the process has universal or universalizable features. In this way, his approach rejects the relativism. This can be seen in different levels where rational deliberation is focused on the procedures. Thus, his pragmatic approach to rationality involves some elements of general character: (i) rationality deals with the processes of truth validation; (ii) it is focused on act-recommending norms; (iii) it affects the processes to answer-determination; and (iv) it is related with the procedures by which the endorsement of hypotheses is validated[649].

By insisting on the processes regarding rationality, the methodological aspect is crucial. But this features does not involve that the methodological aspect is the only we should take into account. Thus, there is always an end that modulates the processes, so the different processes are oriented towards the achievement of a result. In this way, human actions always have a teleological dimension. So, among the different procedures, a rational creature would choice the procedure that leads to the end sought in the most effective and efficient way.

This includes that, if the processes are not self-sufficient in epistemological and methodological terms, then the rationality of the very ends sought must be taken into account. In Rescher judgment, evaluating different courses of action is not good enough when these are about "given" ends. So the very choice of the ends must be evaluated and legitimated form a pragmatic perspective, and this is a task that should be carried through from rationality.

[649] Cf. RESCHER, N., "Pragmatism and Practical Rationality," pp. 45-46.

Within this approach, there is a nexus between practical rationality and prediction. In effect, for Rescher, to predict is mainly a *process* that is oriented towards an end: it is an activity that seeks to answer our meaningful questions about the future. In this way, practical rationality intervenes in prediction, by selecting the adequate process of prediction, which — in relation to the end sought — must be effective and efficient. Thus, the choice of a concrete method or procedure in order to solve a predictive question depends, to a large extent, on the kind of phenomenon that we want to predict.[650] For this reason, he considers that "the comparative efficacy of predictive processes is (…) in the end an empirical matter."[651]

If practical rationality is eventually determined on empirical basis, then his rationality is not only normative, but also descriptive. Moreover, Rescher gives primacy to practice in his approach to rationality, and practice is also crucial in his approach to scientific prediction. In effect, in his judgment, "to act, to plan, to survive, we must anticipate the future, and the past is the only guide to it that we have."[652] This involves an empirical and descriptive component: "practical reasoning serves as the basis for the justification of the *inference* towards the future form past experience."[653] Once again, his "pragmatic idealism" includes elements that are not "idealistic," but rather "realist." In my judgment, this is due to his acceptance of the realist notions of "fact" and "objectivity."[654]

4.2.3. Evaluative Rationality

Rationality also deals with what should be valued regarding the ends,

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[650] On the distinction between "predictive procedures" and "predictive methods," see GONZALEZ, W. J., *Philosophico-Methodological Analysis of Prediction and its Role in Economics*, chapter 10, pp. 251-284.

[651] RESCHER, N., *Predicting the Future*, pp. 111-112.

[652] *Predicting the Future*, p. 65.

[653] GONZALEZ, W. J., *La predicción científica*, p. 265.

[654] Cf. RESCHER, N., "Cognitive Limits," in RESCHER, N., *A System of Pragmatic Idealism.* Vol. I: *Human Knowledge in Idealistic Perspective*, Princeton University Press, Princeton, NJ, 1992, pp. 243-254.

according to the real interests of the human being. This task accompanies the other two already mentioned: (i) to deliberate about what should be believed on the basis of the available information; and (ii) to decide what means should be used in order to achieve an end in an effective and efficient way. Thus, both rationality, in general, and scientific and technological rationality, in particular, are not reduced only to the means that should be used in order to achieve given ends. Rationality should consider the very ends sought. About this issue, Rescher explicitly shows his disagreement with Simon.

For Simon, "reason is wholly instrumental. It cannot tell us where to go; at best it can tell us how to get there. It is a gun for hire that can be employed in the service of whatever goals we have, good or bad."[655] In Rescher's judgment, this type of approaches fade the frontiers between what is rational and what is non-rational, insofar as they do not take into account the nexus between rationality and what is advisable and intelligent.[656] Thus, in his approach, he avoids the term "instrumental" to refer to the rationality of means. Instead, he uses the notion of "practical rationality," since he considers that it is connected with a rationality of ends, which deliberates about the ends of human action.

Therefore, in contrast to Simon's approach, which is clearly of instrumental rationality and empirically based, Rescher considers that "rationality is thus a two-side, Janus-faced conception. On the side of means, it reflects a pragmatic concern for efficient process, while on the side of the 'appropriateness of ends' it reflects a value-geared concern for product. (Moreover, the acceptability of the means themselves also enters in.)"[657] In that case, the issues regarding the efficacy and efficiency of means are only

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[655] SIMON, H. A., *Reason in Human Affairs*, Stanford University Press, Stanford, CA, 1983, pp. 7-8.
[656] Cf. RESCHER, N., *Rationality,* p. 95.
[657] RESCHER, N., *Rationality,* p. 6.

a part of rational action. Thus, in order to be considered as fully rational, human action should take into account the *value* of the ends it seeks.[658]

In this approach, the adequacy of ends — if they are appropriate or not as ends of human action — is an issue that belongs to the evaluative order of rational deliberation.[659] Rescher assumes this evaluative component of rationality. He considers that this requires justification; that is, that rationality not only deals with matters of fact, but also with matters of *values*. This is because, in his judgment, the Humean tradition of separation between reason and values is still widely accepted.

According to Rescher, the rejection of the objectivity of values and, therefore, the dismissal of the rationality of ends, is due to some confusion with the terms "taste" and "value."[660] Tastes are about what people prefer, while values have to do with what should be considered as *preferable*. Thus, although "'There's no disputing about tastes' may be true, (…) 'There's no disputing about values' certainly is not. Values too can be altogether objective, in that value claims admit of rational support through impersonally cogent considerations."[661] Rationality also requires an objective assessment regarding value matters: rationality "asks for an estimation of *preferability*, more than the pure expression of a preference."[662]

Thus, Rescher admits the *objectivity* of values, which in his approach goes hand in hand with the normative character of the rationality of ends. This issue is connected with the "self-interest," that is, with the own welfare and well-being. In his judgment, the "self-interest" can be interpreted in three different ways: (i) what someone *wants*; (ii) what somebody *thinks* is good for

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[658] Both the axiology of research and the ethics of science in Rescher are clearly teleological, insofar as he gives primacy to the perspective of human activity as oriented towards ends.
[659] Cf. RESCHER, N., *Rationality,* p. 93.
[660] Cf. RESCHER, N., *Realistic Pragmatism*, p. 170.
[661] RESCHER, N., "Is Reasoning about Values Viciously Circular?," in RESCHER, N., *Sensible Decisions. Issues of Rational Decision in Personal Choice and Public Policy,* Rowman and Littlefield, Lanham, MD, 2003, p. 31.
[662] RESCHER, N., *Razón y valores en la Era científico-tecnológica,* p. 85.

him or for her on the basis of the available information; and (iii) what somebody objectively *ought* to want (what is, in fact, beneficial for him).[663]

Usually, the third option is beyond our possibilities. But the first of the three options is not good enough, since rationality also has a normative character. Thus, rationality is required a strengthened version of the "self-interest," as it is the case in the second interpretation. Then, self-interest consists on "what someone has *good reason* (in the prevailing state of his information) to think to be truly beneficial to him."[664]

This notion of the self-interest can be understood from either a narrow perspective or a wide viewpoint. Rescher defends a wide notion of self-interest, according to which the self-interest of one individual also encompasses, to some extent, the other's interest.[665] In my judgment, this feature broadens self-interest in order to include reciprocity, active cooperation, and solidarity, which are three stages in interpersonal relationships.[666]

On this wide orientation, Rescher maintains that those values that implement the best interest of people are adequate values. Like the cognitive and the practical rationality, the evaluative rationality is also universal in the following sense: what I should want or prefer is "what the reasonable (impartial, well-informed, well-intentioned, understanding) bystander would think that I ought to want on the basis of what is 'in my best interests.'"[667] Therefore, a theory of rational choice not should be reduced to what people in fact prefer, but it should encompass *what they should prefer* according to their real interests.

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[663] Cf. RESCHER, N., "Rationality and Moral Obligation," p. 79.
[664] "Rationality and Moral Obligation," p. 80.
[665] Cf. RESCHER, N., "Rationality and Moral Obligation," p. 80.
[666] On recent studies about altruism, which is present in the cases mentioned, see the monographic number of *Economics and Philosophy*, which offers papers of Philip Kitcher and others in the case of economics. Cf. KITCHER, PH., "Varieties of Altruism," *Economics and Philosophy*, v. 26, n. 2, (2010), pp. 121-148; and SCHEFCZYK, M. and PEACOCK, M., "Altruism as a Thick Concept," *Economics and Philosophy*, v. 26, n. 2, (2010), pp. 165-187.
[667] RESCHER, N., *Rationality,* p. 102.

Therefore, the rational agent is that who is ready to go from his preference to his interests, by subjecting his desires to rational deliberation. This feature involves an objective judgment. Through this objective judgment, it is possible to decide if our actual ends are rational or not. In this way, the valid or adequate ends are those that result in the best interest of the agents; for example, those ends related to the satisfaction of universally shared needs, such as health or affection; the ends related with the particular role one planes as relative of someone, as professional, etc.; and those ends that have to what one simply happens to want.

In order to consider a certain interest as appropriate, it has to meet the requirement of being connected with some universal interest.[668] Thus, some concrete interest of one agent can be considered as valid if it is possible to subordinate it to a universal interest. With this position, Rescher's approach satisfactorily combines two different aspects: a) the fact of the existence of numerous interests, which are contemplated by the agents in order to select those that will guide their actions; and b) the existence of a universal principle of rationality, which allow us to determine in an objective way the validity of those interests.

If the claims about value matter are not beyond the realm of rationality, then there can be objective. To the extent that values are not simple tastes, rational evaluation follows the same principle as rational action in general. This feature leads to the following principle: "*proceed in the same way than a rational or reasonable personal would proceed in those circumstances.*"[669] Therefore, Rescher admits the realist notion of "objectivity" as a crucial factor in his defense of the evaluative realm of rationality.

However, within a system of pragmatic idealism, the ultimate justification of the evaluative dimension of human rationality does not rest on

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[668] Cf. RESCHER, N., *Rationality,* p. 101; and RESCHER, N., *Realistic Pragmatism*, p. 178.
[669] RESCHER, N., *Razón y valores en la Era científico-tecnológica,* p. 75.

the realist principle of objectivity; instead, it can be seen in the capacity of values to guide our actions and make them meaningful. Thus, "the pragmatic aspect of values lies in the fact that they provide a thought tool that we require in order to achieve a *satisfying* life. By contrast, the idealistic aspect of values lies in the fact that thy alone enable us to achieve a *meaningful* life."[670]

The idealistic aspect of evaluation can be clearly seen when Rescher characterizes values as "indispensable thought-tools."[671] Human knowledge has a clear teleological dimension (an orientation towards ends) and it is never passive. In his approach, values constitute an indispensable requirement in order to orientate human thought towards the ends sought. In this way, the acceptance of the rationality of ends has a clear repercussion in his conception of scientific activity as modulated by values. Among them, Rescher gives primacy to the cognitive values.

When rationality is seen in its three dimensions — cognitive, practical, and evaluative — human being can go beyond what in fact *is* to evaluate what *ought to be*. Thus, "value is concerned not only with what does happen but with what might happen, and not just 'realistically' but even 'by the wildest stretch of the imagination.'"[672] Therefore, as rational beings, we compare different possibilities for the direction of our actions.[673]

In order to accomplish this task, evaluative rationality is crucial. In effect, Rescher considers that human beings are characterized by their capacity to choose on the basis of rational evaluation. For this reason, he

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670 RESCHER, N., *A System of Pragmatic Idealism.* Vol. II: *The Validity of Values: Human Values in Pragmatic Perspective,* p. 248

671 *A System of Pragmatic Idealism.* Vol. II: *The Validity of Values: Human Values in Pragmatic Perspective,* p. 249.

672 RESCHER, N., *A System of Pragmatic Idealism.* Vol. II: *The Validity of Values: Human Values in Pragmatic Perspective,* p. 246.

673 According to Michele Marsonet, Rescher sees rationality as a matter of idealization: "Rationality is the expression of mankind's capacity to see not only how things actually *are*, but also how they *might have been* and how they *could turn out to be* if we were to take some course of action rather than another," MARSONET, M., *The Primacy of Practical Reason. An Essay on Nicholas Rescher's Philosophy*, p. 63.

maintains that “comparative evaluation is also an unavoidable requisite of the human condition. The burden of choice—and thereby of reason-guided evaluation—is one of the definitive features of the human condition.”[674]

Within these coordinates, scientific prediction can have a crucial role when different courses of action are evaluated, in order to choose among them. In fact, prediction makes it possible to anticipate future events and developments, so it provides knowledge that can have an important role in order to orientate human actions. This can be seen, above all, in three realms: (i) applied science, (ii) the application of science, and (iii) the use of predictive knowledge in everyday life. Usually, Rescher is focused in the application of science and in the everyday life realms, while he hardly takes into account the applied science.

First, prediction is required in applied sciences in order to make prescriptions directed to solving a concrete problem. Second, prediction has also a role regarding the ends of the application of science, where scientific knowledge is used by agents in institutional and professional contexts (for example, in hospitals or in problems concerning policy). In this case, prediction can serve as a support in decision-making. Third, agents might use the knowledge about the future provided by scientific predictions as a guide for action in daily contexts (for example, this is what commonly happens with meteorological predictions).

Furthermore, the predictive activity itself is a *rational activity* that is goal-oriented, so it involves an evaluative dimension. This can be seen in two successive levels, which are clear when prediction is seen as a human activity: the *value of prediction* and *the values of prediction*. On the one hand, the role of prediction *as a value* of science can be addressed (that is, insofar as it is a goal sought in order to promote scientific progress). From this

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[674] RESCHER, N., “*Homo Optans*: On the Human Condition and the Burden of Choice,” pp. 1-7, p.5.

perspective, prediction has a role when the aims of scientific research are selected, which are prior to the selection of the processes and the achievement of results. And, on the other hand, the question of the *values of prediction* can be considered; that is, what are the desirable characteristics that should accompany the predictive statements.

Consequently, evaluative rationality intervenes in the scientific activity oriented towards anticipating the possible future, insofar as prediction is — for Rescher — one of the main goals of science. When a prediction is achieved, other more specific ends can be sought (for example, to serve as a test for a theory in basic science or as a previous step to prescription in applied science). But prediction itself must be subjected to evaluation. In this regard, Rescher notices the values that scientific prediction should have, such as correctness, accuracy, precision, etc.[675] First, those values modulate the ends sought; and, second, they also modulate the processes oriented towards those ends. Latter, they have also a role for the evaluation of the result finally obtained and its possible consequences.[676]

4.3. Fallibilism and Predictive Knowledge

Besides the pragmatic approach to rationality, which emphasizes the presence of cognitive and instrumental limitations, Rescher maintains a fallibilistic view of scientific knowledge. He defends that every piece of knowledge we can achieve is always subjected to revision, since it is impossible to achieve perfection in science.[677] However, he rejects both relativistic and skeptical proposals. He considers that the information we have now is the *best possible* and that the desire to enlarge and improve it

[675] Cf. RESCHER, N., *Predicting the Future*, pp. 119-125.

[676] These issues, which connect the evaluative realm of rationality with problems that have to do with the relation between scientific prediction and the axiology of research as well as the ethics of science, are analyzed in the chapters 8 and 9 of this Ph.D. research.

[677] On the imperfect character of science, see RESCHER, N., "The Theoretical Unrealizability of Perfected Science," in RESCHER, N., *The Limits of Science*, revised edition, pp. 145-165.

motivates the research, promoting new advancements.

Within this fallibilistic epistemological framework, successful scientific prediction is connected with truth — in the epistemological realm — and with the progress of science (in the methodological area). Thus, prediction is a statement that provides knowledge about the possible future that can be true. Furthermore, it is a *test* for scientific theories in basic science, so it has a high confirmatory value. In this way, successful prediction allows us to evaluate the content of truth of the scientific theories. Moreover, prediction contributes to problem-solving in applied research. This feature is related to the progress of science, which — in Rescher's judgment — "is mostly strikingly and decisively manifested on its technological side. Science is marked by an ever-expanding predictive and physical control over nature."[678]

4.3.1. Scientific Prediction and the Problem of Truth

Rescher's approach regarding the truth of predictive statements and their role as *test* for theories (basic science) and as a previous step to prescription (applied science) is developed within a framework of fallibilism.[679] According to him, fallibilism maintains that "our theoretical scientific knowledge claims are always vulnerable: they must always be staked tentatively because the prospect that further inquiry and discovery will lead to their modification or replacement can never be eliminated."[680]

Therefore, on this basis, it is not possible to have certainty regarding the cognitive content of the current science. In effect, scientific knowledge is the result of a rational process of research and — for Rescher — rationality is a matter of optimization, instead of maximization. Thus, he maintains that science only can achieve what, in some concrete circumstances, is the best

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[678] RESCHER, N., *The Limits of Science*, revised edition, p. 39.
[679] Rescher attention is usually focused on basic science, and he rarely pays attention to the problems that more specifically have to with the applied sciences. For this reason, he highlights above all the role of prediction as scientific test.
[680] RESCHER, N., *Satisfying Reason. Studies in the Theory of Knowledge*, p. 72.

thing available. In that case, the rational solution to a problem is not, in principle, the best solution in absolute terms; but only the best solution *possible* given certain context. The limited and contextual character of rationality, in general, is also characteristic of scientific rationality, in particular.

In terms of knowledge optimization, in science "the answers we give to our questions are literally the best we can provide."[681] For this reason, it is not possible to be certain that a scientific theory or statement is true; but we can claim that it is the best answer we can offer in order to solve a concrete problem. Therefore, every theory or statement is vulnerable, insofar as they can turn out to be false. With these reflections, Rescher does not put into question the *possibility* of achieve true knowledge; but he acknowledges that it is *probable* that future developments replace or change the knowledge we have now.

Thus, Rescher rejects a skeptic or relativist approach regarding knowledge, since he admits clearly the possibility of achieving true statements. In this regard, he distinguishes "*our truth*" (what we think that is true *now*) y "*the truth*" (what is in fact true).[682] For him, this is a "convenient fiction," as a hypothesis that allows us to make advancements in the process of research.[683] Consequently, it should be acknowledged that every belief we accept that can turn out to be false. Moreover, many of our beliefs will be falsified.[684]

In order to justify this epistemological approach, Rescher contemplates the history of science. The historical dimension of science involves that this

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[681] RESCHER, N., *The Limits of Science*, revised edition, p. 30.
[682] Cf. *The Limits of Science*, revised edition, p. 36.
[683] "We have no alternative to proceeding on the working hypothesis that in scientific matters *our* truth is *the* truth. But we must also recognize that that is simply not so —that the working hypothesis in question is no more than just that, a convenient fiction," RESCHER, N., *The Limits of Science*, revised edition, p. 36.
[684] Cf. RESCHER, N., *The Limits of Science*, revised edition, p. 34.

activity is "one transitory state of things in an ongoing process."[685] In this sense, he thinks that "the clearest induction from the history of science is that science is always mistaken."[686] However, it is not a "pessimistic induction" in the style of Larry Laudan,[687] since in Rescher's approach this induction is connected with an account of science according to which science is progressive regarding knowledge: "later science is better science—that is, better warranted science."[688] In this way, the main lesson is that it is always possible to improve the available knowledge.

Rescher establishes the progressive character of science on the basis of the continuous improvement and increasing of the available knowledge.[689] But the way of evaluating this progress is within a framework of methodological pragmatism, according to which the predictive success and the control over nature are the best available indicators regarding scientific progress.[690] In this realm, prediction connects with his epistemological fallibilism. In my judgment, this connection can be seen in four different directions: 1) insofar as prediction provides knowledge about the future that is fallible; 2) because prediction is a test for the adequacy of theories, so it has a relevant role in the justification of the accepted beliefs; 3) since prediction is a guide for prescription (applied science) or for both individual and social agent's decision-making (application of science); and 4) prediction as an indicator of scientific progress, so the advancement of science can be evaluated on the basis of predictive success.

1) Rescher considers that scientific prediction can have an objective

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[685] *The Limits of Science*, revised edition, p. 38.
[686] RESCHER, N., *The Limits of Science,* revised edition, p. 36.
[687] See LAUDAN, L., "A Confutation of Convergent Realism," *Philosophy of Science*, v. 48, (1981), pp. 19-49. It has been noticed that the pessimistic induction can even lead to semantic antirealism. Cf. FROST-ARNOLD, G., "From the Pessimistic Induction to Semantic Antirealism," *Philosophy of Science*, v. 78, n. 5, (2011), pp. 1131-1142.
[688] *The Limits of Science*, revised edition, p. 40.
[689] Cf. RESCHER, N., *Scientific Progress. A Philosophical Essay on the Economics of the Natural Science*, passim.
[690] Rescher's methodological pragmatism is analyzed in the chapter 5 of this Ph.D. research.

content. Thus, he insists on the rational basis of prediction and the realism of the assumption in all the empirical sciences, also in economics.[691] Then, he rejects the possibility of predicting without reasons and rejects the instrumentalist approaches that defend the absence of realism in predictive models. Scientific prediction rests — in his judgment — in the knowledge and control of the variables important for the phenomenon studied. It is also supported by the adequate inferences. These features seek to reduce the uncertainty about the future and to obtain true predictions.

However, every predictive statement — as all the knowledge — is revisable. From an approach of bounded rationality, the task of predicting is also a task subjected to limits, both cognitive and practical. But accepting that our intent of anticipating the future is subjected to limits does not mean that, for this very reason, it is doomed to failure. For this reason, he maintains that we should persist "in using the resources of reason to doing the best we can in the recognition that while overall this is going to prove to be quite a lot, it will never be nearly as much as we would ideally like."[692]

Therefore, scientific prediction is a rational prediction. It consists in a statement about the future that is obtained as the result of processes in which cognitive, practical, and evaluative rationality intervene. Thus, the rational bases — theoretical or empirical — of prediction justify the anticipation of the possible future. Moreover, as the content of the prediction is the result of a rational process, it can be objective. In this way, the use of scientific prediction as a test for theories is also justified.

2) In effect, scientific prediction can be used as a test for scientific theories. However within a fallibilistic epistemological approach, prediction cannot provide a definitive proof of the validity of theories. For Rescher,

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[691] Thus, he disagrees with Milton Friedman, whose approach Rescher criticizes expressly. Cf. FRIEDMAN, M., "The Methodology of Positive Economics," pp. 3-43; and RESCHER, N., *Predicting the Future*, pp. 109 and 194-196.
[692] RESCHER, N., *Predicting the Future*, p. 222.

prediction is the best we have, but "the scientific bearing of predictive success is not demonstrative but merely evidential, in this domain even our best confirmed theories are no more than reasonable but also provisional estimates of the truth."[693]

3) Furthermore, the reliability of the predictive statements in applied science has repercussions for prescription. On the one hand, prediction can turn to be false. This has a negative incidence on prescriptions, which are designed by using the knowledge about the possible future. And, on the other hand, the fallible character of scientific prediction requires — in my judgment — adopting a wary attitude when the action is designed on the basis of predictive knowledge. This also happens in the context of the application of science, where prediction can serve as a basis for the agents' decision-making. Thus, the fallible character of the cognitive content of scientific prediction makes it difficult the decision-making of the agents (both individual and social) when they try to solve practical problems of acting.

