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

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CHAPTER 6

METHODS OF PREDICTION AND THEIR SCIENTIFIC RELEVANCE

When Rescher analyses the preconditions for rational prediction — data availability, pattern discernability, and pattern stability — he maintains that “rational prediction pivots on the existence of some sort of appropriate *linkage* that connects our predictive claims with the input data that provide for their justification.”[989] Then he considers that there are a variety of predictive methods, according to the processes used in order to establish that linkage between the available information and the anticipation of the possible future.

Rescher classifies the predictive processes in two main types:[990] (i) *estimative or judgmental procedures*, and (ii) *formal or discursive methods*. The former are developed on the basis of the personal estimations of the experts, while the later follow a series of rule or inferential principles well-articulated. In turn, formal methods can be of two kinds: a) *elemental* discursive processes, such as trend extrapolation or the use of analogies; and b) *scientific* discursive methods, which are mainly the inference from laws and the predictive models.

In this chapter, which complements the methodology of prediction addressed in chapter 5, the different predictive processes are analyzed. This means taking into account problems like the reliability of those processes and their adequacy in order to address different predictive issues. To do this, firstly, the estimative procedures of prediction are analyzed. Among them the Delphi procedure is highlighted, because Rescher himself contributed to its creation.[991] Secondly, the elemental discursive processes are considered,

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[989] RESCHER, N., *Predicting the Future*, p. 87.
[990] Cf. *Predicting the Future*, chapter 6, pp. 85-112; especially, pp. 86-88.
[991] On the characteristics of Delphi procedure, 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.

which include trend extrapolation and the use of analogies. Thirdly, the scientific discursive methods are analyzed, which — in principle — are the most reliable processes. Finally, an assessment of the different predictive processes is offered.

6.1. Estimative Procedures of Prediction

By "estimative" or "judgmental procedures" Rescher recognizes those predictive procedures that are developed on the basis of personal estimations of individuals, so they always have an important subjective component. This procedure does not involve necessarily the absence of rules or inferential principles; but those rules — if they are used — are not explicitly shown. In this way, our reliance on prediction's correctness is directly based in the authority of the predictor. Usually, predictors should be experts in the issue that prediction is about, so they can use their knowledge in order to discern the patterns in phenomena.

The estimative procedures are not a scientific method of prediction. This feature is emphasized by Rescher when he notices that, in this kind of procedure, "no substantive rationale for the claim itself [the prediction] need be discernible: our knowledge *that* can outrun our knowledge *why*."[992] For this reason, an estimative prediction is not in rigor a scientific prediction. In a scientific context, it is not good enough to state than something will happen (that is, making a prediction), because scientific prediction must be supported by reasons. Thus, besides predictive knowledge there should be some explicative knowledge,[993] and this knowledge is not accessible in the case of estimative predictions.

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[992] RESCHER, N., *Predicting the Future*, p. 89.

[993] This feature leads to Rescher's "harmony thesis" between explanation and prediction. Cf. RESCHER, N., "On Prediction and Explanation," pp. 281-290; especially, p. 286; and RESCHER, N., *Predicting the Future*, pp. 165-169.

Within the estimative procedures, two initial possibilities might be distinguished: (i) the individually made prediction (that is, a prediction made by one expert), or (ii) the combination of predictions of different experts, that can be made by using different techniques, such as aggregation processes (averaging) or the Delphi procedure (that Rescher himself contributed to create).[994] Both cases alike require a *metaprediction*; that is, a prediction about the reliability of the estimative prediction of the expert or experts,[995] which adds an *evaluative* component that should be taken into account.

6.1.1 The Role of the Experts

When prediction is the result of the estimation of one individual, the main methodological problem has to do with the reliability of the result. Since the *modus operandi* of the processes that lead to the prediction is unknown, "we certainly cannot provide any sort of cogent account for why the predicted result will indeed obtain."[996] For this reason, faced with an estimative prediction, the receiver or receivers of the prediction have a prominent role, insofar as they should evaluate the reliability of the prediction without knowing the reasons that can lead to the predictive statement.

Because the reasons are unknown, the only available criterion for the evaluation of the prediction is the expert's authority, so some objective indicator should be searched in order to evaluate that authority. In this regard, Rescher notices that "we will have to be in a position to see that track record of successful past predictive performance as providing a cogent (inductive) ground for expecting the predictor's analogous future predictions to come true."[997] Then, if a predictor has been successful in the past in

[994] Cf. RESCHER, N., *Predicting the Future*, pp. 91-96.
[995] On "metaprediction" see GONZALEZ, W. J., *La predicción científica*, pp. 84-85, 251, 259 and 267.
[996] RESCHER, N., *Predicting the Future*, p. 89.
[997] *Predicting the Future*, p. 89.

predicting issues related to certain field, this feature provides a sufficient reason in order to trust that his predictions will succeed in the future.

In this way, there is a first limitation that affects this kind of predictions and that has to do with their subject matter. In effect, "the fact is that predictive expertise has to be established with reference to a particular subject-matter area and limited issue domain."[998] Thus, in order to assess the credibility of an estimative prediction, the most reliable indicator is the record of the successes that, in the past, the predictor at issue has achieved with regard to predictive questions within a concrete subject matter.

A difficulty can arise that has to do with the possibility of conflicting predictions.[999] This happens more often in estimative predictions than when more elaborated predictive processes are used. It is a problem that makes the evaluation of the prediction difficult, above all when two experts whose predictions have been successful in the past achieve now conflicting predictions above the same topic. If this happens, there is not, in principle, any rational basis that allows us to give more credibility to one of the conflicting predictions.

Undoubtedly, although there were reasons to consider an estimative prediction as credible, there is always a possibility of error, which is higher than in the case of formal methods of predictions. This is because, in comparison with the formal or scientific methods, in estimative predictions there is a clear prominence of subjective elements. In this regard, there are many well-known examples of incorrect predictions; above all, in the realm of technology. For instance, in 1943 the founder of IBM, Thomas Watson, said that there was a world market for about five computers;[1000] and in the mid-

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[998] RESCHER, N., *Predicting the Future*, p. 90.
[999] Cf. *Predicting the Future*, p. 90.
[1000] Cf. RESCHER, N., *Predicting the Future*, p. 90.

nineties several experts in computer sciences predicted the end of the company Apple.[1001]

This kind of errors can be due a series of cognitive biases of the experts, which affect the correctness of the estimative prediction. Among those biases, the following ones can be highlighted: illusory correlations (i.e., false beliefs about the existence of a correlation between two variables), selective perception (that is, discounting information because it is inconsistent with the predictor's beliefs or expectations), underestimating uncertainty, optimism, overconfidence, etc.[1002]

Rescher takes into account this type of biases as cognitive or psychological obstacles to prediction. Among them, he highlights the following ones:[1003] 1) Imminence and scale exaggeration, which is the tendency to consider that an event or happening will occur "earlier in timing and larger in extent than the actual course of events will bear out in due course."[1004] 2) Conservatism, which is the exaggeration of the stability and durability of the current patterns. 3) Wishful (or fearful) thinking, that makes the predictor predict that things will happen because he thinks that they ought to do so. 4) Probability misjudgment, which can be due either to incorrect evaluations or to erroneous combinations.

Rescher considers that the mentioned factors can affect the predictive task in different circumstances; that it, independently of what concrete methods or procedures has been used, to the extent that predicting is a *human activity*. Thus, he does not circumscribe these problems to the specific realm of the estimative procedures of predictions. But it seems clear that those obstacles can affect to a greater extent the estimative predictions,

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[1001] Cf. POGUE, D., "When Apple Hit Bottom," *The New York Times*, 20.9.2006. Available *http://pogue.blogs.nytimes.com/2006/09/20/21pogue-email/?_r=0*, (access on 3.7.2013).
[1002] Cf. ÖNKAL-ATAY, D., THOMSON, M. E. and POLLOCK, A. C., "Judgmental Forecasting," in CLEMENTS, M. P. and HENDRY, D. F. (eds.), *A Companion to Economic Forecasting*, p. 137.
[1003] Cf. RESCHER, N., *Predicting the Future*, pp. 218-222.
[1004] *Predicting the Future*, p. 219.

which have an important subjective component. For this reason, in my judgment, the acknowledgment and analysis of this kind of psychological or cognitive biases is an especially relevant issue, which can contribute to elaborate the basis in order to overcome the problems of accuracy and precision of the estimative predictions.

6.1.2. Procedures for Combining Predictions

A way to overcome the difficulties posed by the predictions by individual experts consists in using different procedures that allow the combination of predictions made by different experts. Rescher divides these procedures for amalgamating expert predictions into two main groups:[1005] (i) non-interactive mechanical procedures; and (ii) consensus-formation processes such as the Delphi procedure.[1006] The former are simpler than the latter, which require further elaboration.

Within the first group — non-interactive mechanical procedures — Rescher takes into account two possibilities:[1007] a) selecting the majority option; and b) averaging the answers of different predictors. The first procedure is more appropriate for binary issues; for example, predictive questions whose answer can be "yes" or "no." Meanwhile, the second procedure can be used in numerical predictions, so the final prediction would be the average answer of the different predictors.

The adoption of the principle of the majority rule — the first option — is the simplest procedure. It is used in order to achieve a single prediction from the estimations of several experts. Certainly, the application of this procedure is limited, since it is habitually used in order to answer binary predictive uses. Furthermore, the risk than is taken when this procedure is used seems clear,

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[1005] Cf. RESCHER, N., *Predicting the Future*, p. 91.
[1006] Cf. *Predicting the Future*, pp. 92-96.
[1007] Cf. RESCHER, N., *Predicting the Future*, p. 91.

since it involves the assumption that the majority answer is also the correct answers, and this is not always the case.[1008]

Other procedure — the second mentioned — consists in finding the "average" answer. This can be done when different experts are questioned about a predictive answer that requires a numerical answer (for example, what will life expectancy be in 2030 in Spain?). In these cases, instead of taking the answer of one of the experts, the average answer can be used, so one single prediction is obtained, which is the result of the combination of different predictions.

By employing this second procedure, the predictive answer obtained will be certainly closer to the right answer than the worst of the individual predictions of the experts. But there is nothing else to say in favor of this predictive procedure. In this case, Rescher highlights the reliability of this kind of predictions, when he notices that the average is not always better than most individual predictions. [1009]

Therefore, non-interactive mechanical procedures of combination of predictions have, generally, little reliability. On the one hand, the majority option can be the incorrect option; and, on the other, the average answer can be further to truth than most of the individual answers. However, they are — in my judgment — procedures that can be useful when the only alternative is the suspension of judgment (for example, when there are conflicting prediction and there are no reliable indicators to choose one of the predictions, or when it is not possible to apply any other more sophisticated process of combination).

[1008] Cf. *Predicting the Future*, p. 91.

[1009] Cf. RESCHER, N., *Predicting the Future,* p. 91.

However, in Rescher's judgment, there are some contexts where the averaging process has been useful and outperformed most of the individual predictions of the experts. This happens, for example, in the case of the economic forecasts about the production and employment rates. Cf. RESCHER, N., *Predicting the Future*, p. 92.

6.1.3. The Delphi Procedure

An alternative to these mechanical procedures consists in the application of other predictive procedures that seek the consensus among the experts. Delphi procedure is a predictive process of this kind. In happens that Rescher himself contributed to the creation of this predictive procedure, so its analysis is especially interesting when his approach to the methodology of scientific prediction is considered.

Olaf Helmer, Norman Dalkey, and Nicholas Rescher conceived the Delphi procedure in the fifties, when they worked at the RAND Corporation (in Santa Monica, California), which was an institution that offered research support to the United States armed forces. The creation of this procedure of prediction should be related to the socio-political context of that time. Thus, in an international scene marked by the Cold War, Delphi procedure was developed with the aim of predicting the impact that technological innovation would have on the conflict between the United States and the Soviet Union.

By using the Delphi procedure, the aim is to achieve one prediction from the individual predictions of a group of experts, avoiding any direct interaction among them. Thus, an "aggregate prediction" is sought from the consensus of the different predictors.[1010] In order to achieve this aim, the experts should answer anonymously a series of questionnaires in several successive rounds. Besides the experts, there should be one or some persons who monitor the process. Their role is to elaborate the questionnaires and to collect the answers of the experts in statistical terms.[1011] After each round of questionnaires, the experts are given the

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[1010] Cf. RESCHER, N., *Predicting the Future*, p. 92.

[1011] In its "classic" form, the first round of questionnaires of the Delphi procedure serves to identify the relevant questions for the prediction. Instead of giving the experts an elaborated questionnaire, first they are asked to identify the problems that should be considered in relation to the predictive issue. Then, the facilitator or facilitators of the process select the key questions, and they elaborate a structured questionnaire that the experts should answer. Cf. ROWE, G. and WRIGHT, G., "Expert Opinions in Forecasting: The Role of the Delphi results of the group besides a new series of questionnaires. In this way, the predictors have the chance to review their own initial answers.

If the procedure works as planned, the answers of the experts will progressively come together after each successive round of questionnaires. Thus, in the final round, the opinions of the experts will be closer than in the first round, so finally a prediction is achieve with the consensus of opinion of the experts. This final result is achieved by giving the predictors the answers of the group and allowing them to reconsider their own answers in the light of the results obtained. Moreover, there is the possibility of favoring this convergence of the different opinions by using other means, such as, for example, to rule out the extreme answers.[1012]

There are two possible versions of the Delphi procedure: the version made on paper, called "Delphi exercise," and the version developed using computers, labeled "Delphi conference."[1013] In the former — "Delphi exercise" — there is a facilitator or a small group of facilitators that direct the process, make the questionnaires, collect the answers in order to put them in statistical terms, and make the adjustments required. Meanwhile, in the later — "Delphi conference" — the computer replace to a larger extent the figure of the facilitator. In this case, the use of a computer that has been programmed in order to process the results of the questionnaires has the advantage of making the process faster.

Although Delphi procedure can have different versions, these versions have always the following characteristics: (i) anonymity of the experts; (ii) structuring of information flow; (iii) feedback; and (iv) presence of one or

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Technique," in ARMSTRONG, J. S. (ed.), *Principles of Forecasting: A Handbook for Researchers and Practitioners,* p. 126.

[1012] Cf. RESCHER, N., *Predicting the Future*, p. 93.

[1013] Cf. LINSTONE, H. A. and TUROFF, M., *The Delphi Method. Techniques and Applications*, p. 5 of the electronic version. Available in: *http://is.njit.edu/pubs/delphibook/delphibook.pdf* (accessed on 3.7.2013).

several facilitators.[1014] These characteristics make Delphi procedure different from other interactive procedures that seek the consensus of the experts.

In order to avoid some of the cognitive biases, which can affect prediction when the individuals directly interact among then, *anonymity* is crucial. Thus, one of the main advantages of the Delphi procedure over other predictive procedures that allow the social interaction consists is that anonymity minimizes the effect of certain cognitive biases, such as the "bandwagon effect."[1015] It is a bias related to social pressure, which consists in the support of some opinion by an agent because it is the opinion shared by the majority of the group.

Through anonymity, the individuals are prevented of being negatively influenced by the group. In this way, this feature helps to create the adequate conditions so the experts can freely express their opinions. Moreover, it facilitates the open criticism to the results achieved by the group, and allows the experts to revise their own answers without any external pressure. Furthermore, it is avoided that one of the experts acts as a leader of the group, due to his authority, personality, or reputation. In effect, in case of allowing the direct interaction among the experts, one individual could influence the result in a decisive way.

The second main characteristic of Delphi procedure has to do with how the information flow among the experts is structured. Once the predictors have answered the first round of questionnaires, the results are analyzed and they are expressed in statistical terms. Besides the answers, the comments of the experts also appear, so the group can know the reasons that the others have gave in order to maintain a certain opinion. In this way, there is some interaction among the experts, but it is not a direct interaction because

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[1014] Cf. "Delphi Method," *Wikipedia*. Available in: *http://en.wikipedia.org/wiki/Delphi_method* (access on 3.7.2013).

[1015] Cf. SIMON, H. A., "Bandwagon and Underdog Effects and the Possibility of Election Predictions," *Public Opinion Quarterly*, v. 18, (1954), pp. 245-253. Compiled in SIMON, H. A., *Models of Bounded Rationality*. Vol. I: *Economic Analysis and Public Policy*, pp. 460-468.

is mediated by the facilitator or the team of facilitators. Besides anonymity, these features of the Delphi procedure contribute to avoid the negative effects that are usual in a group dynamics.

Continuous *feedback* is other of the characteristics of the Delphi procedure. Feedback is crucial in order to achieve a final consensus among the experts. In this regard, the experts can be asked to do comments on their own answers and on the opinions of the other experts, as well as on the progress of the group in general. This feature makes the experts more prone to review their own answers in the light of the results achieved by the group, which is an unusual feature when a group of persons has to interact until achieving a consensus.

Finally, unlike other predictive procedures, Delphi procedure is characterized by the role played by the *facilitator* or the team of facilitators. Firstly, the facilitators must select the experts who will participate in the process. This selection must be done in the basis of the knowledge of the possible predictors about the topic of the prediction.[1016] Secondly, they elaborate and send the questionnaires, collect the information, and analyze the results obtained. Finally, they identify the conflicting opinions, as well as those questions regarding to which the experts agree, until the eventual aim of the consensus among the experts is achieved.

Together, these four characteristics of the Delphi procedure — anonymity, structuring of information flow, feedback, and the presence of facilitators — make possible to minimize the effects that social pressure can have (either when it is exerted by one individual or by the majority) on the individual opinions. Moreover, to the extent that it is oriented towards the

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[1016] Although it is not a direct criticism to Delphi procedure, it can be assumed that the experts have "bounded rationality"; that is, that their capacity to compute the information is limited. On bounded rationality, see the three volumes by Simon about *Models of Bounded Rationality*: SIMON, H. A., *Models of Bounded Rationality.* Vol. 1: *Economic Analysis and Public Policy*; SIMON, H. A., *Models of Bounded Rationality.* Vol. 2: *Behavioral Economics and Business Organization*; and SIMON, H. A., *Models of Bounded Rationality.* Vol. 3: *Empirically Grounded Economic Reason*.

predictor's consensus, it offers — in principle — better results than the mechanical procedures of aggregation of predictions (such as the majority principle or the average of different numerical predictions). Finally, as the aim is the achievement of one collectively-made prediction, the individual psychological factors have less weight than when the prediction is made by only one expert.

When Delphi was created, it was mainly used to obtain predictions about the development of technology.[1017] Later, it was also used to make predictions about the social realm; for example, in economics. Within the realm of economics, it seems clear to me that Delphi procedure has some advantages over other estimative procedures of predictions. In effect, "Delphi assumes an especially critical role when geographically separated experts with diverse knowledge bases need to interact under conditions of scarce data — an archetypical economic forecasting scenario given the globalization process."[1018]

The application of Delphi procedure to planning issues (especially, in the design of public policy) is related to its use in order to obtain forecasts.[1019] This has been made since the seventies. Moreover, this use involved the introduction of a series of methodological contributions, among which the following ones can be highlighted:[1020]

[1017] An example of this use of the Delphi procedure is in the report made by T. J. Gordon and O. Helmer. The report presents the results of a study whose aim was the forecasting in the long run of the scientific and technological development in several realms: main scientific discoveries, population growth, automation, space development, prevention of war, and future weapon systems. Cf. GORDON, T. J. and HELMER, O., "Report on a Long-Range Forecasting Study," *RAND Corporation Research Paper P-2982*, 1964. Available in: *http://www.rand.org/content/dam/rand/pubs/papers/2005/P2982.pdf* (access on 12.7.2013).

[1018] ÖNKAL-ATAY, D., THOMSON, M. E. and POLLOCK, A. C., "Judgmental Forecasting," in CLEMENTS, M. P. and HENDRY, D. F. (eds.), *A Companion to Economic Forecasting*, p. 141.

[1019] Cf. ZIGLIO, E., "The Delphi Method and its Contribution to Decision-Making," in ALDER, M. and ZIGLIO, E. (eds.), *Gazing into the Oracle. The Delphi Method and its Application to Social Policy and Public Health*, Kingsley Publishers, London, 1996, pp. 3-33. See also RESCHER, N., "Delphi and Values," *RAND Corporation Research Paper P-4182*, 1969. Available in: *http://www.rand.org/content/dam/rand/pubs/papers/2008/P4182.pdf* (access on 12.7.2013).

[1020] Cf. "Delphi Method," in *Wikipedia*. Disponible en: *http://en.wikipedia.org/wiki/Delphi_method*

1) Besides the strictly predictive issues, some aspects that have to do with the problems, the aims, and the possible options should be considered. This leads to the introduction of different scales of evaluation, which are not used when the Delphi procedure — in the standard version — is oriented towards prediction. Thus, parameters are included such as a proposal's desirability and feasibility (both in a technical and in a political sense), importance, and probability.[1021]

2) When Delphi procedure is oriented towards planning, the arguments provided by the experts in order to defend their opinions are more important. This feature is because of the complexity of the problems that they want to solve. For this reason, the experts are asked to elaborate lists with the pros and cons of each concrete option and, moreover, there is always the possibility of adding new relevant questions for planning.

3) The complexity of the problems also involves a higher complexity of the process, so the methods of measuring require frequently more sophisticated methods, such as for example multi-dimensional scaling. It should be noticed that measures should take into account the complex reality, which has two dimensions: structural and dynamic.[1022]

Retrospectively, it can be seen that the realms of application of the Delphi procedure have been broadened and diversified since its creation in the fifties of the 20th century. This feature also involved the introduction of

[1021] Cf. TUROFF, M., "The Design of a Policy Delphi," *Technological Forecasting and Social Change*, v. 2, n. 2, (1970), pp. 149-171. Available in: *http://is.njit.edu/pubs/delphibook/ch3b1.pdf*, (access on 16.7.2013).

[1022] Both prediction and prescription are related with structural and dynamic complexity. This is addressed in 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*, pp. 7-30; GONZALEZ, W. J., "La vertiente dinámica de las Ciencias de la Complejidad. Repercusión de la historicidad para la predicción científica en las Ciencias de Diseño," in GONZALEZ, W. J. (ed.), *Las Ciencias de la Complejidad: Vertiente dinámica de las Ciencias de Diseño y sobriedad de factores*, pp. 73-106; and 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.

variations regarding its initial configuration. However, its use is generally limited to those situations in which information about the future is required, but it is not possible to apply other method that provides more guarantee.[1023] Then, Delphi procedure can be adequate in order to obtain predictions about some complex phenomena — above all, in the social realm — and when there is uncertainty.

But this limitation has repercussions on the reliability of the Delphi procedure as a process of prediction. In effect, insofar as it is used in order to predict matters when uncertainty makes it impossible to use other more reliable predictive processes, it is likely that frequently errors appear in the results. This has a double lecture: on the one hand, it is not a completely reliable method — in fact, it is in rigor a "procedure"[1024] — but, on the other, it is a procedure that has utility, since it allows us to obtain forecasts in those cases where it is not possible to use other predictive processes.

Other issue to be considered when the reliability of this procedure is assessed has to do with the subject-matter of the prediction (economic, technological, socio-political, etc.). In this regard, as Rescher admits, the success achieved by estimative predictions varies, in general, according to their thematic realm. Thus, he notices that its performance is "good in engineering, fair in medicine, shaky in economics, and distinctly poor in sociopolitical affairs."[1025]

It can be thought that the same happens with the use of the Delphi predictive procedure, insofar as the reliability of the achieved predictions varies according to the thematic field of the forecast: technological issues or social matters.[1026] Thus, when the aim is to predict the future development of technology, Delphi procedure has been successful in the forecast in the short

[1023] This is aknowledged by Rescher. Cf. RESCHER, N., *Predicting the Future*, p. 96.
[1024] On the distinction between predictive "procedures" and "methods," see GONZALEZ, W. J., *Philosophico-Methodological Analysis of Prediction and its Role in Economics*, pp. 255-257.
[1025] RESCHER, N., *Predicting the Future*, p. 90.
[1026] Cf. RESCHER, N., *Predicting the Future*, pp. 94-96.

run; while it is less reliable when it is oriented towards prediction in middle and in the long run.[1027]

However, according to Rescher's view, "it would seem that if we are looking for a forecasting method with a proven track record in the area of 'technological forecasting' over the nearer term then we can do no better than to employ the Delphi technique."[1028] Meanwhile, regarding social prediction, Rescher thinks that "all the indications are that on such matters one would not be well advised to put much reliance on Delphi methods."[1029] Therefore, there is a clear acknowledgement of the existence of limits — at least methodological — that involve epistemological limitations regarding prediction.

To sum up, with regard to the reliability of the Delphi procedure, several methodological conclusions with epistemological incidence can be drawn: (i) Their results are generally more reliable than in the case of the predictions made by only one expert, since by seeking an "aggregate prediction" the biases that affect the predictors at the individual level are minimized. (ii) It gives more guarantee that the mechanical procedures of combination of predictions (such as averaging or choosing the majority answer), since the prediction is the result of an active search for consensus.

Moreover, it can be pointed out that the procedure has some methodological advantages and undeniable epistemological limitations. (iii) The characteristics of the procedure — anonymity, structuring of information flow, feedback, and the presence of facilitators — avoid that the social pressure and other biases commonly present in group interactions directly affect the result. (iv) Delphi allows the achievement of forecasts about

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[1027] This can be clearly seen in the report by Gordon and Helmer, published in 1964. The forecasts for the year 1984 achieved generally a higher degree of accuracy than the predictions for the year 2000. Cf. GORDON, T. J., and HELMER, O., "Report on a Long-Range Forecasting Study," *passim*.

[1028] RESCHER, N., *Predicting the Future*, p. 95.

[1029] *Predicting the Future*, p. 96.

complex problems and under conditions of uncertainty, so certain level of error in the results would be expected. (v) The reliability of the procedure varies according to the thematic field of the prediction and its temporal projection. In practice, it is more effective in order to make technological predictions — above all, in the short run — than in social prediction.