4) Within this fallibilistic framework, Rescher's attention goes usually towards the realm of basic science. In this regard, he thinks that scientific prediction has an important role for scientific progress. So, as a test for theories, prediction is also an important indicator of scientific progress.[694] Thus, although his proposal is clearly pragmatic, it is not an instrumentalist approach, since scientific progress is not directly connected with problem-solving. In this regard, the Kantian component of this thought prevails, so scientific prediction is above all a cognitive content, which also has methodological import.

4.3.2. Knowledge of the Variables of Prediction

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[693] *Predicting the Future*, p. 171.
[694] Cf. RESCHER, N., *Predicting the Future*, p. 164.

Although Rescher is usually focused on the role of prediction in basic science, scientific prediction has several roles, according to the type of activity where prediction is achieved or used.[695] I) Prediction can be used in basic science (either natural sciences or social sciences) as a test for establishing the scientific character of the hypotheses and theories. II) Within the realm of applied science (pharmacology, medicine, economics, etc.), prediction is usually the previous step to prescription. Thus, the anticipation of the possible future is required in order to guide the action towards the solution of concrete problems. III) Prediction has also a role in the application of science, where it can serve as a support for the procedures of decision-making.[696]

Above all, Rescher attention goes to the role of prediction as a test for theories, since his main interest is usually in the realm of basic science. In order to meet this function, the knowledge provided by the predictive statement must be an objective knowledge. He admits the objectivity of the knowledge about the future, which can be true. In his approach, the objectivity of prediction is related to its rational character. Then, he rejects the thesis according to which "predictions don't need reasons."[697] So, in his judgment, prediction is not credible when there are not reasons that justify an inference of future: "Outside the context of grammatical examples and imaginative fictions, neither statements nor predictions have any serious interest for us in the absence of reasons for seeing them as credible."[698]

He considers that a scientific prediction can be distinguished from a prophecy because scientific prediction has rational bases. However, not every rational prediction is, *eo ipso*, a scientific prediction. Thus, although the

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[695] Cf. GONZALEZ, W. J., *La predicción científica*, p. 11.
[696] Cf. *La predicción científica*, p. 11. On the application of science, see GONZALEZ, W. J., "The Roles of Scientific Creativity and Technological Innovation in the Context of Complexity of Science," pp. 11-40; especially, p. 18.
[697] MELLOR, D. H., "The Possibility of Prediction," p. 221.
[698] RESCHER, N., *Predicting the Future*, p. 256, n. 81.

rational bases of prediction are generally associated with its scientific character, rational predictions can be of an informal character; that is, predictions made on the basis of everyday experience. Rescher provides the following example of rational non-scientific prediction: it is possible to predict with confidence and appropriateness that the bright sunshine will melt the snow without having knowledge about the sun's thermonuclear processes and the physics of thermal radiation.[699]

Consequently, "scientific predictions are thereby superior as science; but this does not by itself make them superior—or safer—*as predictions*."[700] So, what makes a scientific prediction superior than other rational prediction, based on everyday experience, is the fact that scientific prediction is supported by scientific knowledge about the phenomena, obtained through processes that follow clear rules.[701] This feature allows us to answer with more accuracy and precision the question about why a certain prediction has been achieved. For this reason, the standards for the acceptation of a prediction in science should be more demanding.

From this perspective, the knowledge about the relevant variables for prediction is crucial, since it allows us to justify an inference of future from the available data about the past and present. In fact, a distinction has been proposed in economics between "foresight," "prediction," and "forecast," on the basis of their different degree of control of the variables.[702] Thus, "foresight" is most secure kind of prediction, and "forecast" is the least one, because it is a prediction with a margin of error.

This conceptual distinction is not considered by Rescher, although he

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[699] Cf. *Predicting the Future*, p. 57.
[700] RESCHER, N., *Predicting the Future*, p. 57.
[701] In effect, Rescher thinks that the main difference between scientific and non-scientific prediction lies in the *type of processes*. Thus, non-scientific prediction uses procedures that do not have the same rigor than the scientific methods. Meanwhile, scientific prediction is supported by scientific methods such as predictive models. RESCHER, N., *Personal Communication*, 15.7.2014.
[702] Cf. FERNÁNDEZ VALBUENA, S., "Predicción y Economía," pp. 385-405.

insists in the importance of the information about the relevant variables in order to have predictive success. In effect, he notices that prediction is *sensitive* to the information available. For this reason, “with prediction, as elsewhere, we must be careful not to identify automatically the vastly extensive (ontological) realities that make for the actuality of what is predicted with the comparatively modest (cognitive) considerations that furnish a prediction’s evidential warrant.”[703] This means that the more variables we know and the better our knowledge about these variables is, the more secure the prediction will be.

However, for Rescher, scientific perfection is not always attainable. On the one hand, there is always risk of error; and, on the other, the available information can be incomplete. In this regard, he notices that prediction is inherently risky, so “when we make claims about the future, things can almost invariably go awry.”[704] But it is a risk we must take, because the importance that by the human being has the achievement of knowledge about the future events and developments. Thus, the best perspective of success involves the rational bases of prediction, which are objective and, therefore, reliable.

He suggests that prediction must be the result of a rational process supported by proofs (either theoretical or empirical); because, although the future is observationally and physically inaccessible, it is not inaccessible in a cognitive way. Access to the future is possible through prediction, “even though it always involves an intrinsically risky, error-liable epistemic leap from information regarding the past-&-present to claims regarding the yet unrealized future.”[705] The perspective of error cannot be completely eliminated, but the reliability of a prediction will depend on the quality of the information it is based on. In this way, in the rational process of prediction, knowledge about the variables — in number and quality — is crucial for

[703] RESCHER, N., *Predicting the Future*, p. 59.
[704] *Predicting the Future*, p. 59.
[705] RESCHER, N., *Predicting the Future*, p. 54.

predictive success.

4.4. Epistemological Limits to Predictability

Due to the primacy of the epistemological realm in Rescher's philosophical approach, the epistemological limits to scientific prediction are an especially important issue. Expressly, Rescher maintains that "epistemological limits on prediction exist insofar as the future is *cognitively inaccessible*—either because we cannot secure the needed data, or because it is impossible for us to discover the operative laws, or even possibly because the requisite inferences and/or calculations involve complexities that outrun the reach of our capabilities."[706] Thus, he assumes, *de facto*, an approach of bounded rationality[707] as a framework for the analysis of the epistemological limits that affect predictability. It is another feature that separates Rescher's philosophy of science from the traditional philosophical idealism.

4.4.1. The Problem of Uncertainty

In Rescher's thought, the epistemological realm has primacy over the ontological dimension;[708] because concepts and categories are what allow us to articulate the reality. Thus, science is *our science*: it is the result of an activity carried through by human beings with limited capacities, within a context where the information available is usually also limited. For this reason, Rescher notices that "the limits of our experience set limits to our

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[706] *Predicting the Future*, p. 134.

[707] On the characterization of "bounded rationality," GONZALEZ, W. J., "Racionalidad y Economía: De la racionalidad de la Economía como Ciencia a la racionalidad de los agentes económicos," pp. 65-96.

[708] Cf. GONZALEZ, W. J., "Racionalidad científica y actividad humana: Ciencia y valores en la Filosofía de Nicholas Rescher," in RESCHER, N., *Razón y valores en la Era científico-tecnológica*, pp. 11-44.

science."[709] Now then, this experience can be articulated only from our concepts, our mental structure.

Insofar experience is limited, Rescher sees uncertainty as the main obstacle to scientific prediction in the epistemological realm.[710] His approach insists at this point: "the circumstances of our existence are such that many of our decisions — and many of the most important ones — have to be made under conditions of unavoidable uncertainty."[711] This feature especially affects prediction. In effect, since prediction is usually oriented towards a *possible future*, uncertainty can be a clear obstacle to predictability.

Therefore, uncertainty can limit scientific prediction according to several degrees: (i) uncertainty can involve unpredictability (that is, the impossibility to obtain a prediction); (ii) it is possible that uncertainty entails not-predictability with regard to a concrete issue (the current impossibility to state a prediction);[712] and (iii) uncertainty can make it difficult to achieve an ideal degree of exactness and precision. In this case, it might only be possible to obtain a generic prediction, instead of a specific prediction.[713]

Regarding how to address the problem of predictive uncertainty, cognitive or epistemic rationality is the starting point. But Rescher does not endorse an approach to rationality based on the idea of maximization, as mainstream economists — for example — does.[714] He considers that human

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[709] RESCHER, N., *The Limits of Science*, revised edition, p. 216

[710] See GUILLAN, A., "Epistemological Limits to Scientific Prediction: The Problem of Uncertainty", *The Open Journal of Philosophy*, v. 4, n. 4, (2014), pp. 510-517.

[711] RESCHER, N., "Deliberative Conservatism," in RESCHER, N., *Sensible Decisions. Issues of Rational Decision in Personal Choice and Public Policy*, p. 33.

[712] This distinction between "not-predictability" and "unpredictability" is in GONZALEZ, W. J., *La predicción científica, Concepciones filosófico-metodológicas desde H. Reichenbach a N. Rescher*, p. 289.

[713] Regarding what we can predict or not in science, Rescher thinks that the best source of information we have comes from science itself: it is not an external issue. Moreover, only science itself can inform us about the achievable degree of precision for scientific prediction. This depends on circumstances such as the scope — short, medium or long run —, the available technology, etc. Additionally, it also depends on the question we want to ask. In principle, the more concrete the question is, the more complicated it will be to answer it accurately. Rescher, N., *Personal communication*, 17.6.2014.

[714] About rationality as maximization and the alternative of bounded rationality, see GONZALEZ, W. J., "Rationality in Economics and Scientific Predictions: A Critical

rationality is, in fact, a bounded rationality. In his judgment, rationality is bound to a circumstantial optimization (the best thing that can be done in a concrete situation), instead of being associated with something absolute or maximization.[715] This has to do with the human beings environmental conditions or social milieu, which are usually affected by uncertainty.

Uncertainty is one of the aspects that go hand in hand with bounded rationality. On the one hand, it is not usual that we have *all* the relevant information; and, on the other, human ability to compute information is also limited.[716] Hence, in Rescher's approach, rationality and uncertainty are closely related. This has direct repercussions on scientific prediction, insofar as it is the result of a rational activity. Moreover, this rational activity is oriented to a future that, in principle, has a number of possibilities.

In Rescher's conception, rational prediction is the result of a process. It involves several aspects: 1) prediction is obtained where there is the relevant information about past and present events; 2) the paths reflected in this body of data for prediction are discerned; and 3) the patterns detected in past and present phenomena are stable, to some extent, so they continue into the future.[717] If we consider these preconditions for rational prediction, it seems clear that uncertainty is, *de facto*, one of the main limits to predictability.

Furthermore, Rescher notices that "uncertainty produced by sheer ignorance is clearly the most obvious obstacle to prediction."[718] Thus, although the phenomenon that we are trying to predict is — or may be — a regular one, the failure is still possible when all the relevant information about

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Reconstruction of Bounded Rationality and its Role in Economic Predictions," *Poznan Studies in the Philosophy of the Sciences and the Humanities*, v. 61, (1997), pp. 205-232.

[715] Cf. RESCHER, N., *Rationality. A Philosophical Inquiry into the Nature and the Rationale of Reason*, passim, and RESCHER, N., "Maximization, Optimization, and Rationality. On Reasons why Rationality is not Necessarily a Matter of Maximization," in RESCHER, N., *Ethical Idealism. An Inquiry into the Nature and Function of Ideals*, pp. 55-84; especially, pp. 71-79.

[716] Cf. RESCHER, N., *Epistemology. An Introduction to the Theory of Knowledge*, chapter 11, pp. 187-206

[717] Cf. RESCHER, N., *Predicting the Future*, p. 86.

[718] *Predicting the Future*, p. 135.

its operation is not available. Obtaining the relevant information is a *necessary condition* to predictability. However, too often it is difficult — or even impossible — for human beings to gain access to the information (at least, to the relevant information).

This aspect leads Rescher to accept that "the limits of one's information set unavoidable limits to one's predictive capacities."[719] Nevertheless, it is necessary to distinguish between uncertainty and ignorance. *Ignorance* means the complete lack of information about a concrete issue, whereas *uncertainty* has to do with the characteristic of indecisiveness. Thus, "with uncertainty we know (or think we know) what the range of possibilities is: it is based on (presumed) knowledge of the possibility range for correct. Accordingly we can generally grapple with uncertainty by means of probabilities — at least in favorable circumstances."[720]

But, although it was possible to deal with uncertainty by means of probabilistic knowledge, this may not be good enough to guarantee a scientific prediction. Firstly, available information can be insufficient, making the predictive task difficult: "possibilities rest on actualities that require information to project possibilities, although unfortunately, misinformation will also come into play."[721] Thus, uncertainty might affect the probabilistic calculus, because the available information might be insufficient or wrong.

Secondly, Rescher insists that prediction cannot be reduced to a probabilistic statement. In his judgment, to make a prediction is something more than assigned probability to phenomena's occurrence. In fact, he thinks that "the probability of a prediction thus affords an index of its acceptability — a measure of the extent to which rational confidence in its realization is

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[719] RESCHER, N., *Predicting the Future*, p. 135.
[720] RESCHER, N., "Cognitive Compromise. On Managing Cognitive Risk in the Face of the Imperfect/Flawed," in RESCHER, N., *Epistemological Studies*, Ontos Verlag, Heusenstamm, 2009, p. 57.
[721] RESCHER, N., "Cognitive Compromise. On Managing Cognitive Risk in the Face of the Imperfect/Flawed," p. 58.

warranted in the prevailing circumstances."[722] Consequently, claiming the occurrence of something (that is, making a prediction) is different from claiming that something is going to happen with certain probability.[723] From this viewpoint, probability can be relevant to predict the degree of uncertainty of the obtained forecast.

Thirdly, since scientific prediction is the result of an intellectual rational activity, it should be made on the basis of available knowledge and the control of the variables that are relevant with respect to the phenomenon at issue. It also should be based on the appropriate inferences. This will lead to reduce the uncertainty associated with future phenomena, and to the conclusion of reliable and correct predictions. Thus, probability can be a tool that helps to overcome the obstacles related to uncertainty, but probabilistic knowledge — by itself alone — is not good enough to obtain a prediction.

Furthermore, the difficulty of achieving appropriate knowledge about the studied phenomena has repercussions on the temporal dimension, which affects the scope of prediction. Rescher distinguishes between long-run forecast and short-run forecast, depending on the temporal distance of the predicted phenomenon with respect to the present moment.[724] Thus, to the extent we cannot predict what we cannot conceive, uncertainty will increase as we try to predict a more distant future (however, this is not a general rule: some phenomena can be easier to predict in the long run than in the short run).[725]

According to Rescher's viewpoint, predicting is similar to trying to see through the fog: "very little can be seen at a distance — and that little with but little clarity."[726] Undoubtedly, the problem of complexity can increase

[722] RESCHER, N., *Predicting the Future*, p. 44.
[723] Rescher develops quite interesting ideas on probability in a recent paper. Cf. RESCHER, N., "Probability as Potentially Problematic," *Mind and Society*, forthcoming.
[724] Cf. *Predicting the Future*, pp. 76-78.
[725] This is the case of the desertification of part of the Earth.
[726] RESCHER, N., *Predicting the Future*, p. 76.

uncertainty. Even if it is known that something is possible, this sometimes might be insufficient to make a prediction. The more complex the studied phenomenon, the more problematic it will be, in principle, to obtain a reliable prediction about it.[727]

There is also another aspect that adds difficulty to scientific prediction: uncertainty is related with predictive scatter. When we are dealing with a limited body of information, it is possible that various competing theories arise. This can lead to conflicting predictions. Hence, "the prospect of conflicting predictions has to be accepted as a pervasively recurrent phenomenon."[728] Conflicting predictions concern both the natural sciences and, to a greater extent, the social sciences (especially, in economics).

When the question at issue is the prediction about the development of future science, uncertainty is also present. In fact, Rescher maintains that future science is unpredictable. He thinks on the Kantian "principle of question proliferation" that intervenes here making the knowledge of future science impossible (at least, in a specific way). According to this principle, each answer given to solve a problem makes new questions arise, which, in turn, needs an answer. Furthermore, we cannot predict what questions we will ask in the future, because we cannot anticipate what the answers to currently open questions will be. In this case, the available information about past developments does not justify an inference about the future advancements.[729]

According to Rescher, scientific progress is basically of a conceptual nature. Thus, scientific research advances trough conceptual creativity. Consequently, "the questions we can pose are limited by our conceptual

[727] Cf. GONZALEZ, W. J., "Complejidad estructural en Ciencias de Diseño y su incidencia en la predicción científica: El papel de la sobriedad de factores (*parsimonious factors*)," in GONZALEZ, W. J. (ed.), *Las Ciencias de la Complejidad: Vertiente dinámica de las Ciencias de Diseño y sobriedad de factores*, pp. 143-167.
[728] RESCHER, N., *Predicting the Future*, p. 135.
[729] Cf. RESCHER, N., "The Problem of Future Knowledge," pp. 149-163.

horizons."[730] Following this way, prediction about the future science is only possible at a generic level. This is so because there is a cognitive indetermination here: the more detailed and precise the prediction is, the less confidence we can attribute to it. It is possible, for example, to predict with certainty that scientific means for observation and experimentation will improve in the future, but it is not possible to anticipate what these improvements will be.

This allows us to infer that uncertainty has more weigh in specific predictions than in generic predictions. This is so because there is a relation of balance between informativeness (exactness, detail, precision, etc.) and security, both in scientific knowledge, in general, and in scientific prediction, in particular. Thus, as the degree of detail of the prediction increases, the uncertainty with respect to its reliability also increases. This is an especially relevant question, since the utility of the prediction lies in its informativeness.

In Rescher's words, "an ironic but critically important feature of scientific inquiry is that the unforeseeable tends to be of special significance just because of its unpredictability. The more important the innovation, the less predictable it is, because its very unpredictability is a key index of importance."[731] This increases the problem of uncertainty because, generally, those things we do not know are, for that very reason, the most relevant for us.

On this basis, it is not advisable to obtain predictive security by losing informativeness, since the value of prediction lies in its content. Hence, it has

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[730] RESCHER, N., *Satisfying Reason. Studies in the Theory of Knowledge*, p. 76.

[731] RESCHER, N., *Unknowability. An Inquiry into the Limits of Knowledge*, Lexington Books, Lanham, MD, 2009. p. 15. Rescher does not distinguish clearly creativity and innovation. In this regard, it has been noticed that it is usual to distinguish the concept of "creativity," as it appears in a scientific context, from the notion of "innovation," which connects with the technological realm (where there are often modifications of existing realities rather than something completely new or original). Cf. NEIRA, P., "Complejidad en Ciencias de la Comunicación debido a la racionalidad: Papel de la racionalidad limitada ante la creatividad e innovación en Internet," in GONZALEZ, W. J. (ed.), *Las Ciencias de la Complejidad: Vertiente dinámica de las Ciencias de Diseño y sobriedad de factores*, p. 217.

to aspire to exactness and precision. However, when it is impossible to obtain a specific prediction due to uncertainty, at least a generic prediction could be possible. In this case, uncertainty does not entail unpredictability, but it acts as an obstacle with respect to the achievable degree of exactness and precision.

Comparatively, according to the type of phenomena that prediction is about, it is possible to claim — in my judgment — that prediction generates fewer difficulties in the natural sciences than in the social sciences. This is due to the higher level of complexity that social phenomena can have,[732] where uncertainty also has more weight than natural phenomena.[733] Usually, Rescher's approach is focused on natural sciences (mainly, physics), so he leaves open the question of uncertainty with respect to social sciences (and, undoubtedly, he does not pay especial attention to prediction in the sciences of the artificial).

In principle, social sciences have to do with agents' actions and choices, which make their decisions in changeable social and historical settings. These structural and dynamic factors involve an additional source of complexity for prediction in these sciences. Too often, Rescher is focused on the problem of prediction with regard to the limits of the information, that is, on the internal aspects of science. In the specific case of scientific prediction, uncertainty has to do then with the future environment, so that available information does not allow us to predict or, at least, makes it difficult for those predictions to have the desired degree of exactness and precision.

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[732] Cf. GONZALEZ, W. J., "Complexity in Economics and Prediction: The Role of Parsimonious Factors," in DIEKS, D., GONZALEZ, W. J., HARTMAN, S., UEBEL, TH. and WEBER, M. (eds.), *Explanation, Prediction, and Confirmation,* Springer, Dordrecht, 2011, pp. 319-330; especially, pp. 319-321.

[733] According to Rescher, social phenomena are more difficult to predict than natural phenomena. He considers that there is a very simple reason that explains this issue: social prediction deals, in principle, with people's acts and choices. How people consciously and deliberatively act depends not on the reality of the world, but on what people think about that reality (i.e., it depends on beliefs, ideas, expectations, etc. that are immensely variable). By contrast, natural prediction is about natural processes, which are an objective matter: they depend on the state of affairs of the world. Rescher, N., *Personal communication*, 10.6.2014.

It happens that in social sciences, in general, and in economics, in particular, there is an additional source of uncertainty. It is *decision-making*, which is related with the problem of rational decision. In economics, the problem of uncertainty is not only related with the future environment, but also has to be considered with regard to the agents' decision-making, that is usually carried through in circumstances of uncertainty.[734] Consequently, when prediction is about economic agents' decision-making, it is not usually to obtain a "foresight" (that is, the securest kind of prediction), but a mere "forecast," which always involves a margin of error and hence intrinsically involves uncertainty.

In this context, it is possible to highlight the relevance of the methodological role of uncertainty, especially in the case of economic prediction.[735] When the result of economic forecasts "are known, the corresponding forecast errors and the anticipated forecast uncertainty can be used to evaluate the models from which the forecasts were generated."[736] Thus, uncertainty has a methodological role that has repercussions on the use of the forecast as a test to assess the appropriateness of predictive models.

Therefore, it is possible to state that, with regard to uncertainty, there are more questions than those contemplated by Rescher. In his approach, which is primarily oriented to the natural sciences, uncertainty is the main epistemological obstacle to predictability. It has to do with lack of knowledge about the regularities of phenomena, which is due to epistemic failures in

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[734] About uncertainty as an obstacle to prediction in social sciences, in general, and in economic science, in particular, Cf. SIMON, H. A., "Bounded Rationality in Social Science: Today and Tomorrow," *Mind and Society,* v. 1, n. 1, (2000), pp. 25-39. See Spanish translation: "La racionalidad limitada en Ciencias Sociales: Hoy y mañana," in GONZALEZ, W. J. (ed.), *Racionalidad, historicidad y predicción en Herbert A. Simon*, p. 107.

[735] Cf. GONZALEZ, W. J., "La vertiente dinámica de las Ciencias de la Complejidad. Repercusión de la historicidad para la predicción científica en las Ciencias Diseño," in GONZALEZ, W. J. (ed.), *Las Ciencias de la Complejidad: Vertiente dinámica de las Ciencias de Diseño y sobriedad de factores*, p. 91.

[736] ERICSSON, N. R., "Predictable Uncertainty in Economic Forecasting," in CLEMENTS, M. and HENDRY, D. F. (eds.), *A Companion to Economic Forecasting*, Blackwell, Oxford, 2002, p. 19.

obtaining or computing the information. But, besides the epistemological dimension, there are — in my judgment — a methodological aspect and an ontological feature, which can be seen clearly when the problem of prediction in economics is analyzed.

Methodologically, the problem arises about whether or not prediction is a necessary condition or test to have science. This is a question that has been argued above all in economics, where the problem of the lack of reliability of economic predictions has special relevance.[737] Uncertainty has influence on this question, so that it is possible to ask if it is good enough to obtain forecasts (predictions that involve uncertainty) instead of a genuine foresight.

This methodological problem related with prediction has ontological roots. *De facto*, in the social sciences and the sciences of the artificial, "it sits on the *complexity* of human activity involved in the social environment. This complexity contributes to the frequent lack of reliability of economic predictions, which has its roots in the object of study of this science: economic reality is a social and artificial undertaking (*quehacer*), which is commonly mutable, as a consequence of its dependence on the human activity that develops historically."[738] From this point of view, it is possible to consider uncertainty as a source of complexity in economic activity, so that it is an obstacle of special relevance to prediction in economics.

However, the epistemological dimension is fundamental, because uncertainty has to do, in principle, with the lack of knowledge about the regularities, which is due to the lack of information. For this reason, it is not usual that uncertainty involves "unpredictability", i.e., the actual impossibility

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[737] About prediction as the "scientific test" of economics, see GONZALEZ, W. J., "Prediction as Scientific Test of Economics," pp. 83-112. The approaches' of four Nobel Prize winners in economics are analyzed in this text: Milton Friedman, John Hicks, James Buchanan, and Herbert Simon.

[738] GONZALEZ, W. J., "La vertiente dinámica de las Ciencias de la Complejidad. Repercusión de la historicidad para la predicción científica en las Ciencias Diseño," p. 92.

of predicting. On the contrary, it can be possible to predict under conditions of uncertainty (at least, at the level of forecasts or generic predictions).

It must be considered that a phenomenon we cannot currently predict, because of the presence of uncertainty — or an issue that we can only predict generically, or by means of forecasts —, can be predictable in the future. Even more, the exactness and the degree of precision of the obtained predictions can increase. In this case, it is necessary to stress the rational basis of scientific prediction, since it is possible to overcome uncertainty if the knowledge and control of the relevant variables increase.

4.4.2. Prediction and Decision-Making

Although Rescher is mainly focused on natural science, he also takes into account the role of prediction in social sciences, and notices limits to prediction in this field. In this regard, predicting the behavior of the agents in a social context involves the assumption that these agents make choices in a rational way. They should seek an optimal choice with regard to their context. But, even acting as rational agents, there are situations in which agents are not capable of predicting the optimal course of action.[739] This involves clear limits to the predictive capacity of social sciences.

An especial complex task in social science is to meet the necessary conditions for prediction, because of the obstacles that involves the characteristic of their object of study for predictability. Thus, the *indeterminism* of human affairs must be taken into account, as well as the *predictive errors* related to the knowledge of the variables that intervene in the process.[740] For Rescher, the limits to prediction in social sciences “lie in the intractability of the issues, so that there is little reason to think that the relatively modest record of the past will be substantially improved upon the

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[739] Cf. RESCHER, N., “Predictive Incapacity and Rational Decision,” in RESCHER, N., *Sensible Decisions*, pp. 39-47.
[740] Cf. GONZALEZ, W. J., *La predicción científica*, p. 273.

future."[741]

Initially, social sciences have to do with the actions and choices of the agents, above all if we assume the methodological individualism. In that case, it can be noticed that both — actions and choices — are predictable to the extent that they are also rational. From this perspective, the behavior of the agents can be predicted if they choose the optimal option in their specific circumstances. However, agents' do not always behave rationally. Then, arbitrary choices intervene, which involve non-rational and, therefore, not-predictable decision making (at least with a desired level of accuracy and precision). In this way, it can be possible to predict that an agent will act in an arbitrary way, but then we cannot predict what his action or choice will be in an accurate way.[742]

However, even if the agents act in a rational way, prediction in a social context is not always possible. Rescher contemplates two cases where, although the behavior of the agents is fully rational, it is impossible to state a reliable prediction about their actions.[743] First, he notices the informational underdetermination; and, second, the analysis overdetermination as limits to predictability.

Informational underdetermination can make prediction impossible; because, if we do not have information (or the information that we have is incomplete), then we cannot achieve a rational prediction about the agents' actions and choices, even if they were ideally rational agents. In addition, analysis overdetermination involves that it is possible to reach several rational solutions that are divergent among then. Then, the agent whose actions we want to predict is in a situation where an optimal solution cannot be established, since several different choices are equally rational. The

[741] RESCHER, N., *Predicting the Future*, p. 202.
[742] Cf. RESCHER, N., "Predictive Incapacity and Rational Decision," in RESCHER, N., *Sensible Decisions*, p. 39.
[743] Cf. "Predictive Incapacity and Rational Decision," pp. 40-45.

prisoner's dilemma is a clear example of this kind of obstacle.

Despite the different limits mentioned, Rescher thinks that human actions should be, in principle, predictable, insofar as they are rational actions.[744] In fact, the social system — which is certainly complex — is supported by the predictability of agents' behavior. Thus, even when he admits that "mere arbitrary *choice* can provide resolutions that lie beyond the dictates of reason,"[745] he also understands that "the acts of rational agents are usually predictable."[746]

This idea is related with the thesis maintained by Merrilee Salmon, when she analyses the possibility of predicting in the realm of the social science. This philosopher claims that "if people were completely unpredictable, social life would break down altogether."[747] There are many social phenomena that include regularities and, therefore, they are predictable. On this basis, predictive success in social sciences is an attainable goal. However complexity, to the extent that it involves the lack of regularities, undoubtedly makes scientific prediction more difficult, both in science, in general, and in social sciences, in particular.

4.5. Rationality and the Problem of Risk

Rescher considers that rational behavior involves an important risk: the error. In his judgment, there are three main categories of error, which

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[744] "The acts of rational agents are usually predictable because it is often and perhaps even usually possible to figure out on the basis of general principles what the rational thing to do is in the prevailing situation. This circumstance makes rationality into a crucial predictive resource in matters of human action. Indeed, it is on just this basis that we try to understand people, since we ordinarily credit them with being rational until such time as they prove themselves otherwise. In consequence, the actions of free agents must be substantially predictable — if they are rational, at any rate," RESCHER, N., "Predictive Incapacity and Rational Decision," p. 39.

[745] "Predictive Incapacity and Rational Decision," p. 46.

[746] RESCHER, N., "Predictive Incapacity and Rational Decision," p. 39.

[747] SALMON, M. H., "Philosophy of the Social Sciences," in SALMON, M. H. ET AL., *Introduction to the Philosophy of Science*, Prentice Hall, Englewood Cliffs, NJ, 1992, p. 406. On this topic, see GONZALEZ, W. J., "Sobre la predicción en Ciencias Sociales: Análisis de la propuesta de Merrilee Salmon," *Enrahonar*, v. 37, (2005), pp. 181-202.

corresponds with the three realms of rationality: (i) cognitive error, which arises when there are failures in information acquisition; (ii) practical error, which involves failures with regard to the goals of action; and (iii) axiological error, which has to do with failures in the realm of evaluation.[748]

Consequently, when we accept a belief, make an action, or evaluate different alternatives, there is always certain risk of error. Rescher's interest is mainly in the problem of risk in relation to cognitive rationality. His approach is, above all, a criticism to skepticism. Thus, in his judgment, the acceptation of information as valid always involves certain risk. However, he considers that we need to calculate the risk and, in some cases, assume it, if we expect to obtain some benefit from the cognitive undertaking.

This issue is connected with scientific prediction is several successive levels. Firstly, prediction is a statement that provides information about a potential future. Therefore, it can be considered that, by accepting a predictive statement as true, we assume a higher risk than when we accept as true information regarding past or present facts. In effect, it is not possible to test now what prediction states about the future. Secondly, prediction can anticipate a risk (a natural disaster, for example), so it can be linked with the problem of rational decision-making. Thirdly, the relation between prediction and prescription intervene, because, once the risk is anticipated, decisions should be made about the adequate measures to avoid or, at least, minimize that risk.

4.5.1. Cognitive Rationality and Risk: A Criticism of Skepticism

Within an epistemological framework of fallibilism, it is assumed that every attempt to obtain knowledge — human, in general, and scientific, in particular — involves certain risk. In Rescher's judgment, "virtually all of our

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[748] Cf. RESCHER, N., *Error: On Our Predicament When Things Go Wrong*, University of Pittsburgh Press, Pittsburgh, PA, 2007, p. 1.

ventures in claiming knowledge about reality carry some risk of cognitive error in their wake: it is unavoidable companion of the enhancement of knowledge."[749]

When we try to obtain knowledge, it is not possible for us to achieve conclusions that we can consider true beyond doubt. History of science itself leads us to think that the hypotheses and theories that we accept now will be revised in the future.[750] In effect, Rescher considers that "the skeptical tradition reminds us that all our claims to knowledge and truth carry some element of risk."[751]

Regarding the problem of risk, Rescher maintains that there are three different approaches that are related to three different types of personalities: (i) *risk avoiders*, who are people who have little or no tolerance for risk (ii) *risk seekers*, who are people extremely tolerant for risk; and (iii) *risk calculators*, who proceed in a cautious way, taking risks only when the situation seems to be favorable.[752] Regarding cognition, the first of these approach corresponds with a skeptical position regarding knowledge, according to with no risk should be assumed, since there is no guarantee that it is possible to achieve true knowledge.

But, although they never assume risks, the possibility of error is not completely avoided. This is because, regarding knowledge, errors can be of two different types: errors of commission and errors of omission.[753] Errors of commission can be avoided in two different ways: by giving less informative answers or by giving no answer to the questions posed. In both cases alike there are errors of omission. By offering vague and insufficient answers, the risk of errors of commission is avoided (to accept false claims); but the

[749] RESCHER, N., "Cognitive Compromise: On Managing Cognitive Risk in the Face of the Imperfect/Flawed," p. 59.
[750] Cf. RESCHER, N., "The Problem of Future Knowledge," pp. 149-163.
[751] Cf. RESCHER, N., *Rationality*, p. 72.
[752] Cf. *Rationality*, pp. 54-64.
[753] Cf. RESCHER, N., "Cognitive Compromise: On Managing Cognitive Risk in the Face of the Imperfect/Flawed," in RESCHER, N., *Epistemological Studies*, p. 61.

knowledge that can be achieved in this way is unsatisfactory, because the detail, accuracy, precision, etc. are values that should accompany scientific knowledge.

Furthermore, the achievement of knowledge (human and scientific) is a human need. For Rescher, "the knowledge that orients our activities in this world is itself the most practical of things—a rational animal cannot feel at ease in situations of which it can make no cognitive sense. We have questions and want (nay, *need*), to have answers to them. And not just answers, but answers that cohere and fit together in an orderly way can alone satisfy a rational creature. This basic practical impetus to (coherent) information provides a fundamental imperative to cognitive intelligence."[754]

Therefore, when we accept information as valid we are always taking certain risk. On the one hand, there can be errors of commission (when a false belief is accepted) or there can be errors of omission (when a true belief is rejected). Risk avoiders will incur many errors of omission; while risk seekers will incur may errors of commission. For Rescher, the most adequate position is the approach of the *risk calculators*, who based their choices and actions on "sensible calculation and prudent management."[755] In effect, the achievement of answers is a human need, which should be satisfied. Faced with the risks of this task, the rational thing to do is "acting as best we can to balance the positive risks of outright loss against the negative ones of lost opportunity."[756]

In this way, the practical aspect of rationality and therefore the methodological component of the scientific undertaking are highlighted. So, Rescher agrees when the skeptical tradition when he claims that "*each* of our accepted beliefs *may* turn out to be false, and many of our accepted beliefs

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[754] RESCHER, N., *Rationality,* p. 65.
[755] *Rationality*, p. 59.
[756] RESCHER, N., *Rationality*, p. 59.

will turn out to be false."[757] But this feature does not involve, in his judgment, that every attempt to obtained knowledge is doomed to failure. Skepticism is directed to the content of concrete theses. For Rescher, this is a wrong approach, since the problem is of a methodological character and is related to the policies for the acceptation of theories.[758]

In other words, we have to establish cognitive policies that can be justified and that allow us to accept as valid the concrete statements, hypotheses and theories. This is because, at the level of the cognitive content, there is always certain risk of error. In the case of the knowledge about the future, for example, it should be accepted that both a prophecy of a clairvoyant and a scientific prediction can turn out to be false. However, unlike a prophecy, we can establish that a scientific prediction is reliable, if there are theoretical or empirical proofs that justify the inference of future.

Nevertheless, it is not possible to completely eliminate the cognitive risk. But a policy regarding risk should be accepted, in order to minimize the errors and have the maximum possible benefits, so we can meet our need of knowledge. Once again, practical rationality is crucial, because the costs and the benefits of the scientific research should be correctly calculated. Thus, "the crucial fact is that inquiry, like virtually all other human endeavors, is not a cost-free enterprise. The process of getting plausible answers to our questions also involves costs and risks. Whether these costs and risks are worth incurring depends on our valuation of the potential benefit to be gained."[759]

Therefore, Rescher's approach to the problem of risk is mainly pragmatic. The presence of risks in the cognitive venture must be acknowledged. This feature should not lead us to skepticism, but to a realist

[757] RESCHER, N., *The Limits of Science*, revised edition, p. 34.
[758] Cf. RESCHER, N., *Rationality*, pp. 61-64.
[759] RESCHER, N., "Cognitive Compromise: On Managing Cognitive Risk in the Face of the Imperfect/Flawed," in RESCHER, N., *Epistemological Studies*, p. 61.

position about what is possible — both in the sense of attainable and acceptable — for us. In effect, achieving knowledge is a human need that serves as a basis for action. An action can be performed on the basis of not cognitive policies (instinct or tradition, for example), but this is not good enough. As a rational creature, human being not only seeks to act, but also *to justify* the actions he choices to perform.[760]

Consequently, if no cognitive risk is assumed, the costs are too higher, since it avoids, from the very beginning, every attempt to obtain true knowledge. Also the opposite position — that tends to be extremely tolerant regarding the risk — has problems, because it involves many risks of commission; that is, to accept as valid beliefs that are false. It is necessary some "error management," which allows us to reduce the probability that an error occurs and to reduce the negative consequences of the error when it occurs.[761]

Ideal knowledge is far from the type of knowledge that, in fact, we can achieve. But here "an analogue of the old Roman legal precept is operative here—one is never obliged beyond the limits of the possible (*ultra posse nemo obligatur*).[762] Thus, risk is always present due to the possibility of error, but this possibility can be reduced when the value of knowledge is admitted and, consequently, the potential benefits of the cognitive venture justify the acceptance of certain previously calculated risk. In Rescher's words, "with cognition as elsewhere rationality calls for a pragmatic balance of costs and benefits in the presence of limited resources. Here too we must strike a reasonable compromise between what is ideal and what is affordable."[763]

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[760] Cf. RESCHER, N., *Rationality*, p. 67.
[761] Cf. RESCHER, N., "Cognitive Compromise: On Managing Cognitive Risk in the Face of the Imperfect/Flawed," in RESCHER, N., *Epistemological Studies*, p. 62.
[762] RESCHER, N., *Rationality*, p. 70.
[763] Cf. RESCHER, N., "Cognitive Compromise: On Managing Cognitive Risk in the Face of the Imperfect/Flawed," in RESCHER, N., *Epistemological Studies*, p. 63.

4.5.2. Risk and Prediction

For Rescher, every attempt to obtain knowledge involves risks. In the case of the predictive knowledge this is even clearer, because prediction is about a potential future or a reality that we do not know now, instead of deal with past or present phenomena and events. Thus, prediction can turn to be false. For this reason, by accepting its content we assume risks of error, either of commission or of omission. Assuming the risks is a question that depends on two crucial factors: on the one hand, the *reliability* of the prediction; and, on the other, the *benefits* derived from the knowledge that prediction provides.

The reliability of a statement about the future depends on its rational bases. Thus, when there are not rational bases that justify the inference from the available data, prediction is not credible. In effect, "only reasonable and substantive predictions—those which are both informative and can be rendered plausible to other people by way of substantiation—are of any cognitive interest."[764] Consequently, the risk of error would be higher in a "prediction without reasons" than in a reasoned prediction, since rational prediction has evidential basis that justifies it.

However, predictive success cannot be guaranteed. In fact, Rescher considers that prediction is an inherently risky business.[765] But the risk should be assumed, since the complete lack of knowledge about the future is more damaging than the possible errors derived from our attempt to know it. Thus, he insists that to obtain some knowledge about the future events and developments is a human need: "to act, to plan, to survive, we must anticipate the future."[766] So, in his judgment, every human action depends, to some extent, on information about the future.

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[764] RESCHER, N., *Predicting the Future*, p. 55.
[765] Cf. *Predicting the Future,* p. 59.
[766] RESCHER, N., *Predicting the Future*, p. 64.

Also prediction can be about a matter that involves risks (the anticipation of a natural disaster, for example). In that case, prediction connects with risk management that, in turn, is related with prescription (applied science) and decision-making (application of science). Rescher defines risk as “the chancing of a negative outcome.”[767] Thus, he considers that it is an ontological notion instead of being an epistemological issue. This distinction leads him to differentiating two aspects: on the one hand, *to run a risk*; and, on the other hand, *to take a risk*, which involves an epistemic component that is not present in the first case.[768]

To run a risk is something that happens independently of the knowledge that there is or there will be a situation of risk. In this case, the individual or the society is facing a risk that is unknown, so the situation of risk is not linked with any type of action performed by the agents. Meanwhile, when a risk *is taken*, there is a previous knowledge that some king of harm or lost can occur. Thus, it implies a choice or choices by the individual or the society, which act on the basis of that knowledge. In this way, the anticipation of risks connects with rational choice and leads to ethical problems that have to do with prediction.

In this second case — “to take a risk” — the problem of risk management arises. Thus, although Rescher’s main interest is not the realm of the applied science, his approach to risk connects with the role of prediction in this area. In fact, from this perspective, prediction is crucial, since only by the anticipation of risks — that is, by prediction — policies can be suggested, either to avoid some occurrence or to produce some result. However, he thinks that the anticipation of the possibility of a risk is easier than the identification of the risk and the determination of its magnitude or

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[767] RESCHER, N., *Risk: A Philosophical Introduction to the Theory of Risk Evaluation and Management*, University Press of America, Washington, 1983, p. 5.
[768] Cf. RESCHER, N., *Risk: A Philosophical Introduction to the Theory of Risk Evaluation and Management*, pp. 6-7.

negativity.[769] Therefore, the evaluation of the magnitude and negativity of the risk predicted is the previous step to what is properly the risk management.

In order to evaluate the magnitude of a risk, three main questions must be valued: (i) character, which is the identification of what type of negativity is at issue: physical injury, monetary loss, etc.; (ii) extent, which is the gravity and magnitude of some risk, which involves issues such as the number of persons affected or the amplitude of the area at danger (in the case of a natural disaster, for example); and (iii) timing, which is the duration of the situation of risk.[770]

But there is the possibility that we cannot evaluate in a precise way the three indicators of the magnitude of a risk. Thus, even when the risk is anticipated, there is usually uncertainty. The very risk of error related to every prediction impedes that we consider a predictive statement as absolutely secure. Moreover, there is a cognitive indetermination, according to which the more informative a prediction is, the less secure it is.[771] In the case of a prediction about a risk (earthquakes, tsunamis, volcanic eruptions, etc.), this involves that the prediction is less secure the more we go deeply in questions such as the extent or timing of the risk.

Within this framework, Rescher notices that uncertainty is the indeterminacy of some of the characteristic elements in a situation of risk.[772] This feature is especially important, since "impredictability and risk go hand in hand in human affairs."[773] Therefore, the cognitive limitations that affect prediction should be taken into account, as well as the problem of uncertainty. In turn, these limits affect the human capacity to control the

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[769] Cf. *Risk: A Philosophical Introduction to the Theory of Risk Evaluation and Management*, p. 18.
[770] Cf. RESCHER, N., *Risk: A Philosophical Introduction to the Theory of Risk Evaluation and Management*, p. 19.
[771] Cf. RESCHER, N., *Predicting the Future*, p. 62.
[772] Cf. RESCHER, N., *Risk: A Philosophical Introduction to the Theory of Risk Evaluation and Management*, p. 94.
[773] RESCHER, N., *Predicting the Future*, p. 237.

future phenomena and events, since “a future we cannot foresee is a fortiori a future we cannot control.”[774] Therefore, to avoid or to minimize a potential risk is only possible is that risk has been anticipated. This has repercussions in the configuration of the applied sciences, where prediction is the previous step to prescription and the subsequent application of science.[775]

Through risk management the aim is to have control over the future events or the repercussions that these events can have on people, society, or the environment. For Rescher, control is “*the capacity to intervene in the course of events so as to be able both to make something happens and to preclude it from happening, this result being produced in a way that is not only foreseen but intended or planned*.”[776] Therefore, there are two main kinds of control: negative control (to preclude something from happening) and positive control (to make something happens). Both can be founded in a context of applied science.

Rescher notices that, generally, the control we can have over the future events and phenomena is a negative control.[777] This usually happens in risk-management. Thus, once a risk has been anticipated, the prescription, in principle, seeks to preclude the risk from happening. In order to do this, we need to intervene in the course of events. This requires a *causal participation* of the individuals in the course of events.[778] But this is not always possible in applied science.