6.2. Elementary Formalized Processes

Although Rescher contributed to the creation of the Delphi procedure, which is one of the better-known procedures to obtaining judgmental predictions and also one of the most used, he acknowledges that "it is fortunate that the use of experts is not our only predictive resource."[1030] Thus, besides the estimative or judgmental predictive procedures, based on expertise knowledge, there are formalized or discursive processes, which are based on well-defined rules or principles.

Rescher divides the formalized procedures into two categories: *elementary discursive processes* and *scientific discursive processes*. The former are procedures mainly oriented to establish patterns followed by the phenomena in the past in order to project then those patterns into the future; while the later use scientific laws or predictive models. Within the first group, Rescher considers two main procedures: (i) trend extrapolation, which could be divided into three options: a) linear extrapolation, b) non-linear extrapolation, and c) cyclical analysis; and (ii) the use of analogies.[1031]

6.2.1. Trend Extrapolation

Trend extrapolation is a frequently used predictive process. In its simplest version, it consists in the linear projection of patterns or trends that have been observed in the phenomenon at issue. This involves the

[1030] RESCHER, N., *Predicting the Future*, p. 97.
[1031] Cf. *Predicting the Future*, pp. 97-102.

assumption that the phenomenon is characterized by being regular (that is, highly stable). In that case, its future development can be anticipated through the projection into the future of its past behavior (for this reason, it is mainly used for forecasts in the short run).[1032]

On this basis, the reliability of the trend extrapolation completely depends on the mentioned feature: that the predicted processes are characterized by being stable. Consequently, this makes that their results very sensitive to changes in the prevailing conditions.[1033] So, if a change occurs that alters the prior patterns, prediction will not be successful (at least, in terms of accuracy and precision).[1034] Moreover, the changes are especially difficult to anticipate, to the extent that the prior patterns do not allow us to predict them.

It is usual problematic the assumption that the previous patterns will project themselves into the future without alterations. An example of this problem is provided by the predictions based on the assumption that growth rates of the past will continue into the future. According to Rescher, in most phenomena and processes, both natural and social, the exponential growth does not continue indefinitely, but there is a saturation point: "most growth phenomena eventually conform to an S-shaped saturation curve."[1035]

In those cases, non-linear extrapolations are used instead of linear trend extrapolation. In this way, "it can assume the shape of a curve of some nonlinear sort (exponential, sinusoidal, S-shaped, etc.)."[1036] Thus, although the initial assumption is that the phenomenon is stable in its development, non-linear extrapolation deals better with the possibility of alterations (for

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[1032] Cf. ARMSTRONG, J. S., "Extrapolation for Time-Series and Cross-Sectional Data," in ARMSTRONG, J. S. (ed.), *Principles of Forecasting: A Handbook for Researchers and Practitioners,* pp. 217-243.
[1033] Cf. RESCHER, N., *Predicting the Future*, p. 98.
[1034] On these options, see GONZALEZ, W. J., "The Role of Experiments in the Social Sciences: The Case of Economics," in KUIPERS, T. (ed.), *General Philosophy of Science: Focal Issues*, Elsevier, Amsterdam, 2007, pp. 299-325.
[1035] *Predicting the Future*, p. 99.
[1036] RESCHER, N., *Predicting the Future*, p. 99.

example, anticipating the saturation point when there has been an exponential growth in the phenomenon predicted).

When this method is used for making a prediction, then the analysis of the available data is crucial in order to achieve predictive success. In this case, the aim consists in finding a function in order to accommodate data, at least in a general way.[1037] Statistics is especially useful for this task, since it provides the required mechanisms for detecting patterns from big data.[1038] But there is also a series of values that should accompany the strictly mathematical or statistical considerations, such as simplicity, smoothness, and symmetry.[1039]

However, it is usual to consider to what extent simplicity in the processes (statistical, mathematical, etc.) used for trend or pattern extrapolation is better than complexity. An option might be the principle according to which simple representations of trends should be used when there are no good reasons to do other thing.[1040] Rescher supports this option when he notices that, when a function is search in order to represent a process, "the pivotal task is to fin done that fits reasonably well, is plausible considering the overall situation, and is no more complex than need be."[1041]

Several studies provide support for the thesis that it is not usual that the complexity of an extrapolation leads to increase the accuracy of the prediction obtained.[1042] However, as Rescher maintains, the crucial point is that there is no more complexity than need be. J. Scott Armstrong goes in the

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[1037] Cf. *Predicting the Future*, p. 100.
[1038] Cf. RESCHER, N., *Predicting the Future*, p. 100.
[1039] Cf. *Predicting the Future*, p. 100.
[1040] Cf. ARMSTRONG, J. S., "Extrapolation for Time-Series and Cross-Sectional Data," in ARMSTRONG, J. S. (ed.), *Principles of Forecasting: A Handbook for Researchers and Practitioners,* pp. 227-228.
[1041] RESCHER, N., *Predicting the Future*, p. 99.
[1042] Cf. MAHMOUD, E., "Accuracy in Forecasting: A Survey," *Journal of Forecasting*, v. 3, (1984), pp. 139-159; SCHNAARS, S. P., "Situational Factors Affecting Forecast Accuracy," *Journal of Marketing Research*, v. 21, (1984), pp. 290-297; and MEADE, N. and ISLAM, T., "Forecasting the Diffusion of Innovations: Implications for Time-Series Extrapolation," in ARMSTRONG, J. S. (ed.), *Principles of Forecasting: A Handbook for Researchers and Practitioners,* pp. 577-595.

same direction when he defends that simplicity should be valued in relation with the need for realism. In that case, "complexity should only be used if it is well-supported. Simplicity is especially important when few historical data exist or when the historical data are unreliable or unstable."[1043]

Within the procedures of trend extrapolation there is also the cyclical analysis, which has a series of specific characteristics.[1044] It is a process of prediction that seeks to detect patterns in the data that repeat over time (for example, the business cycle, where there are periods of economic growing followed by periods of contraction). In that case, prediction is based on the fact that the phenomenon at issue follows a cyclical development. In this way, it is possible to anticipate the evolution of that phenomenon once it is known what current stage of the cycle is.

It is a procedure usually used in the social sciences, in general, and in economics, in particular. However, its scientific character can be questioned, since it is only based on pattern detection. Prediction needs *reasons*,[1045] so the simple detection of a cyclical development is not good enough for making a scientific prediction. For this reason, although it is used frequently, it is also habitual to consider its use as problematic.[1046]

According to Rescher, placing the current moment within a cycle is one of the main problems that this procedure poses. In his judgment, "the unfortunate reality is that this matter of positioning [in a cycle] is something that can all too often be done only with the wisdom of hindsight."[1047] Obviously, this feature makes prediction difficult, since the anticipation of the future stages of a cycle depends to a large extent on the correct knowledge about the current stage of that cycle.

[1043] ARMSTRONG, J. S., "Extrapolation for Time-Series and Cross-Sectional Data," p. 227.
[1044] Cf. "Extrapolation for Time-Series and Cross-Sectional Data," p. 233.
[1045] Cf. GONZALEZ, W. J., "On the Theoretical Basis of Prediction in Economics," *Journal of Social Philosophy*, v. 27, n. 3, (1996), pp. 201-228.
[1046] See RESCHER, N., *Predicting the Future*, pp. 100-101 and ARMSTRONG, J. S., "Extrapolation for Time-Series and Cross-Sectional Data," p. 23
[1047] RESCHER, N., *Predicting the Future*, p. 101.

A problem that generally affects extrapolation (both linear and non-linear) consists in establishing in which situations it is adequate to use it as a predictive procedure. In J. S. Armstrong, there are a series of conditions that justify the use of this procedure. These conditions are the following ones: (i) when it is not possible to take the costs of other predictive processes; (ii) when the forecaster has little knowledge about the problem at issue; (iii) when the phenomenon to be predicted is stable; (iv) when other alternative methods would be subject to biases; and (v) when it is used a support for another predictive process.[1048]

1. According to Armstrong, the use of extrapolations can be justified when it is not possible to take the costs (in terms of effort, time, resources, etc.) that might involve the use of other more sophisticated methods of prediction (for example, when many forecasts are required).[1049] However, the success of the predictions or forecasts depends on phenomena themselves. For this reason, in my judgment, it is questionable the selection of trend extrapolation as predictive procedure only based on economic criteria or values.

2. Armstrong thinks that, when the predictor has little knowledge about the problem, it can be reasonable to assume that the processes will follow the same patterns in the future as those observed in the past.[1050] Rescher takes into account this possibility when he notices that "too often, trend projection is simply a matter of the crude extrapolation of everyday experience."[1051] In this case, the result of the extrapolation is not a scientific prediction, to the extent that there is not an understanding of the mechanisms

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[1048] Cf. ARMSTRONG, J. S., "Extrapolation for Time-Series and Cross-Sectional Data," pp. 236-237.
[1049] Cf. "Extrapolation for Time-Series and Cross-Sectional Data," p. 236.
[1050] Cf. ARMSTRONG, J. S., "Extrapolation for Time-Series and Cross-Sectional Data," p. 236.
[1051] RESCHER, N., *Predicting the Future*, p. 98.

that connect the past facts with the future developments.[1052] Furthermore, the absence of reasons has negative repercussions on the reliability of the procedure: "where we lack an understanding of underlying processes, we become particularly vulnerable to defeat by the unexpected."[1053]

3. If the predictive issue is stable, trend extrapolation is frequently the best method available. In effect, it allows us to predict reliability phenomena that are characterized by being stable and it also has the advantage of being a simple, fast, and low-cost procedure. But, even in this case, there are limitations regarding the use of this predictive procedure. Usually, trend extrapolation works better when the prediction in in the short run than when it is in the middle or long run.[1054] This is because in the long run changes are more difficult to predict, so making a prediction in the long run based on the assumption that the patterns will continue into the future is always risky.

4. If the alternative processes might be subject to predictor's biases (psychological, cognitive, etc.), the use of trend projection is — according to Armstrong — appropriate.[1055] This involves the assumption that trend extrapolation, as a formal process of prediction, is always better than any estimative or judgmental procedure. But this is not always the case. If the predictive issue is unstable, estimative procedures can be the best option when it is not possible to use other formal methods.

5. Finally, Armstrong considers that trend extrapolation can be used as a benchmark in assessing the effects of policy changes.[1056] When an expert wants to predict an issue of this kind, he can use the results obtained from trend extrapolation. But, in this case, trend extrapolation is not use in rigor as

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[1052] As it is noticed in different places of the present research, predictivist approaches have background epistemological problems.

[1053] *Predicting the Future*, p. 98.

[1054] Cf. GARDNER, E. S. JR. and MCKENZIE, E., "Forecasting Trends in Time Series," in FILDES, R. and ALLEN, P. G. (eds.), *Forecasting*. *Vol. 1: Traditional Time-Series and Computer-Intensive Methods*, Sage, London, 2011, pp. 45-57.

[1055] Cf. ARMSTRONG, J. S., "Extrapolation for Time-Series and Cross-Sectional Data," p. 236.

[1056] Cf. ARMSTRONG, J. S., "Extrapolation for Time-Series and Cross-Sectional Data," p. 236.

a predictive procedure; but it might serve as a support for an estimative or judgmental prediction.

After considering the cases that Armstrong maintains that favor the use of trend extrapolation, it seems clear to me that conditions 1 and 4, by themselves, do not justify the use of this predictive procedure. In turn, in cases 2 and 5 trend extrapolation is not a formal method of prediction. In effect, in condition 2, it is not a scientific method, since there is no knowledge about the working of phenomena; while in case 5 it is only used as a support for an estimative procedure. Thus, only when condition 3 is the case (i.e., when the patterns are stable) the use of extrapolation as predictive processes can be justified.

Therefore, trend extrapolation is a reliable method, by its realm of application is certainly limited. It should be used only for the prediction of stable processes and phenomena, since its success depends on the premise that the past patterns will continue into the future. For this reason, when there are changes or discontinuities, it is very likely that the use of trend projection as predictive procedure will result in false predictions.[1057] Thus, it also has little interest from a practical viewpoint. As D. F. Hendry notices, "forecasts are most useful when they predict changes in tendencies, and extrapolative methods can never do so."[1058]

6.2.2. The Use of Analogies

Rescher also considers the use of analogies as an elementary predictive process.[1059] Like trend projection or cyclical analysis, analogy is also a procedure based on extrapolation. But, in this case, the patterns

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[1057] Cf. ARMSTRONG, J. S., "Extrapolation for Time-Series and Cross-Sectional Data," in ARMSTRONG, J. S. (ed.), *Principles of Forecasting: A Handbook for Researchers and Practitioners,* p. 237.

[1058] HENDRY, D. F., "How Economists Forecast," in HENDRY, D. F. and ERICSSON, N. R. (eds.), *Understanding Economic Forecasts*, p. 25.

[1059] Cf. RESCHER, N., *Predicting the Future*, pp. 101-102.

discern in a certain phenomenon are used in order to predict other different phenomenon. For this reason, this predictive process is frequently used when there are no available data about the predictive issue (for example, when the prediction is about the sales of a new product, it is possible to resort to data about the sales of other similar products in the past).

The first issue to consider regarding this procedure is how the analogy can be established (i.e., on what basis it is made the decision that the use of the patterns from one realm can be used to predict another different realm). In this regard, Rescher considers that an analogy can rest on several types of similitudes: (i) descriptive similarities; (ii) shared structures; and (iii) common processes.[1060] Obviously, the more similar the phenomena are — either in descriptive, structural, or procedural terms — the higher the probability of predictive success will be.

Consequently, to a large extent, the use of analogies as predictive process will be reliable if the analogies are well-grounded. Thus, Armstrong's claim that "information from analogies can reduce the effects of potential biases because analogies provide objective evidence"[1061] is — in my judgment — questionable. In effect, although there are many similitudes between two phenomena, these are never identical, so there is always certain risk of error: "The situations we analogize are never exactly identical, so that all analogies are of limited elasticity and have an eventual breaking point."[1062]

Furthermore, sometimes the prediction might be false because the predictor has the false belief that two processes or events are analogous. Thus, it is especially important the truthful information about the working and characteristics of phenomena. Certainly, it is a useful procedure when there

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[1060] Cf. *Predicting the Future*, p. 101.

[1061] ARMSTRONG, J. S., "Selecting Forecasting Methods," in ARMSTRONG, J. S. (ed.), *Principles of Forecasting: A Handbook for Researchers and Practitioners,* p. 379.

[1062] RESCHER, N., *Predicting the Future*, p. 102.

are no data about a certain phenomenon, but we have information enough to establish an analogy with a different phenomenon. However, taking a wary attitude towards the forecasts obtained though this procedure seems to be advisable. The reason is clear: there is always certain risk of error when, in order to predict a phenomenon, data are used about a different phenomenon, even if there are many similarities between them.

6.3. Formalized Scientific Methods

Unlike estimative procedures, formalized processes are based on a series of well-articulated rules or inferential principles. Within them, there are "scientific" methods. Formalized scientific methods are the most reliable predictive processes. The crucial factor is an epistemological one: they are articulated on the basis of a rigorous (scientific) knowledge of the predicted phenomena. Among them, the following ones can be highlighted: a) the use of correlations as predictive indicators; b) the inference from scientific laws; and c) the use of predictive models.[1063]

6.3.1. Correlation as a Predictive Indicator

A method that is frequently used in order to predict the possible future consists in "employing *predictive indicators* that are based on an empirical finding that two (usually quantitative) factors are closely correlated in such a way that the behavior of the one foreshadows the behavior of the other (either invariably or with statistical preponderance)."[1064] From this perspective, correlations have predictive value: they can serve as indicators that make the prediction possible.

"Correlation" is a linear association (positive or negative) between two variables. The correlation coefficient (r) covers the interval [-1, 1]. If $0 < r < 1$,

[1063] Cf. RESCHER, N., *Predicting the Future*, p. 106-110.
[1064] *Predicting the Future*, pp. 102-103.

then there is a positive correlation between two variables. If $r = 1$, there is a positive perfect correlation; that is, a total dependence between the variables. Thus, if the value of one of them increases, the values of the other one will increase in constant proportion. But the correlation can also be negative. This happens when $-1 < r < 0$. The negative correlation is perfect if $r = -1$. In that case, if the values of one the variables increase, the values of the other one decrease in constant proportion. Meanwhile, there is no linear correlation between the variables when $r = 0$.

When the existence of a correlation between two variables is known, this knowledge can be used in order to predict changes in those variables. In fact, it is possible to anticipate either an increase in the value of one of the variables — if the correlation is positive — or a decrease in its value (if the correlation is negative), if it has been observed previously that the value of the other variable has been increased. Obviously, the closer the correlation coefficient (r) is to the extreme values -1 and 1, the more reliable the prediction will be.

However, correlation does not necessarily imply a causal relation[1065] (even if it is a perfect correlation). In this regard, the notion of "spurious correlation" is used for those correlations that do not imply causality.[1066] But spurious correlations can be the result of a causal structure, for example, when the two events or processes that form the correlation are related with a third variable, which is the cause of them.[1067]

[1065] A discussed issue is what "causal relation" is. Over the last decades, there have been many proposals, among them the one offered by Woodward. Cf. WOODWARD, J., *Making Things Happen: A Theory of Causal Explanation*, Oxford University Press, N. York, 2003. See also CAMPANER, R., "Causality and Explanation: Issues from Epidemiology," in DIEKS, D., GONZALEZ, W. J., HARTMAN, S., UEBEL, TH. and WEBER, M. (eds.), *Explanation, Prediction, and Confirmation,* pp. 125-135.

[1066] Cf. SIMON, H. A., "Spurious Correlation: A Causal Interpretation," *Journal of the American Statistical Association*, v. 49, n. 267, (1954), pp. 467-479.

[1067] Cf. WARD, A., "Spurious Correlations and Causal Inferences," *Erkenntnis*, v. 78, (2013), p. 701.

Certainly, the prediction made on the basis of a spurious correlation can be problematic. In effect, sometimes there is no an explicative knowledge about the correlation: we do not know why two variables are correlated. Prediction, in this case, is possible; but its scientific character can be easily questioned. Babylonians, for example, could predict eclipses with accuracy on the basis of correlations, but this predictive success is not supported by a scientific knowledge of astronomical phenomena.[1068] A scientific prediction cannot be limited to claim that something will happen, but there should be also a theoretical framework that provides an account about why the predicted phenomenon or process will happen.[1069]

Although in the case that we cannot provide reasons why two variables are correlated, correlation has anyway predictive value. In Rescher's judgment, "people's reliance on such unexplained predictive indicators is itself reasonable and explicable, being validated by the very fact of that established correlation."[1070] So he considers that "if suicide rates are coordinated with phases of the moon, that by itself is good enough [in order to predict]; the question of 'the reason why' is in this context something secondary."[1071]

Despite this practical value of spurious correlations, it is preferable to use as predictive indicator the correlations that do involve a causal relation between the two variables, or used them when the causal structure of the correlation is known (for example, when there is a third variable that is the cause of both the correlated variables). Rescher admits this feature when he holds that "unless predictive indicators rest on a secure explanatory foundation, those who rely on them build their houses on sand."[1072]

[1068] Cf. RESCHER, N., *Predicting the Future*, p. 103.
[1069] Cf. RESCHER, N., "On Prediction and Explanation," pp. 281-290; especially, p. 286; and RESCHER, N., *Predicting the Future*, pp. 165-169.
[1070] RESCHER, N., *Predicting the Future*, p. 103.
[1071] *Predicting the Future*, p. 103.
[1072] RESCHER, N., *Predicting the Future*, p. 104.

Sometimes, the only thing that can be done is to rely on predictive indicators that we cannot explain. But, in this case, a wary attitude should be maintained about the prediction finally obtained. In effect, the best we know the predicted phenomena, the more reliable will be — in principle — the predictions achieved. Meanwhile, a prediction that is not supported by reasons is always more vulnerable to error, due to the presence of obstacles such as chance, change, or chaos.

A field where the use of correlations as predictive indicators is more usual is the realm of the applied sciences. In this regard, Rescher provides an example from economics, where a correlation has been established between an increase in travel between two regions and a rise in commercial activity between them.[1073] Thus, when an increase in the travel between two countries is observed, this can be used as a predictive indicator in order to anticipate that there will be a rise in commercial activity between them. In this case, correlation does not involve a causal correlation (the increase in the travel is not the cause of the rise in commercial activity), but the prediction is, in principle, reliable.

Besides the problem of the reliability of these predictions, which are not based on knowledge oriented towards the causes, in the realm of applied science the use of correlations poses other problems that have to do with prescription. Thus, as applied science is oriented to the solution of concrete problems, the use of prediction as a previous step to prescription is usual in this context.[1074] However, when Rescher analyses the use of correlations as predictive indicators, he does not take into account this issue. This is

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[1073] Cf. RESCHER, N., *Predicting the Future*, p. 103.

[1074] On the role of prediction and prescription in applied sciences, Cf. SIMON, H. A., "Prediction and Prescription in Systems Modeling," *Operations Research*, v. 38, (1990), pp. 7-14. Compiled in SIMON, H. A., *Models of Bounded Rationality*. Vol. 3: *Empirically Grounded Economic Reason*, pp. 115-128; GONZALEZ, W. J., "Prediction and Prescription in Economics: A Philosophical and Methodological Approach," *Theoria*, v. 13, n. 2, (1998), pp. 321-345; and 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*, pp. 165-186; especially, pp. 179-183.

because his attention is mainly focused on prediction, instead of paying attention to prescription.

However, this is an especial important issue when the role of correlations in applied sciences is addressed, both in order to obtain reliable predictions and to prescribe in an effective way. Moreover, it is relevant for the application of science, where prediction can be the basis of decision-making by the agents. In this regard, the practical value of correlations has been considered; that is, the value of correlations in order to design strategies oriented towards the achievement of a concrete aim.[1075] In a paper published in 1979, entitled "Causal Laws and Effective Strategies," Nancy Cartwright maintained that an effective strategy — that is, an effective and efficient way of achieving a goal sought — should be supported by knowledge oriented towards the causes.[1076]

In this regard, Cartwright distinguished between "laws of association" and "causal laws." Laws of association are correlations that do not involve causality: they "tell how often two qualities co-occur; but they provide no account of what makes things happen."[1077] Meanwhile, causal laws do provide account of what makes things happen (for example, "force causes change in motion"). In her judgment, a spurious correlation — or "law of association" — is not an adequate basis for action.[1078] If there is a correlation between two events E_1 and E_2, which are effects of a third variable that is the common cause of both, then it cannot be justified a strategy design to produce a change in E_2 by modifying the values of E_1, and vice versa.

Instead of this, effective strategies should be supported by causal relations, insofar as "the objectivity of the strategies requires the objectivity of

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[1075] Cf. LEURIDAN, B., WEBER, E. and VAN DYCK, M., "The Practical Value of Spurious Correlations: Selective Versus Manipulative Policy," *Analysis*, v. 68, n. 4, (2008), pp. 298-303; and WARD, A., "Spurious Correlations and Causal Inferences," pp. 699-712.

[1076] Cf. CARTWRIGHT, N., "Causal Laws and Effective Strategies," *Nous*, v. 13, n. 4, (1979), pp. 419-437.

[1077] CARTWRIGHT, N., "Causal Laws and Effective Strategies," p. 419.

[1078] Cf. "Causal Laws and Effective Strategies," p. 430.

causal laws."[1079] Thus, although it could be possible to use spurious correlations as predictive indicators, the prediction obtained in this way is not a good basis for prescription. Knowledge about the causes that explain the correlation is also required. For this reason, "knowledge of spurious correlations, along with knowledge of the underlying causal structure and its stability, is sufficient for identifying effective strategies of change."[1080] Therefore, the practical value of correlations is certainly limited.

In my judgment, the existence of these limits that affect the predictive value of correlations, which have also repercussions on their practical value as a basis of prescription, calls into question the following Rescher's claim: "for purposes of rational planning in economic policy matters actual prediction is not necessary; it suffices to have information about the ways of *influencing the probabilities of outcomes*."[1081] However, when the use of correlations as predictive indicators is analyzed, it seems clear that rational planning (as well as prescription) cannot be only supported by knowledge of probabilities. Instead, a prediction or, at least, a specific forecast (the less secure kind of prediction) is required.

In order to describe a prediction as *scientific*, there should be rational bases that support the prediction. In this way, prediction "should tell us not only *what* to expect but also *why* to expect it.[1082] This why-knowledge is also required in order to prescribe (and also for planning). If there is a correlation between two events E_1 and E_2, but there is no a causal relation between them so E_1 is the cause of E_2, the knowledge of this correlation is not a good basis in order to prescribe. In this case, promoting a modification in the values of E_1 will not lead necessarily to a change in the values of E_2, and vice versa.

[1079] Cf. CARTWRIGHT, N., "Causal Laws and Effective Strategies," p. 436.
[1080] WARD, A., "Spurious Correlations and Causal Inferences," p. 710.
[1081] RESCHER, N., *Predicting the Future*, p. 198.
[1082] Cf. *Predicting the Future*, p. 164.

Therefore, both prediction and prescription need to be supported by rigorous knowledge. On the one hand, reliability of prediction depends, to a large extent, on the reliability of the knowledge about the phenomena in order to exert an effective control on phenomena. And, on the other hand, prediction needs to be supported by knowledge — predictive or prescriptive — as reliable as possible.

6.3.2. Inference from Laws

Other scientific method of prediction consists in inferring a statement about the future from scientific laws, plus a series of initial conditions. In principle, it is the most reliable method of prediction, to the extent that the patterns that have been observed in phenomena can be expressed in the form of a scientific law (either in deterministic or probabilistic terms), instead of being simple trends or regularities.

For Rescher, "while all forms of pattern detection call for screening the empirical/phenomenological data in the endeavor to detect structure in this domain, the laws of nature (or what we accept as such) are the most important and fundamental sorts of patterns there are. Accordingly, our most sophisticated predictive method is that of *inference from formalized laws* (generally in mathematical form), which govern the functioning of a system."[1083]

When there are scientific laws, reliability is higher in the different methodological levels, which have to do with data availability, pattern discernability, and pattern stability. The presence of laws involves that there are nomic regularities that can serve as linking mechanisms between the events of the past and the future phenomena. Moreover, nomic stability allows the secure inference of future statements, from universal laws and initial conditions.

[1083] RESCHER, N., *Predicting the Future*, p. 106.

Hans Reichenbach especially insisted in the use of scientific laws — in the probabilistic sense — as means to making predictions. In his judgment, "scientific propositions make assertions about the *future*. Indeed, there is no scientific law which does not involve a prediction about the occurrence of future events; for it is of the very essence of a scientific law to assure us that under certain given conditions, certain phenomena will occur."[1084] Thus, according Reichenbach, a scientific law includes statements that are oriented towards the future.[1085] This position is in tune with Rescher's proposal about the predictive utility of scientific laws, which are the basis of "our most sophisticated predictive method."[1086]

In effect, Rescher considers that the predictive power of the natural sciences is, to a large extent, related to the availability of laws regarding natural phenomena: "nature is predictable insofar as its phenomena exhibit discernible patterns that reveal rulish lawfulness in its operations."[1087] Therefore, the scientific laws have *predictive import*, insofar as they involve regularities that allow us to infer concrete conclusions about future occurrences or events (for example, the prediction of an eclipse).

Within this framework, predictability is closely related with the availability of laws. Moreover, Rescher considers that anarchy — the absence of laws in the strict sense — can involve unpredictability.[1088] Thus, a question arises about to what extent predictability of phenomena depends on the availability of laws regarding the behavior of those phenomena. In my

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[1084] REICHENBACH, H., "Logistic Empiricism in Germany and the Present State of its Problems," p. 152.

[1085] This linkage with the future of the scientific laws and propositions leads Reichenbach to reject the logical positivism of the Vienna Circle. Cf. GONZALEZ, W. J., *La predicción científica. Concepciones filosófico-metodológicas desde H. Reichenbach a N. Rescher*, pp. 23-26.

[1086] RESCHER, N., *Predicting the Future*, p. 106.

[1087] *Predicting the Future*, p. 176.

[1088] "Irregularity of phenomena is compatible with prediction-admitting lawfulness, but 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," RESCHER, N., *Ignorance: On the Wider Implications of Deficient Knowledge,* p. 104.

judgment, the possible answer to this question should take into account, at least, two different methodological levels: a) general methodology of science, and b) the special methodology of science.[1089] In turn, within the special methodology, it should take into account: (i) the methodology of the natural sciences, and (ii) the methodology of the social sciences.

From the perspective of the general methodology of science, the inference from laws has a high value as a method of prediction. The presence of lawful regularities and the nomic stability have a positive repercussion on the *reliability* of the process, insofar as the preconditions for rational prediction are fulfilled: 1) there are enough data about the working of phenomena; 2) those data exhibit the presence of patterns; and 3) the patterns are stable into the future.

However, the availability of laws is not a necessary condition for predictability. There are other methods that can be used in order to predict: estimative procedures, trend extrapolation, use of analogies, predictive models, etc. They can be used when there is no nomic stability, either due to epistemic failures (the "ignorance of the law") or due to the very character of phenomena (when there is chance, chaos, change, etc.).

Within the broad scope of the methodology of science, which has to do with the methodology of the natural sciences and the methodology of the human and social sciences, there is — in my judgment — a duality regarding the relation between predictability and law availability. In this regard, Rescher considers that, to a large extent, predictability in natural sciences is due to the presence of patterns in phenomena that can be expressed by laws.[1090] Meanwhile, human and social phenomena are less predictable, because they

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[1089] Cf. GONZALEZ, W. J., "Marco teórico, trayectoria y situación actual de la Filosofía y Metodología de la Economía," pp. 13-59.
[1090] Cf. RESCHER, N., *Predicting the Future*, p. 176.

are generally more complex,[1091] so it is not so usual to have laws regarding their working.

According to Rescher, "the difficulties that underlie the mixed-to-poor predictive performance of economic models are easy to see. In the case of modeling in physics, we understand the background phenomenology and its laws pretty well, and since they are stable we can apply this well-established theoretical information in making our predictive models. (…). But in economic modeling, it is the model itself that is supposed to provide for our understanding of the phenomenology—we have no prior, independent, well-confirmed laws on which to base its operations."[1092] There is then a background problem, which affects the methodological approaches to prediction in social sciences: is it possible to have social laws? And, if so, which might their characteristics be?

Merrilee Salmon has made important contributions to the study of scientific prediction in the social sciences.[1093] Regarding the existence and characteristics of the social laws, she maintains that "if it turns out that the only laws possible for social science are statistical, this is no great defect. Laws are an indispensable part of science, but genuine scientific laws may be either statistical or universal."[1094] Thus, she considers that, unlike in the natural sciences, "laws of social science tell us what *usually*, *typically*, or *rarely* happens rather than what always, without exception, or never happens."[1095] From this perspective, prediction from laws is also possible in

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[1091] 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; and 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.

[1092] RESCHER, N., *Predicting the Future*, p. 197.

[1093] Cf. SALMON, M. H., "Predicción en las Ciencias Sociales," *Enrahonar*, v. 37, (2005), pp. 169-179.

[1094] SALMON, M. H., "Philosophy of the Social Sciences," in SALMON, M. H. ET AL., *Introduction to the Philosophy of Science*, p. 416.

[1095] SALMON, M. H., "Philosophy of the Social Sciences," p. 416.

the social sciences, but there is a background instability that affects the reliability of the prediction.

Rescher, to some extent, is in tune with this approach. He considers that can be laws with a mathematical expression, but they are usually of a statistical character. However, he admits that these kinds of laws are also used in natural sciences (which includes bio-medicine) or in the sciences of the artificial (for instance, in pharmacology).[1096] Nevertheless, he thinks that it is usual that the laws in social sciences express qualitative relations instead of quantitative relations.[1097]

In Rescher's judgment, also the qualitative laws have predictive utility: "the utility of those predictive principles is not negated by their lack of mathematical form; qualitative or phenomenological relationships can meet the needs of the situation."[1098] Thus, it is possible to predict on the basis of social laws. In this case, they can be either statistical laws or statements that express qualitative relations among several phenomena or processes.

From the approaches of Merrilee H. Salmon and Nicholas Rescher, it seems that — in principle — two main differences between laws in the natural sciences and laws about social phenomena can be noticed: (i) while in the natural sciences there can be quantitative laws of a universal character, quantitative laws in social sciences are usually of a statistical

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[1096] Cf. RESCHER, N., *Personal Communication*, 17.6.2014. In this regard, Rescher insists in the importance of the value of reliability. In order to consider that a prediction is reliable, it can be good enough that it is based on some understanding of regularities. On the one hand, this feature involves that there is not — in his judgment — a radical discontinuity between scientific prediction and other kinds of rational predictions; and, on the other hand, it involves that this radical discontinuity neither exists between prediction in natural sciences and prediction in social sciences. Thus, obstacles such as chance, chaos, etc. might intervene in both realms (natural and social), so regarding certain predictive issues, predictive accuracy can be only achieved at the statistical, aggregate level. Cf. RESCHER, N., *Personal Communication*, 2.6.2015.

[1097] A defense of the existence of general laws in the social sciences, which can be used as a basis for social explanations, in general, and historical explanations, in particular, is in JOYNT, C. B. and RESCHER, N., "On Explanation in History," *Mind*, v. 68, n. 271, (1959), pp. 383-388.

[1098] RESCHER, N., *Predicting the Future*, p. 107.

character; and (ii) in social sciences the use of qualitative laws for prediction is frequent, while this kind of laws are not as usual in the natural sciences.

The first difference between the two groups of sciences has to do with the *indeterminism*, which habitually characterizes human matters, and also has to do with the diversity of variables, both endogenous and exogenous, which are open to the future.[1099] Meanwhile, the second feature mentioned — qualitative laws — deals with the complexity of selecting the social factors that can be quantified and the study of the representative interrelations in quantitative terms, instead of being merely qualitative.[1100]

These issues have incidence on the complexity and reliability of social predictions. Thus, the indeterminism of the human matters complicates having social laws of a universal character. Furthermore, the problems related to the quantification of the social variables involves that frequently the notion of "social law" refers to the expression of a qualitative relation between two variables. However, both the "statistical laws" and the "qualitative laws" can be used in order to infer statements about the future.

Nevertheless, there are a series of obstacles that might affect the inference of statement about the future from laws, both in the natural sciences and, to a larger extent, in the social sciences.[1101] On the one hand, *chance* and *chaos* can intervene, so the relevant variables follow random or stochastic trajectories that break the previous paths and make prediction difficult. And, on the other, *change* can play a role, which makes that the discernible patterns are continuously broken.

Those obstacles add complexity to the process of prediction. Rescher admits this feature when he maintains that "in domains whose phenomenology is so complex as to put the operative laws outside the range of our cognitive vision, we obviously cannot accomplish our predictive work

[1099] Cf. GONZALEZ, W. J., *La predicción científica*, p. 273.
[1100] Cf. *La predicción científica*, p. 221.
[1101] Cf. RESCHER, N., *Predicting the Future*, p. 107.

by their means."[1102] Frequently, this is what happens in social sciences, in general, and in economics, in particular. Thus, the level of complexity of social phenomena — among them, economic phenomena — is generally comparatively higher than the complexity of the natural phenomena.[1103]

In philosophy and methodology of economics, the problem of complexity and its repercussions on prediction has been widely discussed over the last decades.[1104] In this regard, it is usual to compare prediction in economics with prediction in the natural science; and, more concretely, with predictions in physics.[1105] Through this comparison, it is possible to see that there is a difference between the two kinds of predictions — economic and physical — that has to do with the level of regularity of the events.[1106] Thus, while natural phenomena have in general a higher level of regularity, "economic regularities cannot be usually derivated from 'economic laws' (whose universality and, even, existence is questioned)."[1107]

Thus, in economics it is usually accepted that "more generally, economists must resort to statistical inference."[1108] Moreover, some economists think that economics is a complex system. This is, in general,

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[1102] *Predicting the Future*, p. 107.

[1103] Cf. GONZALEZ, W. J., "La vertiente dinámica de las Ciencias de la Complejidad. Repercusión de la historicidad para la predicción científica en las Ciencias de Diseño," in GONZALEZ, W. J. (ed.), *Las Ciencias de la Complejidad: Vertiente dinámica de las Ciencias de Diseño y sobriedad de factores*, pp. 73-106; especially, pp. 94-96.

[1104] On complexity of economic phenomena, see ROSSER JR., J. B., "On the Complexities of Complex Economic Dynamics," *Journal of Economic Perspectives*, v. 13, n. 4, (1999), pp. 169-192. Compiled in ROSSER JR., J. B. (ed.), *Complexity in Economics. Vol. 1: Methodology, Interacting Agents and Microeconomic Models*, E. Elgar, Cheltenham, 2004, pp. 74-97. Spanish version by Amanda Guillan: ROSSER JR., J. B., "Sobre las complejidades de la compleja dinámica económica," in GONZALEZ, W. J. (ed.), *Las Ciencias de la Complejidad: Vertiente dinámica de las Ciencias de Diseño y sobriedad de factores*, pp. 107-139.

[1105] "Economists cannot and will never be able to predict with the very high degrees of probability and accuracy which many natural scientists can achieve for their predictions," HUTCHISON, T. W., "On Prediction and Economic Knowledge," in HUTCHISON, T. W., *Knowledge and Ignorance in Economics*, Blackwell, Oxford, 1977, p. 10.

[1106] Cf. RESCHER, N., *Predicting the Future*, p. 198.

[1107] GONZALEZ, W. J., "La vertiente dinámica de las Ciencias de la Complejidad. Repercusión de la historicidad para la predicción científica en las Ciencias de Diseño," in GONZALEZ, W. J. (ed.), *Las Ciencias de la Complejidad: Vertiente dinámica de las Ciencias de Diseño y sobriedad de factores*, p. 95.

[1108] HAHN, E., "Predicting the Economy," in HOWE, L. and WAIN, A. (eds.), *Predicting the Future*, Cambridge University Press, Cambridge, 1993, p. 78.

what Rescher actually thinks. In fact, in his judgment, "economic systems (and social systems in general) are in large measure chaotic."[1109] Furthermore, the creativity of the agents adds other feature of complexity to economic predictions, to the extent that it increases the possibility of novelty in phenomena.[1110] In this way, the obstacles to predictive inference from laws (chance, chaos, and chance) have an important weight. For this reason, other predictive processes are frequently used, such as time-series or econometric models.

6.3.3. Predictive Models

Within the "scientific" or "sophisticated" methods of prediction, Rescher considers the use of predictive models as one of the most reliable supports for methods of prediction. When it is oriented towards scientific prediction, the use of models consists in "exploiting for predictive purposes an artificially structured collection of processes that parallels the system's operations."[1111] Thus, the predictive models should select the important variables — endogenous and exogenous — that intervene in the system and their interactions, so the model would be *representative* of the system at issue.

Rescher distinguishes two main types of models: *physical models* and *symbolic models*.[1112] Physical models are oriented towards obtaining predictions by simulating the properties and physical operations of a system (for example, an scale plane model that uses aerodynamic tunnels in order to test its stability under different atmospheric conditions). Meanwhile, symbolic

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[1109] RESCHER, N., *Predicting the Future*, p. 197.
[1110] 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*, p. 147.
[1111] RESCHER, N., *Predicting the Future*, p. 107.
[1112] Cf. *Predicting the Future*, p. 107.

models use symbolic representations, habitually of a numeric kind (for example, an econometric model).[1113]

According to Rescher, the success of a model — both physical and symbolic — depends on an epistemological factor: to what extent the model corresponds with the system at issue. For this reason, he considers that predictive models should have realist assumptions. Thus, he explicitly criticizes Milton Friedman's methodological conception,[1114] who maintained that "the only relevant test of the validity of a hypothesis is comparison of its predictions with experience."[1115] In fact, for Friedman, an economic model cannot be evaluated on the basis of the realism of its assumptions, but only through its predictive capacity according to the result.

In contrast to the methodological instrumentalism defended by Friedman, Rescher maintains that the realism of the assumptions is crucial in order to have predictive success. In his judgment, "a model's faithfulness to its original and its predictive efficacy are bound to go hand in hand, and a model's options will generally not manage to prefigure a reality whose operations it does not reflect."[1116] For this reason, a model that does not reflect reality in an adequate way will not be, in principle, predictively successful.

It seems to me that Rescher is right when he defends the thesis that the realism of the assumptions is crucial regarding the reliability of the predictive models. Realism of the assumption is, in my judgment, the main criterion of demarcation between scientific prediction and non-scientific prediction. Thus, the issue is not only that a model that does not reflect reality in an adequate way will have problems in order to predict with success, but that, although it

[1113] However, not every symbolic model should have quantitative variables: "Computers can process symbols of all kinds, including symbols that represent natural language or diagrams," SIMON, H. A., "Prediction and Prescription in Systems Modeling," p. 13.
[1114] Cf. RESCHER, N., *Predicting the Future*, p. 109.
[1115] FRIEDMAN, M., "The Methodology of Positive Economics," pp. 8-9.
[1116] RESCHER, N., *Predicting the Future*, p. 109.

would achieve predictive success, there are no theoretical bases that allow us to justify the scientific character of the model.

It is usual to think of predictive models as the best option to obtain predictions about a complex system (natural, social, or artificial). In fact, some authors think that the main aim of the so-called "sciences of complexity" is to overcome the simplifications that can lead to the design of non-realist models.[1117] However, there is not a widely accepted definition of "complex systems" or "complexity."[1118] In order to address this problem, an option can be give primacy to the structural dimension of complexity. This is what H. A. Simon made. He considered a complex system as "one made up of a large number of parts that have many interactions."[1119]

Instead, Rescher considers that Simon's conception of complexity is too generic. For this reason, besides the compositional complexity — that is about the number and variety of the elements that form a system — and the structural complexity (that takes into account the way in which the different subsystems are structured within the complex system), Rescher thinks that the complexity of a system can be also functional, [1120] which opens the door to complexity in dynamical terms. Furthermore, he recognizes two aspects of the functional complexity: operational complexity (when the system shows dynamical complexity in the temporal development of its processes) and nomic complexity, which is "a timeless complexity in the working interrelationships of its elements."[1121]

Therefore, in order to model a complex system, different ontological features of complexity should be taken into account, which have to do with

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[1117] Cf. CHU, D., STRAND, R. and FJELLAND, R., "Theories of Complexity. Common Denominators of Complex Systems," *Complexity*, v. 8, n. 3, (2003), p. 19.

[1118] "There is still no generally accepted definition of complexity, despite a vast number of proposed *ansatzes*," CHU, D., STRAND, R. and FJELLAND, R., "Theories of Complexity. Common Denominators of Complex Systems," p. 19.

[1119] SIMON, H. A., *The Sciences of the Artificial*, 3rd ed., pp. 183-184.

[1120] Cf. RESCHER, N., *Complexity: A Philosophical Overview*, p. 9.

[1121] *Complexity: A Philosophical Overview*, p. 12.

the composition, the structure, and the function of the system. But complexity can be also epistemic, which adds difficulty to the task of designing a model. Rescher identifies three modes of epistemic complexity: (i) descriptive complexity; (ii) generative complexity; and (iii) computational complexity.[1122] Descriptive complexity has to do with the level of complexity that entails describing adequately the system; generative complexity deals with the number of steps required in order to generate the complex system; and computational complexity is about the quantity of resources that are required in order to solve problems about the system.

In my judgment, besides the ontological dimension and the epistemological aspect, the methodological component of complexity should be also considered, which has to do with the difficulty of the *processes*.[1123] In the case of the scientific models and, concretely, predictive models, methodological complexity seems clear. In effect, in order to deal with complex systems, "we must separate what is essential from what is dispensable in order to capture in our models a simplified picture of reality which, nevertheless, will allow us to make the inferences that are important to our goals."[1124]

Certainly, this task is difficult, so complications can arise that have to do with the process of designing a model that has predictive success. This feature has been highlighted in the case of economics, where it is usual to consider economic systems as more complex than physical systems. Thus, according to Donald Saari, "even the simple models from introductory economics can exhibit dynamical behavior far more complex than anything found in classical physics or biology."[1125] This is because the difficulties in

[1122] Cf. RESCHER, N., *Complexity*, p. 9.
[1123] 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*)," p. 152.
[1124] SIMON, H. A., "Prediction and Prescription in Systems Modeling," p. 7.
[1125] SAARI, D. G., "Mathematical Complexity of Simple Economics," *Notices of the American Mathematical Society*, v. 42, n. 2, (1995), p. 222.

order to calculate the interactions of the agents when they make decisions add an aspect of complexity to economics that does not exist in other disciplines (for example, in physics).[1126]

In effect, when a model about a complex system (for example, an economic system) is developed with the aim of predicting, difficulties can arise that mainly have to do with the selection of the variables and the kind of interactions among those variables. In this regard, it can be considered to what extent a high degree of sophistication and complexity in the models can contribute to the accuracy and precision of the predictions. In principle, it seems that, the most elaborated a model is, the higher its capacity to adequately grasp the reality of a system will be. However, a high degree of sophistication will lead invariably to a series of problem of practical kind (difficulties for information accessing and processing, an increase of the possibility of error, complications in the evaluation of the model, etc.).[1127]

Regarding this problem, Rescher's proposal does not seek to offer solutions. Instead, he tries to show how a high level of sophistication in a model is a desirable characteristic but one that is difficult to achieve in practice. In his judgment, "the difficulty is that most realistic forecasting models are based on a vast host of interrelated assumptions on which the outcomes predicted hinge in a highly sensitive way. And in the study of complex phenomena (…) it is somewhere between difficult and impossible to establish the tenability of these assumptions sufficiently firmly to engender ready confidence in the resultant predictions."[1128]

In these epistemological-methodological terms, it seems than the choice is between more sophistication and complexity in the models to make them more realist, or the simplification of the model in order to make it more

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[1126] Cf. ROSSER JR., J. B., "On the Complexities of Complex Economic Dynamics," *Journal of Economic Perspectives*, v. 13, n. 4, (1999), p. 171.
[1127] Cf. RESCHER, N., *Predicting the Future*, p. 109.
[1128] *Predicting the Future*, p. 110.

manageable form a cognitive viewpoint. But, in my judgment, parsimony of factors can be crucial to deal with complexity, instead of seeking the mere simplicity. Herbert A. Simon has highlighted this aspect.[1129] Unlike simplicity, the methodological conception of parsimony, understood as austerity in the selection of the essential elements, leads to focusing on the necessary and sufficient elements in order to encompass the complex system.

Methodologically, regarding parsimonious factors there are two main problems: a) the identification of the necessary and sufficient factors in order to grasp the complex system; and b) the consideration of what their contribution to the system is, so they can be the basis of the elaboration of a predictive or prescriptive model.[1130]

Regarding the first problem (which elements can configure the "parsimonious factors" and what are the relevant relations among them), W. J. Gonzalez considers four forms of analysis that can lead to the identification of the parsimonious factors of a complex system (natural, social, or artificial). These four forms of analysis are the following ones:

1) The holological analysis, which deals with the relation between the whole and its parts, so it allows us to see the nexus among the different components of the system. 2) The etiological analysis, which seeks the causes in the system and studies the relations with the effects. 3) The teleological analysis, which considers the dynamics of the system regarding the relations from means to ends, either from a synchronic perspective or

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[1129] 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.

[1130] 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*)," p. 154.

form a diachronic viewpoint. 4) The logical analysis, which studies the relations in relation to conceptual contents.[1131]

From these four forms of analysis — holological, etiological, teleological, and logical — once the factors have been identified, it is possible to address the second problem. It has to do with the contribution of the parsimonious factors to the analyzed system.[1132] Thus, once there is an understanding of the key elements of the system and their relations, a model oriented towards the future can be designed on realist basis and, furthermore, it can be manageable from a cognitive viewpoint. In fact, it seems that an inadequate selection of factors is the reason that explains many of the problems of reliability that some economic models have.[1133]

Therefore, regarding this problem, the methodological conception of parsimonious factors can be crucial in order to overcome the complexity of the predictions, in general, and the economic predictions, in particular. Concretely, it can contribute to increase the accuracy and precisions of the predictive models.[1134] Thus, by focusing on the necessary and sufficient elements in order to encompass the system, the realism of the assumptions is possible, as well as the overcoming of practical problems that affect the models that either try to grasp all the factors at stake or do not select adequately the relevant factors.

6.4. Assessment of the Predictive Procedures and Methods

[1131] Cf. “Complejidad estructural en Ciencias de Diseño y su incidencia en la predicción científica: El papel de la sobriedad de factores (*parsimonious factors*),” pp. 154-157.

[1132] On this issue, see 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*),” pp. 157-160.

[1133] “Actual econometric models incorrectly omit important linkages and include irrelevant ones. This class of problems is called model mis-specification, and it adds to the forecasters’ difficulties. In particular, model mis-specification complicates calculating the likely magnitudes of forecast errors,” HENDRY, D. F. and ERICSSON, N. R., “Edictors’s Introduction,” in HENDRY, D. F. and ERICSSON, N. R. (eds.), *Understanding Economic Forecasts*, p. 6.

[1134] 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*),” p. 148.

The methodological analysis of Rescher about prediction highlights that there is a *diversity of procedures and methods* oriented towards predicting the future. This methodological plurality reflects different degrees of rigor in predictive processes. Firstly, there are *estimative* or *judgmental* procedures that are developed on the basis of the personal judgment of individual agents (the experts on the topic), which follow processes of reasoning non-formalized or even "inarticulable." Secondly, predictive methods can be *formalized or inferential*, which follow explicitly articulated modes of reasoning. In turn, formalized methods can be divided into two groups: a) *elementary* processes of prediction (such as trend extrapolation or the use of analogies); and b) *scientific* or sophisticated methods (such as the inference from laws or the use of predictive models).

6.4.1. Reliability and Characteristics of Predictive Procedures and Methods

An assessment of the methods of prediction and their scientific import should emphasize the reliability and characteristics of the different predictive procedures and methods. Certainly, there are different levels of rigor and sophistication in the processes, which varies from the lowest level — the estimation of the experts — to the maximum possible rigor, when the methods are properly scientific (as in the case of the predictive models or the inference from scientific laws). Moreover, the rigor of the processes has repercussions on the reliability of the predictions. Then, it is possible to maintain that "the level of reliability of the former (judgmental or intuitive in proceeding and personally mediated) is clearly lower than the latter (discursive in proceeding and methodologically oriented), because this can have a higher level of objectivity."[1135]

[1135] GONZALEZ, W. J., *Philosophico-Methodological Analysis of Prediction and its Role in Economics*, p. 258.

Furthermore, the *estimative procedures* of predictions are not scientific methods; since they are based on the judgment of the experts, instead of being based on modes of reasoning that follow clearly-articulated rules or principles. For this reason, there is a clear prominence of subjective elements, which can affect both the *credibility* and the *reliability* of the predictions. In this regard, the main contribution of Rescher is — in my judgment — the identification of some of the most important obstacles to the estimative prediction: (i) imminence and scale exaggeration; (ii) conservatism; (iii) wishful or fearful thinking; and (iv) probability misjudgment.[1136]

The identification of this cognitive or psychological obstacles has two main methodological roles: on the one hand, they allow us to understand many of the errors of the estimative predictions; and, on the other, it can contribute to elaborate the basis in order to increase the accuracy and precision of this kind of predictions (a task that can be made through the development of mechanisms in order to introduce corrections in the forecasts).[1137]

Generally, the cognitive or psychological biases of predictors have more weight when the prediction is made by only one expert. For this reason, a way of overcoming those obstacles can be the use of procedures to combine predictions.[1138] Rescher divides these procedures into two main groups: a) non-interactive mechanical procedures (such as averaging or the majority option); and b) interactive procedures (as in the case of the Delphi procedure). The former are less reliable, while the later are more sophisticated procedures that seek a consensus among the experts.