For example, we can anticipate an earthquake, but we cannot prevent it from happening. In this case, the aim of the prescription (applied science) and the planning (application of science) is to minimize the harm predicted. In this causes, the so-called “precautionary principle” is used, according to

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[774] *Predicting the Future*, p. 236.
[775] Cf. GONZALEZ, W. J., “Rationality and Prediction in the Sciences of the Artificial,” pp. 165-186; especially, pp. 181-182.
[776] RESCHER, N., *Predicting the Future*, p. 235.
[777] Cf. *Predicting the Future*, p. 235.
[778] Cf. RESCHER, N., *Predicting the Future*, pp. 235-236.

which measures of protective character should be taken if there is some indicator that a situation of risk will happen (a natural disaster, for example) or when a certain product or technological device might involve risks for health or for the environment.[779] Thus, although it was not possible to anticipate a risk with certainty, we should act in order to prevent it.[780]

However, in principle, the prescription will be more effective if the risk is known in detail. In that case, prediction is crucial, because the evaluation of risk; and, after it, the prescription to orientate the action, will be made on the basis of the kind of knowledge about the future that we can achieve. Therefore, although — as Rescher notices — "impredictability" or, at least, not-predictability "and risk go hand in hand in human affairs,"[781] two things should be sought: firstly, to reduce the uncertainty that accompanies the risk in order to achieve reliable predictions; and, secondly, to implement an effective and efficient risk-management in order to minimize the harms that have been anticipated.

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[779] Cf. GÓMEZ, A., "El principio de precaución en la gestión internacional del riesgo medioambiental," *Política y Sociedad*, v. 40, n. 3, (2003), pp. 113-130.

[780] On this issue, see LUJÁN, J. L. and LÓPEZ CEREZO, J. A., "La dimensión social de la Tecnología y el principio de precaución," *Politica y Sociedad*, v. 40, n. 3, (2003), pp. 53-60; and LUJÁN, J. L. and TODT, O., "Precaution: Building Bridges Between Innovation and Regulation," in GONZALEZ, W. J. (ed.), *Creativity, Innovation, and Complexity in Science*, pp. 173-185.

[781] RESCHER, N., *Predicting the Future*, p. 237.

CHAPTER 5

CONCEPTUAL FRAMEWORK OF THE METHODOLOGY OF PREDICTION AND PRECONDITIONS FOR RATIONAL PREDICTION

In Nicholas Rescher's conception, the methodological characters of scientific prediction are within a framework of methodological pragmatism. According to this proposal, scientific claims and theories should be evaluated following methodological criteria.[782] To do this, there is a procedure that consists of two successive steps: (i) the truthlikeness of scientific propositions[783] or theories can be evaluated through methods of a cognitive character, which are oriented towards the confirmation of those propositions or theories; and (ii) the validity of the methods used should be evaluated on the basis of practical criteria; mainly, the capacity of those methods to achieve successful predictions and control over nature.

Within this context, Rescher's methodology of scientific prediction is connected with his general methodological approach, which is pragmatic. Prediction has a fundamental role in it, since it is the main indicator of methodological efficacy. In order to clarify the conceptual framework of the methodology of prediction, this chapter follows several steps. First, the study is focused on Rescher's methodological pragmatism as a framework for the analysis of scientific prediction from a methodological perspective. Second, the roles of prediction in scientific activity are considered. Third, the attention goes to the different groups of empirical sciences (the natural sciences, the social sciences, and the sciences of the artificial),[784] which have their own

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[782] Cf. RESCHER, N., *Methodological Pragmatism*. *A Systems-Theoretic Approach to the Theory of Knowledge*, chapter 5, pp. 66-80.
[783] "Proposition" is used here with the meaning of the content expressed by a statement, a content that can be evaluated regarding truth or truthlikeness.
[784] The three types of sciences are analyzed here, although Rescher is mainly interested in the natural sciences.

characteristics that have repercussions on prediction in each one of those realms.

Thereafter, the preconditions for rational prediction are analyzed. In Rescher's judgment, those preconditions are three: data availability, pattern discernability, and pattern stability.[785] In his approach, they are necessary and sufficient conditions for predictability, so they are basic in his methodological proposal about scientific prediction. His analysis is made within the framework of methodological pragmatism, which connects with the roles of prediction in sciences, in general, and in each group of sciences, in particular.

5.1. Methodological Pragmatism as a Framework for Scientific Prediction

For Rescher, the questions about the validity of scientific knowledge can (and should) be addressed in an objective way form a methodological perspective. Then, he seeks to clarify the process for the rational warrant of knowledge. According to his approach — which he labels *methodological pragmatism* — we can "monitor tour acceptance of theses via the methods that substantiate them, and then validate these methods by pragmatic tests—specifically considering how well we fare *in applying and implementing its professed claims in matters of prediction and control*."[786]

In this regard, prediction has a crucial role in the articulation of a methodological pragmatism. So, in Rescher's judgment, the validity of theories is considered through the use of methods that lead to the confirmation or disconfirmation of those theories; and, after that, the validity of the methods is assessed in relation to their capacity to provide successful predictions. For this reason, the methodological characters of scientific

[785] Cf. RESCHER, N., *Predicting the Future*, pp. 86-87.
[786] RESCHER, N., *Realistic Pragmatism. An Introduction to Pragmatic Philosophy*, p. 96.

prediction in Rescher's work should be analyzed from the viewpoint of the methodological pragmatism. To do this, first, his characterization of this approach to pragmatism is considered; and, second, the repercussions of methodological pragmatism to scientific prediction are analyzed.

5.1.1. Nicholas Rescher's Characterization of Methodological Pragmatism

Certainly, nowadays pragmatism is not a homogenous philosophical doctrine.[787] There is, in effect, a great diversity of philosophico-methodological approaches within what is generically called "pragmatism."[788] So it is important to notice a set of features that are characteristic of Rescher's methodological pragmatism, which allow us to establish important differences between his approach and other pragmatist proposals. Above all, these differences are related to the notions of "objectivity" and "truth." Moreover, he considers that many of the thesis maintained by authors like William James, John Dewey and, later, by philosophers such as F. C. S. Schiller and Richard Rorty, are not properly pragmatic, but they are the result of a "deformation" of pragmatic philosophy.[789]

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[787] In this regard, see MARGOLIS, J., *Reinventing Pragmatism. American Philosophy at the End of the Twentieth Century*, Cornell University Press, Ithaca, NY, 2002; BACON, M., *Pragmatism: An Introduction*, Polity Press, Cambridge/Malden, 2012; BURKE, F. TH., *What Pragmatism Was*, Indiana University Press, Bloomington, IN, 2013; and CAAMAÑO, M., "Pragmatic Norm in Science: Making them Explicit," *Synthese*, v. 190, (2013), pp. 3227-3246.

[788] It should be highlighted that frequently pragmatism goes hand in hand with other complementary philosophical approach, above all regarding epistemological matters. For example, Philip Kitcher combines realism with pragmatism. Cf. GONZALEZ, W. J. (ed.), *Scientific Realism and Democratic Society: The Philosophy of Philip Kitcher*, Poznan Studies in the Philosophy of the Sciences and the Humanities, Rodopi, Amsterdam, 2011.

[789] "A noteworthy —and distinctly curious— aspect of contemporary American philosophy relates to the fate of 'pragmatism,' which has undergone a remarkable deformation from its original conception. Many —indeed most— philosophers nowadays think of pragmatism as something radically different from what was originally at issue with this conception. And, oddly enough, this latter-day sort of pragmatism is not a 'new improved version' but a markedly inferior product," RESCHER, N., "Pragmatism at the Crossroads," in RESCHER, N., *Pragmatism. The Restoration of its Scientific Roots*, p. 1. (This paper was originally published in *Transactions of the C. S. Peirce Society*, v. 41, n. 2, (2005), pp. 355-365.)

On this matter, Rescher writes that “deflationary epistemologists, including such soft-line pragmatists as William James, are fearful that if we take a hard objectivistic line on the meaning of truth, then truth becomes transcendentally inaccessible and scepticism looms. And they accordingly insist that we soften up our understanding of the nature of truth. But another option is perfectly open, namely to retain the classical (hard) construction of the *meaning* of truth as actual facticity (‘correspondence to fact’) and to soften matters up on the epistemological/ontological side by adopting a ‘realistic’ view of what is *criteriologically* required for staking rationally appropriate truth claims.”[790]

Clearly, he prefers the second option. For this reason, he criticizes Richard Rorty’s conception, according to which pragmatists “suggest that we not ask questions about the nature of Truth and Goodness.”[791] In Rescher’s judgment, the abandonment of the notions of “truth” and “value” or the attempt to replace them with other concepts, such as “utility,” would finally lead to abandoning philosophy.[792] Thus, he does not think that Rorty’s approach is properly a pragmatic approach. In effect, as Rescher sees it, pragmatism must admit the notions of “truth,” “fact,” “objectivity,” and “value.” Furthermore, a realist approach to these notions can be compatible with a pragmatic proposal about the rationality of the human beliefs, actions, choices, and evaluations.

In this way, Rescher’s philosophy is in tune with the pragmatist tradition of Charles Sanders Peirce, who sought to provide a standard of objectivity that can be used as a test for the appropriateness of our factual beliefs.[793]

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[790] RESCHER, N., “Pragmatism and Practical Rationality,” p. 59.

[791] RORTY, R., *Consequences of Pragmatism,* University of Minnesota Press, Minneapolis, 1982, (10th printing 2003), p. xi. This passage is quoted in RESCHER, N., *Realistic Pragmatism*, p. xi.

[792] “On such a view, pragmatism is not so much a philosophical doctrine as a position that urges the abandonment of philosophy and recommends finding something else to do instead,” RESCHER, N., *Realistic Pragmatism*, p. xi.

[793] *Realistic Pragmatism*, p. 58.

Moreover, he sees his own proposal of methodological pragmatism as a return to the Peircean roots of pragmatist thought.[794] Thus, he rejects other proposals, such as James' subjectivist pragmatism, Dewey's pragmatism as social and cultural constructions, and Schiller's and Rorty's relativistic approaches.[795]

Within pragmatism, which he sees as a heterogeneous philosophical doctrine, Rescher distinguishes two main directions: a) pragmatism of the left; and b) pragmatism of the right.[796] "Pragmatism of the left" has its origins in William James' approach, which is articulated on the basis of the preferences of the individuals. It is an account that admits cognitive pluralism and relativism, since it is orientated towards the local and personal dimensions. In this way, it gives primacy to the subjective or intersubjective components.

By contrast, "pragmatism of the right" — which has its origin in the theses maintained by Ch. S. Peirce and C. I. Lewis — seeks objective components. Against the simple preferences, it is focused in what is effective and efficient in the satisfaction of universal human needs. Furthermore, it considers that both the very notion of efficiency and the determination of the universal human needs are questions that can be established in an objective way. For this pragmatic approach, objectivity is crucial and it is connected with an ontological realism that allows us to preserve the notion of truth.

According to Rescher, pragmatism of the left is not properly a pragmatic approach, but an "inferior product."[797] In his judgement, "pragmatism properly understood is a positive doctrine—not one that substitutes practice for truth

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[794] Cf. RESCHER, N., "Pragmatism at the Crossroads," pp. 10-11.
[795] Cf. RESCHER, N., *Realistic Pragmatism*, chapter 1, pp. 1-56; especially, pp. 15-31 and 44-47; and chapter 2, pp. 57-80.
[796] Cf. *Realistic Pragmatism*, pp. 64-69.
[797] RESCHER, N., "Pragmatism at the Crossroads," p. 1.

but one that involves practice as our best available *test* of truth."[798] For this reason, Rescher sees his *methodological pragmatism* as a return to the Peircean roots of the pragmatist tradition.

With this background vision about the processes of research, methodological pragmatism — as Rescher conceives it — is a proposal about how is it possible to evaluate the truth or truthlikeness of scientific propositions or theories. There are, in his analysis, two main ways of justifying beliefs: a) discursively; and b) methodologically.[799] Thus, a belief is justified discursively when other previously accepted claims are offered as reasons for the acceptance of the belief. Meanwhile, a belief is methodologically justified when considerations are used that appeal to methods; that is, to processes of research that have clear rules.

When a belief is evaluated methodologically, a procedure is used that follows two successive steps:[800] Firstly, theses are justified by the application of a method; and, secondly, the adoption of a particular method is justified on the basis of certain practical criteria, "preminently, success in prediction and efficacy in control."[801] In this regard, it should be noticed that Rescher's thought, which is a system of pragmatic idealism, combines a realist notion of truth with a pragmatic approach to the evaluation of the content of truth of the scientific claims and theories.

Thus, Rescher considers that the truth of a proposition or theory depends on its agreement with the reality, and he conceives reality as something independent from the knowing subject.[802] In this way, the results of the research — the thesis themselves — can be objective. However, as an idealist philosopher, he insists that the access of human beings to that

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[798] RESCHER, N., "Pragmatism in Crisis," in RESCHER, N., *Profitable Speculations. Essays on Current Philosophical Themes*, Rowman and Littlefield, Lanham, MD, 1997, p. 34.
[799] Cf. RESCHER, N., *Methodological Pragmatism*, pp. 69-70.
[800] Cf. *Methodological Pragmatism*, p. 67.
[801] *Methodological Pragmatism*, p. 67.
[802] Cf. RESCHER, N., "Communicative Pragmatism," pp. 1-48; especially, p. 36.

extramental reality is always mediated by our concepts and mental categories, so scientific knowledge is the result of the interaction between the subject — the researcher — and the reality researched (that in his case is usually the natural reality).[803]

Therefore, within a framework of pragmatic idealism, Rescher thinks that it is not good enough to justify a belief on the basis of other beliefs that were previously accepted, since this only can be done within a concrete conceptual scheme and, hence, it is a process that depends on the subject. Furthermore, the justification of a belief on the basis of previously accepted knowledge is a circular procedure, so there are not objective basis.

These reflections can be seen as an objection to approaches such as the Bayesian, where beliefs have a basic role.[804] In effect, when a belief is discursively justified, other beliefs are offered as reasons for its acceptance. In turn, these other beliefs are justified through other theses that support them, and so on.[805] By contrast, an *instrumental* justification[806] (i.e., properly methodological) is thought-independent, and — on the basis of the efficacy and efficiency of the processes — it avoids the circular character that inheres a discursive justification.

For Rescher, "the truth/reality connection that is operative here is certainly not a cognitively isolated issue subject to no theory-external quality controls. 'Thought externalized' objectivity is still at our disposal. For with

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[803] On this basis, Rescher develops a proposal about science as *our science*. Cf. RESCHER, N., "Our Science as O-U-R Science," in RESCHER, N., *A Useful Inheritance. Evolutionary Aspects of the Theory of Knowledge*, pp. 77-104.

[804] See, in this regard, HOWSON, C. and URBACH, P., *Scientific Reasoning*: *The Bayesian approach*, Open Court, La Salle, IL, 1989 (reprinted in 1990; 2nd edition in 1993).

[805] Cf. RESCHER, N., *Methodological Pragmatism*, p. 70.

[806] Although Rescher uses many times the term "instrumental" regarding his methodological approach, it is certainly not an instrumentalist approach in the sense of a subordination of theory to practice in terms of importance. In effect, practical rationality that, in his judgment, allows us to decide about the rationality of the processes also encompasses a theoretical dimension. Practice and theory are equally important. However, "it takes considerations of purposive effectiveness to provide the test-standard for the adequacy of the operative principles of human endeavor —alike in theoretical and in practical matters. Effective implementation is its pervasive standard of adequacy," RESCHER, N., "Pragmatism and Practical Rationality," pp. 43-44.

regard to our methodological resources of truth-estimation we can indeed deploy a theory-external means of quality control, such as applicative efficacy."[807] Thus, in his judgment, the question whether a method works (that is, if it is effective and efficient in achieving a goal) can be determined in an objective way on the basis of predictive success.

There is a search for objectivity: the pragmatism that Rescher suggest does not reduce the questions about the validity of scientific knowledge to intersubjective or merely subjective criteria. On the contrary, objective bases are sought in order to establish the truth of a claim or theory (or, at least, its truthlikeness). In order to perform this task, the effectiveness of the methods has a crucial role, since it is a matter that is independent from the subject: "methods possess an inherent objectivity and freedom form any sort of personal dependence."[808] In addition, on the basis of the efficacy and efficiency of the processes, the comparative evaluation of alternative methods is possible, as well as to assess the improvements of a concrete method.

Furthermore, Rescher thinks that the efficacy of a method is not only the best criterion for its evaluation, but also the "natural" way of establishing its adequacy.[809] In order to support this claims, he notices the two main characteristics of the scientific methods, in general, and the cognitive methods, in particular: (i) they are teleological (that is, scientific methods are *means* orientated towards the achievement of a certain goal); and (ii) they seek generality, so they can be used in successive occasions.[810]

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[807] RESCHER, N., "Pragmatism and Practical Rationality," p. 59.
[808] RESCHER, N., *Methodological Pragmatism*, p. 73.
[809] Cf. *Methodological Pragmatism*, p. 4.
[810] Cf. RESCHER, N., *Methodological Pragmatism*, pp. 2-5. On the problem of the methodological universalism, see GONZALEZ, W. J., "Methodological Universalism in Science and its Limits. Imperialism versus Complexity," in BRZECHCZYN, K. and PAPRZYCKA, K. (eds.), *Thinking about Provincialism in Thinking*, Poznan Studies in the Philosophy of the Sciences and the Humanities, vol. 100, Rodopi, Amsterdam/N. York, 2012, pp. 155-175.

Regarding the methodology of science, Rescher claims that an *instrumental* conception should be adopted, understood as a combination of mediation and utility, to the extent that methods "are *means for doing things of a certain sort*."[811] Therefore, insofar as they are instruments, methods require an instrumental justification. In turn, this instrumental justification involves taking into account the teleological character of the processes, since a method is always oriented to the attainment of some end: "a *method*, after all, is something intrinsically purpose-relative."[812] This feature involves that methods, in some sense, are contextual and can be diversified according to the different ends sought.

Due to the primacy of the practical view,[813] the justification of a method should be — for Rescher — pragmatic. Because the methods are means in order to achieve some goal, their validity is something that directly depends on their efficacy and efficiency in the achievement of that goal. For this reason, he considers that "the pragmatists were surely right: there can be no better or more natural way of justifying a *method* than by establishing that 'it works' with respect to the specific appointed tasks that are in view for it."[814] Then, the basic criterion for a rational evaluation of a method is its *success*, which he understands as efficacy and efficiency regarding the goal sought.

For Rescher, when something is oriented towards the achievement of a certain goal, for this very reason it should be subject to an evaluation that takes into account its efficacy. Thus, the adequacy of a method depends on what extent it achieves it goal in an effective and efficient way. This connects the notion of efficacy with human rationality, since the role of economic rationality is highlighted with regard to the selection of the processes: "a

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[811] *Methodological Pragmatism*, p. 3.
[812] RESCHER, N., *Methodological Pragmatism*, p. 3.
[813] Cf. RESCHER, N., *The Primacy of Practice*, Basil Blackwell, Oxford, 1973. Spanish version: *La primacía de la práctica*. *Ensayos en torno a una teoría pragmático-kantiana del conocimiento empírico*, Tecnos, Madrid, 1980.
[814] *Methodological Pragmatism*, p. 3.

rational creature will prefer whatever method process or procedure will, other things equal, facilitate goal realization in the most effective, efficient, and economical way."[815]

Besides its teleological character, another characteristic of the methodology of science is its general character.[816] For this reason, what matters is not success as such, but success regarding methods should be *systematic*.[817] On the basis of the general character of the scientific methods, Rescher maintains that "one success does not validate a method."[818] Thus, the occasional or isolated success is something irrelevant.[819] In this way, his perspective regarding the methodology of science is clearly systematic. Moreover, it assumes the general character of scientific methods.

This systematic character allows Rescher to face the objection regarding the role that chance or luck can have in the success of an action or procedure. He admits that the success of a method — that is, that it achieved its goal in one occasion in an effective and efficient way — cannot be de basis to claim the validity of that method. The same happens when a method "fails" in one particular occasion. Undoubtedly, an action performed on the basis of false beliefs can have a positive result, and also an action performed on the basis of truth beliefs can have a negative result.

Therefore, Rescher considers that the generality of scientific methods should be taken into account, insofar as they are characterized by being capable of implementation on numerous occasions. For this reason, he maintains that a "sensible pragmatism" would propose an instrumental

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815 RESCHER, N., "Pragmatism and Practical Rationality," p. 44.
816 Rescher considers that a method consists of a series of general rules or patterns in order to perform a task, so it is possible to use a method in successive occasions. However, there are different levels of generality or abstraction regarding the methods, depending on the general or specific character of the matter at issue. In this way, he assumes that different levels of scales of reality (macro, meso, and micro) require different methods. Cf. RESCHER, N., *Personal Communication*, 10.6.2014.
817 Cf. RESCHER, N., *Realistic Pragmatism*, p. 84.
818 RESCHER, N., *Methodological Pragmatism*, p. 5.
819 Cf. RESCHER, N., *Realistic Pragmatism*, p. 84.

justification at a generic and systematic level.[820] In this way, the success of a method should be evaluated taking into account its performance on numerous occasions and in the long run. In these terms, Rescher's methodological pragmatism seeks an evaluation of scientific knowledge on the basis of objective indicators. Methodological efficacy is a key factor, since it is "a matter of how things go 'across the board' generally and in the long run."[821]

On the basis of the efficacy and efficiency of the processes as objective matters that are independent from the subjects, Rescher defends a procedure to decide about the truth of scientific propositions and theories that takes into account the success of methods. He does not reject a realist notion of "truth," neither he suggests replacing it with the concepts of "efficacy" or "efficiency;" but he does consider efficacy and efficiency at the methodological level as the best criterion about the truthlikeness of scientific propositions and theories. Thus, as procedures, scientific methods depend in no way on subjective (or intersubjective) considerations (in this way, he rejects the primacy of the consensus), but they are susceptible of an objective evaluation, which takes into account how they, in fact, perform their function.

Within this framework, prediction has a fundamental role. It is crucial in Rescher's methodological pragmatism; because, in order to claim that a scientific theory is true or has truthlikeness, the main criterion is ultimately its capacity to predict with success future phenomena. This use of prediction as a test for theories is because prediction, in a clear way, can be tested with the experience. The success of prediction allows us to confirm theories, while its lack of success leads to the disconfirmation of the theories.[822] Thus, in his

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[820] Cf. *Realistic Pragmatism*, p. 85.

[821] RESCHER, N., *Methodological Pragmatism*, p. 5.

[822] In this regard, Rescher notices that "on the standard 'inductive' model of scientific method, the predictions of science are generated by logico-mathematical derivations that

approach, the success of predictions is "the pivotal controlling factor for quality control in scientific theorizing."[823]

5.1.2. Application of Methodological Pragmatism to Scientific Prediction

The applicative efficacy of a method is its capacity to provide successful predictions and effective control over phenomena. Thus, scientific prediction is very important in the framework of methodological pragmatism. Rescher maintains that the acceptability of theories can be justified on the basis of methods. In turn, the adequacy of the methods depends on their efficacy in obtaining successful prediction and in the achievement of control over phenomena. Therefore, prediction is a test for the acceptability of theories, which, in rigor, should vary in order to adequate the different objects (natural, social, or artificial).[824]

As a test for theories, Rescher considers that prediction is also an important indicator of scientific progress. Thus, there is progress when there is an increasing success in prediction. In this regard, Ilkka Niiniluoto has highlighted the discrepancies between Rescher's methodological pragmatism and a realist approach to scientific progress. Niiniluoto writes that, "according to Rescher, science is realist 'in its intention,' but its achievements or its progress must be defined in terms of its increasing success in the control or 'physical domain over nature.' Here, the realist [philosopher] disagrees with the pragmatist [author]: this pragmatic success is, at the most, one indicator of cognitive success. Furthermore, there can be genuine cognitive success

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apply general theories to situation-specific facts so as to preindicate future observations. Then, insofar as the actual observations *agree* with those predictions, the theories at issue are confirmed and thereby evidentially substantiated, and insofar as they *diverge*, the theories are disconfirmed and evidentially undermined," RESCHER, N., *Predicting the Future*, p. 161.