[1136] Cf. RESCHER, N., *Predicting the Future*, pp. 218-222.
[1137] Cf. HARVEY, N., “Improving Judgment in Forecasting,” in ARMSTRONG, J. S. (ed.), *Principles of Forecasting: A Handbook for Researchers and Practitioners,* pp. 59-80.
[1138] Cf. STEWART, TH. S., “Improving Reliability of Judgmental Forecasts,” in ARMSTRONG, J. S. (ed.), *Principles of Forecasting: A Handbook for Researchers and Practitioners,* pp. 81-106; especially, pp. 95-96.

But consensus offers no guarantees regarding the success of predictions.[1139] Rescher admits this feature, although he personally contributed to the creation of the Delphi procedure. In effect, he notices that "the history of science amply illustrates that consensus in error is no less common that consensus in truth."[1140] Thus, it can be concluded that formal methods (elementary or scientific) are preferable to estimative procedures. But the possibility of using formal methods depends on the available resources and on the very character of the phenomena at issue. For this reason, when more sophisticated methods cannot be implemented, the estimative procedures are a good option in order to obtain predictive statements about the future.

Also the *elementary discursive procedures* have clear limits regarding their application. Thus, the use of trend extrapolation seems only appropriate for the prediction of phenomena and processes that are characterized by being stable, since their success depends on the principle of continuity: i.e., that the patterns of the past will maintain into the future. For this reason, if discontinuities or changes occur, trend extrapolation will lead to false predictions. In addition, the reliability of the analogies as predictive procedure requires a real similitude between the phenomena. But, although this condition is fulfilled, and analogy is never indefinitely valid; and, certainly, this procedure does not allow us to anticipate the moment when the analogy will disappear.

Generally, elementary discursive procedures do not lead to anticipate changes in phenomena, so they do not grasp, in principle, the historicity that accompanies the human activity.[1141] On the one hand, this feature makes

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[1139] On consensus, see RESCHER, N., *Pluralism. Against the Demand for Consensus*, Clarendon Press, Oxford, 1993.
[1140] RESCHER, N., *Predicting the Future*, p. 96.
[1141] The analysis of historicity is not usually considered in the predictive analysis in economics. It is not just that phenomena have a past and a potential future, but that there is variability in phenomena according to decisions made in the framework of the "economic

that predictions obtained though these processes have little interest, both from a theoretical and form a practical perspective. And, on the other hand, the possibility of error in these predictions is always present. In effect, as Rescher notices, we can safely predict that changes will happen in the trends,[1142] above all in the long run. However, the problems of reliability are not only limited to the use of elementary processes. In this regard, it should be noticed that "no predictive methodology (…) can ever immunize forecasting against the prospect of failure;"[1143] although there are methods that, in principle, are more reliable.

This is the case of the formalized or *discursive scientific methods*, insofar as they have the highest level possible of rigor. Rescher addresses some of these scientific methods of prediction (i) the use of correlations as predictive indicators; (ii) the inference from scientific laws; and (iii) the use of models oriented towards prediction.[1144] On these methods, his proposal offers some of the key issues that are required in order to analyze them from the philosophy and methodology of science. But he does not encompass all the issues at stake, because his approach is mainly focused on the natural sciences and, furthermore, he does not pay much attention to the realm of the applied sciences.

On the use of correlations as predictive indicators, Rescher is right when he notices that "unless predictive indicators rest on a secure explanatory foundation, those who rely on them build their houses on

activity" and "economics as activity." See 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.

[1142] Cf. *Predicting the Future*, p. 102. He also considers that, in human matters, the capacity to anticipate changes is especially important. For this reason, it is especially useful the anticipation of when and how conditions will change. Cf. RESCHER, N., *Personal Communication*, 17.6.2014.

[1143] Cf. RESCHER, N., *Predicting the Future*, p. 102.

[1144] Cf. *Predicting the Future*, p. 88, pp. 102-104 and 106-110.

sand."[1145] The success of a prediction made on the basis of a correlation does not depend on our knowledge about the causes that explain the correlation. Thus, a spurious correlation can have predictive values.[1146] But, in this case, there are no reasons for seeing the predicted result as credible. In fact, if there is no knowledge about the background structure of the correlation, prediction is more vulnerable to error, due to the presence of obstacles such as chance, chaos, or change.

These reflections can be lead to the realm of prescription, when the correlations are used in order to design strategies oriented towards the achievement of concrete goals. This problem does not receive Rescher's attention, because he is mainly focused on prediction rather than prescription. In this regard, a question arises about to what extent knowledge of the causes (instead of simple correlations) is required in order to prescribe.

N. Cartwright's and A. Ward reflections on this problem point at the need of knowing the causal relations, so it would be possible to exert an effective influence over the effects.[1147] Undoubtedly, knowledge about the causes is preferable in order to make effective prescription, instead of knowledge about probabilities or simple trends. Thus, once the causes are known, the effects can be in principle anticipated, and this anticipation of the possible future (prediction) is the previous step to prescription.

Due to the problems posed by the use of correlations, the inference from scientific laws is undoubtedly a more reliable method of prediction. In effect, when there are scientific laws about the working of phenomena, it is possible to give reasons about why it is expected that something will occur. Regarding the use of laws as a basis for predicting, Rescher proposal is

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[1145] RESCHER, N., *Predicting the Future*, p. 104.

[1146] The logic of conditionals shows that from something false something true can follow, since from false things can follow anything, even something true. So the eventual result by itself is not good enough.

[1147] Cf. CARTWRIGHT, N., "Causal Laws and Effective Strategies," pp. 419-437; and WARD, A., "Spurious Correlations and Causal Inferences," pp. 699-712.

mainly focused on the natural sciences. In his judgment, predictability of natural phenomena is related to the availability of laws.[1148] For this reason, prediction in social sciences is more problematic, since a background issue here is if there can be genuine "social laws."[1149]

Regarding this problems, Merrilee Salmon's and Nicholas Rescher's proposals accept the possibility of having social laws.[1150] These laws can be based on knowledge about the causes. For this reason, admitting causality in human matters can be crucial for prediction,[1151] although a series of problems should be taken into account that makes prediction difficult, especially in this field: (i) the presence of chance and chaos can made that the relevant variables follow random or stochastic paths that break the previous patterns; and (ii) *change* is also an obstacle to prediction, since the previous patterns are constantly broken.

From this perspective, when prediction is about a complex phenomenon or system, it is not possible to predict only from laws.[1152] Usually, predictive models are the best option in order to predict complex systems (natural, social, or artificial). Both in the methodology of prediction, in general, and in the predictive models, in particular, *the realism of the assumptions* is crucial. In this regard, Rescher's proposal is — in my judgment — right, insofar as he considers that demarcation between scientific and non-scientific prediction begins with the realism of the assumptions.

6.4.2. Parsimonious Factors

[1148] Cf. *Predicting the Future*, p. 176.

[1149] Cf. HAUSMAN, D. M., "¿Necesita leyes la Economía," *Argumentos de Razón Técnica*, v. 3, (2000), pp. 115-137.

[1150] Cf. SALMON, M. H., "Philosophy of the Social Sciences," in SALMON, M. H. ET AL., *Introduction to the Philosophy of Science, passim*; and RESCHER, N., *Predicting the Future*, p. 107.

[1151] Cf. SALMON, M. H., "La explicación causal en Ciencias Sociales," in GONZALEZ, W. J. (ed.), *Diversidad de la explicación científica*, pp. 161-180. An analysis of this problem is in GONZALEZ, W. J., *La predicción científica*, pp. 212-215.

[1152] Cf. RESCHER, N., *Predicting the Future*, p. 107.

But Rescher does not take into account the methodological conception of parsimonious factors, which can be the key in order to overcome the problems that can lead to designing non-realist models. In my judgment, parsimonious factors — understood as those necessary and sufficient elemens regarding a given whole — can contribute to increase the accuracy and precision of the predictive models, to the extent that allow us to focus on the necessary and sufficient factors to encompass a system. Moreover, this is especially important when the system studied — as some biological systems or certain social systems — is very complex.[1153]

Although there is a clear progression in the rigor of the predictive processes, from the less rigorous procedures (the estimative procedures) to the more sophisticated methods (the scientific discursive methods), Rescher does not claim that there is a methodological superiority of some processes over other ones regarding the success of the results. Thus, in his judgment, "determining the effectiveness of any particular predictive method with respect to a given predictive issue is therefore something that must always await the lessons of experience. Only by trial and error can one eventually assess (…) the efficacy of a particular predictive method with respect to a particular sort of predictive issue."[1154]

Through this pragmatic criterion, the methodological superiority of a process over other ones cannot be established *a priority* and in a general way. The capacity of a concrete process to provide accurate and precise predictions is a question that should be assessed according to the characteristics of the predictive issue (both from an epistemological perspective and an ontological viewpoint). For this reason, although the discursive or inferential methods are more rigorous than the estimative

[1153] However, as Rescher notices, simple systems can be also difficult to predict (and even unpredictable), such as for example systems that exhibit Brownian motion. And conversely, some complex systems might be highly predictable (a modern airplane, for instance). Cf. Rescher, N., *Personal Communication*, 2.6.2015.
[1154] *Predicting the Future*, p. 111-112.

procedures, this feature by itself does not provide more guarantees regarding the success of the predictions (for example, when a phenomenon is highly stable, an estimative procedures such as Delphi can be a better option than a discursive process such the use of analogies). In this regard, it would be desirable to have more studies about the comparative efficacy of the different predictive processes.

PART III

From Reality to Values: Ontological Features, Axiological Elements, and Ethical Aspects of Scientific Prediction

CHAPTER 7

ONTOLOGY OF SCIENTIFIC PREDICTION

Although Nicholas Rescher's philosophy is a system of pragmatic idealism, his ontology of science has basically a realistic character. Idealism is open to realistic contributions in his approach, because the former is characterized mainly in conceptual terms whereas the latter is commonly focused on ontological features. These realistic contributions are accepted insofar as they are compatible with pragmatism in the style of Charles S. Peirce.[1155] Even more, ontological realism —especially, his idea of objectivity together with the notion of "fact"— is a key aspect of Rescher's thought.[1156] In effect, ontological realism is the support to the epistemological and methodological realms of science, in general, and scientific prediction, in particular.

From this viewpoint, the analysis of the ontological features of scientific prediction is an especially relevant issue. In order to do this analysis, a series of steps are followed in the present chapter. In the first place, the research is oriented towards the characteristics of the reality that is predicted, which can be a natural, social or artificial reality. In the second place, the future is analyzed from an entitative perspective. This perspective involves taking into account several issues: (i) the reality of future phenomena; (ii) the entitative incidence of the prediction's temporal horizon; and (iii) the relations between prediction and control. In the third place, the attention goes to the ontological limits to scientific prediction, because there are obstacles to predictability that are rooted in the reality of phenomena.

[1155] Cf. GONZALEZ, W. J., *La predicción científica*, p. 256.

[1156] Maybe the books that better reflect the ontology of Rescher are: RESCHER, N., *Scientific Realism: A Critical Reappraisal*, D. Reidel, Dordrecht, 1987; RESCHER, N., *Objectivity. The Obligations of Impersonal Reason*, University of Notre Dame Press, Notre Dame, 1997; RESCHER, N., *Realism and Pragmatic Epistemology*, University of Pittsburgh Press, Pittsburgh, PA, 2005; RESCHER, N., *Reason and Reality. Realism and Idealism in Pragmatic Perspective*, Rowman and Littlefield, Lanham, MD, 2005; and RESCHER, N., *Reality and its Appearance*, Continuum, London, 2010.

On the ontological realism, within the varieties of realist approaches, 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. 11-58; especially, pp. 50-55.

Among the possible obstacles, Rescher highlights the following ones: a) anarchy and volatility; b) chance, chaos and arbitrary choice; and c) creativity[1157]. Thereafter, the ontology of scientific prediction is analyzed from the angle of complexity (structural and dynamic). It is — in my judgment — a perspective that can shed light on the reality of future phenomena and the difficulties to predict them. In this regard, historicity can be seen as a key notion to investigate the complexity of the real things (above all, in the social and artificial realms) and its impact on prediction.

7.1. Scientific Prediction and the Reality of Phenomena

Even though Rescher's thought is a system of pragmatic idealism, where the idea of a *system* — with an insistence on the conceptual realm — is combined with the primacy of *practice*, his approach to ontology of science is basically of a realistic kind. When he describes his own philosophical approach, he characterizes it as a "middle-of-the-road idealism that makes significant concessions to realism."[1158] Even more, he thinks that "the sensible move is to opt for the middle ground and to combine a plausible version of realism with a plausible version of idealism."[1159]

On the one hand, Rescher defends the existence of a reality that is independent from the mind of the knowing subject; and, on the other hand, he accepts that reality has its own properties, that are accessible to the knowing subjects.[1160] He thinks that the independence of reality from mind should be accepted on the basis of six reasons, which are of a pragmatic kind: "1) to preserve the distinction between true and false with respect to factual matters and to operate the idea of truth 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

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[1157] Cf. RESCHER, N., *Predicting the Future*, pp. 133-156.

[1158] RESCHER, N., *A System of Pragmatic Idealism.* Vol. I: *Human Knowledge in Idealistic Perspective*, p. xiv.

[1159] RESCHER, N., "Realism and Idealism," in RESCHER, N., *A System of Pragmatic Idealism.* Vol. I: *Human Knowledge in Idealistic Perspective*, p. 324.

[1160] These two features are crucial for the objectivity of knowledge that goes with a realist approach, cf. GONZALEZ, W. J., *La Teoría de la Referencia. Strawson y la Filosofía Analítica*, p. 37. See also NIINILUOTO, I., *Is Science Progressive?*, chapter 1, pp. 1-9.

inquiry. 5) To provide for the fallibilistic view of human knowledge. 6) To sustain the causal mode of learning and inquiry and to serve as basis for the objectivity of experience."[1161]

Nevertheless, there are idealistic aspects of his thought, in particular in his insistence on the theory as mediated by mind. Thus, his approach involves that "our only access to information about what the real is through the mediation of mind"[1162]. From this viewpoint, he maintains that science is the result of the interaction between the researcher and the reality that is researched (above all, the natural environment).[1163] So human categories and, in general, concepts allow us to articulate the reality, so that it could be distinguished reality *as such* and reality *as it presents itself to us*.[1164] Nonetheless, Rescher thinks that there is objectivity in scientific knowledge, since reality — that has its own properties — is open to the mind that investigates it, so our concepts and ideas can have an objective content.[1165]

Within this framework of pragmatic idealism, which is clearly open to ontological realism, ontology of science has a fundamental role, because — for Rescher — is the support to the epistemology and methodology of science. In the more specific case of scientific prediction, this means that the kind of predictions that we can make (with regard to their reliability, accuracy, precision, etc.) depends, to a large extent, on the reality that is predicted. In this regard, a relevant distinction is that related to the differentiation between the natural reality, the social real, and the artificial field.

7.1.1. Natural Phenomena

Usually, Rescher is mainly interested in the sciences of nature.[1166] In effect, when he deals with scientific prediction, he basically pays attention to

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[1161] RESCHER, N., "Pragmatic Idealism and Metaphysical Realism," pp. 390-391.
[1162] RESCHER, N., "Realism and Idealism," in RESCHER, N., *A System of Pragmatic Idealism. Vol. I: Human Knowledge in Idealistic Perspective*, p. 324.
[1163] 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.
[1164] Cf. RESCHER, N., "Our Science as O-U-R Science," p. 77.
[1165] Cf. RESCHER, N, "Objectivity and Comunication. How Ordinary Discourse is Committed to Objectivity," pp. 85-97.
[1166] This can be seen in books like RESCHER, N., *Scientific Progress. A Philosophical Essay on the Economics of the Natural Science*, *passim*; RESCHER, N., *Razón y valores en la Era científico-tecnológica*, *passim*; RESCHER, N., *The Limits of Science*, revised edition, *passim*; and RESCHER, N., *Unknowability*. *An Inquiry into the Limits of Knowledge*, *passim*.

natural phenomena. Ontologically, he admits that there are natural phenomena that are not homogeneous, so that there are relevant differences between the phenomena that are studied by the different natural sciences. These ontological differences have an impact on the epistemological differences and affect prediction. Thus, there are some disciplines where it is possible to predict accurately (for instance, astronomy). Meanwhile, prediction is generally based on probabilities in other natural sciences, so that it has less accuracy and precision (as can happen in the realm of biomedicine).[1167]

Therefore, Rescher considers that the ontological side is crucial for science, because only "through the learning on the characteristics of phenomena we can know if it is possible to predict and to what extent it is possible."[1168] To a certain extent, his conception links the possibility to predict in a rigorous way in natural sciences with the availability of laws. This is because scientific prediction needs to be supported by the regularities that phenomena have shown in the past and in the present; and "the laws of nature (or what we accept as such) are the most important and fundamental sorts of patterns there are."[1169]

On the basis of the existence of this property of the real things (that is, to the extent that natural phenomena are regular), these regularities can be expressed in the form of scientific laws. Afterwards, these laws can be used as a support for the scientific procedures oriented towards prediction.[1170] Nevertheless, there are ontological limits to predictability with regard to the natural phenomena. These limits arise when the future that we want to predict is open to the development of unexpected patterns due to the contingencies of chance, volatility or chaos.[1171] In these cases, the patterns that the phenomena have followed until now are broken, so predictions that can be reached are generally less reliable (for instance, in certain phenomena studied by meteorology).

[1167] Cf. RESCHER, N., *Personal Communication*, 15.7.2014.
[1168] RESCHER, N., *Personal Communication*, 15.7.2014.
[1169] RESCHER, N., *Predicting the Future. An Introduction to the Theory of Forecasting*, p. 106.
[1170] Cf. RESCHER, N., *Predicting the Future*, pp. 106-110.
[1171] On the epistemological and ontological limits to predictability, see RESCHER, N., *Ignorance. On the Wider Implications of Deficient Knowledge*, chapter 6, "Obstacles to Predictive Foreknowledge," pp. 91-122.

When possibilities such as chance, volatility, chaos, etc. appear in the phenomena of nature, then a basic issue has to do with the temporal horizon of prediction. Thus, the ontological obstacles such as chance or chaos do not prevent intrinsically prediction; but they affect the type of prediction that can be achieved and its reliability. So predictions are generally more reliable —as can be seen in the phenomena of nature— in the short run than in the long run.[1172] This happens especially when the predicted phenomena are volatile or when they become chaotic (for instance, in a prediction about the weather).

Nevertheless, Rescher maintains that natural phenomena are generally more stable than social phenomena.[1173] For this reason, the unreliability of prediction is a more frequent problem in social sciences than in natural sciences. In addition, he thinks that, when changes occur in the sciences of nature (especially, in the phenomena of physics), these changes are usually evolutionary changes. In principle, this makes these phenomena predictable, because "evolution involves some kind of continuity"[1174]. Meanwhile, in the social realm, changes are more variable and discontinuous. From this perspective, there are more methodological difficulties to prediction in the social sciences than in the natural sciences, in accordance to the kind of issues addressed by the social sciences.

7.1.2. The Social Realm

Although Rescher's focus of attention goes to the natural sciences, he also pays attention to prediction in the social sciences. In his judgment, the main problems to prediction in this sciences are of an ontological kind, instead of been epistemological problems. This is because "what impedes prediction in this domain is not a mere lack of information, a mere failure to develop the discipline as far as one can. Rather, the root cause is something very different, something that lies in the very nature of the operative realities

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[1172] Cf. RESCHER, N., *Predicting the Future*, p. 77.
[1173] Cfr, RESCHER, N., *Personal Communication*, 29.7.2014.
[1174] RESCHER, N., *Personal Communication*, 29.7.2014. Here the concept of "evolution" that Rescher uses is the current idea of evolution as change over time that follows a certain line towards the future, instead of being the ramified idea of Darwinian evolution (as can be seen in the graph that Darwin made in the chapter IV of *On the Origin of Species*, in the first edition of 1859).

at issue. It is the nature of the phenomology 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"[1175].

Comparatively, the possibility of *novelty* in the social realm is greater than in the natural phenomena, where — in principle — regularity prevails to a larger extent[1176] and is the main element to achieve reliable predictions. Novelty in the phenomena studied is an issue that — in my judgment — should be considered with regard to the problem of complexity. This is because when prediction is about the social realm, it has to deal with the complexity of the social systems. In this regard, it is usual to consider that complexity in the social realm is greater than the complexity of the phenomena of nature.[1177]

This is something that Rescher acknowledges expressly. In his judgment, "in this domain [the social sciences], where the causal phenomenology at issue is so enormously complex, volatile, and chaotic, there is only so much that can be done [in matters of prediction]. The limits of social prediction here 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 in the future"[1178]. Nevertheless, his analysis does not contemplate the *historicity* as an ontological feature of the social reality. In this regard, it seems to me that this is a lacuna, since historicity gives the appropriate framework to address the complexity of the social realm. Historicity affects both structural complexity and dynamic complexity. This feature has clear repercussions on the possibility of predicting the social

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[1175] RESCHER, N., *Predicting the Future*, p. 202.

[1176] The possibility of "new facts" in the realm of the social sciences (for example, in economics) is comparatively higher than in the case of the natural sciences. There are a series of contextual elements that have repercussions on economics ("Economics as activity") together with the components of variability of the economic activity itself ("economic activity"), Cf. GONZALEZ, W. J., "Economic Prediction and Human Activity. An Analysis of Prediction in Economics from Action Theory," *Epistemologia*, v. 17, (1994), pp. 253-294.

[1177] 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; and 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.

[1178] RESCHER, N., *Predicting the Future*, p. 202.

systems and on the kind of predictions achievable (with regard to their reliability, accuracy, precision, etc.).[1179]

However, for Rescher, there are two main reasons that shed light on the greater difficulty of social prediction than natural prediction and its frequent unreliability. On the one hand, social prediction is often about the actions and choices of the agents. These actions and choices are difficult to predict, because they are made on the basis of what agents think about reality (their beliefs, wishes, expectations, etc.), instead of being based on reality itself.[1180] Therefore, social prediction should deal with psychological factors that are subjective, and this involves a greater difficulty in predicting.

On the other hand, Rescher acknowledges that social systems are not independent of the environment (social, political, ecological, etc.). Thus, although he hardly pays attention to the external factors, he admits that there is an interrelation of social systems and the environment where they are placed (which is of a changing character). In his judgment, this is a feature that limits the predictive capability of social sciences. In effect, he thinks that "insofar as developments in social affairs reflect human choices, and insofar as these are influenced by circumstances (such as technical innovation and fashion) that develop in a chaotic way, the course of development in human affairs can only be predicted to a small extent"[1181].

But these two features that Rescher points out —psychological factors and the influence of the external factors in social systems— are better addressed, in my judgment, within the framework offered by the notion of historicity. In the first place, historicity is a feature of science, in general, and of each science, in particular. It is a characteristic that can be seen in the structure of science (it is in the configuration of its constitutive elements) and in its dynamics. It can be seen both from an internal perspective —that takes

[1179] This feature has been highlighted by Wenceslao J. Gonzalez with regard to the sciences of design. 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*, pp. 73-106.

[1180] Cf. RESCHER, N., *Personal Communication*, 10.6.2014.

[1181] RESCHER, N., *Predicting the Future*, p. 202.

into account the aims, processes, and results— and from the external angle (which deals with the relations with the environment).[1182]

In the second place, historicity is a feature that configures the agents who develop the scientific research, since they are human beings in a concrete historical context. Historicity affects both the approaches to address the research topics and the circumstances that surround the research of the agents. In the third place, historicity modulates the reality itself that is researched, above all, when it is a social or artificial reality.[1183] In effect, social reality is historical in itself, so that historicity is a key ontological feature of social systems. From this perspective, social reality has in itself a component of variability that adds complexity to prediction.

Nevertheless, it is important to point out that *historicity* —that includes the change in the real things— is compatible with the objectivity of scientific knowledge.[1184] In this way, historicity should not be seen as an obstacle to prediction in social sciences, but rather as a feature of the social reality, which is a complex reality (both from the point of view of its structure and from the perspective of its dynamics). Thus, when the prediction is made within the social realm, it often has to deal with a wide variety of factors, where changes are frequent. This aspect generally makes social prediction more difficult and less reliable than prediction in the natural sciences.

7.1.3. The Artificial Realm

Frequently, when Rescher analyses science, in general, and scientific prediction, in particular, he does not pay attention to the artificial realm. However, prediction is a main aim in the sciences of the artificial, which are applied sciences.[1185] Within these sciences, prediction is usually the previous

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[1182] 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*, pp. 7-30; especially, pp. 13-14.

[1183] Cf. GONZALEZ, W. J., "Conceptual Changes and Scientific Diversity: The Role of Historicity," p. 43.

[1184] Cf. GONZALEZ, W. J., "El enfoque cognitivo en la Ciencia y el problema de la historicidad: Caracterización desde los conceptos," pp. 51-80; especially, pp. 68-71.

[1185] An especially influential proposal on the different kinds of scientific activity —basic, applied, and of application— is in NIINILUOTO, I., "The Aim and Structure of Applied Research," pp. 1-21; and NIINILUOTO, I., "Approximation in Applied Science," pp. 127-139.

step to prescription. Thus, the anticipation of the possible future (prediction) is required before we can give indications about what should be done (prescription) when we want to solve a concrete problem.[1186]

A characterization of the artificial realm from an ontological perspective is offered by Herbert A. Simon. In his judgment, there are four main differences between artificial things and the phenomena of nature: "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."[1187]

According to these features, the sciences of the artificial are disciplines that have to do with the reality of the human-made.[1188] Thus, their field is the realm of what is made by humans, where the ontological aspect of historicity is a key feature: "insofar as it is a realm of specific human elaboration that seeks to enlarge the existing potentialities or to achieve new and more ambitious aims, there is always a contextual component that is modulated by historicity."[1189] However, Simon did not manage to grasp this relevant feature of historicity, which goes with the creativity of the designs.

Certainly, the sciences of the artificial —especially, as sciences of design— are disciplines that are not limited to the knowledge or the reality that is researched, but they actively search new possibilities to enlarge that reality. Thus, the reality of the artificial realm is changeable. In effect, it is a field that is open to novelty, which can appear through the creativity of the agents.[1190] This creativity involves a clear obstacle to prediction when it deals

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[1186] 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*, pp. 165-186; especially, pp. 179-183.

[1187] SIMON, H. A., *The Sciences of the Artificial*, 3rd ed., p. 5.

[1188] It is a characteristic pointed out by Herbert A. Simon in his characterization of the sciences of the artificial. Cf. *The Sciences of the Artificial*, 3rd ed., pp. 4-5.

[1189] GONZALEZ, W. J., "Las Ciencias de Diseño en cuanto Ciencias de la Complejidad: Análisis de la Economía, Documentación y Comunicación," p. 14.

[1190] On the role of creativity in the sciences of design, see GUILLÁN, A., "Analysis of Creativity in the Sciences of Design," in GONZALEZ, W. J. (ed.), *Creativity, Innovation, and Complexity in Science*, Netbiblo, A Coruña, 2013, pp. 125-139.

with artificial things, because "human creativity and inventiveness defies predictive foresight."[1191]

So historicity and creativity are two main features of the artificial realm. Through these features, there is a great possibility of novelty in the artificial phenomena. This adds complexity to the task of making predictions in the sciences of the artificial. In this way, it can be seen that the ontological basis has direct epistemological and methodological repercussions. On the one hand, changes and the continuous presence of novelty affect the kind of achievable knowledge about the future (with regard to its reliability, accuracy, precision, etc.); and, on the other hand, predictive models must address the nature of the things, where creativity and the interactions with the environment have an important role.

7.2. Characterization of the Future from an Entitative Perspective

An important feature of scientific prediction, as Rescher sees it, is that prediction is a statement with a content oriented towards a potential future, independently of the concrete reality it is about (i.e., natural, social or artificial). He considers then that every "authentic" prediction is oriented towards an open future, which is inaccessible to observation in the moment when prediction is made.[1192] Thus, in principle, prediction foretells that something may occur or can happen when there are some given circumstances. Consequently, a genuine "retrodiction" or "prediction about the past" can be rejected based on ontological reasons.[1193]

This approach to scientific prediction leads to the problem of the characterization of the future, which is studied here from an entitative perspective. In this regard, several issues can be considered: (i) how to characterize the reality of future phenomena, since the future is something that does not yet exist; (ii) what can be the entitative incidence of the time

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[1191] RESCHER, N., *Predicting the Future*, p. 149.

[1192] Cf. *Predicting the Future*, p. 59.

[1193] On the notion of "retrodiction," see TOULMIN, S., *Foresight and Understanding*, pp. 18-43. On the philosophico-methodological differences between prediction and retrodiction, see GONZALEZ, W. J., "The Evolution of Lakatos's Repercussion on the Methodology of Economics," pp. 1-25; and GONZALEZ, W. J., "Prediction and Prescription in Biological Systems: The Role of Technology for Measurement and Transformation," pp. 133-146 and 209-213.

horizon of prediction, which can be, in principle, in the short, middle or long run; and (iii) the relation between scientific prediction and the effective control of phenomena (natural, social or artificial).

7.2.1. The Reality of Future Phenomena

For Rescher, scientific prediction is a statement about the future. From an ontological point of view, he considers that the future has two main characteristics: a) it does not yet exist, by definition;[1194] and b) it is something that unavoidably will come, in one way or another.[1195] Another feature of a different kind — an epistemological one — comes from these characteristics: the information we have about the future is usually incomplete; and, consequently, the control we can exert on future phenomena is commonly very limited.[1196] Therefore, there are limits to scientific predictability due to the reality itself of the future phenomena, which make these phenomena difficult for our knowledge and it is not easy having control over them.

In effect, "there are ontological limits in the starting point: the *future* is the ontological axis of prediction; but, strictly speaking, the future is something that *does not yet exist*, since its being depends on what will happen."[1197] It is the first feature that Rescher points out in his ontological characterization of the future. Thus, in his judgment, "the future is nonexistent."[1198] In this way, the future has not facticity (it does not yet exist) and, consequently, it is not accessible to us from an ontological point of view.

But, although the future *is not* available ontologically yet, it can be considered if the future can have effectiveness on the facts of the present. In this regard, it has been extensively discussed the possibility of a genuine backward causation. This involves that the future can have a causal effect on the present. It is a possibility defended by M. Dummett,[1199] among others. According to these authors in favor of backward causation, causes do not

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[1194] Cf. RESCHER, N., *Predicting the Future*, p. 2.
[1195] Rescher does not defend an ontological determinism. Rather, he makes clear that there is a reality of the future as something that will show up.
[1196] Cf. RESCHER, N., *Predicting the Future*, p. 2.
[1197] GONZALEZ, W. J., *La predicción científica*, p. 268.
[1198] RESCHER, N., *Predicting the Future*, p. 70.
[1199] Cf. DUMMETT, M., "Can an Effect Precede its Cause?," *Proceedings of the Aristotelian Society*, v. 28, (1954), pp. 27-44; and DUMMETT, M., "Bringing about the Past," *Philosophical Review*, v. 73, (1964), pp. 338-359.

necessarily precede the effects, but effects might go before the causes. In this way, the future can have a genuine causal influence on the present. A possible example is the prediction of a hurricane (for example, a new Katrina), above all if the prediction has a high degree of probability and is stated several days before the disaster, which can motivate the decision making on important issues for an individual, a group or a town.

Rescher rejects in an explicit manner the idea of backward causation. In this judgment, the future cannot have a causal influence on the present, since the future, strictly speaking, does not happen yet.[1200] However, he admits that the decisions we made in the present are influenced by our ideas about what is to happen in the future.[1201] Even more, he thinks that "to act, to plan, to survive, we must anticipate the future."[1202] Therefore, what can have influence on the decision making of the human beings is the cognitive anticipation of the possible future — the prediction — instead of being the future itself what has an influence (causal or non-causal) on the facts of the present.

In a scientific context, this is what usually happens in the applied sciences, where prediction is the previous step to prescription. In this case, prediction provides the knowledge about the future and this knowledge is used to establish what should be done to solve a concrete problem.[1203] Thus, the knowledge offered by prediction, which deals with what can be expected to happen in the future, allow us to direct the action towards the sought aims. In this case, it is not the future as such what has influence on the decision making, but the decisions are made on the basis of prediction, which offers knowledge about the possible future.

According to Rescher, the second main feature that characterizes the future consist of that it is something that unavoidably will be (in one way or another).[1204] Thus, he thinks that the future will happen when we do not want it. But Rescher does not support a fatalistic proposal or an ontological

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[1200] RESCHER, N., *Predicting the Future*, p. 70.
[1201] Cf. RESCHER, N., *Personal Communication*, 8.7.2014.
[1202] RESCHER, N., *Predicting the Future*, p. 65.
[1203] Cf. GONZALEZ, W. J., "Rationality and Prediction in the Sciences of the Artificial: Economics as a Design Science," pp. 179-183.
[1204] Cf. RESCHER, N., *Predicting the Future*, p. 2.

determinism, according to which the future is something fixed beforehand.[1205] In effect, he thinks that, to some extent, it is possible for us to shape the future, although he acknowledges that there are important limitations to this task.[1206] In addition, he defends that human beings have free will, so that human actions do not happen necessarily.[1207]

These ontological features that characterize the future have an epistemological incidence, since the character itself of the future phenomena leads to the difficulties to obtain information about them. Thus, Rescher considers that the future remains open, so it is possible to think that it has, in principle, many different possibilities. Additionally, the future is something that does not yet exist, so we cannot have access to it through observation.[1208] Consequently, the information we can obtain about the nature of the reality of the future phenomena is always limited. This, in turn, has negative repercussions on our ability to control those future phenomena, since the effective control requires, in principle, that the information needed becomes available.[1209]

7.2.2. The Entitative Incidence of the Time Horizon

The time horizon has to do with the temporal distance between the anticipated phenomenon and the present moment. This concerns prediction insofar as it pays attention to a possible future. Regarding this issue, Rescher distinguishes between the short-range forecasts and the long-range forecasts, depending on the temporal distance of the predicted phenomenon with regard to the moment when the prediction is stated.[1210] However, it is usual in the diverse science to classify predictions in three different types in accordance with the length of time: the short, the middle, and the lung run.

[1205] On the topic of determinism both in social sciences and in the sciences of nature, it could be see the set of papers published in GONZALEZ, W. J. (ed.), *Freedom and Determinism: Social Sciences and Natural Sciences*, monographic issue of *Peruvian Journal of Epistemology*, v. 1, (2012).

[1206] Cf. RESCHER, N., *Predicting the Future*, pp. 232-238.

[1207] Cf. RESCHER, N., *Free Will. A Philosophical Reappraisal,* passim. This volume offers renewed approaches in favor of human freedom.

[1208] Cf. RESCHER, N., *Predicting the Future*, p. 59.

[1209] Cf. *Predicting the Future*, p. 2.

[1210] Cf. RESCHER, N., *Predicting the Future*, pp. 76-78.

Even though there is a not a clear-cut division between them, commonly 1) prediction is *in the short run* when the scientific statement is up to a near future. 2) When the prediction deals with a distant future (a number of years), then it is a prediction *in the long run*. 3) When the predictive statement is about a future that is in an intermediate point between the near future and the more distant future, then the prediction is *in the middle run*.[1211] It is — in my judgment — a classification more complete than Rescher's distinction, since scientific prediction certainly can be about a future that is between the short run and the long run.

An element that makes it difficult to specify in detail this classification consist in establishing where the short, middle, and long run are situated. In this regard, the ontological aspect has a key role, since where the short, middle, and long run are located is an issue that depends, to a large extent, on the kind of reality researched. For Rescher, the volatility of phenomena that we want to predict is one of the key factors we must take into account. Thus, when the phenomena are characterized by being volatile, the long run encompasses a shorter temporal distance than when the phenomena are more stable.[1212]

In effect, the short, middle, and long run in meteorological predictions is, for instance, different from the short, middle, and long run in the astronomical predictions; because the reality meteorological predictions are about has different characteristics from the reality studied by astronomy. But there are other factors that should be taken into account, such as the kind of variables used or the type of data available.[1213] This leads to the fact that there are differences within a scientific discipline. An example in this regard is provided by economics, where "the short, middle, or long run in unemployment could be different from the case of business cycles."[1214]

[1211] Cf. GONZALEZ, W. J., *Philosophico-Methodological Analysis of Prediction and its Role in Economics*, pp. 65-67.

[1212] "A weather forecast is long range if it looks ahead for more than a month, an economic forecast is long range if it looks ahead for more than a year, a population forecast would have to look several generations ahead to qualify as long run," RESCHER, N., *Predicting the Future*, p. 78.

[1213] Cf. GONZALEZ, W. J., *Philosophico-Methodological Analysis of Prediction and its Role in Economics*, p. 66.

[1214] *Philosophico-Methodological Analysis of Prediction and its Role in Economics*, p. 66.

Thus, even when the classification of scientific prediction in three types in accordance with the temporal distance (in the short, middle or long run) could be generally valid, achieving a highest level of sophistication to establish where we can place each one of these types is a task that must be done with regard to each discipline. In economics, for example, it has been proposed a distinction which typifies five types of predictions, where the time horizon is specified: the immediate horizon (between 0 and 3 months), the short run (between 3 and 12 months), the middle run (between 1 and 3 years), the long run (between 3 and 10 years) and the very long run (beyond 10 years).[1215]

Concerning this topic, philosophers commonly accept that the time horizon of the prediction has epistemological relevance. Thus, the kind of prediction that we can obtain (with regard to its reliability) is something that varies in accordance with the temporal distance to the reality that is predicted. In Rescher's judgment, "in general and by and large it is more difficult to predict matters in the more distant future"[1216]. Regarding this issue, he quotes a well-known statement of John Maynard Keynes: "in the long run we are all dead"; and he adds: "and in the *very* long run the universe will presumably be so as well"[1217].

On this ontological basis, in principle, the larger the temporal distance is, the higher the possibility of error is. However, it is possible to find phenomena more predictable in the long run than in the short run. Rescher gives an example related to the meteorological prediction that can illustrate this possibility: "It is March, a very changeable month for our region. And so we cannot predict the weather for next week—though we can be pretty sure that three months hence, in July, the weather will be sunny and warm"[1218]. But these are exceptions, since those things that are in the near future are generally more attainable. Thus, it should be acknowledge that "the variables

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[1215] Cf. FIRTH, M. *Forecasting Methods in Business and Management*, E. Arnold, London, 1977, p. 19. On this classification, see GONZALEZ, W. J., *Philosophico-Methodological Analysis of Prediction and its Role in Economics*, p. 66.
[1216] RESCHER, N., *Predicting the Future*, p. 77.
[1217] *Predicting the Future*, p. 77.
[1218] RESCHER, N., *Predicting the Future*, p. 78.

are, in principle, more knowable when they are close to the researcher (and, thus, within the field of experience and expertise to the researcher)."[1219]

7.2.3. Scientific Prediction and the Control of Phenomena

A central issue in Rescher's approach to scientific prediction is its relation to the control of phenomena, which is one of the features that goes with its characterization of the scientific activity as *our* science. In his approach, control "consists in bending the course of events to our will, of attaining our ends within nature."[1220] So his analysis of control is commonly focused in the realm of the sciences of nature, although this problem can certainly be posed in relation to the social and artificial phenomena and systems.

Control is a notion that Rescher relates to the concept of "intervention"[1221]. Because control requires, in his judgment, having "*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")."[1222]

Both if the control is negative (preclude something from happening) and if the control is positive (make that something happens), the relation with prediction is clear, since "the limits of predictability set limits to control as well."[1223] From this perspective, the question at issue is to exercise control over the future phenomena, and to do this the prediction is required. But control may also be considered with regard to the variables used to predict the future in a scientific way. In this respect, the difficulties to control the

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[1219] GONZALEZ, W. J., *Philosophico-Methodological Analysis of Prediction and its Role in Economics*, p. 219.
[1220] RESCHER, N., *Predicting the Future*, p. 233.
[1221] It should be noticed that the concept "intervention" and its differences with "representation" received an especial attention after the publication of the book by HACKING, I., *Representing and Intervening*, Cambridge University Press, Cambridge, 1983.
[1222] *Predicting the Future*, p. 235.
[1223] RESCHER, N., *Predicting the Future*, p. 237.

variables that are relevant to the prediction —both with regard to the knowledge of these variables and in relation to the possibility of measure them— set limits to the ability to predict the phenomena.[1224]

Thus, the relation between the prediction and the control of the phenomena can be contemplated in two different ways: a) prediction as a *necessary condition* to the control of future phenomena (in the positive meaning and in the negative sense); and b) the control of the variables as an *element required* to prediction. Usually, Rescher attention goes to the first kind of relation, since he thinks that "a future we cannot foresee is *a fortiori* a future we cannot control"[1225]. It is implicit here the methodological path that is frequently followed in the applied science, where prediction is needed in order to prescribe.

Within the applied sciences, to the extent that "they do not describe reality, but rather tell what we ought to do in order to realize our goals"[1226], there is a clear interest in exercise a control over the systems (natural, social, and artificial). Rescher considers that prediction is required in order to make that control possible, together with an understanding of how the phenomena at issue work.[1227] However, there are phenomena that, due to their very nature, we cannot control, even when there is an understanding of their operation and we can predict them.

Certainly, as Simon points out —with a pragmatic vision—, predictive models in applied sciences are usually oriented towards predicting matters that are impossible to control, so that the main aim is the prescription: to suggest patterns for favoring the best possible adaptation to the anticipated problems. In effect, "we do not expect to change the weather, but we can take steps to moderate its effects. We predict populations so that we can plan to meet their needs for food and education. We predict business cycles

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[1224] Even more, it is possible to distinguish four types of scientific prediction (foresight, prediction, forecasting, and planning) according to the degree of control of the variables. Cf. GONZALEZ, W. J., *Philosophico-Methodological Analysis of Prediction and its Role in Economics*, pp. 68-72.
[1225] RESCHER, N., *Predicting the Future*, p. 236.
[1226] NIINILUOTO, I., "Approximation in Applied Science," p. 128.
[1227] Cf. RESCHER, N., *Personal Communication*, 10.6.2014.

in order to plan our investments and production levels."[1228] Thus, it seems clear that the very nature of the phenomena sets limits to our ability to exercise an effective control over the future occurrences, even when it is possible to predict them.

If we think of the relation between scientific prediction and the control of phenomena in the second sense that has been pointed out — the control of the variables as an element required to predicting — then the notion of "control" at issue is more epistemological and methodological than ontological. The reason is clear: it has to do with the knowledge of the relevant variables to the prediction and with the possibility to measure them. In this regard, there are important differences between the degree of control that is achievable in the sciences of nature (for example, in physics) and the degree of control that is possible in the social sciences (for instance, in sociology) and the sciences of the artificial (for example, in economics).

On this issue, it should be pointed out that "physical predictions, in spite of the problems generated by the theory of chaos, work often with a range of events that, in principle, could be under our control, insofar as they are repeatable."[1229] Meanwhile, in other sciences, such as economics, control is more difficult. This leads to the difficulties to predict. Thus, (i) the repeatability of the events might be questioned (are they actually the "same" events?); and (ii) there are more factors that should be considered and, in addition, they could be really varied and show complex interactions.[1230]

These considerations allow us to see the relevance of analyzing the diversity of the reality (natural, social, and artificial) that is researched by science, which can be complex (both with regard to its structure and in respect of its dynamics). Within this thematic framework, a crucial issue is the study of the ontological limits to scientific prediction, which are those difficulties to prediction that derivate from the very status of the phenomena. They are features that, certainly, involve a source of complexity for prediction

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[1228] SIMON, H. A., "Prediction and Prescription in Systems Modeling," pp. 10-11. On this matter, see also SIMON, H. A., "Forecasting the Future or Shaping it?," *Industrial and Corporate Change*, v. 11, n. 3, (2002), pp. 601-605.

[1229] GONZALEZ, W. J., *Philosophico-Methodological Analysis of Prediction and its Role in Economics*, p. 194.

[1230] Cf. *Philosophico-Methodological Analysis of Prediction and its Role in Economics*, p. 194.

and also have repercussions on our ability to control (for example, when a system is chaotic or when it is open to changes through human creativity).

7.3. Ontological Obstacles to Scientific Prediction

Certainly, the knowledge of the extramental reality is an indispensable aspect of prediction, since predicting is a cognitive anticipation of a possible future. Thus, it happens that prediction "is a cognitive venture whose successful pursuit is inseparably bound up with factual matters regarding the nature of the world's *modus operandi*."[1231] In this case, the ontology of science is in the service of the epistemology and the methodology of science. Obviously, it is an important field within the study of scientific prediction.

Due to this unbreakable nexus between the reality of the phenomena and the success in the prediction about those phenomena, it seems clear that the reliability and credibility that must characterize a successful prediction only can be achieved under certain conditions. In this regard, one of the main contributions of Rescher to the research about scientific prediction is, in my judgment, the identification and analysis of the obstacles to predictability (above all, epistemological and ontological). Within the ontological obstacles, some of them might be highlighted: (i) anarchy and volatility, (ii) chance, chaos, and arbitrary choice, and (iii) creativity.

7.3.1. Anarchy and Volatility

There are ontological limits that affect prediction, above all because prediction is about phenomena which have not happened yet and, therefore, they are still open. This is highlighted by Rescher when he considers the obstacles to prediction. In his judgment, "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."[1232]

[1231] RESCHER, N., *Predicting the Future*, p. 81.
[1232] *Predicting the Future*, p. 134.

If the preconditions of the rational process of prediction are considered, it can be clearly seen that complexity of phenomena and events set limits to our predictive ability.[1233] In effect, form a methodological point of view, Rescher admits a plurality of processes that can lead us to achieve predictions. This methodological plurality responds, in the first place, to the kind of question that is posed; and, in the second place, it is due to the diversity of phenomena that we want to predict.[1234]

Independently of the methodological pattern that is used, Rescher demands that every predictive procedure meets several requirements. 1) *Data availability* (the relevant data about the past-and-present happenings can be obtained). 2) *Pattern discernability* (there are discernable patterns that can be detected in the body of data). 3) *Pattern stability* (since the prediction success largely depends on the stability of the past-and-present patterns, so these patterns continue into the future).[1235]

Thus, for Rescher "rational prediction pivots on the existence of some sort of appropriate *linkage* that connects our predictive claims with the input data that provide for their justification."[1236] In this way, he brings again to the forefront the ontological level, as a support to the epistemology and methodology of science. In that case, the complexity of the reality conditions the complexity of knowledge and the consequent method in this regard. This is because we do not want just predict, but achieve reliable, accurate, and precise predictions.

This leads to admit the existence of ontological obstacles to predictability, since the very nature of phenomena can make it difficult or even impossible to meet the preconditions of rational prediction: the availability of the relevant data, pattern discernability, and the stability of the patterns followed by the phenomena. From this ontological perspective, a first distinction that we should take into account has to do with the separation between unpredictability and not-predictability.[1237]

There is "unpredictability" when the nature of phenomena makes it

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[1233] Cf. GONZALEZ, W. J., *La predicción científica*, pp. 271-274.
[1234] Cf. RESCHER, N., *Predicting the Future*, p. 245.
[1235] Cf. *Predicting the Future*, p. 86.
[1236] RESCHER, N., *Predicting the Future*, p. 87.
[1237] On this distinction, see GONZALEZ, W. J., *La predicción científica,* p. 289.

impossible the prediction —now and in the future—, so that it involves the *complete* impossibility to predict. Meanwhile, to be "not-predictable" has to do with the *current* impossibility to achieve a prediction, on the basis of the knowledge or the process of prediction that are available in a given moment. Thus, the former is a methodological-ontological issue (the very reality of the phenomena and events makes it impossible the prediction); while the later involves a methodological-epistemological feature (the future knowledge might allow us to overcome the current difficulties).[1238]

Unpredictability can appear as a result of the presence of phenomena of anarchic character.[1239] Because, in this case, there are no regularities that allow the inference oriented towards the future, so the second precondition of the rational process of prediction cannot be met (i.e., pattern stability). However, it seems that, in principle, it can be too drastic to claim that there is a phenomenon or event clearly unpredictable. This difficulty is due to the dynamic character of scientific knowledge, which involves historicity. From this perspective, it is problematic to give examples of unpredictable issues without taking into account the historical dimension of knowledge.[1240]

According to Rescher, only science can inform us of its own limits,[1241] so that it is not the society what sets the limits. This position involves that the limits of science are always with regard to a historical moment of scientific development. For this reason, even when he admits that there are anarchic phenomena, which can be intractable from a predictive viewpoint, he takes a wary attitude with regard to the existence of "unpredictability" in the strict sense. This is because, in his judgment, we can only claim that a phenomenon is anarchic on the basis of the available knowledge about that phenomenon, which can change in the future.[1242]

In contrast to "unpredictability," to be "not-predictable" has to do with the *current* impossibility to obtain a prediction. In Rescher's account of the ontological obstacles to scientific prediction, to be "not-predictable" is related

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[1238] Cf. GONZALEZ, W. J., *Philosophico-Methodological Analysis of Prediction and its Role in Economics*, pp. 54-56.
[1239] Cf. RESCHER, N., *Predicting the Future*, pp. 136-138.
[1240] Cf. GONZALEZ, W. J., *Philosophico-Methodological Analysis of Prediction and its Role in Economics*, p. 56.
[1241] Cf. RESCHER, N., *Personal Communication*, 17.6.2014.
[1242] Cf. RESCHER, N., *Personal Communication*, 1.7.2014.

to the volatility of the phenomena or events.[1243] Usually, the current impossibility to predict is due to the instability of phenomena, so that the discernible patterns from the past can vary in the future.[1244]

When volatility is considered as an ontological limit to predictability, the time dimension is crucial. Thus, frequently the processes are more stable in the short run than in the long run. For this reason, when prediction is in the long run, it is more likely that errors appear; while predictions in the short run are generally more reliable. Here the information used is another factor to consider, since the available information to predict in the short run is generally more relevant than when prediction is in the long run.[1245]

But it should be pointed out that volatility of phenomena or events is a matter of degree. In this regard, Rescher suggests a classification of the volatile processes in two groups: (a) moderately volatile processes (for example, the weather in the temperate regions); and (b) very volatile processes, which are characterized as processes which exhibit sudden and fortuitous changes (for example, wind velocity in the English Channel).[1246] Thus, a prediction in the long run that is about a process moderately volatile can be more reliable than a prediction in the short run about a process very volatile.

7.3.2. Chance, Chaos, and Arbitrary Choice

In Rescher's judgment, the main ontological obstacles to predictive success are chance, chaos, and arbitrary choice.[1247] He describes chaos and chance as stochastic or random processes that make the laws at issue probabilistic laws.[1248] Furthermore, arbitrary choices can be considered as another important obstacle to prediction. In effect — in his approach — predictability of human actions depends, to some extent, on their rational

[1243] Cf. RESCHER, N., *Predicting the Future*, p. 79.
[1244] Cf. *Predicting the Future*, pp. 79-82.
[1245] Cf. GRANGER, C. W. J., *Forecasting in Business and Economics*, 2nd ed., Academic Press, San Diego, CA, 1989 (1st ed., 1980), p. 7.
[1246] Cf. RESCHER, N., *Predicting the Future*, p. 79.
[1247] Cf. *Predicting the Future*, p. 134.
[1248] Cf. RESCHER, N., *Predicting the Future*, p. 134.

character. [1249] Thus, those actions and choices that are arbitrary (and consequently non-rational) can be not-predictable in principle.