[823] *Predicting the Future*, p. 161.

[824] Usually, Rescher does not distinguish between the subject matters of the natural sciences, the social sciences, and the sciences of the artificial. His approach seeks to be as general as possible.

without practical applications: all science is not reducible to applied research."[825]

However, there are several points where Rescher's approach — of methodological pragmatism — and Niiniluoto's proposal about scientific progress (open to some pragmatic components) are close. This is because Rescher's pragmatic idealism accepts realistic contributions in key concepts (truth, fact, etc.). For this reason, in my judgment, Niiniluoto's criticism does not grasp adequately Rescher's proposal about the role of prediction as indicator of cognitive success and, therefore, of scientific progress. In this regard, a comparison between the approaches of both authors should take into account several levels of analysis:[826] (i) the *semantic* level, which seeks to clarify the concept of "progress;" (ii) the *methodological* dimension, which is focused in the question about what are the reliable indicators in order to claim that a theory is "progressive" with regard to a alternative theory; and (iii) the *factual* level, which analysis when we can claim that science, in fact, has made some progress.

Rescher and Niiniluoto agree with the characterization of scientific progress from a *semantic* perspective: they accept scientific theories as sets of propositions (expressed through statements) oriented towards the truth or, at least, towards truthlikeness. Both authors see "scientific progress" as a notion relative to the goals of science. This claim appears explicitly in Niiniluoto,[827] and it is implicit in Rescher's proposal, according to which we can defend that scientific progress is continuous on the basis of the goals of science.[828] In this case, the concept of "progress" has commonly a positive

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[825] NIINILUOTO, I., "Límites de la Tecnología," p. 402.
[826] Cf. GONZALEZ, W. J., "Progreso científico e innovación tecnológica: La 'Tecnociencia' y el problema de las relaciones entre Filosofía de la Ciencia y Filosofía de la Tecnología," pp. 261-283.
[827] "'Progress' is a normative or goal-relative —rather than purely descriptive— term," NIINILUOTO, I., "Scientific Progress," p. 427. See also NIINILUOTO, I., *Is Science Progressive?*, Reidel, Dordrecht, 1984.
[828] Cf. RESCHER, N., *The Limits of Science*, revised edition, chapter 10, pp. 145-165.

connotation, since it involves an improvement with regard to what was previously available. In this way, it is different from other terms such as "development" or "change."[829]

Regarding the *methodological* issue about which the reliable indicators of scientific progress are, Niiniluoto writes that those indicators are "cognitive factors such as true, information, explanatory power, predictive capacity, precision, and simplicity."[830] Then, he considers that Rescher insistence in prediction as indicator of the truthlikeness of theories results in a partial view of scientific progress. Pragmatic success would be, at most, an indicator of cognitive success, but neither the only one nor the most important one.[831]

But Rescher, in rigor, does not claim that predictive success is by itself an indicator of the truthlikeness of theories. In his judgment, "only a reciprocally interactive gearing of explanation, prediction, and control can in the final analysis provide a satisfactory standard of scientific adequacy."[832] This is because usually scientific prediction should be supported by an explicative knowledge of phenomena. Furthermore, this interrelation of explanation and prediction is the basis to establish the barriers between scientific prediction and non-scientific prediction.[833] For this reason, when there is some improvement in the predictive capacity of science, there is also progress at the theoretical level.[834]

The main difference between both approaches — scientific critical realism and pragmatism — is then rooted in the way they address the *factual* question about when we can claim that science, in fact, has progressed. The answer, for Niiniluoto, is in the notion of truthlikeness. Thus, we claim that

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[829] Changes might be positive or negative as well as developments, which might be positive or negative.
[830] NIINILUOTO, I., "Límites de la Tecnología," p. 402.
[831] Cf. "Límites de la Tecnología," p. 402.
[832] RESCHER, N., *Predicting the Future*, p. 165.
[833] Cf. *Predicting the Future*, pp. 169-171.
[834] This can be clearly seen in Rescher's "thesis of harmony," according to which explanation and prediction are not symmetrical processes, but they are closely interrelated as crucial goals of science. Cf. RESCHER, N., *Predicting the Future*, pp. 167-169.

science has made some progress in accordance to the relative success of scientific theories in the achievement of true or, at least, verisimilar knowledge about reality.[835] Meanwhile, for Rescher, this *factual* issue is, in fact, methodological. Thus, the capacity of the methods to achieve successful predictions or an effective control over reality is the best criterion we have in order to assess the theoretical adequacy of theories.

From this perspective, when Rescher maintains that "science does indeed progress not, to be sure, by way of "approaching the ultimate truth," but by providing us with increasingly powerful instrumentalities for prediction and control,"[836] he does not claim that because he consider that there is scientific progress only in pragmatic lines. Successful prediction is not, for Rescher, the only indicator about the comparative theoretical adequacy of theories, but it is the best criterion we have. Predictive efficacy is, in his judgment, "the best available token for the explanatory adequacy of our theories."[837]

According to Niiniluoto's approach, scientific progress consists of an increasing truthlikeness,[838] where prediction has also a role. Rescher also considers that science makes progresses in that direction. However, in his judgment, prediction should be emphasized when the question at stake is to justify that, in fact, truthlikeness has been achieved. This is because successful prediction provides an objective criterion in order to confirm or disconfirm a theory and to compare its adequacy in relation to other alternative theories. In that case, prediction appears as a result, which acquires the form of a statement and is backed up by experience.

Therefore, prediction is a key notion in Rescher's characterization of scientific progress. He addresses this issue mainly from the methodological

[835] Cf. NIINILUOTO, I., "Límites de la Tecnología," p. 402.
[836] RESCHER, N., *The Limits of Science*, revised edition, p. 42.
[837] RESCHER, N., *Predicting the Future*, p. 164.
[838] Cf. NIINILUOTO, I., *Is Science Progressive?*, chapter 5, pp. 75-110.

realm, as a process oriented towards the increase of knowledge and the control over phenomena. Furthermore, the prominent role of prediction in his methodological pragmatism has also incidence in the configuration of the methodological characters of scientific prediction. This can be seen in the importance of the methodological component within the whole set of the philosophico-methodological characters of prediction (semantic, logical, epistemological, methodological, ontological, axiological, and ethical).

Moreover, in my judgment, many of the most important contributions of Rescher to the study of scientific prediction are in the realm of the methodology of prediction. Then, it can be highlighted his effort in order to offer a methodological approach to prediction that is exhaustive and appropriate to scientific practice. This involves taking into account the roles of prediction in the scientific activity, which varies in the contexts of basic science, applied science, and the application of science. Thus, Rescher considers prediction as an aim of science. Within an approach of methodological pragmatism, he especially insists in the role of prediction as a test for theories and guide for discovery; but he also takes into account its use in the applied sciences, where prediction is usually the previous step to prescription.[839]

He also wants to clarify the common features of the different processes of prediction, insofar as they are rational processes. In this regard, he suggests three *preconditions* for rational prediction: data availability, pattern discernability, and pattern stability.[840] Concurrently, he assumes a methodological pluralism regarding prediction. Thus, he offers an analysis of the diverse predictive processes, which he classifies in three groups: (i)

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[839] Cf. GONZALEZ, W. J., “Análisis de las Ciencias de Diseño desde la racionalidad limitada, la predicción y la prescripción,” in GONZALEZ, W. J. (ed.), *Las Ciencias de Diseño: Racionalidad limitada, predicción y prescripción*, Netbiblo, A Coruña, 2007, pp. 3-38; and SIMON, H. A., “Prediction and Prescription in Systems Modeling,” *Operations Research*, v. 38, (1990), pp. 7-14 (reprinted in SIMON, H. A., *Models of Bounded Rationalitity*, *Vol. 3: Empirically Grounded Economic Reason*, The MIT Press, Cambridge, MA, 1997, pp. 115-128).

[840] Cf. RESCHER, N., *Predicting the Future*, pp. 86-87.

estimative procedures; (ii) discursive elemental processes; and (iii) discursive scientific methods.[841]

Thereafter, his contribution to the analysis of the methodological characters of scientific prediction encompasses different problems at stake: (a) the roles of prediction in scientific activity; (b) the preconditions for rational prediction; and (c) the methods of prediction. Furthermore, regarding the methods, he made an effective contribution, because he was one of the creators of the Delphi predictive procedure.[842] Within the special level of the methodology of science — which takes into account the distinctive features of each science or each group of sciences (the natural sciences, the social sciences, or the sciences of the artificial) — he pays more attention to the realm of the natural sciences; although he also takes into account the role of prediction in the methodology of the social sciences. Thus, he also addresses some specific problems of economics and sociology.[843]

Nevertheless, due to his methodological pragmatism, he highlights above all the methodological aspect of scientific prediction as a test for theories. In turn, this feature leads to a pragmatic approach of prediction itself, according to which prediction is, above all, an *instrument*.[844] The instrumental aspect of prediction appears insofar as he considers that prediction allows us to judge the comparative theoretical adequacy of the theories and to the extent that prediction might serve as a guide for human action. This approach to prediction as an instrument is due to its connection with practice, but it does not involve an instrumentalist account of science.

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[841] Cf. *Predicting the Future*, p. 87.

[842] On the predictive procedure Delphi, see AYYUB, B. M., *Elicitation of Expert Opinions for Uncertainty and Risks*, pp. 99-105; and BELL, W., *Foundations of Futures Studies. History, Purposes, and Knowledge*, *Human Science for a New Era, Vol. 1*, pp. 261-272.

[843] Cf. RESCHER, N., *Predicting the Future*, ch. 11, pp. 101-208; especially, pp. 193-202.

[844] "Prediction, in sum, is our instrument for resolving our meaningful questions about the future, or at least of *endeavoring* to solve them in a rationally cogent manner," RESCHER, N., *Predicting the Future*, p. 39.

De facto, Rescher is clearly against the methodological instrumentalism. He maintains that “some philosophers take this matter of the predictive utility of good theories too far by adopting a wholly ‘instrumentalistic’ view of the theories of natural science as mere predictive instruments, altogether dismissing the issue of describing and explaining the world’s occurrences. On this approach, prediction is *all* that matters and thereby constitutes the alpha and omega of science.”[845]

Therefore, Rescher’s methodological pragmatism involves an instrumentalist approach to prediction, but it does not encompass a methodological instrumentalism that subordinated scientific methods to the aim of predicting.[846] In this way, he highlights prediction as a fundamental component of science (this can be mainly seen in relation to the roles that prediction plays in scientific activity) without subscribing a strong predictivist thesis, according to which prediction has a clear primacy over any other goal of science.

5.2. The Roles of Prediction in Scientific Activity

In order to analyze the roles of prediction in scientific activity, the distinction between basic science and applied science should be considered. Because basic science and applied science are different activities,[847] the uses of prediction in them can be also different. Wenceslao J. Gonzalez has highlighted that the differences between both kinds of sciences have to do with three successive levels of the scientific research: (i) the goals or aims; (ii) the processes; and (iii) the results.[848] In turn, those differences between

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[845] RESCHER, N., *Predicting the Future*, p. 164.
[846] Cf. RESCHER, N., *Predicting the Future*, p. 39.
[847] On the differences between basic science and applied science, see NIINILUOTO, I., "The Aim and Structure of Applied Research," pp. 1-21; NIINILUOTO, I., "Approximation in Applied Science," pp. 127-139; and GONZALEZ, W. J., “The Philosophical Approach to Science, Technology and Society,” pp. 3-49.
[848] Cf. GONZALEZ, W. J., “Ciencia y valores éticos: De la posibilidad de la Ética de la Ciencia al problema de la valoración ética de la Ciencia Básica,” in GONZALEZ, W. J. (ed.), *Ciencia y*

both kinds of sciences have incidence on the uses of prediction in scientific activity.

From the perspective of the *aims* of the research, we have basic research when scientific activity seeks either to obtain new knowledge or to increase the knowledge already available. Thus, the basic research is mainly oriented towards giving answers to questions of a cognitive character. Meanwhile, applied science seeks to achieve new knowledge with a specific purpose, which can be either to solve a concrete problem or solving it in a more efficient way.[849]

There are also differences between both kinds of sciences regarding the *processes*. From this perspective, scientific methods in basic science are mainly oriented towards the achievement of new knowledge or the improvement of the available knowledge (both predictive and explicative), so a main feature is the search for empirical support for the hypotheses and theories. However, in applied science "the means acquire an operative character, on having had direct relation with specific ends (that means, the practical knowledge has to allow to achieve more efficient processes to solve the particular problems that have been raised)."[850]

Moreover, there are differences between basic science and applied science from the point of view of the *results*. These differences have to do, above all, with the criteria for evaluating the results obtained. In basic science, the criterion of truthlikeness is the main one. Thus, the results are evaluated on the basis of the increase of the available knowledge, to the extent that the main aim of truthlikeness is achieved. Meanwhile, in applied science, the evaluation of the results can be done following cognitive criteria

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valores éticos, p. 158; and GONZALEZ, W. J., *Philosophico-Methodological Analysis of Prediction and its Role in Economics*, pp. 32-40.

[849] Cf. NIINILUOTO, I., "The Aim and Structure of Applied Research," pp. 3-5.

[850] BEREIJO, A., "The Category of 'Applied Science'. An Analysis of its Justification from 'Information Science' as Design Science," in GONZALEZ, W. J. (ed.), *Scientific Realism and Democratic Society: The Philosophy of Philip Kitcher, Poznan Studies in the Philosophy of the Sciences and Humanities*, v. 101, Rodopi, Amsterdam/N. York, 2011, p. 338.

(the adequacy of the knowledge in order to solve the concrete problem at stake) or according to practical parameters (efficacy and efficiency in the solution of the problem).[851]

In this way, the differences between basic science and applied science — which have to do with the aims or goals, the processes, and the results — highlight a background difference between both kinds of research: there is a pragmatic or instrumental feature that is more emphasized in applied science than in basic science, which gives primacy to the theoretical or epistemic component. In turn, these differences between basic science and basic science have repercussions on the role played by prediction in both kinds of sciences. Thus, the roles of prediction vary according to the context in which it is made: basic research or applied research.

Basic science seeks to, firstly, describe phenomena; and, secondly, explain or predict these phenomena. If it is merely confined to describing phenomena, then there is not a genuine scientific contribution. Thus, prediction is a main aim of basic research, because it provides knowledge about future events or happenings. For this reason, scientific methods can be oriented towards prediction, which also has a fundamental role in the evaluation of the results. In effect, the knowledge about the future can be used as a test for hypotheses and theories, since it provides the empirical content that is required for testing them.

But, when prediction is made in applied science, prediction is — besides an important aim by itself — a tool for decision-making. In this way, prediction is connected with prescription, because in order to prescribe (i.e., to suggest paths of action to solve a concrete problem), it is necessary to predict. Thus, in the realm of the applied science, prediction is the previous step of prescription. For this reason, prediction in applied sciences can be

[851] Cf. BEREIJO, A., "The Category of 'Applied Science'. An Analysis of its Justification from 'Information Science' as Design Science," p. 338.

considered as a methodological tool: the prediction about the possible future is needed in order to establish the paths that should be followed.[852]

Now then, when the distinction between applied science and the application of science is posed, it seems clear that we should take into account another role of prediction, which is related to practical problem-solving (in political contexts, economic, ecological, etc.). This distinction between applied science and the *application of science* has been highlighted by Niiniluoto. In his judgment, "the former is a part of knowledge production, the latter is concerned with the use of scientific knowledge and methods for the solving of practical problems of action (e.g., in engineering or business)."[853] From this perspective, prediction can be the basis of decision-making in contexts of policy.[854]

Within the application of science, the use of knowledge by agents (individual or institutional) prevails. In this way, on the basis of the same applied knowledge, two agents can apply knowledge in different ways in their respective contexts. A prediction about the possible future has been obtained, but what prevails is an agent-relative component, since the agents make decisions according to different contexts. This feature also affects the prescriptions.[855]

Therefore, prediction encompasses several roles.[856] 1) In basic science, prediction can be used as a test for theories, in general, and hypotheses, in particular. This use of prediction can be seen both in natural sciences (for example, physics, chemistry, or astronomy) and in social sciences (among

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[852] Cf. GONZALEZ, W. J., "Rationality and Prediction in the Sciences of the Artificial," in GALAVOTTI, M. C., SCAZZIERI, R. and SUPPES, P. (eds.), *Reasoning, Rationality and Probability*, p. 181.
[853] NIINILUOTO, I., "The Aim and Structure of Applied Research," p. 9.
[854] On the distinction between basic science, applied science, and the application of science, see GONZALEZ, W. J., "The Roles of Scientific Creativity and Technological Innovation in the Context of Complexity of Science," pp. 11-40; especially, pp. 17-18.
[855] Cf. GONZALEZ, W. J., "The Roles of Scientific Creativity and Technological Innovation in the Context of Complexity of Science," pp. 17-18.
[856] Cf. GONZALEZ, W. J., *La predicción científica*, p. 11.

others, economics or sociology) 2) In the case of the applied science (pharmacology, medicine, applied economics, etc.), prediction is usually the previous step to prescription. In this realm, the anticipation of the future is necessary before paths of action can be suggested in order to solve concrete problems. 3) When the problem of the application of science is considered, prediction has also a role, since it can serve as the basis of the procedures of decision-making.

5.2.1. The Role of Prediction as Test in Basic Science

When Rescher considers the uses of scientific prediction, he usually focuses his attention in the role of prediction as test for theories. In this regard, he notices that prediction has mainly two uses in science: "as a test of the acceptability of theories and as a guide to discovery. No other factor shows more clearly that we are making real (rather than merely putative) progress in natural science than the successful prediction of new phenomena."[857]

Commonly, Rescher contemplates this use of prediction regarding the sciences of nature. In general, he thinks that the predictive capacity is much higher than in the case of social sciences (he does not address expressly the sciences of the artificial). Concretely, in the case of economics, he considers that quantitative prediction — in accurate and precise terms — is usually not possible. Thus, predictive success in this science is habitually obtained at the level of generic predictions regarding trends and probabilities.[858]

For this reason, it is possible to maintain that there is a duality in Rescher's methodological approach to prediction and its roles in scientific activity. At the general level, he considers prediction as a reliable test for the theories; while in the special level (regarding the social sciences and,

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[857] RESCHER, N., *Predicting the Future*, p. 160.
[858] Cf. *Predicting the Future*, pp. 193-199; especially, p. 198.

concretely, economics) it seems that usually predictions do not achieve the level of detail required in order to serve as a test for theories. To a certain extent, he seems to agree with Herbert A. Simon, who maintained that we should have a *wary* attitude regarding the use of prediction as a test for economics as a science.[859]

When Rescher thinks of prediction as a test for theories in the natural sciences, he considers the most specific case of the *surprising predictions*. In this regard, he notices that the importance of prediction is in the *cognitive novelty* that it encompasses: “After all, it would seem to be *cognitive* novelty that is the crux, and futurity as such (mere *chronological* novelty) seems immaterial. The predictive aspect is surely incidental; surprising predictions are important for confirmation, but on account of their surprinsingness rather than their predictivity, seeing that it is epistemic novelty that carries the burden of the work.”[860]

When Rescher analyses scientific prediction, he assumes two different components of the notion of “novelty:” an ontological feature and an epistemic aspect.[861] Scientific prediction involves, in principle, novelty in the ontological sense, because it is oriented towards a possible future. But Rescher highlights the epistemic aspect. In this way, the cognitive content (and, therefore, the epistemic novelty) is the most important feature of a prediction. For this reason, when prediction is used as a test for theories, surprising predictions should have more weight: “if the [predicted] fact is something new in kind —a new phenomenon or a new type of fact that was

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[859] Cf. RESCHER, N., *Predicting the Future*, pp. 198-199 y p. 277, n. 264.
[860] *Predicting the Future*, p. 162.
[861] There is also a third possibility: heuristic novelty. See GONZALEZ, W. J., “The Evolution of Lakatos's Repercussion on the Methodology of Economics,” *HOPOS: The Journal of the International Society for the History of Philosophy of Science*, v. 4, n. 1, (2014), pp. 1-25; especially, pp. 14-16.

not experienced before— then it indeed is in a position to make significant evidential contribution."[862]

In this regard, Rescher considers two options for prediction, which should be taken into account when predictive success is evaluated in the context of basic science: (i) prediction of new instances of familiar phenomena; and (ii) prediction of the occurrence of new phenomena that have not been investigated before.[863] In his judgment, the most important thing is not just having more elements from a quantitative perspective about something already known, but the qualitative achievement of new fields.[864] Thus, in principle, scientific prediction involves a strictly temporal or ontological factor (it is oriented towards a possible future); but surprising predictions are characterized by their *epistemic novelty*, which gives them their value as a test for theories.

Moreover, this use of prediction as a test for hypotheses and theories is a central feature of Rescher's methodological pragmatism. Thus, in his judgment, theories are justified by methods for the validation or confirmation of factual statements; and, in turn, those methods must be evaluated according to practical criteria (above all, the success in prediction and the efficacy in the control of phenomena).[865] In this case, scientific methods should be oriented towards prediction, to the extent that successful prediction is "the pivotal controlling factor for quality control in scientific theorizing."[866]

From this perspective, Rescher's account — in the context of the discussion between "prediction" and "accommodation"[867] — is certainly predictivist. When empirical support is required for theories, in general, and

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[862] RESCHER, N., *Predicting the Future*, pp. 162-163.
[863] Cf. *Predicting the Future*, p. 163.
[864] Cf. GONZALEZ, W. J., *La predicción científica,* p. 267.
[865] Cf. RESCHER, N., *Realistic Pragmatism*, p. 96.
[866] RESCHER, N., *Predicting the Future*, p. 161.
[867] On this controversy about the methodological weight of "prediction" and "accommodation," cf. GONZALEZ, W. J., *La predicción científica*, pp. 288-292. A defense of the predictivist position is in WHITE, R., "The Epistemic Advantage of Prediction over Accommodation," *Mind*, v. 112, n. 448, (2003), pp. 653-683.

for hypotheses, in particular, prediction is — in his judgment — the decisive factor. It is decisive insofar as prediction provides an *epistemic novelty* that can be compared with the future observations: "insofar as the actual observations agree with those predictions, the theories at issue are confirmed and thereby evidentially substiantiated, and insofar as they diverge, the theories are disconfirmed and evidentially undermined."[868]

Consequently, the most rigorous knowledge that science can provide is the knowledge obtained through the predictive success. For this reason, it is possible to claim that scientific methods should be mainly oriented towards prediction, since it is the best test we have for the scientific character of theories. However, Rescher's methodological pragmatism does not involve an instrumentalist approach of scientific methods; i.e., he does not think that scientific methods are simple instruments of prediction. In effect, in his judgment, prediction is not a necessary condition for having science.