Certainly, the presence of chance is an obstacle to predictability. This is the case because, "where chance is at work, the world can exhibit a fixed past and nevertheless confront us with distinct but altogether feasible futures—situations that are descriptively indistinguishable may unfold in different ways and issue in totally different results."[1250] From this perspective, chance does not make it impossible to predict, but it affects the possibility to achieve predictions with certainty.[1251]

From this point of view, chance does not involve unpredictability in a strict sense, but it may involve a phenomenon that is not-predictable. However, the degree in which a phenomenon or event characterized by chance is not-predictable is an issue that depends, in turn, on the kind of predictive question posed about that phenomenon or event. As Rescher points out, when there is chance, it is usually possible to achieve generic predictions and predictions on a large scale: "Individual chance events are indeed unpredictable,[1252] but the very randomness of chance fluctuation means that large-scale phenomenology will be predictable via the laws of chance codified in probability theory."[1253]

This leads to acknowledge the interrelation between the epistemological and the ontological realms, which is especially clear in the case of the scientific prediction. This is because predictability of phenomena or events does not depend only on the nature of those phenomena (the presence of chance, chaos, arbitrary choices, etc.), but they also depend on the questions posed and, therefore, on the type of prediction that we expect to obtain (generic or specific, conditional or categorical, qualitative or quantitative, etc.).

When chance is considered, it can happen that what is actually an epistemological limitation gets mixed up with an ontological obstacle. It is

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[1249] Cf. RESCHER, N., "Predictive Incapacity and Rational Decision," in RESCHER, N., *Sensible Decisions*, pp. 39-47.
[1250] Cf. RESCHER, N., *Predicting the Future*, p. 138.
[1251] Cf. RESCHER, N., *Ignorance*, p. 108.
[1252] Note that in Rescher's terminology, "unpredictability" is used instead of "not-predictability."
[1253] RESCHER, N., *Ignorance*, p. 107.

what Rescher calls "fallacy of misattributed chance."[1254] It consists of attributing erroneously to chance something that belongs to other factor. This is because, occasionally, we think that our difficulties to predict are due to the presence of chaos, when actually they are due to ignorance (or, potentially, to other factor). This can happen when phenomena at issue are complex and we do not have an appropriate understanding on their working.

Together with chance, chaos is —in Rescher's judgment— another ontological factor that makes it difficult to predict to a greater extent. He associates chaos with extreme volatility, so that in a chaotic system small differences in its initial state can cause big differences in the result. He considers that "a process if chaotic if *observationally indistinguishable* initial conditions can eventuate in different results, irrespective of how sophisticatedly we make our observations."[1255]

In this sense of sensitive dependence of initial conditions, M. Mitchell points out that chaos has been observed "in cardiac disorders, turbulence in fluids, electronic circuits, dripping faucets, and many other seemingly unrelated phenomena. These days, the existence of chaotic systems is an accepted fact of science."[1256] In effect, chaos can intervene in a great variety of phenomena (natural, social, and artificial). This affects the very possibility of predicting, as well as the level of accuracy and precision that can be achieved by predictions.

In the case of the natural sciences, chaos theory has pointed out that even a deterministic system can give rise to unpredictable results, since it might be sensitive to variations in the initial conditions.[1257] Thus, the difficulties to predict are due to chaos, instead of being dependent on chance or randomness.[1258] However, prediction in social sciences is usually more difficult than prediction in the natural sciences. In this regard, the ontological

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[1254] Cf. RESCHER, N., *Predicting the Future*, p. 141.
[1255] *Predicting the Future*, pp. 144-145.
[1256] MITCHELL, M., *Complexity: A Guided Tour*, Oxford University Press, Oxford, 2009, p. 20.
[1257] Cf. GONZALEZ, W. J., *Philosophico-Methodological Analysis of Prediction and its Role in Economics*, pp. 36-38.
[1258] RESCHER, N., *Predicting the Future*, p. 143.

aspect is crucial, since "it seems clear that the differences in the kind of subject matter have incidence in the role of prediction."[1259]

On the one hand, chaos can intervene in the social systems, just like in the natural phenomena. According to Rescher "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. This of course is the characteristic situation of chaos (…). Economic systems (and social systems in general) are in large measure chaotic in exactly this sense."[1260] Thus, some of the difficulties to social prediction can be due to the presence of chaos.

But, on the other hand, there are other ontological obstacles —besides chaos— that have to do to a greater extent with social phenomena. In this regard, Rescher considers the arbitrary choice as an obstacle to social prediction. In his judgment, "the idea of rationality and its ramifications thus provides us with a very important and useful predictive instrument in the context of human activities."[1261] Thus, when the behavior of the agents is characterized by being rational, this involves, to some extent, the possibility of anticipating their choices.

From this perspective, it seems clear that irrational behavior sets a limit to predictability about social matters. In effect, if the choices of the agents are arbitrary, it is not possible to anticipate them in a reliable way. However, Rescher considers that arbitrary choice does not involve necessarily impredictability; because "even where agents behave in erratic and impredictable ways, this need not preclude predictive foreknowledge in the large. For as long as those eccentricities cancel out in the statistical aggregate or become lost in a statistical fog, we can obtain perfectly stable large-scale aggregate effects."[1262]

However, Rescher considers that, even when the agents' choices are rational, we can have problems to predict them in a reliable way. This is

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[1259] GONZALEZ, W. J., *Philosophico-Methodological Analysis of Prediction and its Role in Economics*, p. 62.
[1260] RESCHER, N., *Predicting the Future*, p. 197.
[1261] RESCHER, N., *Ignorance*, p. 113.
[1262] *Ignorance*, p. 114.

because agents make choices on the basis of the available information. It happens then that, frequently, this information is not about *how* the things in the world *are*, but about *what* the agents *think* with regard to the reality. This has clear epistemological repercussions, since it involves difficulties to know in an objective way what information the agents use in the decision-making.

Rescher considers that this feature, which goes with many human decisions, allows us to account for the greater difficulty of the social prediction in comparison with the prediction about natural phenomena, as well as its frequent unreliability.[1263] In my judgment, the difficulties to social prediction require a broader thematic framework. Thus, they should be analyzed within the *framework of complexity*, instead of relating them just with the ontological or epistemological obstacles to predictability. In fact, there is often less complexity in natural system than in social system, where there are more levels at stake.

This greater complexity of the social systems has direct repercussions on the level of regularity of the phenomena and events that we want to predict. Thus, it is frequent to find regularities in the natural sciences, where it is possible in many cases to predict in an accurate and precise way due to the possibility of reproduce the phenomena.[1264] Meanwhile, when the studied reality is social or artificial, there is always a contextual component that is modulated by historicity and that adds complexity to prediction.[1265]

From this perspective, when the prediction is about the actions of the agents "one source of this complexity lies in the difficulty in anticipating human behaviour, which can be influenced by a tremendously varied collection of social, political, psychological, biological and other factors. Another source is the inherent difficulty in anticipating the results of interactions of millions of human beings with different values, objectives, motivations, expectations, endowments, rights, means and circumstances,

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[1263] Cf. RESCHER, N., *Personal Communication*, 10.6.2014.

[1264] Cf. GONZALEZ, W. J., *Philosophico-Methodological Analysis of Prediction and its Role in Economics*, p. 61.

[1265] 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," pp. 73-106.

dealing with each other in a wide variety of institutional settings."[1266] Undoubtedly, these difficulties due to complexity contribute to the frequent unreliability of the social predictions.

7.3.3. Creativity as an Obstacle to Prediction

When creativity is considered as an obstacle to scientific prediction there are, in principle, two successive levels of analysis: (i) creativity as an element that *configures the object studied* by science (the economic, social, cultural, or politic reality, among others), where agents' creativity can generate changes that involve novelty; and (ii) creativity as a factor that *is part of the very scientific activity* of research (basic or applied) that is relevant both form an structural point of view and from a dynamic perspective.[1267]

In the first case —when there is creativity in phenomena or events that are the object of study of science— agents' creativity can be a clear obstacle to scientific prediction (above all, in social sciences and in the sciences of the artificial). In this regard, Rescher relates creativity to impredictability. Fundamentally, he does this with regard to contexts such as Arts, where the presence of creativity allows us to account the difficulties to prediction and even to the impossibility of achieving a prediction.[1268]

When human creativity intervenes, it happens that the pattern followed by a system in the past does not allow us to infer its development in the future. [1269] For this reason, Rescher considers that "human creativity and inventiveness defies predictive foresight."[1270] Even more, one might consider that creativity is a source of complexity. This has been highlighted, above all, in economics, where it is usual to see the creativity of the agents as an obstacle to economic predictions.

[1266] SEN, A. "Prediction and Economic Theory," en MASON, J, MATHIAS, P. and WESTCOTT, J. H. (eds.), *Predictability in Science and Society*, The Royal Society and The British Academy, London, 1986, p. 5.

[1267] Cf. GUILLAN, A., "Analysis of Creativity in the Sciences of Design", in GONZALEZ, W. J. (ed.), *Creativity, Innovation, and Complexity in Science*, pp. 125-139.

[1268] "The future of American poetry is impredictable: we simply have no grip on any laws or regularities that provide for rational prediction," RESCHER, N., *Ignorance*, p. 103.

[1269] Cf. RESCHER, N., "Political Pragmatism," in RESCHER, N., *Pragmatism. The Restoration of its Scientific Roots*, p. 210.

[1270] RESCHER, N., *Predicting the Future*, p. 149. Rescher suggests this issue with regard to humanistic realms, as literature, so that he does not consider how it can affect the scientific disciplines related to designs.

Regarding this issue, Wenceslao J. Gonzalez points out that economic agents "frequently develop *creativity* when they perform some actions (e.g., in the design of new financial products). This creativity of the agents adds another element more of complexity while the task is doing economic predictions, because it increases the possibility of novelty in the phenomena instead of [having] the prevalence of the regularity, which is the main ingredient for promoting the reliability of the predictions."[1271] From this perspective, agents' creativity is another element that gives additional complexity to the economic predictions.

But, together with human creativity *in general*, there is another level of analysis —the second that has been pointed out before— that has to do with *scientific* creativity, in particular. This is because creativity can be also a feature of the scientific activity; both form a structural point of view and from a dynamic perspective. Nevertheless, it is difficult to characterize what *creativity* consists in, as "the term 'creativity' as commonly used covers too much ground. It refers to very different entities, thus causing a great deal of confusion."[1272].

This difficulty has been acknowledged by several authors, such as Subrata Dasgupta or Margaret A. Boden. For Dasgupta, there are "many interpretations — some differing in only subtle ways — that may be placed on the very *idea* of creativity."[1273] Meanwhile, Boden has noticed that, in the study of creativity, problems may arise "because of conceptual difficulties in saying what creativity *is*, what *counts* as creative."[1274] In spite of these difficulties, it is usual to accept that the notion of "creativity" involves, in principle, something positive, which is related to something both valuable and novel or original.[1275]

In this regard, for the sake of a more rigorous characterization of the notion of "scientific creativity," this concept should be distinguished from the

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[1271] 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. 147.

[1272] CSIKSZENTMIHALYI, M., *Creativity. Flow and the Psychology of Discovery and Invention*, Harper/Collins, N. York, 1996 (reprinted in 1997), p. 25.

[1273] DASGUPTA, S., *Creativity in Invention and Design*, p. 16.

[1274] BODEN, M. A., *The Creative Mind. Myths and Mechanisms*, 2nd ed., Routledge, London, 2004 (1st ed., 1990), p. 13.

[1275] On the notion of creativity, see GONZALEZ, W. J., "The Roles of Scientific Creativity and Technological Innovation in the Context of Complexity of Science," pp. 11-40.

term "innovation." Thus, "creativity" is usually related to a scientific context; while the notion of "innovation" is frequently connected with the realm of technology, where there are often modifications of existing realities rather than something completely new or original.[1276] However, "creativity" and "innovation" are interrelated notions, since there are relevant connections between scientific creativity and technological innovation (for instance, in the case of the sciences of design and the information and communication technologies).[1277]

When scientific creativity is considered in relation to prediction, then creativity can have —in my judgment— a double role: a) it might be, in principle, an obstacle for predicting the future science; and b) it can be a key factor for problem-solving, so it can contribute to overcome the current unpredictability of the phenomena and events. Usually, Rescher's attention is focused in the first case: creativity as an impediment to the prediction about the development of the future science.[1278] But he offers a thematic framework that makes it also possible the second option; i.e., to analyze creativity as a medium to deal with the obstacles to predictability (above all, in the epistemological and methodological levels).

Regarding the first role —creativity as an obstacle to the prediction of the future science—, Rescher focuses his attention in one of the aspects of scientific creativity: conceptual creativity. This is because, within a framework of pragmatic idealism, concepts are crucial for the articulation of knowledge. In this way, his thought gives priority to the epistemological realm, as a path to address the problems posed. This also happens when he considers scientific creativity. Thus, he thinks that science is open to conceptual creativity, so changes occur regarding the scientific concepts.[1279]

It is a key feature to address scientific progress and the problem of the limits of science, since research is always carried through from a conceptual

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[1276] 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.

[1277] Cf. GONZALEZ, W. J., "The Roles of Scientific Creativity and Technological Innovation in the Context of Complexity of Science," pp. 11-14.

[1278] Cf. RESCHER, N., "The Problem of Future Knowledge," pp. 149-163.

[1279] On conceptual change, see GONZALEZ, W. J., "Conceptual Changes and Scientific Diversity: The Role of Historicity," pp. 39-62.

framework open to changes. So it happens that taking a concrete conceptual framework sets, in practice, limits to scientific research, insofar as "the major discoveries of later stages are ones which the workers of a substantially earlier period (however clever) not only have failed to make but which they could not even have understood, because the requisite concepts were simply not available to them."[1280] Thus, conceptual creativity affects the predictive ability of science, since certainly we cannot predict those things that we cannot conceive.[1281]

However, conceptual creativity is — in my judgment — an aspect *among others* of scientific creativity. In effect, from a structural point of view, creativity can be considered in relation to the constitutive elements of science: language, structure, knowledge, method, activity, ends, and values.[1282] Therefore, there might be creativity in scientific language (through the introduction of new terms or through changes of meaning in the existing terms), in the structure of scientific theories (where there are alternatives to the dominant theory), in scientific knowledge (through new concepts), in methods (where there are changes in the procedures), with regard to scientific activity (that involves novelty regarding the aims, processes, and results of the research) and in scientific values (internal and external) that modulate the selection of ends.[1283]

From this perspective, scientific creativity might involve the possible "not predictable" situation or even the "unpredictability" about the development of future science in the diverse elements pointed out (language, structure, knowledge, method, activity, ends, and values), instead of being something due only to changes regarding the concepts. At the same time, it might be noticed that the problems to predict the future science, which are mainly the result of the presence of creativity, depend to a large extent on the time horizon of the scientific prediction. Thus, it seems possible to anticipate

[1280] RESCHER, N., "The Problem of Future Knowledge," p. 151.

[1281] Cf. "The Problem of Future Knowledge," pp. 149-163. From this point of view, it is a mistake to think of the experiments as prior to the concepts related to them or the technological doing as prior to the conceptual support for its use in the research.

[1282] On the constitutive elements of science, see GONZALEZ, W. J., "The Philosophical Approach to Science, Technology and Society," pp. 3-49; especially, pp. 10-11.

[1283] Cf. GONZALEZ, W. J., "The Roles of Scientific Creativity and Technological Innovation in the Context of Complexity of Science," pp. 15-17.

with enough reliability the aims, processes, and results of science in the short run; while it could be certainly impossible to predict them in the long run.[1284]

It happens that scientific creativity, besides being an important obstacle to the predictability of future science, can be also a medium to overcome the limits of science, in general, and the limits to scientific prediction, in particular. This can happen both in a context of basic science, where creativity connects above all with explanation and prediction, and in the realm of the applied science, where creativity is mainly related to prediction and prescription. In addition, creativity can be considered in relation to the application of science, which has to do with the use of scientific knowledge by agents, so creativity can lead to new applications of the available knowledge.[1285]

Therefore, while human creativity, in general, is a clear obstacle to scientific prediction (for example, in economics, insofar as it favors a high degree of novelty), scientific creativity can be dual in this regard. On the one hand, creativity is certainly an obstacle that makes it difficult to predict the future science, above all when the prediction is in the long run. But, on the other hand, it can contribute to overcome the limits to predictability, because it allows us to open new routes, regarding explanation and prediction in basic science as well as with regard to prediction and prescription in applied science.

7.3.4. Obstacles on Predictors

Clearly, the limits to the task of predicting —among them, the ontological limits— make it impossible to achieve perfection in the predictive domain. From the point of view of predictors, the existence of a perfect predictor is also unfeasible, both from a theoretical point of view and from a cognitive or epistemic perspective. In the first place, there are what Rescher calls “inherent limits of prediction,” that are mainly related to the presence of

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[1284] Cf. GONZALEZ, W. J., “Rethinking the Limits of Science: From the Difficulties for the Frontiers to the Concern on the Confines,” forthcoming.

[1285] Cf. GONZALEZ, W. J., “The Roles of Scientific Creativity and Technological Innovation in the Context of Complexity of Science,” pp. 17-18.

unsolvable problems of self-prediction.[1286] In the second place, there are cognitive limitations on predictors that make it difficult to achieve accurate predictions.[1287]

Regarding the first problem —the *inherent* limits to prediction—, Rescher thinks that the existence of a perfect predictive engine is something impossible; that is, he sees unfeasible an artifact designed to predict everything that, in principle, is considered as predictable. This is because problems of inconsistency unavoidably appear when the predictive engine is asked about its own working and, more concretely, about its future predictions. Thus, for example, if a predictor (either a human subject or an engine designed to predict) is asked "will you answer this very question by 'no'"?, three answers are possible: "yes," "no" or "I can't say." If the predictor answers "yes" or "no", then the prediction about its own answer is false; and, in the case of answering "I can't say", then the predictor cannot achieve an actual prediction.

In view of this kind of problems, we can claim that it is possible to establish *a priori* the impossibility of perfection in the predictive domain. In effect, there are reflexive questions about the future predictions of an agent that cannot be answered in an adequate way. In this regard, Gregor Betz maintains that this kind of *a priori* limits are not relevant.[1288] In my judgment, I do consider that they are relevant when the limits of science are considered. This is because, on the basis of the inherent limits of prediction, scientific prediction can be clearly seen as a limited venture, so that it is impossible for science to achieve perfection in the predictive domain.

Besides this theoretical limits that affect predictors, Rescher has also into account other limitations that are cognitive or epistemic. He highlights the following ones: (i) *immicency and scale exaggeration*, that is, the tendency to exaggerate the magnitude and promptness of the predicted developments;

[1286] Cf. RESCHER, N., *Complexity*, pp. 159-161. There is an important tradition on the study of the "reflexive prediction." A classic paper with regard to this issue is BUCK, R. C., "Reflexive Predictions," *Philosophy of Science*, v. 30, (1963), pp. 359-369. See also KOPEC, M., "A More Fulfilling (and Frustrating) Take on Reflexive Predictions," *Philosophy of Science*, v. 78, n. 5, (2011), pp. 1249-1259.

[1287] Cf. RESCHER, N., *Predicting the Future*, pp. 218-222.

[1288] Cf. BETZ, G., *Prediction or Prophecy? The Boundaries of Economic Foreknowledge and Their Socio-Political Consequences*, Deutscher Universitäts-Verlag, Wiesbaden, 2006, pp. 3-4.

(ii) *conservatism*, which affects prediction when the stability and durability of the existing order of things is exaggerated; (iii) *wishful or fearful thinking*, which affects prediction when it is influenced by those thing we wish or fear; and (iv) *probability misjudgment*, which are due to errors in evaluations or combinations.[1289]

It seems that, in principle, these cognitive limitations can be more relevant when prediction is made through estimative procedures than in the case of predictions obtained by properly scientific methods. This is because, in the case of the estimative procedures, there is always present a subjective component that is specially prominent.[1290] However, the acknowledgment and analysis of the limitations that affect predictors is important, both when the processes used are estimative procedures and scientific methods, since — as Rescher insists — to predict is a *human activity*. For this reason, this kind of cognitive biases can affect the predictive task independently of the processes used (estimative procedures or scientific methods).

Taken them together, the ontological limitations to predictability involve the impossibility of achieving what Rescher calls "predictive completeness." This includes that science could accurately predict those things that are in principle recognized as predictable by science itself.[1291] So, due to the limits that affect prediction, the predictability of phenomena is not something that can be established *a priori*. Thus, "only the course of experience can inform us about the extent to which the phenomena of a particular domain are predictable. And with predictability in general, just as with specific issues of prediction, one must simply wait and see."[1292].

7.4. Ontology of Prediction from the Perspective of Complexity

Ontological limits to predictability (volatility, chance, chaos, etc.) can be seen as sources of complexity for predictions. Certainly, the perspective of complexity is relevant when scientific prediction is analyzed from an ontological point of view. This is because prediction can be about a reality

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[1289] Cf. RESCHER, N., *Predicting the Future*, pp. 218-222.

[1290] On the different processes oriented towards predicting, see RESCHER, N., *Predicting the Future*, chapter 6, pp. 85-112.

[1291] Cf. RESCHER, N., *Razón y valores en la Era científico-tecnológica*, pp. 137-148.

[1292] RESCHER, N., *Predicting the Future*, pp. 81-82.

(natural, social or artificial) that can be characterized as complex. Thus, its complexity has repercussions that go in two directions: on the one hand, it has repercussions on the very possibility of predicting; and, on the other, it modulates the configuration of the predictive processes and the type of prediction that can be achieved (its reliability, accuracy, precision, etc.)[1293]. In this regard, it should be taken into account that complexity is a twofold notion: it has a structural dimension and a dynamic trait.[1294]

The structural dimension of complexity has to do with the parts that compound the complex system and the interactions between those parts. Meanwhile, the dynamic trait of complexity has to do with the changes that occur in the system over the time, both from an internal point of view (usually in terms of aims, processes, and results) and from an external perspective (that deals with the relations with the environment). Usually, Rescher pays more attention to the structural dimension of complexity than to the dynamic trait. A broader approach to complexity must also pay attention —in my judgment— to the complex dynamics ("internal" and "external"), where historicity can be a key aspect, above all when the reality researched is a social or artificial reality.

7.4.1. Varieties and Relevant Modes of Complexity

When the complexity of a system (natural, social or artificial) is considered, two different dimensions of complexity should be taken into account in principle: a) the structural dimension (that has to do with the parts that compound the system and their interactions); and b) the dynamic trait (that deals with the change over the time in the system).[1295] Frequently, the studies of complexity are focused on the structural perspective. Even more,

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[1293] It has been noticed that complexity sets limits to science: "the study of the characteristics of complex dynamic systems are showing us exactly why limited knowledge is unavoidable — or, to be more precise, why knowledge *has to be* limited," CILLIERS, P., "Why We Cannot Know Complex Things Completely," in CAPRA, F., JUARRERO, A., SOTOLONGO, P., and VAN UDEN, J. (eds.), *Reframing Complexity. Perspectives from the North and South*, *Exploring Complexity,* vol I., ISCE, Mansfield, MA, 2007, p. 82.

[1294] Cf. GONZALEZ, W. J., "The Sciences of Design as Sciences of Complexity: The Dynamic Trait," pp. 299-311.

[1295] A recent study of both aspects is in GONZALEZ, W. J., "Prediction and Prescription in Biological Systems: The Role of Technology for Measurement and Transformation," pp. 133-146 and 209-213.

there are characterizations of complexity, in general, that only address the complex structure, without taking into account, in fact, the dynamic complexity.[1296]

An interesting and especially influential approach to complexity is that offered by Herbert A. Simon, centered in the sciences of the artificial, in general, and the sciences of design, in particular. His focus is on “organized complexity,” instead of paying attention to a kind of complexity that is disorganized (for example, a chaotic structure). From this perspective, Simon considers that designs consist of a series of elements that are coordinated, and they may have a hierarchic configuration, in such a way that complex systems are nearly-decomposable. Thus, their components cannot be completely separated, since they are interdependent.[1297]

In this way, Simon considers that, in scientific research, *analysis* is the complement of the task of synthesis carried out by design sciences.[1298] From the structural perspective, his conception of the analysis is commonly *holological*, and it is oriented towards nearly-decomposability. So, when the aim is to clarify the structural complexity of design sciences, he thinks that a holological analysis is required. This is so because “the complexity of a whole should be decomposed (…), where there are numerous parts that interact. When this operation is carried out, insofar as the subsystems that compound the complex system are inter-dependent, it is not possible that the subsystems can split up completely ones from others.”[1299]

Simon’s view of a complex system is based mainly on a holological perspective: the relations between the parts and the whole are emphasized, although he avoids giving a precise definition of “complex systems.”[1300]

[1296] “Complexity depends on the number of elements of the system, the number of its properties and the number of relationships between these elements or properties.” BETZ, G., *Prediction or Prophecy? The Boundaries of Economic Foreknowledge and Their Socio-Political Consequences*, p. 81. This characterization can be valid with regard to the complex structure of a system, but it does not encompass —in my judgment— the whole realm of complexity, since it does not take into account the dynamics.

[1297] Cf. SIMON, H. A., *The Sciences of the Artificial*, 3rd ed., chapter 8, pp. 183-216.

[1298] Cf. SIMON, H. A., “Problem Forming, Problem Finding, and Problem Solving in Design,” p. 246.

[1299] GONZALEZ, W. J., “Las Ciencias de Diseño en cuanto Ciencias de la Complejidad: Análisis de la Economía, Documentación y Comunicación,” p. 17.