It is important to point out that scientific prediction is fallible as a test for theories (a false theory can lead to true predictions, and even a true theory can make prediction that will be disconfirmed by future observations).[869] This feature is acknowledged by Rescher: "the complex interweaving of fact, theory, and conjecture in scientific prediction means that even good theories sometimes yield poor predictions. And contrariwise, even where we make successful predictions this will not necessarily mean that the basis of theory from which they emerge is scientifically appropriate."[870]

Moreover, prediction should not be the only aim of scientific research. For Rescher, prediction is an important aim of science; but it is an aim *among others*. Thus, besides prediction, science should be oriented towards the description, explanation, and control over nature. For this reason, scientific

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[868] RESCHER, N., *Predicting the Future*, p. 161.
[869] Cf. BATITSKY, V. and DOMOTOR, Z., "When Good Theories Make Bad Predictions," pp. 79-103.
[870] RESCHER, N., *Predicting the Future*, p. 169.

methods cannot be simple predictive instruments. However, the methods that allow us to predict have a high values, because successful prediction is the best criterion in order to evaluate the theoretical adequacy of theories.

However, according to the harmony thesis between explanation and prediction suggested by Rescher, scientific methods (in basic science) should be oriented towards the two main aims of the scientific activity: the explanation about past (and present) phenomena and the prediction about the future phenomena. Methods should lead research to the achievement of theories with both explicative and predictive power, since — in Reshcer's judgment — "theories that do not yield predictions are sterile, and predictions—however successful—that lack a theoretical backing are for that very reason cognitively unsatisfactory."[871]

In this regard, it should be noticed that some of our best theories, such as the theory of evolution, do not make, properly speaking, predictions. On this objection, Rescher maintains that "while evolutionary theory does not predict specific outcomes by way of forecasting the modifications of particular species, it does, nevertheless, provide [the content] for predictive inferences at the general level of trends and statistical tendencies."[872]

From these elements, it is possible to maintain that there are theories that are only oriented towards past developments (and that, therefore, do not make predictive inferences), which can have *predictive import*, to the extent that their content can serve as a support in order to achieve statements about the future.[873] Obviously, Rescher is thinking of the natural sciences. But in the realm social sciences, where human events are involved, this

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[871] *Predicting the Future*, p. 167. This is a clear expression of his rejection of the instrumentalist predictivism without realism of the assumption, which was defended by M. Friedman. Cf. FRIEDMAN, M., "The Methodology of Positive Economics," pp. 3-43.

[872] RESCHER, N., *Predicting the Future*, p. 161.

[873] On this issue, Wenceslao J. Gonzalez notices the parallelism between Rescher's distinction between "predictive inference" and "predictive import" and W. C. Salmon's distinction between "predictive import" and "predictive content." Cf. GONZALEZ, W. J., *La predicción científica*, p. 266. See also SALMON, W. C., "Rational Prediction," pp. 115-125.

approach to prediction as a test for hypotheses and theories is more problematic. In effect, there are sciences mainly oriented toward the explanation (for example, history). So if Rescher's approach is accepted, without the required qualifications, the scientific character of these disciplines would be questioned.

5.2.2. The Role of Prediction as a Guide in the Task of Applied Science

Besides the use of prediction as a test for theories, other important role of prediction is to serve as a guide for action, which is its usual role within the framework of applied science. In this realm, prediction is the previous step to prescription, because the anticipation of the possible future is required in order to perform the task of problem-solving. Therefore, prediction is a methodological tool in this context: knowledge of the possible future is required in order to suggest what paths of action should been followed.[874] Thus, in this context of the applied sciences, prediction is a tool for prescription, which is oriented towards providing information in order to solve practical problems.

Since in applied sciences the aim is the solution of concrete problems, the usual procedure is to give predictions in order to prescribe then.[875] In this regard, two features can be highlighted in the relation between prediction and prescription: (i) prediction is prior to prescription, because the indications about how to solve a problem (prescription) are given once the problem has been anticipated (prediction);[876] and (ii) prediction makes it possible the prescriptive task of applied science, because in order to make a prescription

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[874] Cf. GONZALEZ, W. J., "Rationality and Prediction in the Sciences of the Artificial," p. 181.
[875] Cf. "Rationality and Prediction in the Sciences of the Artificial," pp. 181-182.
[876] Cf. GONZALEZ, W. J., "Rationality and Prediction in the Sciences of the Artificial," pp. 181-182.

some knowledge about the possible future is always required.[877] The first one is a chronological feature with methodological incidence; while the second feature leads to a clearly epistemological-methodological aspect.

Regarding prediction as a guide for the applied science's task, Herbert A. Simon has offered a quite interesting proposal. In his judgment, the main aim of the applied sciences, in general, and of the sciences of design, in particular, is the prescription. He thinks that most of the predictive models are oriented towards the prediction of phenomena that human beings cannot control (for example, the meteorological models). For this reason, the main aim of applied science is prescription, which seeks to favor the best possible adaptation to those phenomena.[878]

Unlike Simon, Rescher's main interest is not focused on the sciences of the artificial, but he focuses his attention on the natural sciences. Moreover, he rarely takes into account the role of prediction as a guide for prescription in the realm of applied science. This is because his pragmatism goes hand in hand with a Kantian approach, so prediction is mainly a cognitive content valuable by itself. However, as a pragmatic philosopher, his interest in the nexus between prediction and human action should be highlighted. In this regard, he addresses the problem of the human capacity to shape the future.[879]

But, very often, Rescher addresses this problem in relation to human action, in general, instead of doing so with regard to scientific activity, in particular. In effect, in his judgment, "to act, to plan, to survive, we must anticipate the future."[880] Thus, he does not insist in the use of prediction as a

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[877] Cf. SIMON, H. A., "Prediction and Prescription in Systems Modeling," *passim*. See also GONZALEZ, W. J., *Philosophico-Methodological Analysis of Prediction and its Role in Economics*, chapter 12, pp. 317-338.

[878] Cf. SIMON, H. A., "Prediction and Prescription in Systems Modeling," compiled in SIMON, H. A., *Models of Bounded Rationality*. Vol. 3: *Empirically Grounded Economic Reason*, pp. 115-128; especially, p. 122.

[879] Cf. RESCHER, N., *Predicting the Future*, chapter 14, pp. 231-246; especially, pp. 232-236.

[880] *Predicting the Future*, p. 65.

guide for the development of the scientific activity that seeks to provide solutions to practical problems (that is, the role of prediction in applied science); but his main concern is the use of prediction by agents (or groups of agents) in the everyday context.

However, Rescher makes some reflections about important background issues that have to do with the relation between prediction and prescription. Firstly, he addresses the problem of the tractability of the future; that is, to what extent we can shape the future; and, secondly, he takes into account the human capacity to *control* future phenomena or events in an effective way. In this regard, he thinks that the control of phenomena is one of the main aims of the natural sciences (besides description, explanation, and prediction),[881] which clearly leads to a context of applied science.

On the first issue — the tractability of the future — he thinks that, in principle, three positions can be maintained:[882] (i) the future is completely intractable because reality is determined, so it is not possible for us to exert any kind of influence over the future events; (ii) the future is completely tractable, so we can influence the future course of events without any limitation; and (iii) and intermediate position, according to which we can shape the future within certain limits.

Rescher subscribes the third option. He considers that the future events can be influenced in an intentional way by human agents. However, this is something that only can be done within certain limits, which are mainly due to our capabilities to anticipate the possible future. In effect, in his judgment, "a future we cannot foresee is *a fortiori* a future we cannot control."[883] Here the common methodological path of applied sciences is implicit, to the extent that prediction is required in order to prescribe. Certainly, prescription

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[881] Cf. RESCHER, N., *Razón y valores en la Era científico-tecnológica*, p. 106.
[882] Cf. RESCHER, N., *Predicting the Future*, pp. 234-235.
[883] *Predicting the Future*, p. 236.

encompasses the problems related to the human ability to control the future phenomena.

In effect, Rescher defines control as "*the capacity to intervene in the course of events so as to be able both to make something happen and to preclude it from happening, this result being produced in a way that is not only foreseen but intended or planned.* Control thus calls for the possibility of causal participation ("intervention") in the course of event ("to make something happen or preclude it") with a power that can be exercised both positively ("to make happen") and negatively ("to preclude from happening")."[884]

Therefore, he is interested in the relation between prediction and the control of phenomena; i.e., to what extent we can intervene in phenomena in an effective way, so we can make something happen or prevent something from happen. In this regard, he thinks that our abilities are limited: "the limits of predictability set limits to control as well."[885] However, as Simon's notices, the prescriptive task of the applied science is usually oriented to provide paths of action in order to deal with matters that we cannot control. So it is usual to seek the best possible adaptation to the foresight problems. This is the case, for example, of the models oriented toward meteorological prediction.[886]

Within the applied science, prediction has to do with providing paths for action in order to solve specific problems, so it does not necessarily involve a control over phenomena (natural, social, or artificial). Nevertheless, Rescher sees "planning" as a tool to deal with "not predictability" (or even

[884] RESCHER, N., *Predicting the Future*, p. 235.
[885] *Predicting the Future*, p. 237.
[886] Cf. SIMON, H. A., "Prediction and Prescription in Systems Modeling," in SIMON, H. A., *Models of Bounded Rationality*. Vol. 3: *Empirically Grounded Economic Reason*, pp. 115-128; especially, p. 122.

"unpredictability"), instead of being a way of configuring the actions, made on the basis of a previous knowledge of the future.[887]

Rescher thinks that "by canalizing our actions into tried and true patterns we can clearly render the future less obscure, and thus less problematic."[888] In this way, "prediction as such is not altogether essential to the rational management oof our affairs. Very rough prediction will often serve our planning needs perfectly well: to make adequate provision for the future we (most frequently) do not have to know its precise character in many or most cases."[889]

In my judgment, such an approach highlights that Rescher is not thinking of a scientific context of problem-solving, where prediction is required in order to provide prescriptions about what should be done. He is mainly interested in the use that agents can make of this knowledge of the future provided by science, either in an individual way — the everyday behavior — or in a collective way (in issues related to policy). Thus, it is a proposal about the applications of science, which takes into account the possible uses of scientific prediction in the direction of practical actions. It is not properly an approach to the role of prediction in the realm of applied science.

In this regard, it seems clear that prescription should be performed on the basis of an anticipation of the future. In order to make an effective prescription, forecasts (the less secure kind of prediction) can be good enough, instead of having a genuine foresight. But prediction is always needed, since it is prior to prescription from a chronological viewpoint and, moreover, it makes prescription *possible*. This can be clearly seen in the case of the sciences of design, where the usual procedure is to anticipate

[887] Cf. RESCHER, N., *Predicting the Future*, p. 238.
[888] *Predicting the Future*, p. 238.
[889] RESCHER, N., *Predicting the Future*, p. 238.

possible design problems and, then, give the paths in order to solve those predicted problems.[890]

Therefore, Rescher does not offer an exhaustive analysis of prediction as a guide for the problem-solving activity of the applied sciences. Instead of that, his attention is focused in issues related with the role of prediction in a context of application of science, so he is focused on the use of prediction as a guide for human action. However, he addresses some questions that are very important when prescription is considered, such as the *tractability* of the possible future and the human capacity to *control* future phenomena and events. In this regard, his main contribution is — in main judgment — that he highlights the *limits* of the task oriented towards shaping the future, which are derived from the limits of the predictive activity itself.

5.2.3. The Problem of the Application of Science: The Role of Prediction

Regarding the roles of prediction, an important issue is the problem of the applications of scientific prediction. This question is connected with the distinction between "applied science" and "application of science," which has been pointed out by Niiniluoto. As this philosopher notices, in the realm of applied science, the research is oriented towards the solution of concrete problems, so the search for new knowledge has a specific purpose. Meanwhile, the problem of the application of science deals with the use that can be made of the scientific knowledge in order to solve practical problems of action (as it happens, for example, in professional practices).[891]

Certainly, this is an issue that has repercussions in the roles of scientific prediction. Thus, while in applied science prediction has mainly a role as a

[890] Cf. GONZALEZ, W. J., "Rationality and Prediction in the Sciences of the Artificial," pp. 181-182.
[891] Cf. NIINILUOTO, I., "The Aim and Structure of Applied Research," p. 9. On this distinction, see also GONZALEZ, W. J., "The Roles of Scientific Creativity and Technological Innovation in the Context of Complexity of Science," pp. 17-28.

guide for the task of problem-solving; in a context of application of science, prediction can be the basis for the decision-making of agents, either in an individual mode or in a collective way. Rescher pays especial attention to this problem, due to the pragmatic character of his thought. Thus, he is interested in how agents use scientific knowledge, in general, and knowledge about the future, in particular.

Because his philosophical conception is in terms of "system," Rescher addresses the problems that have to do with decision-making, above all, in public policy matters, where scientific prediction can have an important role.[892] It is a problem he sees in relation to complexity, since "the decision problems that we face in contemporary public affairs are often too complex to allow a resolution by way of rational calculation and what might be called the application of 'scientific principles.'"[893] In this way, complexity has repercussions on the application of scientific predictions, so when the aim is to manage complex systems, a large number of variables that are open to the future must be taken into account.

In general, complex systems are less predictable than the systems characterized by being simple. For this reason, when the applications of science deal with complex systems — which is usually the case in policy — the obstacles that hinder prediction have repercussions on the human capacity to manage and control the system, as well as in our ability to planning in order to solve practical problems. Furthermore, Rescher considers that complex systems, in general, and social systems, in particular, can be unpredictable (or at least not-predictable) in the long run.[894]

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[892] Cf. RESCHER, N., "Political Pragmatism," in RESCHER, N., *Pragmatism. The Restoration of its Scientific Roots*, pp. 205-215. In this paper, Rescher develops the proposals published in "Risking Democracy (Some Reflections on Contemporary Problems of Political Decision)," *Public Affairs Quarterly*, v. 12, (1999), pp. 297-308; compiled RESCHER, N., *Sensible Decisions. Issues of Rational Decision in Personal Choice and Public Policy*, pp. 113-124.
[893] RESCHER, N., "Political Pragmatism," p. 205.
[894] Cf. "Political Pragmatism," p. 209.

In this case, unpredictability can be due to several factors. 1) It is possible that chaos and chance intervene, so "the course of events over the longer term in matters of social interest depend too much on subtle interactions which, while virtually indiscernible at present and negligible in the short term, can make an enormous difference to what happen over the long term."[895] 2) There can be also factors such as novelty, spontaneity, and creativity, so the patterns that a system followed in the past cannot allow us to infer its development in the future.[896]

The difficulties to prediction such as chaos, chance, or novelty have repercussion in the human capacity of management. Thus, "complex systems are inherently less amenable to successful comprehension, management, and control."[897] In effect, in order to manage or control a system in an adequate way, firstly, we need some kind of knowledge about how this system will behave in the future; and, secondly, the success of the management depends, to a large extent, on the correct anticipation of the results and consequences of the measures suggested.

But, when the matter that we want to manage is a complex one, "the eventual effects of the measures we take to address the challenges become lost in a fog of unpredictability."[898] This is a problem that makes the decision-making process difficult, to the extent that different possible solutions can be suggested in order to solve the same problem. As Rescher points out, "the fact is that in a complex modern society there is often no way to get a rational grip on the consequences of public policy measures and employ 'scientific intelligence' to foretell the consequences. There are no calculable solutions

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[895] RESCHER, N., "Political Pragmatism," p. 209.
[896] Cf. "Political Pragmatism," p. 210.
[897] RESCHER, N., "Technology, Complexity, and Social Decision," in RESCHER, N., *Sensible Decisions*, p. 86.
[898] RESCHER, N., "Technology, Complexity, and Social Decision," p. 89.

here—all that we ever seem to get is a clash of 'my experts' versus 'your experts.'"[899]

Therefore, when predictions do not reach the desirable level of detail, the interpretations of the experts or entities that manage a problem are possible. For this reason, on the same basis, such as a prediction or a set of predictions that anticipate a problem, different possible solutions might be suggested. In turn, there are difficulties for the correct anticipation of the results of the measures adopted. Moreover, regarding one solution, different experts may have opposite opinions about the results and consequences of that solution.

In view of these problems posed by the applications of science, Rescher considers that "the best that we can do is to feel our way cautiously step by step—to experiment, to try plausible measures on a small scale and see what happens, and to let experience be our guide."[900] He labels this way of proceeding "political pragmatism." It is a proposal about the rational procedure in decision-making about issues of public interest; because, in his judgment, complexity of the matters of public policy involves the impossibility of trusting that the experts would offer adequate solutions.

Based on the lack of a direct transfer of the solutions suggested by the scientists, Rescher thinks that the process of decision-making in order to solve practical problems should be a "democratic" process, with a collective participation.[901] Certainly, the applications of science in many of the applied sciences (such as economics, medicine, or pharmacology) have to do with questions of public interest, to the extent that they can affect the people, the society, or the environment (either in a positive or a negative way). This issue can be analyzed in three successive levels: aims, processes, and results

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[899] RESCHER, N., "Political Pragmatism," p. 212.
[900] "Political Pragmatism," p. 212.
[901] Cf. RESCHER, N., "Political Pragmatism," pp. 213-215.

(and the consequences) of the applications of science.[902] At each one of these levels, ethical values are important; above all, those related to social responsibility (which might lead to a legal responsibility).[903]

It should be highlighted that, in Rescher's approach, the decision-making should be collective, at least regarding issues that have social repercussion, such as for example the problems of policy. But this make it difficult the attribution of responsibilities, for "when things go wrong—when even our best conceived measures do not deliver on their promises and live up to expectation—in a system of genuinely participatory decision making, 'we the people' will at least have no one to blame other than ourselves."[904]

Thus, an important problem that arises here is — in my judgment — that responsibility can fade when groups of agents (instead of individual agents) make the decisions. This might make it difficult to talk about a "collective responsibility" in decision making. In this regard, Rescher maintains that collective responsibility is rooted on the individual members of a group, on the condition that the individuals act in a coordinate and intentional way — either through consensus or by delegation — in order to generate a result. He considers that only in this case there can be a genuine collective responsibility.[905]

Rescher rejects a naïve view of the capacity of science to solve practical problems of action. In effect, when the problems are complex, science can have difficulties in order to offer optimal solutions, "and this occurs not because the experts are incompetent but because the problems are intractable. They are of such complexity that scientific analysis and

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[902] Cf. GONZALEZ, W. J., "The Philosophical Approach to Science, Technology and Society," p. 26.

[903] These ethical features are analyzed in-depth in chapter 9 of this Ph.D. research.

[904] RESCHER, N., "Political Pragmatism," p. 214.

[905] Cf. RESCHER, N., "Collective Responsibility," *Journal of Social Philosophy*, v. 29, (1998), pp. 44-58, pp. 125-138. Compiled in RESCHER, N., *Sensible Decisions*, *Issues of Rational Decision in Personal Choice and Public Policy*, pp. 125-138; especially, p. 136.

expert deliberations simply cannot settle matters."[906] So he rejects a scientism of the application of science: the prediction of the possible future is not always followed by prescriptions that, in the practical life, are directly applicable in order to provide the results sought.

It seems clear that, in this case, the existence of limits to scientific prediction due to the complexity of the reality (that is, the complex systems) should be considered. This is highlighted by Rescher when he notices the nexus between scientific prediction and the management or control of a system. Thus, when predictions are not possible or they are not reliable, management can lead to undesired or even undesirable effects. For this reason, successful predictions are needed, insofar as they can provide secure basis for acting. In view of this problem, the methodological dimension is — in my judgment — crucial, since the improvement of the predictive processes is basic in order to achieve predictive success.

5.3. From the General Realm to the Special Level

Usually, Rescher is concerned about prediction in the natural sciences, but he also considers the role of prediction in the methodology of the social sciences (above all, in economics).[907] In this regard, he highlights that there is generally a problem of *unreliability* that affects predictions about social and human matters; while the predictions about the natural phenomena are, in principle, more reliable. This is a methodological problem that leads to ontological roots, since it rests on the complexity of the human activity that is developed in a social milieu.[908]

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[906] RESCHER, N., "Political Pragmatism," p. 209.
[907] Cf. RESCHER, N., *Predicting the Future*, chapter 11, pp. 191-208.
[908] Cf. GONZALEZ, W. J., "La vertiente dinámica de las Ciencias de la Complejidad. Repercusión de la historicidad para la predicción científica en las Ciencias Diseño," in GONZALEZ, W. J. (ed.), *Las Ciencias de la Complejidad: Vertiente dinámica de las Ciencias de Diseño y sobriedad de factores*, p. 92.

But prediction has also an important role in the sciences of the artificial, which is a realm that Rescher does not take into account expressly. In this realm, the sciences of design seek to enlarge the human possibilities in the human made field. In this way, these sciences develop an activity of a teleological character, where applied knowledge is needed in order to solve concrete problems. In this context of applied science, prediction and prescription have a relevant role, because the activity of design requires the anticipation of the possible problems (*prediction*) in order to suggest what should be done (*prescription*).

5.3.1. Prediction in the Natural Sciences and in the Socieal Sciences

On scientific prediction, Rescher's approach is mainly focused on the natural sciences. However, in *Predicting the Future*, there is one chapter devoted to prediction in the social sciences, where he makes a comparison with prediction in the realm of the natural sciences. Thus, he considers that, from a methodological perspective, prediction in social sciences is more difficult that in the natural sciences. In his judgment, "the difficulties that the predictive project encounters in [natural] science pale in comparison with those it encounters in human affairs."[909]

This feature — the difficulty of predicting about social and human matters — leads to an ontological dimension, because it is rooted in the characteristics of the reality (natural or social) predicted. So, when the prediction is about social phenomena, "it is the nature of the phenomenology of the domain—its volatility, instability, and susceptibility to chance and chaos—that is responsible for our predictive incapabilities here, rather than our imperfections as investigators."[910] However, those obstacles to

[909] RESCHER, N., *Predicting the Future*, p. 192.
[910] *Predicting the Future,* p. 202.

predictability can also affect natural phenomena, so it should be considered to what extent indeterminism *especially* affects the social prediction.

Rescher's attention goes to the natural reality when he analyses the relation between *predictability* and *predetermination*. Regarding this issue, he maintains that claims "that this world of ours indeed is such a deterministic, wholly predictable Laplacean world is, in the present state of our knowledge, somewhere between implausible and false. The role of predetermination-blocking factors (chance, choice, and the like) is a real and prominent fact of life in the world as we know it."[911]

It can be noticed that, although there are factors such as volatility, instability, chaos, or chance that can clarify the lack of predictive success in social sciences, it does not seem that they can elucidate, by themselves, why social sciences have generally less predictive capacity than the natural sciences. In effect, as Rescher himself admits, natural sciences have to deal with this kind of ontological obstacles, so the chaotic or volatile character of some social phenomena is not the only reason for the methodological difficulties of the social prediction.

Furthermore, Rescher considers that the indeterminism that characterizes human matters does not necessarily involve "impredictability" (i.e., the complete impossibility of predicting): "the operation of a power of free choice certainly does not mean that there *must* be unpredictability."[912] In his judgment, to the extent that the human actions and choices are *rational*, they might be also predictable. Thus, he thinks that "the acts of rational agents are usually predictable because it is often and perhaps even usually

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[911] RESCHER, N., *Predicting the Future,* p. 73. On the discussions about determinism and freedom, see GONZALEZ, W. J., "New Reflections on an Old Problem: Freedom and Determinism in the Scientific Context," in GONZALEZ, W. J. (ed.), *Freedom and Determinism: Social Sciences and Natural Sciences*, monographic volume of *Peruvian Journal of Epistemology*, v. 1, (2012), pp. 3-20.

[912] RESCHER, N., *Free Will. A Philosophical Reappraisal,* Transaction Publishers, New Brunswick, NJ, 2009, p. 46.

possible to figure out on the basis of general principles what the rational thing to do is in the prevailing situation."[913]

Nevertheless, Rescher admits that the free choice of agents can be an obstacle for predictability in social sciences. In those sciences, predictions are about issues that are related with the actions and choices of rational agents that have free will, so these actions and choices are open to changes.[914] Therefore, although factors such as change, chance, or chaos are not only present in the social reality, it is possible to claim that, in general, social phenomena are more instable that natural phenomena, because these factors are more pervasive in the social realm.

From this perspective, an important difference between natural phenomena and social events has to do with the *regularity* of these events or happening. This is an ontological issue, which has clear methodological repercussions, to the extent that the preconditions for rational prediction demand the discernability and stability of the patterns exhibited by phenomena. For this reason, if it is admitted that social phenomena are generally less regular and more instable than natural phenomena, then it is also possible to claim that there are more methodological difficulties for prediction in social sciences, due to the kind of issues they deal with.

In this regard, Rescher relates the predictability of natural phenomena to the existence of laws about those phenomena. In his judgment, "nature is predictable insofar as its phenomena exhibit discernible patterns that reveal rulish lawfulness in its operations."[915] In that case, not only it is possible to discern patterns in natural phenomena, but those patterns have also a nomic expression. Thus, in natural sciences the inference from laws is a usual predictive method.

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[913] RESCHER, N., "Predictive Incapacity and Rational Decision," *European Review*, v. 3, n. 4, (1995), p. 327.
[914] Cf. RESCHER, N., *Predicting the Future*, p. 192.
[915] *Predicting the Future,* p. 176.

Certainly, when a prediction is the result of an inference from laws, it is more reliable than when other predictive procedures are used. Firstly, the presence of laws involves that there are lawful regularities in phenomena, which can serve as mechanisms of connection between the events of the past and the happenings of the future; and, secondly, nomic stability makes the secure inference of statements about the future possible. Meanwhile, regarding the social phenomena, there is a higher instability, so the use of less reliable methods is more usual: estimative procedures, trend extrapolation, etc.

Regarding prediction in social sciences, one of the main difficulties is due — in my judgment — to the diversity of variables (endogenous and exogenous) that are open to the future. Furthermore, there are difficulties due to the complexity of selecting the *quantifiable* factors and the analysis of the representative interrelations among different variables in quantitative (and not just qualitative) terms.[916] These are questions that have repercussions on the complexity and reliability of social predictions. In this way, it can be claimed that scientific-social prediction is generally more complex than prediction in the natural sciences.[917]

For Rescher, “the predictive limitations of social science are ultimately rooted in the immense complexity of the processes through which human beliefs and desires are shaped in the first place.”[918] But his approach to complexity in social science is — in my judgment — too generic, insofar as he seems to associate complexity with the presence of factors such as chaos, volatility, chance, etc.[919] Thus, this approach to complexity of social

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[916] Cf. GONZALEZ, W. J., *La predicción científica*, p. 221.
[917] Cf. GONZALEZ, W. J., "Complexity in Economics and Prediction: The Role of Parsimonious Factors,” in DIEKS, D., GONZALEZ, W. J., HARTMAN, S., UEBEL, TH. and WEBER, M. (eds.), *Explanation, Prediction, and Confirmation,* pp. 319-330; especially, pp. 319-321.
[918] RESCHER, N., *Predicting the Future*, p. 201.
[919] Cf. *Predicting the Future*, p. 202.

phenomena contradict, to a certain extent, his own approach to the problem of complexity.

In effect, as Rescher maintains in his book *Complexity*, the study of complexity cannot be only determined by the extent to which factors such as chance, randomness, and lawful regularity is absent.[920] This feature leads him to suggest a framework of complexity with many aspects. In his analysis, there are mainly two dimensions of complexity: epistemological and ontological (to which it is possible to add a methodological facet). Furthermore, although his approach in preferentially of structural complexity, it is also open to dynamic complexity, which has to do with the changes of complex systems over time.

However, his analysis of the complexity of prediction in social sciences is too generic. In an explicit way, he maintains that "the comparatively limited progress of the social sciences in matters of prediction does not lie in a want of trying, a lack of dedication or intelligence, a deficiency of method or of information-collecting methods, or in some other error of omission or commission. Instead, chance, chaos, choice—in fact, all of the bugaboos of rational prediction—play a prominent part throughout the social sphere. In this domain, where the causal phenomenology at issue is so enormously complex, volatile, and chaotic, there is only so much that can be done."[921]

On the one hand, Rescher is right in considering that the difficulties to deal with complexity in the realm of social sciences allow us to elucidate the poor predictive success in those sciences. But, on the other hand, his approach in this regard is — in my judgment — excessively general: there is no the desirable degree of detail. This is because his interest in prediction is mainly focused in the realm of the sciences of nature, so he does not develop

[920] "As many writers see it, complexity is determined by the extent to which chance, randomness, and lack of lawful regularity in general is absent. But this cannot be the whole story, since law systems themselves can clearly be more or less complex," RESCHER, N., *Complexity: A Philosophical Overview*, Transaction Publishers, N. Brunswick, NJ, 1998, p. 8.
[921] RESCHER, N., *Predicting the Future*, p. 202.

in depth the specific issues of the methodology of prediction in the social sciences.

The methodological repercussions of the problem of complexity in the realm of social sciences have been emphasized above all in philosophy and methodology of economics. In this regard, it has been highlighted that *complexity* "contributes to the frequent lack of reliability of economic predictions, which has its roots in the object of study of this science: economic reality is a social and artificial undertaking (*quehacer*), which is commonly mutable, as a consequence of its dependence on the human activity that develops historically." [922]

Certainly, economics has a dual status: it is a science of design, insofar as it has artificial elements that enlarge the human possibilities; and, moreover, it is a social science, because it deals with human needs, such as food, housing, etc.[923] But, when Rescher analyses the problem of prediction in economics, he only takes into account the dimension of social science, so his approach does not grasp all the issues at stake. In his judgment, the methodological difficulties to economic prediction are rooted in the changeableness of the social reality, where there is a great diversity of variables, both endogenous and exogenous, which are instable or even chaotic.[924]

But economics is also a science of design. This feature of being a dual science (that is, social and artificial) adds more factors of analysis to the problem of the economic prediction, which Rescher does not take into account. For this reason, in my judgment, his methodological approach to scientific prediction can be completed through the analysis of the role of prediction in the sciences of the artificial. Firstly, prediction has an important

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[922] GONZALEZ, W. J., "La vertiente dinámica de las Ciencias de la Complejidad. Repercusión de la historicidad para la predicción científica en las Ciencias Diseño," p. 92.
[923] Cf. "La vertiente dinámica de las Ciencias de la Complejidad. Repercusión de la historicidad para la predicción científica en las Ciencias Diseño," p. 88.
[924] Cf. RESCHER, N., *Predicting the Future*, pp. 193-199.

role in this group of sciences (so it is not only present in the field of the natural sciences and the social sciences); and, secondly, there are social sciences (such as economics) that are also sciences of design, so an exhaustive analysis of prediction in those sciences cannot be limited to the study of their features as social disciplines.

5.3.2. The Artificial Realm: Prediction in the Design Sciences

From an epistemological perspective, the sciences of design develop contents of the sciences of the artificial, because of the type of object they deal with; because scientific designs belong to the realm of the "human-made" and can be considered as the result of a task of *synthesis*,[925] where prediction and prescription have an important role. This issue connects with an ontological dimension, which Herbert A. Simon highlighted when he made the distinction between artificial objects and natural items.

He made this distinction in order to establish the boundaries for the sciences of the artificial. In his judgment, there are four main differences between them: "1. Artificial things are synthesized (though not always or usually with full forethought) by human beings. 2. Artificial may imitate appearances in natural things while lacking, in one or many respects, the reality of the latter. 3. Artificial things can be characterized in terms of functions, goals, adaptation. 4. Artificial things are often discussed, particularly when they are being designed, in terms of imperatives as well as descriptives."[926]

Following the epistemological and ontological features, design can be characterized as a human-made undertaking, which is made through a task of synthesis and brings about an artificial thing. Moreover, according to Simon, the concept of "synthesis" can be used as a synonymous with the

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[925] Cf. SIMON, H. A., *The Sciences of the Artificial*, 3rd ed., The MIT Press, Cambridge, MA, 1996 (1st ed., 1969; 2nd ed., 1981), pp. 4-5.
[926] SIMON, H. A., *The Sciences of the Artificial*, 3rd ed., p. 5.

notion of "design." In his judgment, "design, as I am using the term, means synthesis. It means conceiving of objects, of processes, or ideas for accomplishing goals, and showing how these objects, processes, or ideas can be realized."[927] Thus, to some extent, "design" and "synthesis" can be understood within this approach in the broad-sense of devising objects and processes, and thinking of how they can be accomplished in an effective and efficient way.

This teleological character of "design," which has a relation with the artificial domain, makes Simon stress the linkage between design sciences and technology. In his judgment, "as soon as we introduce 'synthesis' as well as 'artifice,' we enter the realm of engineering. For 'synthetic' is often used in the broader sense of 'designed' or 'composed.' We speak of engineering as concerned with 'synthesis,' while science is concerned with 'analysis.' Synthetic or artificial objects and more specifically prospective artificial objects having desired properties are the central objective of engineering activity and skill. The engineer, and more generally the designer, is concerned with how things *ought* to be in order to *attain goals*, and to *function*."[928]

De facto, both technology and design sciences share the need for designs to attain their goals.[929] Nevertheless, "'design sciences' belong to a realm that is *scientific* rather than technological, and they have a scientific rationality that is different from technological rationality."[930] The main difference between them is neat: science seeks a variety of aims by cognitive means in order to increase our knowledge (basic science) or solve specific

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[927] SIMON, H. A., "Problem Forming, Problem Finding, and Problem Solving in Design," in COLLEN, A. and GASPARSKI, W. W. (eds.), *Design and Systems: General Applications of Methodology*, Transaction Publishers, N. Brunswick, NJ, 1995, p. 246.
[928] SIMON, H. A., *The Sciences of the Artificial*, 3rd ed., pp. 4-5.
[929] Cf. GONZALEZ, W. J., "Rationality and Prediction in the Sciences of the Artificial: Economics as a Design Science," in GALAVOTTI, M. C., SCAZZIERI, R. and SUPPES, P. (eds.), *Reasoning, Rationality and Probability*, p. 168.
[930] GONZALEZ, W. J., "Rationality and Prediction in the Sciences of the Artificial: Economics as a Design Science," p. 168.

practical problems (applied research).[931] Meanwhile, technology is oriented towards a creative transformation of reality in order to bring about new results (generally, an artifact, which is a tangible reality).[932] Thus, "science" and "technology" are different human activities, although there are connections between them, which are especially relevant in the case of design sciences.

These differences between "science" and "technology" have repercussions on the concept of design. In effect, there are differences between "designs," in general, and "scientific designs," in particular. These differences are clear insofar as scientific design involves the addition of epistemological and methodological features to the kind of design that is common in professional practices.[933] Therefore, scientific design seeks to solve concrete problems through the use of applied scientific knowledge and scientific methods.[934]

In Simon's view, "design like science is a tool for understanding as well as for acting."[935] This feature appears insofar as design "is concerned with how things ought to be, with devising artifacts to attain goals."[936] Thus, when a design is elaborated, there is a purposed aim. Consequently, it is necessary to choose the most appropriate processes, and those processes may eventually lead to previously established outcomes.[937] In this way, design is a teleological activity, and sciences of design — as sciences of

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[931] Cf. NIINILUOTO, I., "The Aim and Structure of Applied Research," pp. 1-21; especially, pp. 3-6; and NIINILUOTO, I., "Approximation in Applied Science," pp. 127-139.

[932] On the differences between science and technology, see GONZALEZ, W. J., "The Philosophical Approach to Science, Technology and Society," pp. 3-49; especially, pp. 11-12.

[933] Since Simon emphasizes the connections between sciences of design and technology, his approach to the notion of design is somewhat ambiguous, insofar as it doesn't make it possible to distinguish "design" form "scientific design." Cf. GONZALEZ, W. J., "Análisis de las Ciencias de Diseño desde la racionalidad limitada, la predicción y la prescripción," in GONZALEZ, W. J. (ed.), *Las Ciencias de Diseño: Racionalidad limitada, predicción y prescripción*, p. 11.

[934] Cf. GONZALEZ, W. J., "Análisis de las Ciencias de Diseño desde la racionalidad limitada, la predicción y la prescripción," p. 11.

[935] SIMON, H. A., *The Sciences of the Artificial*, 3rd ed., p. 164.

[936] *The Sciences of the Artificial*, 3rd ed., p. 114.

[937] Of course, the outcomes attained could differ from the stated aims. This can happen commonly when the possible problems are not correctly anticipated.

synthesis — involve the enlargement of human possibilities by the use of creative designs to solve particular problems.

The teleological character of scientific design involves a link between the activity of design and the applied knowledge. In fact, sciences of design are applied sciences oriented towards problem-solving activities. In this way, the goal-oriented nature of design sciences involves a *prescriptive* component that deals with how things *ought to be* in order to attain certain goals. This feature involves that the elaboration of a scientific design requires both prediction and prescription. Firstly, prediction is needed to know whether the design is feasible as well as to anticipate any possible problem, and, secondly, prescriptions are made on what should be done to achieve the goals.[938]

Therefore, in the realm of the sciences of design, as they are applied sciences, the most prominent role the prediction is in its relation with prescription. In this case, prediction is mainly a methodological tool, because the knowledge about the possible future is required in order to establish the relevant paths for the prescription.[939] In this way, in applied sciences, in general, and in the sciences of design, in particular, the usual methodological path is to predict in order to prescribe.

This has been emphasized by Wenceslao J. Gonzalez when he analyzes the role of prediction in economics as a design science. In this regard, he notices that, "in order to carry out a design activity in science, the common path is to consider in advance whether the project is feasible (prediction), before we give indications about how to solve the problem that is foreseen (prescription). Thus, to make a prediction is, in principle,

[938] On the role of prediction and prescription in the sciences of the artificial, see GONZALEZ, W. J., "Rationality and Prediction in the Sciences of the Artificial: Economics as a Design Science," section 4, pp. 179-183.
[939] Cf. "Rationality and Prediction in the Sciences of the Artificial: Economics as a Design Science," p. 181.

chronologically prior to establishing a prescription when the problems involved are in the realm of design science."[940]

Explicitly, Simon has paid special attention to this problem. In fact, his approach gives primacy to prescription over prediction, because he considers that prediction is the most important goal of science, instead of just predicting what is going to happen in the future. In his judgment, prediction is prior to prescription both in science, in general, and in sciences of the artificial (and among them design sciences), in particular. Additionally, he thinks that the knowledge about the future (i.e., the prediction) is what makes it possible the prescriptive task of science.[941]

Within this context, a question arises about the level of accuracy and precision that predictions should achieve in order to establish effective prescriptions. On this problem, José Francisco Martínez Solano notices that, for Simon, prescription "does not involve the need for accurate prediction of the future because the main concern is to shape the future by designing it correctly, instead of predicting accurately what is going to occur."[942] Nevertheless, it seems clear that some kind of knowledge about the future is needed in order to prescribe, although it might be good enough to have a forecast (the least reliable type of prediction) instead of having a genuine foresight.

In my judgment, a forecast might be good enough, but a genuine prediction or foresight — the most reliable kind of knowledge about the future — provides us a more rigorous knowledge in order to establish a prescription. In principle, the more accurate and precise the prediction is, the more successful the prescription could be. It is for that reason that I consider

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[940] "Rationality and Prediction in the Sciences of the Artificial: Economics as a Design Science," pp. 181-182.

[941] Cf. SIMON, H. A., "Prediction and Prescription in Systems Modeling," *Operations Research*, v. 38, (1990), pp. 7-14; especially, pp. 10-12.

[942] MARTÍNEZ SOLANO, J. F., "La complejidad en la Ciencia de la Economía: De F. A. Hayek a H. A. Simon," in GONZALEZ, W. J. (ed.), *Las Ciencias de la Complejidad: Vertiente dinámica de las Ciencias de Diseño y sobriedad de factores*, p. 248.

that applied sciences, in general, and the sciences of design, in particular, should be oriented towards the search for more and more reliable and informative predictions. In this way, it would be possible to choose between alternative courses of action those which lead us to an effective and efficient solution to stated problems.

However, this aim can be difficult to attain due to the role of human creativity in the scientific activity of design. On this issue, it seems to me that creativity can influence prediction and prescription in two different ways: (i) as an obstacle to achieve accurate predictions; and (ii) as a key factor for problem-solving. According to Rescher, human creativity is a major limit to predictability. In his judgment, "human creativity and inventiveness defies predictive foresight."[943] From this perspective, creativity can be seen as a source for complexity in design sciences.[944]

But creativity can be also a key factor in the problem-solving activity of the applied sciences, where prescription has a main role. This feature is especially clear in the case of the sciences of design, insofar as "the science of design is directly connected to prescribing: design looks for courses of action whose aims are to change existing situations into preferred ones, and those processes require identification of some prescribed paths to be followed."[945]

Certainly, this task can be accomplished through a creative act, because the role of creativity in the sciences of the artificial is related "to the *invention of forms that are to satisfy some requirements or purpose*."[946] Therefore, creativity can be considered as a dual notion: on the one hand, it can be a source of complexity in design sciences, so it is a clear obstacle to

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[943] RESCHER, N., *Predicting the Future. An Introduction to the Theory of Forecasting*, p. 149.
[944] Creativity as an ontological limit to predictability, which affects above all the social sciences and the sciences of the artificial, is analyzed in chapter 7 of this Ph.D. research.
[945] GONZALEZ, W. J., "Rationality and Prediction in the Sciences of the Artificial: Economics as a Design Science," p. 182.
[946] DASGUPTA, S., *Creativity in Invention and Design*, Cambridge University Press, Cambridge, 1994, p. 8.

predictability in this realm. But, on the other hand, it can be an element which helps us to overcome that complexity, insofar as it seeks new ways that serve as key elements for prescription in design sciences.

5.4. Preconditions for Rational Prediction

Epistemologically, Rescher characterizes scientific prediction as a rational prediction. Therefore, scientific predictions have rational bases that distinguish them from other non-rational attempts to anticipate the future (for example, the prophecies). In his judgment, “we who do not ourselves directly observe or experience the future, and lack any self-authenticating precognitive insight into it, can only get knowledge about it by way of rational evidentiation, of ‘inference’ from the available data regarding accomplished facts. Prediction as we know it is a matter of thought and not perception. To us, ordinary nonclairvoyant humans, the future can only be conjectured on the basis of experience-derived information.”[947]

Unlike authors like D. H. Mellor, who maintains that predictions do not need reasons,[948] Rescher argues in favor of the rational bases of scientific prediction. In his approach, opposite to the simple prophecy, scientific predictions are credible to the extent that there are some bases (theoretical or empirical) that justify the inference from the past to the future.[949] Furthermore, he thinks that the predictive inference must be *necessarily* supported by information about the behavior of the phenomena in the past and in the present, since we cannot directly “observe” the future.

As the future is something that is not yet, when the problem of the characterization of the scientific prediction is addressed, the methodological orientation is crucial. In Rescher’s judgment, scientific prediction is the result of a *rational process*. Thus, he admits a methodological pluralism in relation

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[947] RESCHER, N., *Predicting the Future*, p. 54.
[948] Cf. MELLOR, D. H., “The Possibility of Prediction,” pp. 207-223.
[949] Cf. RESCHER, N., *Predicting the Future*, pp. 53-56.

to scientific prediction: there is a variety of methods — estimative and discursive — that scientists can use in order to achieve the aim of predicting. But, as *rational* processes, the different methods share a series of characteristics.

On methodology of prediction, Rescher's attention goes in two different directions: on the one hand, he wants to make the different predictive methods explicit, which involves taking into account the distinctive features of each concrete process; and, on the other hand, he pays attention to the common features of the different predictive procedures and methods. This second line of analysis — the bases shared by the predictive processes — is developed by Rescher according to the "preconditions for rational prediction."[950]

These are a series of conditions that he consider *prior* and *necessary* for the methods oriented towards predicting, since "any sort of rational prediction—no matter how naive or how complex and sophisticated is mode of operation—will accordingly require informative input material that indicates that three conditions are satisfied."[951] In his judgment, those three preconditions for rational prediction are the following ones:

1) Data availability, which involves that data should be obtained in an accurate, reliable, and timely way (i.e., prior to the occurrence or non-occurrence of the phenomenon predicted). 2) Pattern discernability; that is, there should be identifiable patterns in the data obtained. 3) Pattern stability, since the success of prediction depends, to a large extent, on the fact that the patterns followed by the phenomena in the past and in the present have certain stability towards the future.[952] These three preconditions justify the inference of future, because "rational prediction pivots on the existence of

[950] Cf. GONZALEZ, W. J., *La predicción científica*, pp. 271-274.
[951] RESCHER, N., *Predicting the Future*, p. 86.
[952] Cf. *Predicting the Future*, p. 86.

some sort of appropriate *linkage* that connects our predictive claims with the input data that provide for their justification."[953]

5.4.1. Data Availability

The first one of those three preconditions — data availability — has to do mainly with two fundamental issues: (i) the access to information (to what extent we have the data required in order to make the prediction), and (ii) the quality of the data, where problems such as the accuracy or reliability of the data should be contemplated. Both problems are connected with the epistemological limits to scientific prediction, which Rescher addresses mainly with regard to the obstacles that have to do with information.[954]

Regarding the first issue — *the access to the relevant data* — two problems can be considered, which affect scientific prediction in different degrees: (a) ignorance (the lack of information), and (b) uncertainty (which initially affects prediction when some data are not available). Both cases are obstacles to scientific prediction from the perspective of the access to information.