[1300] It must been pointed out that there is not a deffinition of “complexity” or “complex system” that is generally accepted. Cf. CHU, D., STRAND, R. and FJELLAND, R., “Theories of Complexity. Common Denominators of Complex Sistems,” p. 19.

Generally, he considers that a complex system is "one made up of a large number of parts that have many interactions."[1301] In these systems, the whole is more than the sum of the parts, in such a way that "given the properties of the parts and the laws of their interaction, it is not a trivial matter to infer the properties of the whole."[1302] Thus, in a broad sense, complexity can be understood as opposite to simplicity.[1303]

In my judgment, such an approach to complexity is too general. On the one hand, structural complexity cannot be only an organized complexity, but it can also be found disorganized complexity in complex systems (for example, in chaotic systems). At the same time, the notion of "hierarchy" is not good enough to undertake the whole organized complexity, since it is also possible to have a "poli-hierarchy." In this respect, the need for "coordination" has been highlighted.[1304] On the other hand, Simon's approach to complexity is too focused on the structural perspective.[1305] In this regard, in order to grasp the whole complexity, it seems necessary a deeper conception open to dynamic complexity, both of science considered in itself and of the studied reality (above all, when it is a social or an artificial reality).

[1301] SIMON, H. A., *The Sciences of the Artificial*, 3rd ed., pp. 183-184.

[1302] *The Sciences of the Artificial*, 3rd ed., pp. 183-184.

[1303] 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.

However, it should be acknowledge that even simple sistems can have a complex behavior. See SPROTT, J. C., "Complex Behavior of Simple Systems," in MINAI, A. A. and BAR- YAM, Y. (eds.), *Unifying Themes in Complex Systems*, Vol. IIIB, *New Research*, Proceedings of the Third International Conference on Complex Systems, Springer, Berlin/Heidelberg/N.York, 2006, pp. 2-11.

[1304] Cf. RESCHER, N., *Complexity: A Philosophical Overview*, Transaction Publishers, N. Brunswick, NJ, 1998, pp. 10-11. A comparison between Rescher and Simon's approaches to complexity is offered in GONZALEZ, W. J., "La vertiente dinámica de las Ciencias de la Complejidad. Repercusión de la historicidad para la predicción científica en las Ciencias de Diseño," in GONZALEZ, W. J. (ed.), *Las Ciencias de la Complejidad: Vertiente dinámica de las Ciencias de Diseño y sobriedad de factores*, pp. 76-79; and 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. 151-153.

[1305] Certainly, the dynamic trait is also present in Simon's analysis of the sciences of design as sciences of complexity, but he is more interested in the structure of the complex systems than in the dynamic complexity. Cf. SIMON, H. A., *The Sciences of the Artificial*, 3rd ed., *passim*.

Rescher's approach to complexity goes further — in my judgment — than Simon's proposal. In effect, Rescher considers that Simon's conception on complexity is too generic, since there are few real things that can escape complexity when it is understood in terms of the relations between the parts and the whole.[1306] Thus, although Rescher is also mainly focused on "structural complexity," he highlights that there are numerous features of complexity. He does this through a breakdown of the modes of complexity according with two basic levels: the epistemic and the ontological ones.

Epistemic complexity — as Rescher sees it — is related to formulas. Within this first level of complexity, he proposes three epistemic or cognitive modes of complexity: (i) descriptive complexity, which deals with the level of difficulty that involves describing a system in a proper way; (ii) generative complexity, which reflects the number of steps that are required to give rise to the complex system; and (iii) computational complexity, which is associated with the number of resources required in order to solve problems related to the system.[1307]

There is another level of complexity in Rescher, which is of an *ontological* kind (the complexity in reality itself). In this regard, he distinguishes three ontological modes of complexity. In turn, each one of them has several possible options: a) compositional complexity (constitutional and taxonomic); b) structural complexity (organizational and hierarchical); and c) functional complexity (operational and nomic).[1308] With this collection of the epistemic and ontological modes of complexity, Rescher offers a framework of complexity that is certainly more systematic and broader than other approaches.

His analysis of ontological complexity can be used to address the problem of scientific prediction. In this regard, when scientific prediction is analyzed from an ontological perspective, Rescher's proposal on the ontological modes of complexity certainly has philosophical relevance. This is because the reality predicted as well as the reality used for prediction could

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[1306] Cf. RESCHER, N., *Complexity*, p. 22, note 44.
[1307] Cf. *Complexity*, p. 9.
[1308] Cf. RESCHER, N., *Complexity*, p. 9. He just point out two possible options within the three ontological modes, but they can be enlarged if we take into account dynamic aspects.

be a complex reality. So the study of this ontological complexity (that has repercussions on the epistemological and methodological levels) can have a key role to characterize the prediction to be made. On the one hand, it allows us to report some obstacles to predictability; and, on the other, it can help to overcome those obstacles.

Thus, Rescher's proposal on complexity is really interesting, but it is excessively focused on the structural complexity and he scarcely pays attention to the dynamic trait. A broader approach to complexity should —in my judgment— pay attention to dynamic complexity too, that is connected with the notion of historicity. This is especially clear when scientific prediction is considered, since it is oriented towards a possible future, so it has to deal with the changes that occur in the systems over time.[1309]

7.4.2. Ontological Modes of Complexity and Their Incidence on Prediction

A system can be complex due to its own ontological characteristics. This issue underlies Rescher's identification of the "modes of complexity." His analysis is focused on the epistemic modes of complexity (those related to knowledge) and the ontological modes of complexity (that are related to reality itself). The *methodological modes* of complexity can be added to his proposal, since the complexity related to reality and to knowledge has repercussions on the scientific processes (for example, in the case of the predictive models).

All these modes of complexity (epistemic, ontological, and methodological) have repercussions on science, in general, and on scientific prediction, in particular. In this regard, within a pragmatic idealism such as that defended by Rescher, ontological complexity is especially relevant, insofar as it is the support for the epistemological level (the achievable knowledge) and the methodological side (the scientific processes). From an ontological perspective — which has to do with the reality itself researched

[1309] This is relevant not only for the social sciences and the sciences of the artificial, but also for natural sciences such as biology. See GONZALEZ, W. J., "Prediction and Prescription in Biological Systems: The Role of Technology for Measurement and Transformation," pp. 133-146 and 209-213.

(natural, social or artificial) — a system can be complex (for him) in accordance with three modes of complexity: (i) compositional complexity; (ii) structural complexity; and (iii) functional complexity.[1310]

Compositional complexity is related to the elements that compound the system and the variety of those elements. Thus, Rescher distinguishes two forms of complexity related to system's composition: *constitutional complexity* and *taxonomic complexity* or *heterogeneity*. Constitutional complexity is associated with the number of elements that compound a system, while taxonomic complexity or heterogeneity has to do with the variety of those elements.[1311]

Structural complexity has in Rescher a restricted sense, since it is circumscribed to the organization and relation between the elements of the system, instead of encompassing all the structural factors of complexity. Within what he calls "structural complexity," there are also two possibilities: *organizational complexity* and *hierarchical complexity*. The former is related to the forms of organization that can be seen in the system (i.e., it has to do with the possible forms of interrelations between its components). The later has to do with the possible ways to relate the elements of the system.[1312]

Meanwhile, functional complexity is related to the behavior of the system that clearly involves a temporal dimension. It is diversified, in turn, in two modes of complexity: *operational complexity* and *nomic complexity*. Operational complexity studies the variety of the modes of operation and the types of functioning that appear in the system, an issue that he sees in terms of processes. Nomic complexity is related to the patterns that regulate the relations between the elements of the system.[1313]

Through this framework about the ontological complexity —that pays attention to three features: the composition, the structure, and the function of the complex systems—, Rescher highlights that, when we try to encompass the complex reality of a complex system (natural, social or artificial) there are

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[1310] Cf. RESCHER, N., *Complexity*, p. 9.
[1311] Cf. *Complexity*, p. 11.
[1312] Cf. RESCHER, N., *Complexity*, pp. 11-12.
[1313] Cf. *Complexity*, pp. 12-13. This functional complexity involves some kind of openness to a teleological component insofar as the operations are oriented to ends. But this aspect as well as its dynamic consequences are not the focus of attention of Rescher's approach to complexity.

a wide variety of factors to take into account. Thus, the ontological complexity of a system involves that we have to take into account the components (their number and variety), the structure (regarding the organization and the relations between the components), and the functions (the types of operation and the working patterns).

From this perspective, it can be clearly seen that prediction of a complex system with ontological complexity has to deal with a wide variety of factors. This is so because, although a system does not need to be complex in all the aforementioned senses, "the different modes of complexity do tend to run together in practice."[1314] Thus, when a system is complex with regard to its composition and structure, it is usually complex regarding their function too.[1315] Certainly, this makes it difficult to predict, and has repercussions on issues such as the reliability or the degree of accuracy and precision that can be achievable.

But it happens that, regarding complex systems, there are still more factors to take into account than only the epistemic and ontological modes of complexity. Thus, although Rescher's approach to complexity is really detailed, his attention is mainly on the structural dimension of complexity (understood in a broader sense, which also encompass the compositional complexity). For that reason, although his approach is open to the dynamic trait —that has to do with the changes that occur in the system over the time—, it is a perspective that, in my judgment, is not exhaustively developed in Rescher.

In effect, when dynamic complexity is considered, we must take into account, initially, two dimensions: the "internal" dynamics and the "external" dynamics.[1316] The internal dynamics is related to the activity of the system itself, whereas the external dynamics deals with the relations to the environment. Rescher pays special attention to the "internal" dynamics of the complex system, which he considers in accordance with the notion of

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[1314] RESCHER, N., *Complexity*, p. 15.
[1315] Cf. *Complexity*, p. 15.
[1316] Cf. GONZALEZ, W. J., "Las Ciencias de Diseño en cuanto Ciencias de la Complejidad: Análisis de la Economía, Documentación y Comunicación," pp. 13-14.

"process."[1317] But he does not pay attention *de facto* to the "external" dynamics, where there are sources of complexity regarding the relations of the system with the environment.

In this regard, the concept of "historicity" has been proposed to characterize the change in the complex dynamics ("internal" and "external") and its repercussions on scientific prediction.[1318] It is a notion that goes further than the mere temporality, since it is difficult to think of a reality that escapes from the temporal dimension. However, historicity is a characteristic of the human realm: it links with the human activity that is *eo ipso* historic, in the sense that it changes over time, and some changes are particularly relevant.[1319] In addition, historicity is also in the context that surrounds human activity, which can have relevant changes as well.

Thus, historicity is related to three levels of analysis: science, the agents, and the reality itself that is researched. This was pointed out by Wenceslao J. Gonzalez: "1) Historicity (*Geschichtlichkeit/historicidad*) is a trait of science, in general, and each science, in particular. This facet can be found in the whole set of constitutive elements of science, such as language, structure, knowledge, method, activity, ends, and values. 2) Historicity configures the agents themselves involved in the development of scientific research, insofar as they are human beings within a historical context. 3) Historicity is a characteristic of the reality itself that is researched (above all, in the social and artificial realms)."[1320]

When these three levels of analysis are considered, it seems clear that the notion of *historicity* is relevant when the problems of complexity, in general, and its repercussions on scientific prediction, in particular, are considered. In the first place, historicity is a feature that modulates science. This happens in three successive levels: the constitutive elements of science (that lead to the structural dimension of complexity), the configuration of the

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[1317] On the notion of "process" in Rescher, see GONZALEZ, W. J., "La vertiente dinámica de las Ciencias de la Complejidad. Repercusión de la historicidad para la predicción científica en las Ciencias de Diseño," pp. 79-80.

[1318] Cf. "La vertiente dinámica de las Ciencias de la Complejidad. Repercusión de la historicidad para la predicción científica en las Ciencias de Diseño," pp. 79-88.

[1319] Cf. GONZALEZ, W. J., "Racionalidad y Economía: De la racionalidad de la Economía como Ciencia a la racionalidad de los agentes económicos," p. 88.

[1320] GONZALEZ, W. J., "Conceptual Changes and Scientific Diversity: The Role of Historicity," p. 43.

aims, processes, and results (the internal dynamics of scientific activity), and the relations with the changing environment (the external dynamics).

In the second place, historicity configures the agents who develop the scientific activity, who are in a concrete socio-historical context. This feature can add more complexity (for instance, through human creativity, both individual and social). Finally, historicity can be a feature of the reality itself studied by science, above all when it is a social or artificial reality. From this perspective, historicity can be the basis to understand why prediction is more difficult in social sciences and the sciences of the artificial, where the complex systems are historical.

7.4.3. Complexity and Historicity in the Social Sciences and the Sciences of the Artificial

A key issue for the reflection on social sciences and the sciences of the artificial is the problem of complexity. Even more, these sciences can be analyzed as sciences of complexity, both with respect to their structure and with regard to their dynamics (internal and external). In effect, they are sciences with structural complexity. This can be seen in relation to their constitutive elements, such as language, internal articulation, knowledge, method, activity, ends, and values.[1321] Additionally, they have a complex dynamics (internal and external), above all when they are configured as applied sciences.[1322] Thus, in their internal dynamics, there is an articulation of aims and processes, which generate a result. At the same time, they involve an external dynamics, since their activity is developed in a changing environment.

Both the structural dimension and the dynamic trait of complexity in social sciences and the sciences of the artificial are modulated by historicity. This is a feature that they have in common with the natural sciences, since every science is the result of the human activity, which is historic in itself. But historicity is also an ontological feature of the reality researched by social

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[1321] Cf. GONZALEZ, W. J., "La vertiente dinámica de las Ciencias de la Complejidad. Repercusión de la historicidad para la predicción científica en las Ciencias de Diseño," p. 74.
[1322] Cf. GONZALEZ, W. J., "Las Ciencias de Diseño en cuanto Ciencias de la Complejidad: Análisis de la Economía, Documentación y Comunicación," pp. 8-9.

sciences and the sciences of the artificial, since they are disciplines that study the social reality and the human-made realm, respectively. The social ontology and the artificial ontology are both under the influence of historicity.

From this perspective, it seems clear that there is also a contextual component in the scientific undertakings. "Because the agents — individual and social — act usually with regard to contexts (historical, cultural, political, …), which are changing."[1323] So historicity allows us to understand the huge variability of the reality (above all, social and artificial), because it offers the appropriate framework to address factors like human creativity or the choices of the agents that are a source of complexity for predictions in social sciences and sciences of the artificial.

It is usual to consider that prediction in social sciences is more difficult than in natural sciences, both in term of possibility and in terms of results. At the same time, it is also usual to think that this difficulty of social prediction is because there are more complexity in the social systems (or in the artificial systems) than in the natural systems.[1324] Thus, from a structural point of view, more factors might intervene in them, with more complex interactions; and, from a dynamic perspective, the variability is usually higher than in natural systems.

However, the studies on complexity, both in social sciences and in the sciences of the artificial, do not take usually into account historicity. Commonly, they are focused in notions as "evolution" or "process," which do not achieve the depth that historicity achieves.[1325] In my judgment, a more sophisticated analysis of complexity (structural and dynamic) can be developed through historicity, above all in the social and artificial realms. In the case of economics, this has been highlighted by Wenceslao J. Gonzalez. Economics is a dual science (it is a social science and also a science of the artificial), so it involves features of both groups of disciplines.

[1323] "Las Ciencias de Diseño en cuanto Ciencias de la Complejidad: Análisis de la Economía, Documentación y Comunicación," p. 14.

[1324] Cf. GONZALEZ, W. J., "Complexity in Economics and Prediction: The Role of Parsimonious Factors," pp. 319-330; especially, pp. 319-321.

[1325] Cf. GONZALEZ, W. J., "La vertiente dinámica de las Ciencias de la Complejidad. Repercusión de la historicidad para la predicción científica en las Ciencias de Diseño," pp. 79-84.

Gonzalez considers that, when the problem of complexity in economics and its repercussions on economic prediction is analyzed, there is an ontological duality that must be taken into account in its configuration. This ontological duality is the differentiation between “economic activity” and “economics as activity.”[1326] It is a distinction that involves a relevant source of complexity for economics, as a human endeavor imbued with historicity. This complexity adds difficulty to economic prediction, which has to take into account the duality of components “economic activity” and “economics as activity.”

On the one hand, *economic activity* can be understood, in principle, as autonomous regarding other human activities, since it has its own characteristics. Thus, it involves the activities carried through by human beings, which include supply and demand, the transactions of good and services, etc. On the other hand, *economics as activity* is a human endeavor that is related with other human activities (cultural, political, social, ecological, etc.). Commonly, it is interconnected with them in many ways. From this perspective, there are relations with the environment, so that economics as human activity —which is interrelated with other activities— is not independent of the context.[1327]

It happens that, through *economic activity*, “prediction has to deal with forms of complexity that are genuinely of an economic character.”[1328] At the same time, *economics as activity* “involves that scientific prediction should consider a series of different types of complexity (social, political, cultural, ecological, etc.), that certainly have repercussions on the economic variables.”[1329] In both cases, historicity is a key feature, since economic reality cannot be understood without taking into account the historicity of human activity, which is developed in a social environment.

[1326] Cf. GONZALEZ, W. J., “Economic Prediction and Human Activity. An Analysis of Prediction in Economics from Action Theory,” pp. 253-294.

[1327] Cf. GONZALEZ, W. J., “La vertiente dinámica de las Ciencias de la Complejidad. Repercusión de la historicidad para la predicción científica en las Ciencias de Diseño,” pp. 86-87.

[1328] 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. 146.

[1329] “Complejidad estructural en Ciencias de Diseño y su incidencia en la predicción científica: El papel de la sobriedad de factores (*parsimonious factors*),” p. 146.

Therefore, the duality "economic activity" and "economics as activity" involves that "the predictability of economic activity —which is, in principle, autonomous— is possible, and the prediction could be reliable; whereas predictability of economics as a human activity among others appears more unreliable, precisely due to the interdependence with other activities."[1330] But accepting the historicity of the economic reality does not involve, certainly, neglecting its objectivity. Both "economic activity" and "economics as activity" are objective realities. However, whereas economic activity is, in principle, measurable, economics as activity is more difficult to measure, so it is not usually included in the neoclassical econometrical models.[1331]

With regard to the difficulties to predict in social sciences, in general, and in economics, in particular, Rescher insists on the fact that those difficulties are mainly rooted in the presence of cognitive factors. This is because social prediction, *prima facie*, is about the acts and choices of the agents, and it happens that agents do not make decisions on the basis of the reality of the world, but they make decisions on the basis of what they *think* of that reality. In this way, the acts and choices of the agents depend on factors such as their beliefs, ideas, etc., that are variable.[1332] This means that there is a subjective component, and social prediction has to deal with it.

However, if the distinction "economic activity" and "economics as activity" is taken into account, it seems that there are even more sources of complexity that affect economic prediction, so there are more factors than those contemplated by Rescher. This situation, in my judgment, allows us to understand the higher difficulty of economic prediction in comparison with prediction in the sciences of nature (for example, in physics). In addition, this distinction — that has as it starting point the acknowledgement of the historicity that configures the social and artificial reality — can be applied to other dual sciences, such as the communication sciences.[1333]

[1330] GONZALEZ, W. J., "La vertiente dinámica de las Ciencias de la Complejidad. Repercusión de la historicidad para la predicción científica en las Ciencias de Diseño," p. 87.

[1331] Cf. "La vertiente dinámica de las Ciencias de la Complejidad. Repercusión de la historicidad para la predicción científica en las Ciencias de Diseño," 92.

[1332] Cf. RESCHER, N., *Personal Communication*, 10.6.2014.

[1333] Cf. ARROJO, M. J., "La sobriedad de factores en el análisis de la complejidad en las Ciencias de la Comunicación. El estudio de la Televisión Digital Terrestre," in GONZALEZ, W.

All these considerations allow us to see how the analysis of complexity from the historicity of the human activity can shed light on the problem of scientific prediction, in general, and prediction in the social sciences and the sciences of artificial, in particular. Certainly, Rescher's approach to the epistemic and ontological modes of complexity allows us to understand some of the methodological difficulties to prediction. But this approach should be incorporated into a broader account of complexity. Thus, we have to consider two aspects of complexity: the structural dimension and the dynamic trait (internal and external). In order to do this, historicity — in my judgment — should be explicitly acknowledged, since it is a key feature of science, the agents, and the reality itself that is researched (above all, social and artificial).

J. (ed.), *Las Ciencias de la Complejidad: Vertiente dinámica de las Ciencias de Diseño y sobriedad de factores*, pp. 337-358.

CHAPTER 8

AXIOLOGICAL ELEMENTS OF SCIENTIFIC PREDICTION

Axiology of scientific research is one of Rescher's main interests in the realm of the philosophy of science. This can be seen in the number and quality of his work in this thematic field. Thus, the second of his three volumes of Princeton University Press devoted to *A System of Pragmatic Idealism* — where Rescher seeks to make the coordinates of his system of thought explicit — has as subtitle *The Validity of Values: Human Values in Pragmatic Perspective.* This is relevant, since the book is entirely devoted to the reflection on human values, in general, and scientific values, in particular.[1334] This importance of the axiology of research can be also seen when Rescher addresses the problem of scientific prediction, since axiological elements are especially relevant in this topic.[1335]

To carry through the analysis of the axiological elements of scientific prediction, it should be noticed that axiology of research is twofold: it has a structural dimension and a dynamic trait. When the structural dimension is addressed, the attention is focused on the constitutive elements of science (language, structure, knowledge, method, etc.), so above all the internal side of analysis is stressed.[1336] Thus, when the study of the axiological elements of scientific activity is made from the structural dimension, the focus is usually on the values (semantic, logical, epistemological, methodological, etc.) that modulates scientific activity *itself considered*.

Meanwhile, the perspective changes when the dynamic trait is considered: the *historical character* of scientific activity — that is modulated

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[1334] Cf. RESCHER, N., *A System of Pragmatic Idealism.* Vol. II: *The Validity of Values: Human Values in Pragmatic Perspective, passim*.
[1335] Cf. RESCHER, N., *Predicting the Future*, chapter 7: "The Evaluation of Predictions and Predictors," pp. 113-131.
[1336] On the constitutive elements of science, see GONZALEZ, W. J., "The Philosophical Approach to Science, Technology and Society," pp. 3-49; especially, pp. 10-11.

by several factors — is then emphasized. This activity involves, on the one hand, pay attention to the aims, processes, and results[1337] ("internal" dynamics) and, on the other hand, to the relations with the context — social, cultural, politic, economic, etc.—, which is changeable ("external dynamics").[1338]

In turn, aims, processes, and results — and the connected values — change in accordance with the type of activity: basic science, applied science or application of science.[1339] In this way, when values are contemplated from the dynamic trait, external values of science can be seen clearer, which are those values that modulate science as an activity related to other human activities (social, cultural, politic, economic, etc.).[1340]

Within this thematic framework about values, which emphasizes the twofold character of the axiology of science — the structural dimension and the dynamic trait — and the double perspective of analysis — the internal aspect and the external viewpoint — Rescher's axiology of science defends a *holism* of values. He suggests this holism from the idea of a system, so the different values (internal and external) form a network of interdependences. Due to the attention to values as a system, his axiological approach stresses the structural dimension, where the internal values (especially, epistemological and methodological) have primacy.

[1337] 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*, pp. 1503-1521.

[1338] 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*, pp. 7-30; especially, pp. 8-9.

[1339] 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," pp. 139-171; especially, pp. 158-159.

On the distinction between applied science and the 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.

[1340] This happens, especially, when the research is oriented towards applied science or the application of science, because the nexus with the context (social, cultural, economic, etc.) are clearer than in the case of basic science.

But, to the extent that his axiology is holistic, the dynamic trait should be also considered, which deals to the aims, processes, and results ("internal" dynamics), as well as to the relations to the changing context ("external" dynamics). However, because Rescher has little interest in the *historicity* of human activity, he does not develop the dynamic trait of the relation between science and values. This can be clearer seen when his attention goes to the axiology of scientific prediction; because, in his judgment, prediction is mainly a cognitive content with methodological import, so the structural factors have primacy (especially, the epistemological and methodological features).

Within these coordinates, this chapter has two main aims: (i) to clarify the framework of Rescher's axiology of science; and (ii) to offer a critical analysis of his axiology of scientific prediction. To do this, several steps are followed. Firstly, the research is oriented towards his holistic conception of values, which sees science as a human activity. This is related to his approach to rationality, which includes an evaluative rationality or rationality of ends, so scientific rationality is not merely an instrumental rationality.[1341] Secondly, his approach to the *system* of values of science is stressed, where the internal component has primacy. In this way, it can be seen how the main values are — for Rescher — epistemological and methodological values.

Thirdly, the attention is focused on the axiological elements of scientific prediction. In this regard, it can be pointed out that axiological perspective of scientific prediction is initially twofold: a) the value of prediction as such; and b) the values that are or might be characteristic of scientific prediction. In that case, there is then a duality that should be considered — structural and dynamic — that has to do with the values of prediction.

On this basis, the analysis offered about the axiological elements of scientific prediction has into account three aspects: 1) prediction as a value

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[1341] Cf. RESCHER, N., *Rationality. A Philosophical Inquiry into the Nature and the Rationale of Reason*, passim.

of science, that is related to the problem of predictivism from an axiological viewpoint; 2) the values of scientific prediction from the structural perspective, which is the dominant viewpoint in Rescher's approach; and 3) the values of prediction from the dynamic point of view, which allows us to broaden his axiological proposal through the attention to historicity.