In his analysis of ignorance, Rescher makes an initial distinction between two different types of ignorance: contingence ignorance and the ignorance of a necessary character. When ignorance is contingent, it is "grounded in operations of nature that render certain fact-determinations impossible in the circumstances, and it is sometimes grounded in the insufficiency of our information-accessing resources."[955] In the first case, ignorance has ontological roots; while in the second case the problem is epistemological. Meanwhile, the necessary ignorance is rooted in logico-

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[953] RESCHER, N., *Predicting the Future*, p. 87.
[954] Cf. RESCHER, N., *Ignorance. On the Wider Implications of Deficient Knowledge,* University of Pittsburgh Press, Pittsburgh, 2009; especially, chapter 6, "Obstacles to Predictive Foreknowledge," pp. 91-122.
[955] RESCHER, N., *Ignorance. On the Wider Implications of Deficient Knowledge*, p. 141.

conceptual considerations,[956] so it involves unpredictability (for example, in the cases of self-prediction).[957]

Within this framework, ignorance that affects data availability in order to make predictions is a contingent ignorance of epistemic basis. According to Rescher, this type of ignorance is rooted in the inadequate character of our resource for information accessing, among which there are the current means of observation.[958] The result of this type of ignorance is the impossibility of accessing the relevant data, either in order to prescribe, explain, or predict a certain matter.

When there is ignorance with regard to the relevant data for the prediction, the first precondition for rational prediction — which has to do with the availability of the information — is not fulfilled. In that case, the required data are not available, so prediction appears as an impossible task from the very beginning. In other words, those phenomena about which we have no knowledge, either explicative or merely descriptive, are phenomena unpredictable or, at least, not-predictable.

However, to the extent that it is a *contingent* ignorance — it is not a *necessary* ignorance — it can be overcome in principle (for example, to the extent that there are improvements in the means of observation or experimentation). For this reason, when the impossibility of prediction is due to ignorance, the research should be firstly oriented toward obtaining the required data; that is, toward guarantying the access to the relevant information for the prediction.

Uncertainty is another problem that has to do with the access to data. In Rescher's judgment, it is usual that not *all* the relevant information is available, so he considers uncertainty as the main epistemological obstacle to prediction: "In view of the inevitable incompleteness of our information, we

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[956] Cf. *Ignorance. On the Wider Implications of Deficient Knowledge,* pp. 140-141.
[957] Cf. RESCHER, N., *Predicting the Future*, pp. 211-215.
[958] Cf. RESCHER, N., *Ignorance. On the Wider Implications of Deficient Knowledge*, p. 141.

cannot eliminate the risk of error in prediction; even the best of predictions can in principle go awry."[959] Unlike ignorance, uncertainty does not involve the complete lack of information, but it has to do with the *limited* character of the available information, so it can affect the reliability of the prediction. Thus, Rescher links uncertainty and fallibilism.

As an epistemological feature, when can generally deal with uncertainty to the extent that the available information about past and present phenomena is increased or improved. In this way, it is possible to reduce the uncertainty that affects some predictive matter. In turn, this feature has repercussions on the reliability of the prediction; since, in principle, the better we know the phenomena that we want to predict, the more reliable the prediction about those phenomena will be.

However, this is not a general rule. As Rescher notices, "the access of further information can sometimes make the future less predictable."[960] If someone we know is going to take a trip, we can predict quite securely that he will use his car. But, if we later know that his car is in the garage, not only the initial prediction turns out to be false, but also it is not possible now to make a reliable prediction about his means of transport. By this and other examples of ordinary life, Rescher illustrates how sometimes the access to additional information increases the uncertainty regarding the future.[961]

Therefore, a prediction can turn out to be false due to the presence of errors in the initial data; but also due to incomplete data.[962] In that case, the access to further information can have two main consequences: firstly, it is possible that it allows us to predict in a more reliable way certain phenomenon; and, secondly, it might increase the uncertainty regarding what is going to happen in the future. Despite of this, the access to more

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[959] RESCHER, N., *Predicting the Future*, p. 59.
[960] *Predicting the Future*, p. 58.
[961] Cf. RESCHER, N., *Predicting the Future,* pp. 58-59.
[962] Cf. *Predicting the Future*, p. 59.

information has always — in my judgment — a positive character for our knowledge about the future, either because it increases the security and reliability of the prediction, or because it might highlight that certain prediction is incorrect.

Besides the problem of the access to the data, there is the question about the *quality* of those data: how are the characteristics that they should have in order to make the prediction possible. Rescher identifies three features that, in his judgment, characterize the relevant data for prediction: (i) they should be obtained timely; that is, previous to the occurrence of the phenomena or event that we want to predict; (ii) they should be accurate; and (iii) they should be reliable.[963]

The first of these characteristics has to do with the temporal factor of prediction. Thus, the relevant data for the prediction must be about the past and present development of the phenomena that we want to predict; i.e., the information, from a chronological perspective, deals with a reality that is previous to the referent of the prediction. This temporal feature of the information is connected with Rescher's proposal according to which a scientific prediction is a statement oriented towards the future. Then, in order to anticipate the future, information is necessarily about previous events or phenomena: "for to evidentiate our predictive claims about the future, we have no alternative but to look to the past-&-present."[964]

Besides the temporal factor, from an axiological perspective, Rescher considers accuracy and reliability as two major values that must characterize the relevant information for the prediction. Accuracy deals with the correctness of the data. It is a relevant value, since error in the information usually leads to incorrect predictions. Meanwhile, data reliability has to do

[963] Cf. RESCHER, N., *Predicting the Future,* p. 86.
[964] Cf. RESCHER, N., *Predicting the Future*, p. 86.

with the security that can be attributed to those data; and, therefore, involves a level of certainty.

Within Rescher's approach, where credibility is more important than correctness, reliability appears as an especially important value.[965] Regarding the relevant data for the prediction, reliability can be evaluated according to issues such as the source from which the data have been obtained or the means used in order to obtain the date. Since it is usual that the process of prediction is performed in a context of limited information, the most accurate and reliable the data are, the higher will be, in principle, the probability of attaining true predictions.

5.4.2. Pattern Discernability

The second precondition for rational prediction has to do with pattern discernability. Once the data have been obtained, firstly, the researcher should discern the patterns followed by the phenomena; and, secondly, he should anticipate their future behavior. On the one hand, this question leads to an ontological dimension; and, on the other, it is related to an epistemic feature. In effect, it is assumed that phenomena that we want to predict should follow some patters; and, then, it is accepted that the subject who makes the prediction has to be able to discern those patterns from the available data.

Here, the problem of complexity (both structural and dynamic) can be crucial. In effect, when the system we want to predict is a complex system, this feature can make it difficult the task of establishing the patters of the relevant variables in the system. In this regard, the main contribution of

[965] According to Rescher, we are not really interested in prediction as such; but our interest is in reliable predictions. In his judgment, the reliability of a prediction might rest partly in the evidence and partly in the kind of phenomenon at issue (for example, if it is stable or volatile). In this case, the ontological aspect involves the attention to the context, which may influence the behavior of the phenomena. Cf. RESCHER, N., *Personal Communication*, 2.6.2015.

Rescher is in the identification of the different modes of complexity, which in his judgment belong to two dimensions: the epistemological component and the ontological level.[966] Thus, complexity can have repercussions on the concrete obstacles (epistemological and ontological) that makes pattern discernability difficult.

On this basis, in order to study the problem of the patter discernability, two successive steps should be followed. Firstly, the ontological and epistemological aspects of this issue can be considered (the existence of regularities or patterns and our capacity to grasp those patterns). And, secondly, the incidence of complexity — in its epistemological and ontological modes — on scientific prediction can be analyzed, because complexity can be an obstacle when we try to grasp the regularities of a system.

Regarding pattern discernability, the initial matter to take into account is of an ontological character. Thus, when we want to predict certain phenomenon or process, there are two initial possibilities: that it is a regular phenomenon or that, on the contrary, it is what Rescher calls an "anarchic" phenomenon; that is, a phenomenon that has followed no patterns.[967] It is usual to consider pattern discernability as a necessary condition for predictability, which in principle excludes the possibility of predicting phenomena characterized by being completely irregular (i.e., anarchic phenomena).

David F. Hendry has also insisted in the existence of regularities as a necessary condition for scientific prediction. His approach is with regard to economic forecasts. In his judgment, the success of economic forecasts is only possible if a series of requirements are fulfilled: "(a) there are regularities to be captured, (b) the regularities are informative about the future, (c) the

[966] Cf. RESCHER, N., *Complexity: A Philosophical Overview*, pp. 8-16.
[967] Cf. RESCHER, N., *Ignorance: On the Wider Implications of Deficient Knowledge*, p. 101.

proposed method captures those regularities, and yet (d) it excludes non-regularities."[968]

It can be maintained that this proposal coincides — in general lines — with Rescher's conception about the preconditions for rational prediction; although Rescher's approach is — in my judgment — more complete. This is because, besides the ontological feature and the strictly methodological component, he takes into account what has to do with the information needed for the prediction — data availability and the characteristics of the data — and he also adds an epistemological aspect: that there are regularities is not good enough, but the human capabilities to discern those regularities should be taken into account.

Despite those differences, both Rescher — from the perspective of the requirements needed for scientific prediction, in general — and Hendry — in the concrete realm of the economic forecasts — consider that the existence of regularities is needed in order to obtain reliable predictions. According to Rescher, "all modes of rational prediction call for scanning the data at hand in order to seek out established temporal patterns, and then set about projecting such patterns into the future in the most efficient way possible."[969]

Nevertheless, it is possible to think that the complete absence of regularities can make prediction impossible. In this regard, Rescher considers anarchy as one of the main ontological obstacles to predictability. He defines anarchy as "lawlessness—the absence of lawful regularities to serve as linking mechanisms."[970] Insofar as anarchy encompasses the absence of patterns in phenomena, it involves that the second prediction for rational prediction — patter discernability — cannot be fulfilled. Therefore, it might make impossible the task of predicting.

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[968] HENDRY, D. F., "How Economists Forecast," in HENDRY, D. F. and ERICSSON, N. R. (eds.), *Understanding Economic Forecasts*, The MIT Press, Massachusetts, 2003, p. 24.
[969] RESCHER, N., *Predicting the Future*, p. 86.
[970] RESCHER, N., *Ignorance. On the Wider Implications of Deficient Knowledge*, p. 101.

Rescher highlights this feature when he points out that “irregularity of process—the eccentricity of modus operandi at issue in anarchy—precludes rational prediction. A world without a stable order—even if only a probabilistic one—must inevitably fail to be predictively tractable.”[971] Thus, anarchic phenomena might be unpredictable, instead of being merely not-predictable. However, when prediction deals with an anarchic system, there are several possibilities:

1. It might be the case that the system is not really anarchic. Then, the apparent absence of patterns or regularities can be due to the incapacity of the agents to discern those patterns. Therefore, the obstacle to prediction is not an ontological limit, but an obstacle of an epistemological character. This happens more frequently when the system at issue is a complex system.

2. It is not probable that the system changes in the short or middle run; that is, anarchy — as an ontological feature — will be a characteristic of the system in the future (in the short and middle run). However, it is possible that its dynamic change in the long run, so something that is now unpredictable can be predictable in the future. In that case, the phenomenon or process is just not-predictable, instead of being genuinely unpredictable.

3. Finally, Rescher takes into account another possibility that, in principle, excludes unpredictability in the strong sense. Thus, in his judgment, “we can safely predict that they will keep on being anarchic, since no order-engendering processes are (by hypothesis) at work.”[972] In this way, he contemplates unpredictability regarding anarchic phenomena, but it is a qualified unpredictability, which only affects the possibility of obtaining specific predictions. Meanwhile, generic prediction is possible with regard to anarchic systems: we can securely predict that they will be anarchic in the future, at least, in the short and middle run.

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[971] *Ignorance, On the Wider Implications of Deficient Knowledge*, p. 104.
[972] RESCHER, N., *Predicting the Future,* p. 136.

Then we have that, regarding patter discernability, the anarchic character of phenomena and processes is an important obstacle in order to predict those phenomena or processes. To the extent that there are no relevant regularities that can be discerned, there is no possibility to obtain informative predictions about those systems. But, besides this ontological problem, Rescher has into account an epistemic difficulty. Thus, even when the phenomena are regular, the second precondition for rational prediction can be not satisfied. This might happen when the agents have difficulties in order to discern the patterns exhibited by the phenomena.

In this regard, "inferencial incapacity" should be taken into account, which is — for Rescher — one of the epistemological obstacles to predictability. It consists in "the infeasibility of carrying out the needed reasoning (inferences / calculation)—even where we may have the requisite data and know the operative inferential linkages."[973] An example can be the predictive models, where there is the possibility of ignoring some minor effects — although they can be potentially important — in order to carry through the required inferential processes.[974]

Seen in these terms, inferential incapacity can be an especially important limit to the prediction of complex systems (for example, the economic system). This issue has been highlighted by the conception of bounded rationality. Thus, when a system consists of a large number of variables with complex interactions among them (so the whole is more than the sum of the parts),[975] our capacities can be inadequate in order to encompass the system.

In effect, in the case of economics, it is usual to think of complexity as one of the features that raise more problems for prediction in this realm: "Very frequently — both from an epistemological viewpoint and from a

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[973] RESCHER, N., *Ignorance. On the Wider Implications of Deficient Knowledge*, p. 102.
[974] Cf. RESCHER, N., *Predicting the Future,* p. 153.
[975] Cf. SIMON, H. A., *The Sciences of the Artificial*, 3rd ed., p. 184.

methodological perspective — complexity is among the main reasons for maintaining that, in principle, the prediction of economic phenomena — its possibility and reliability — is more difficult than the prediction about natural happenings (including the weather forecast or, even, the prediction about the climate change)."[976]

Although Rescher does not pay especial attention to social sciences, in general, and to economics, in particular (which is where the interest in the problem of complexity and its repercussions on scientific prediction is usually focused), he has made important contributions to the study of this problem. His contribution is through the analysis of the modes of complexity, which he considers in two fundamental realms: the epistemological and the ontological ones.[977] It is an indirect contribution, since his aim is to offer a general framework of the possibilities regarding complexity.

Regarding this issue, he considers the "epistemic modes" of complexity, which has to do with formulaic complexity, and the "ontological modes," which deal with the complexity of reality itself. Within the epistemic modes, there are three possibilities: (i) descriptive complexity; (ii) generative complexity; and (iii) computational complexity. In the ontological level, there are also three modes of complexity. Each one of them is concreted in two possible lines: a) compositional (that can be constitutional and taxonomic); b) structural (organizational and hierarchical); y c) functional (operational and nomic).[978]

With this framework of complexity offered by Rescher, it is highlighted that there are a large number of factors — mainly epistemological and ontological — that are at stake when the aim is the prediction of a complex

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[976] GONZALEZ, W. J., "Complejidad estructural en Ciencias de Diseño y su incidencia en la predicción científica: El papel de la sobriedad de factores (*parsimonious factors*)," p. 145.
[977] Cf. RESCHER, N., *Complexity: A Philosophical Overview*, p. 9.
[978] Cf. *Complexity: A Philosophical Overview*, p. 9. On this issue of complexity, see additional aspects in this PhD research, section 7.4.: "Ontology of Prediction from the Perspective of Complexity."

system. For this reason, inferential incapacity, which can affect pattern discernability, has more weight when the prediction is made in a context of complexity. In a complex system, the number of variables and the interactions among them can exceed the human capacities to encompass the system and grasp in an adequate way the regularities that are important for the prediction.

Related to this problem, Rescher analyzes the difficulties for scientific prediction that have to do with factor exfoliation. In his judgment, "when effective prediction requires the resolution of various subordinated issues, we may have a situation where the chain is no stronger than its weakest link. For if any one of the subordinate factors is predictively intractable, the whole problem remains unresolved. Where the overall issue is systematically holistic, malfunction in a single component may well engender an overall breakdown."[979]

So he considers that "issues of this factor-exfoliating sort can readily prove to be predictively intractable because the outcome becomes veiled in the fog of a complexity into which we have —and can obtain— little or no secure insight."[980] In my judgment, parsimonious factors should be taken into account when a prediction is about a system of this kind (modulated by complexity) According to Simon, parsimony should not be equated to simplicity; since parsimony does not seek what is merely simple, but the necessary and sufficient factors in order to make the system manageable.[981]

When the systems are complex, the methodological role of the parsimonious factors conception should be emphasized, as a way of dealing

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[979] RESCHER, N., *Predicting the Future*, p. 153-154.
[980] *Predicting the Future,* p. 155.
[981] Cf. SIMON, H. A., "Science Seeks Parsimony, not Simplicity: Searching for Pattern in Phenomena," in ZELLNER, A., KEUZENKAMP, H. A. and MCALEER, M. (eds.), *Simplicity, Inference and Modelling. Keeping it Sophisticatedly Simple*, Cambridge University Press, Cambridge, 2001, pp. 32-72. Spanish version: "La Ciencia busca sobriedad, no simplicidad: La búsqueda de pautas en los fenómenos," in GONZALEZ, W. J. (ed.), *Las Ciencias de Diseño: Racionalidad limitada, predicción y prescripción*, pp. 71-107.

with the prediction of those complex systems. In effect, “due to the high number of factors at stake, prediction should start with something ‘tractable’ or feasible: it should search those factors that, in principle, are more relevant in order to encompass all the field of interest.”[982] Thus, it seems clear that the methodological conception of parsimony can provide solutions when the difficulty of prediction is related to pattern discernability within a complex system. This involves both the structural realm and the dynamic component.[983]

Therefore, when the whole system is not manageable, a solution might be focusing in the patterns of the necessary and sufficient factors in order to encompass the system. But, besides the structural complexity — that usually centers Rescher’s attention — the dynamic dimension should be also considered, which has to do with the changes over time. This issue leads to the third precondition for rational prediction: pattern stability. In this regard, historicity can be crucial in order to predict future phenomena (above all, in the social and artificial realms).

5.4.3. Pattern Stability

Once data have been obtained and patterns have been detected, the success of prediction requires that those patters are stable towards the future (either in the short, middle, or long run). In this regard, Rescher identifies two obstacles to scientific prediction that are related to *pattern stability*: 1) *Volatility* or absence of nomic stability; and, therefore, the lack manageable laws from a cognitive perspective; and 2) *haphazard*, which involves that the linking mechanisms do not permit the secure inference of particular

[982] GONZALEZ, W. J., “Complejidad estructural en Ciencias de Diseño y su incidencia en la predicción científica: El papel de la sobriedad de factores (*parsimonious factors*),” p. 153.
[983] Cf. GONZALEZ, W. J., “The Sciences of Design as Sciences of Complexity: The Dynamic Trait,” in ANDERSEN, H., DIEKS, D., GONZALEZ, W. J., UEBEL, TH. and WHEELER, G. (eds.), *New Challenges to Philosophy of Science*, Springer, Dordrecht, 2013, pp. 299-311.

conclusions. In turn, haphazard can be due to the presence of three factors: a) chance and chaos; b) arbitrary choice; and c) change and innovation.[984]

From the perspective of the need for stability in the patterns, it is clear the importance of the dynamic viewpoint when the preconditions for rational prediction are considered. Thus, besides the structural dimension, there is a dynamic component of complexity, which is related through the change over time. That change can involve novelties (for example, when human creativity intervenes) that are difficult to predict. Furthermore, as Rescher notices, "*the more important the innovation, the less predictable it is, because its very unpredictability is a key component of importance*."[985]

However, the structural aspect has primacy over the dynamic dimension of complexity in Rescher's account. Moreover, when he addresses the dynamic complexity, he uses the notion of "process." In his judgment, the metaphysics of processes has advantages over a substantialist approach in order to analyze the future from an ontological perspective. In this regard, he maintains that "the processual nature of the real means that the present constitution of things always projects beyond itself into one as yet unrealized future."[986]

In my judgment, the notion of "process" is not good enough by itself in order to address the study of the complex dynamics (both internal and external) and its repercussions on scientific prediction. As Wenceslao J. Gonzalez has noticed, in order to make advancements in the study of the changes in the phenomena and systems, historicity must be taken into account, insofar as it is a broader notion than the concept of "process." In rigor, *historicity* deals with three successive levels of analysis: science, agents, and the reality itself researched (above all, in the social and artificial

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[984] Cf. RESCHER, N., *Predicting the Future*, p. 134. The epistemological and ontological limits to predictability are analyzed in more detail in chapters 4 and 7 of this Ph.D. research.
[985] RESCHER, N., "The Problem of Future Knowledge," p. 152.
[986] RESCHER, N., *Process Metaphysics. An Introduction to Process Philosophy*, p. 54.

realms).[987] Thus, the notion of "historicity" is required — in my judgment — when the problem of the absence of pattern stability is analyzed.

But Rescher is mainly focused in the problem of predictability regarding the natural sciences, where historicity has less weight than in the social sciences or in the sciences of the artificial. Thus, in a sciences such as economics, which is a dual science (i.e., social and artificial), *historicity* can be considered as a factor that poses more difficulties for economic prediction than for prediction in the natural sciences.[988] In effect, the regularity of the phenomena (and, therefore, the stability of the patterns) is higher in natural sciences than in the social sciences and the sciences of the artificial, where the component of *historicity* leads to a dynamic dimension that involves changes over time.

Despite this difficulties, prediction is still possible if the stable elements are emphasized (or those elements that have some kind of regularity) in the different processes. Volatility and haphazard (in its diverse forms: chance and chaos, arbitrary choice, change and innovation) make the task of predicting difficult, and they can have negative repercussions on the accuracy and reliability of the predictions. Pattern stability of the processes is crucial for scientific prediction, so predictive methods must take into account the operations of the phenomena in order to predict them.

In this regard, Rescher's proposal offers — in my judgment — an adequate synthesis of the preconditions required for predictive success, which encompass different factors that are important from a methodological perspective: (i) data availability; (ii) pattern discernability; and (iii) pattern stability. With this approach he highlights the requirements that are necessary for predictability. Thus, by using the relevant information about the

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[987] Cf. GONZALEZ, W. J., "Conceptual Changes and Scientific Diversity: The Role of Historicity," p. 43.

[988] Cf. GONZALEZ, W. J., "La vertiente dinámica de las Ciencias de la Complejidad. Repercusión de la historicidad para la predicción científica en las Ciencias Diseño," p. 95.

phenomena's operations in the past and in the present, prediction requires discerning the stable patterns followed by those phenomena, so it is possible to infer their future behavior.

Furthermore, it should be highlighted Rescher's interest in making explicit the obstacles — above all, epistemological and ontological — that can affect each one of these three successive levels of the rational process of prediction. His perspective is preferentially focused on the natural science, so he barely pays attention to the social sciences and the sciences of the artificial. For this reason, the notion of historicity is not conveniently emphasized. This feature makes his approach — in my judgment — unsatisfactory in order to address the problem of change (either ontological or epistemological) and its repercussions on scientific prediction.