8.1. Nicholas Rescher's Axiology as a System of Science and Values

As the background of his "pragmatic Kantism," Rescher defends a holism of values, which is related to the idea of a *system*.[1342] On the one hand, there is in his approach a clear predilection for the internal values to science (that he sees above all from the structural perspective). But, on the other hand, he develops a *broad* axiology of research.[1343] Thus, even when it is certainly possible to establish distinctions regarding values (for example, internal values in contrast to external values), it is not possible, strictly speaking, a complete separation between them.[1344] This is the case because, *de facto*, values of science (internal and external) are related to the full set of human values and, in the last analysis, they are rooted in human needs, which are of universal character. Hence Rescher considers that human values, in general, and scientific values, in particular, are objective.[1345]

Together with the objectivity of values, as based in human needs, Rescher develops an approach that involves that scientific rationality is not merely an instrumental rationality or rationality of means, but rather it also

[1342] 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.
[1343] Cf. GONZALEZ, W. J., "Economic Values in the Configuration of Science," pp. 85-112.
[1344] Cf. GONZALEZ, W. J., "Racionalidad científica y actividad humana. Ciencia y valores en la Filosofía de Nicholas Rescher," pp. 11-44; especially, p. 22.
[1345] Cf. RESCHER, N., *Razón y valores en la Era científico-tecnológica*, pp. 74-76.

includes an evaluative rationality or rationality of ends.[1346] It is an approach to the axiology of research that allows us to overcome proposals of instrumental reductionism, where the values only have a role for the choice and evaluation of the means with regard to given ends. Moreover, Rescher's proposal contributes to clarify the relations of scientific rationality with technological rationality, where the instrumental component usually has a more prominent role.

8.1.1. A Holistic View of Values as a Human Activity

Rescher's axiology of science can be characterized as a combination of pragmatic elements (the primacy of practice), Kantian features (the coordination of a system), and realist aspects (the emphasis on objectivity). In this way, his axiology of scientific research is in the same direction as his philosophy and methodology of science, which configures a system of pragmatic idealism open to elements of realism. Thus, his axiology is pragmatic insofar as he sees scientific activity as a practice connected to the entire human experience. This leads him to a holism of values, which is linked to his Kantism, where values configure a system. Moreover, the most important values are — in his judgment — the internal values to science (above all, epistemological and methodological values).

This "pragmatic Kantism" that modulates his axiology of scientific research is rooted on realist basis, which appeals to the objectivity of values, so Rescher considers that it is possible the rational deliberation about evaluative issues.[1347] This objectivity leads him to distinguish between values rooted in human needs and values of optional character. Furthermore,

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[1346] Cf. RESCHER, N., *Rationality. A Philosophical Inquiry into the Nature and the Rationale of Reason*, passim.

[1347] "Value issues should also be seen in a 'realistic' light. Matters of value too can and should be regarded as objectively factual—the difference is just that we are dealing with *evaluative* rather than simply *informative* facts," RESCHER, N., "Fact and Value in Pragmatic Perspective," in RESCHER, N., *The Pragmatic Vision. Themes in Philosophical Pragmatism*, p. 77.

objectivity leads to the idea of "impartiality;"[1348] that is, an unbiased or not particular character, open to a universal feature (i.e., present in the diverse human agents).

Rescher's starting point is the idea that human values, in general, and the values of science, in particular, are related to *human activity*. In this way, values "do not need an 'isolated world' ('*mundo aparte*') — in the Platonic way — in order to based them, neither they are about a transcendental subject or a pure consciousness, but [they are] about people."[1349] This attention to human activity as the axis of his axiology of science leads him to a holistic view of values. Because scientific activity can be thought as a human activity *among others*, so it is not isolated from other realms of human experience (social, cultural, economic, ecological, etc.).

In effect, "Rescher conceives scientific goals (mainly, cognitive ones) as related to the rest of our goals (social, cultural, economic, etc.). Thus, besides the teleological character of science, this viewpoint insists on science as a human undertaking in a contextual setting rather than in a purely cognitive project or an isolated doing. In other words, science belongs to a human network."[1350] From this perspective, science is modulated by a plurality of values (internal and external) that configure a *system*, so there is an interdependence network among them. But the idea of a system is compatible with a hierarchy of values. Once again the Kantian influence on Rescher's thought is considerable, since — among the values of the system — the internal values (above all, epistemological and methodological) are the most important.

Besides the holism of values — that is compatible with an articulation that gives priority to internal values — the objective character of Rescher's

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[1348] On his approach to objectivity, see RESCHER, N., *Objectivity: The Obligations of Impersonal Reason*, University of Notre Dame Press, Notre Dame, 1997.
[1349] GONZALEZ, W. J., "Racionalidad científica y actividad humana. Ciencia y valores en la Filosofía de Nicholas Rescher," p. 11.
[1350] GONZALEZ, W. J., "Economic Values in the Configuration of Science," p. 90.

axiology should be highlighted. This is other main aspect in his characterization of values, in general, and the values that modulates scientific activity, in particular. For him, values are not a mere subjective or intersubjective matter, but it is possible the rational deliberation about the *validity* of values. This involves that, in contrast to the mere "tastes" or "preferences," the notion of "value" is linked to what is *preferable* — not simply preferred — in an objective way.[1351] In his judgment, the objectivity of values (scientific and non-scientific) has an ontological basis that is rooted in human needs.[1352]

These background coordinates that articulate Reshcer's proposal about the relation between science and values allow him to configure a *broad* axiology of research, where the internal dimension and the external component are interrelated. Thus, even when he shares with authors such as Larry Laudan a pragmatic view of knowledge and certain predilection for the internal values (above all, the cognitive ones),[1353] Rescher's proposal goes certainly further than the simple attention to the role of the cognitive values in the configuration of the aims of research.[1354] This greater richness can be seen both in the internal and external aspects.

[1351] Cf. RESCHER, N., *Razón y valores en la Era científico-tecnológica*, pp. 74-76 and 90-93.

[1352] "Our values themselves are not—and should not be— arbitrary and haphazard. For in the final analysis, they pivot not on mere wants and the vagaries of arbitrary choice in fortuitous preference, but on our best interests and real needs—on what is necessary to or advantageous for a person's well-being. (…) For the fact is that values are valid just exactly to the extent they serve to implement and satisfy our needs and our correlatively appropriate interests," RESCHER, N., "Pragmatism and Purpose," in RESCHER, N., *Pragmatism. The Restoration of its Scientific Roots*, p. 38. On human needs as the support of objectivity of values, see RESCHER, N., *Razón y valores en la Era científico-tecnológica*, pp. 85-90.

[1353] Both Laudan and Rescher were students of Hempel. Even more, Rescher claims that both — he and Laudan — are part of the "younger generation" of the legacy of the Berlin School. Cf. RESCHER, N., "The Berlin School of Logical Empiricism and its Legacy," pp. 281-304. The influence of the received view in both authors can be seen in the fact that, when they think of the relation between science and values, internal criteria prevails, above all, cognitive criteria. However, Laudan was also influenced by Thomas Kuhn and especially by Imre Lakatos, so his concern for the historicity of science is much higher than in the case of Rescher.

[1354] In effect, Laudan's proposal about the relation between science and values are focused on cognitive values and their role with regard to the aims of research. Cf. LAUDAN, L., *Science and Values. The Aims of Science and Their Role in Scientific Debate*, University of California Press, Berkeley, 1984.

On the one hand, the holism of values maintained by Rescher involves assuming that axiology of research can follow, in principle, two different (although connected) thematic orientations: the internal perspective and the external orientation. From the internal perspective, the attention goes to the values of science itself considered (cognitive values, methodological values, …). Meanwhile, from the external orientation the values studied are those that goes with science insofar as it is a human activity connected with other human activities (social, cultural, economic, ecological, etc.).[1355]

And, on the other hand, Rescher's proposal assumes that values (internal and external) have a role in science: firstly, they have to do with the selection of the aims of the scientific activity; and, secondly, the have incidence on the selection of the more adequate means to achieve those aims. Thirdly, values intervene in the evaluation of the results of the research (and their possible consequences).[1356] This has repercussions for the characterization of scientific rationality. Thus, Rescher considers that the deliberation on *value* matters: it is a rational deliberation that has an objective basis. He maintains then that human rationality, in general, and scientific rationality, in particular, is not only an instrumental rationality or rationality of means, but there is also an evaluative rationality or rationality of ends, which deals with what we should estimate value.[1357]

8.1.2. From the Internal Dimension to the External Aspect: Importance of Evaluative Rationality and Relation to Technology

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In this regard, see Wenceslao J. Gonzalez's comparison between the axiology of scientific resesearch of Laudan and Rescher's approach: GONZALEZ, W. J., "Economic Values in the Configuration of Science," pp. 85-112.

[1355] 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," pp. 148-149.

[1356] Cf. GONZALEZ, W. J., "Economic Values in the Configuration of Science," pp. 93-96.

[1357] This is developed by Rescher in several works. Among them, they can be seen RESCHER, N., *Rationality. A Philosophical Inquiry into the Nature and the Rationale of Reason*; RESCHER, N., *Satisfying Reason. Studies in the Theory of Knowledge*, Kluwer, Dordrecht, 1995; RESCHER, N., "Pragmatism and Practical Rationality," p. 43; and RESCHER, N., "Rationality and Moral Obligation," pp. 79-93.

Rescher thinks that values are mainly related to the aims of the scientific activity. In his axiology of research, "values have a central role in science and (…) this role is not something arbitrary or added, but it is inherent to the goal structure that is definitive of science as rational search."[1358] The means are not all what matters, because — to the extent that science is a rational activity — there should be a rational deliberation about the validity of the aims of the scientific activity. This is because, in his judgment, "true rationality calls for the pursuit of *appropriate* ends based on valid human interests, rather than following the siren call of unexamined wants or preferences."[1359]

In effect, Rescher admits three types of rationality in accordance with their object of deliberation: (i) cognitive rationality, which deals with what can be accepted in the realm of knowledge; (ii) practical rationality, which is about what actions can be made; and (iii) evaluative rationality, which has to do with what should be considered as valuable or preferable.[1360] If this approach is lead to the realm of scientific rationality, the repercussion for the axiology of science is clear: scientific rationality is not just an instrumental rationality, because it involves a rationality of ends. This task — the selection of the ends of scientific activity — must be made in accordance with values.[1361]

Thus, in the first place, values have a role for science insofar as they modulate the *aims* of the research. Afterwards, in the second place, values intervene in the selection of the best *means* to achieve those previously selected ends. Finally, in the third place, the achieved *results* can be valued taken into account if they meet or not the sought ends. In this way, the framework proposed by Rescher does not just remain in the instrumental

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[1358] RESCHER, N., *Razón y valores en la Era científico-tecnológica*, p. 95.
[1359] RESCHER, N., *Rationality. A Philosophical Inquiry into the Nature and the Rationale of Reason*, p. 107.
[1360] Cf. *Rationality. A Philosophical Inquiry into the Nature and the Rationale of Reason*, p. 3.
[1361] Cf. RESCHER, N., *Razón y valores en la Era científico-tecnológica*, pp. 93-96.

level, because there is a selection of aims, which is prior to the rational deliberation about the means and is also before the potential results.[1362]

This involves an improvement with regard to H. A. Simon's approach to rationality as a matter that only has to do with the means. It is also an advancement with respect to any other account of instrumental reductionism in social sciences and in the sciences of the artificial (such as, for example, the approach that has been dominant in neoclassical economics).[1363] Obviously, the acknowledgement of the role of values is higher in Rescher that what was accepted by instrumentalist authors in the line of Friedman.[1364]

Concurrently, to the extent that scientific rationality is — for Rescher — mainly a rationality of ends, there are clear differences with regard to technological rationality. In effect, science and technology are different activities, at least when they are analyzed from a conceptual perspective. This is because science seeks a variety of aims through cognitive means, either in order to increase our knowledge (basic science) or to solve concrete problems (applied science).[1365] Meanwhile, technological rationality is oriented towards a creative transformation of reality in order to generate new results (usually, an artifact).[1366] Consequently, "science" and "technology" are different human activities with different types of rationality, although there are

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[1362] 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," pp. 147-148.

[1363] Cf. GONZALEZ, W. J., "Racionalidad y Economía: De la racionalidad de la Economía como Ciencia a la racionalidad de los agentes económicos," pp. 70-72.

[1364] Cf. FRIEDMAN, M., "The Methodology of Positive Economics," pp. 3-43.

[1365] 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.

[1366] 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. Obviously, this conceptual difference, which has to do with the aims, processes, and results of science and technology, is compatible with the acknowledgement of a clear practical interaction, above all in certain companies, between science and technology. This intense interaction is one of the reasons that have led to think of "technoscience" for several years. There is a line of thought about this topic, where diverse senses of "technoscience" can be considered.

Javier Echeverría has contributed to this realm. Cf. ECHEVERRÍA, J., "Tecnociencia y sistemas de valores", in LÓPEZ CEREZO, J. A., and SÁNCHEZ RON, J. M. (eds.), *Ciencia, Tecnología, Sociedad y Cultura en el cambio de siglo*, Biblioteca Nueva, Madrid, 2001, pp. 222- 223; and ECHEVERRÍA, J., *La revolución tecnocientífica*, Fondo de Cultura Económica, Madrid, 2003.

frequent and intense relations between them,[1367] which are especially important in the case of the sciences of design, where the level of interaction is very high.

Certainly, the differences between scientific activity and technological doing involve differences in the type of rationality. Thus, the instrumental component — the rationality of means — prevails in technological rationality, insofar as technology is a *doing that transforms reality.* From this point of view, the most important values in technology are those related to processes (efficacy, efficiency, etc.). This is even clearer in engineering, which is basically praxeological and, therefore, the epistemological aspect remains is secondary.[1368] Concurrently, the importance of the external values (social, political, economic, ecological, etc.) is clearer in the case of technology than in science, because the effect of the technological artifacts on the society and the environment is usually more direct than in the case of science (above all, in basic science).[1369]

Among the features of science, it is oriented towards the search of *aims*, which are generally cognitive. These aims of knowledge usually guide the research both in formal sciences and in empirical sciences.[1370] In addition, these aims are modulated by values, which can be either internal (for example, cognitive values such as truth) or external (social, cultural, political, etc.). Once the rational analysis of those aims — they are selected

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[1367] Since Rescher is mainly focused on the natural sciences, especially when they are oriented towards basic research, the relation with technology is centered, above all, in the need for technological artifacts in order to develop the scientific activity. See, for instance, RESCHER, N., *Razón y valores en la Era científico-tecnológica*, p. 100.

[1368] Cf. NEIRA, P., "La racionalidad tecnológica y los problemas de predicción en Herbert Simon," in GONZALEZ, W. J. (ed.), *Racionalidad, historicidad y predicción en Herbert A. Simon*, p. 151.

[1369] On values in technology, see GONZALEZ, W. J., "Valores económicos en la configuración de la Tecnología," *Argumentos de Razón Técnica*, n.2, (1999), pp. 69-96. The relation between technology and values (with especial attention to the ethical values) is analyzed from diverse perspectives in the papers of the book GONZALEZ, W. J., (ed.), *New Perspectives on Technology, Values, and Ethics: Theoretical and Practical Discussions*, Boston Studies in the Philosophy of Science, Springer, Dordrecht, forthcoming.

[1370] Cf. GONZALEZ, W. J., "The Philosophical Approach to Science, Technology and Society," pp. 3-49; especially, pp. 10-11.

according to values — is made, there is also a rational deliberation about the more suitable *processes*. The use of these processes will eventually produce a result. This attention to the aims, processes, and results involves a dynamic perspective in order to address the axiology of research. It is an approach that is contained in the axiological framework proposed by Rescher, but he does not develop it, because he gives primacy to the structural perspective.

8.2. Axiology of Scientific Research in the Pragmatic Idealism

Rescher defends a holism of values, so there is an explicit acknowledgement of the presence of values — internal and external — in scientific activity. He addresses this holism of values from the idea of a *system*, which is mainly articulated as a structural approach to the axiology of scientific research, so the dynamic trait is habitually avoided.

According to the structural approach, values are above all related to the constitutive elements of science (language, structure, knowledge, method, etc.), so the internal dimension of analysis has primacy. In this regard, it can be clearly seen the Kantism that characterizes Rescher's thought, because he gives more importance to the *content* of science than to the relations with the social milieu. From this point of view, the values that prevail are — in his judgment — internal values to science; especially, epistemological and methodological values.

8.2.1. Values as a System in the Case of Science: The Primacy of the Internal Dimension

As it usually happens in the idealist authors, there is in Rescher a conception of a *system*.[1371] In his approach to the axiology of research, the

[1371] The idea of a "system," which serves to characterize the three volumes where Rescher synthesizes his contributions, appears also in many other publications. See, for example, relation between science and values can be seen from several viewpoints: (i) insofar as science is oriented towards aims such as information and truth. (ii) Since there are economic values that modulates the search of those aims and that are related to the pattern of cost-benefit, so there is an "economics of research" that modulates scientific progress. (iii) From the feature of science as a social activity that is based on a process of human cooperation. (iv) In accordance with the consequences of the scientific activity, which involve the evaluation of the applications and uses of science.[1372] Each one of these steps requires more attention.

1. There is a teleological starting point in Rescher's axiology of research. It consists in the characterization of the scientific activity as an activity *goal-oriented*. In his judgment, "values have a central role in science and (…) this role is not something arbitrary or added, but it is inherent to the goal structure that is definitive of science as rational search."[1373] When those goals or aims are considered, we have that "certain factors of values represent the *roles of scientific research* itself considered: concretely, effective description, explanation, prediction, and control over nature."[1374] Therefore, they are goals valuables in themselves.

In addition to these values of the investigation itself, there are values that modulate scientific theories.[1375] Rescher gives them an *instrumental* character, in the sense of specification: their search contributes to the achievement of the aims of scientific research (description, explanation,

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RESCHER, N., *Conceptual Idealism*, *passim*; RESCHER, N., *Methodological Pragmatism. A Systems-Theoretic Approach to the Theory of Knowledge*, *passim*; RESCHER, N., *Scientific Progress. A Philosophical Essay on the Economics of the Natural Science*, passim; RESCHER, N., *Rationality. A Philosophical Inquiry into the Nature and the Rationale of Reason, passim*; and RESCHER, N., *The Limits of Science*, revised edition, *passim.*

[1372] Cf. GONZALEZ, W. J., "Racionalidad científica y actividad humana. Ciencia y valores en la Filosofía de Nicholas Rescher," p. 16.

[1373] RESCHER, N., *Razón y valores en la Era científico-tecnológica*, p. 95.

[1374] *Razón y valores en la Era científico-tecnológica*, p. 94. In this regard, his higher interest in basic science than in applied science can be seen in the fact that he does not mention expressly *prescription* as one of the aims of scientific research.

[1375] Cf. RESCHER, N., *Razón y valores en la Era científico-tecnológica*, p. 94.

prediction, and control). In this regard, the values he points out are cognitive: coherence, consistency, generality, simplicity, accuracy, precision, etc. Besides cognitive values there are also methodological values, since the values related to the standards of proof and rigor also intervene here. They specify what is worthy in the processes. Thus, they are related to the quantity and the type of proofs that are needed in order to establish a statement as a scientific claim.[1376]

Those values that go with scientific theories can be different in formal sciences and empirical sciences. In turn, within empirical sciences, values can vary in natural sciences, social sciences, or the sciences of the artificial.[1377] From this perspective, although Rescher is usually focused on the sciences of nature, he admits that there are differences regarding the values between the different groups of sciences. Therefore, his axiological proposal is not naturalistic. However, he does not address how those scientific values can vary over time. Thus, even when the pays attention to the context, he does not take into account historicity.

2. Rescher insists on the "economics of research." Thus, he considers that, form a methodological viewpoint, science requires an economy of means. In this way, he highlights the importance of the *economic values* in "our science." He emphasizes then values such as profitability, efficacy, efficiency, etc. "He places those values in several successive levels (cognitive, methodological, social and related to policy), that corresponds with elements related to science from an internal perspective (the first two) or external (the second ones)."[1378] Therefore, they are values that modulate scientific research and that have a key role for scientific progress. This is

[1376] This directly affects the hypotheses and, therefore, the scientific theories, especially if they are contemplated from statements that convey contents regarding real things.
[1377] Expressly, he mentions the case of formal sciences: "We do not ask social scientists for the same criterion of rigor that a mathematician imposes himself," RESCHER, N., *Razón y valores en la Era científico-tecnológica*, p. 94.
[1378] GONZALEZ, W. J., *La predicción científica*, p. 270.

because, in Rescher's conception, that process centers around the cost-benefit relation.[1379]

On the one hand, the achievement of knowledge involves a benefic that can be theoretical or practical. In this way, there is scientific progress to the extent that science increases its capability to explain and predict phenomena (basic science) and when it solves more concrete problems or solves them in a more efficient way (applied science). But, on the other, there are costs that make the advancement of science difficult.[1380] Those costs can be due either to the increasing complexity of the studied phenomena or to an increasing in the resources needed.[1381] Regarding this issue, Rescher highlights the relation between science (above all, natural sciences and sciences of the artificial) and technology, because the advancement of science requires a more and more costly technology.[1382]

3. There are also values in science insofar as it is a *social activity*. This is reasonable because science is social in its goals or aims, to the extent that it does not start from scratch and the new goals require the cooperation of the researchers. It is also social in its means, because scientific progress needs social support in order to have the adequate tools of research. Furthermore, science is social in its results, because scientific evaluation is a task made by persons and organizations devoted to these ends.

As social values of science, Rescher points out values such as truthfulness, honesty, or perseverance. They are values that go with the aims of research and the processes that contribute to achieve those aims. Besides

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[1379] Rescher's proposal on scientific progress appears in several of his works. Among then, the following can be seen: RESCHER, N., *Peirce's Philosophy of Science*, University of Notre Dame Press, Notre Dame, 1978; RESCHER, N., *Scientific Progress. A Philosophical Essay on the Economics of the Natural Science*, *passim*; RESCHER, N., *Cognitive Economy. The Economic Dimension of the Theory of Knowledge*, *passim*; RESCHER, N., *Priceless Knowledge? Natural Science in Economic Perspective*, *passim*; and RESCHER, N., *Epistemetrics*, *passim*.

[1380] Cf. GONZALEZ, W. J., "Economic Values in the Configuration of Science," pp. 85-112; especially, p. 93.

[1381] Cf. RESCHER, N., *Complexity*, p. 85.

[1382] Cf. RESCHER, N., *Razón y valores en la Era científico-tecnológica*, pp. 100-103.

these values, he admits the presence of desires that have to do with the self-promotion of the individuals or groups: influence, power, prestige, etc.[1383] These desires do not have the character that Rescher attributes to "values," since they lack objective basis. In effect, they are due to the preferences of the concrete individuals or groups, instead of being something desirable for science in objective way.

4. This framework is completed by the set of values of science *as application*. In Rescher's judgment, these values represent the benefit of the products of science. They are values "related mainly with the application of science to human *desiderata*, such as wellbeing, health, longevity, comfort, etc., in medicine, engineering, agriculture…"[1384] From this perspective, the results of the research and their possible uses and consequences are explicitly considered. Furthermore, this leads to a relation between the values of science and the values of technology, where ethical values have an important role (for example, in biomedicine).

Once again, these values of the applications of science arise from knowledge (it is about their "consequences"), where practical knowledge gains especial prominence, because it adapts to the context where it is used. They are values related to the use of the cognitive content and the processes of application, so what is worthy is something that wants to avoid what is momentary or transitory. To sum up, it is an "intellectual" approach to values, so it is not a "volitive" account of values: *content* prevails over the decision regarding what is "worthy."

Therefore, when Rescher's axiology of Rescher addresses the four realms mentioned — the aims, the economic values, the social component, and the consequences of scientific activity — it gives priority to the internal dimension. The values that characterize the human activity of making

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[1383] Cf. *Razón y valores en la Era científico-tecnológica*, p. 76.
[1384] RESCHER, N., *Razón y valores en la Era científico-tecnológica*, p. 95.

science are values "internal" to scientific activity itself considered (semantic, logical, epistemological, methodological, ontological, etc.). Thus, they modulates the aims of the research — description, explanation, prediction, and control (to which prescription should be added),[1385] that seek to increase the available knowledge (basic science) or to solve concrete problems (applied science).

Although he insists on the "internal" dimension, "external" values have also an important role. Rescher admits this when he notices that scientific knowledge is a good *among others*: "It is only one element of the constellation of human desiderata —one valuable project among others, whose cultivation is only one component of the wider framework of human purposes and interest."[1386] In this way, the role of the external values (cultural, political, economic, ecological, etc.) is not merely secondary, but they can be also relevant, due to a holistic view of values.

Now then, this interrelation between the internal dimension and the external component highlights that scientific activity can be subject to external limitations. This is because the whole set of human values serve human needs, so the search for knowledge should not interfere with other legitimate goods (health, wellbeing, etc.). In that case, the "internal" values to scientific activity (semantic, logical, epistemological, methodological, etc.) are interrelated with the "external" values (social, cultural, ecological, etc.).

Rescher avoids an "atomism" of values: they are not "isolated" values, because they are interrelated. Consequently, the search for 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. Whatever other projects we may have in view—justice, health, environmental

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[1385] Prescription is required in order to encompass applied science.
[1386] RESCHER, N., *The Limits of Science*, revised edition, p. 243.

attractiveness, the cultivation of human relations, and so on—it is pretty much inevitable that their realization will be facilitated by the knowledge of relevant facts."[1387]

It happens that Rescher addresses this double perspective of analysis — internal and external — from a structural viewpoint, that appeals to values as a *system*. For this reason, although his approach has into account the aims, processes, and results — that are the three moments that configure the internal dynamics — and the relations with the changing context (the external dynamics), he does not develop a satisfactory dynamic approach. In my judgment, the dynamic approach must assume the *historicity* (of science, agents, and the reality itself that is researched).[1388]

In contrast to a conception of this type (open to historicity), Rescher's proposal is more static. In effect, the dynamic approach, whose starting point is the acknowledgement of the historical character of scientific research, involves several aspects. Firstly, it requires paying attention to the changes that occur in the aims, processes, and results of the research (and the connected values); and, secondly, it involves the study of the relations with the context, that is also changeable. Meanwhile, values in Rescher are always structural, so he does not think of values that can be modulated by historicity.

8.2.2. Main Values: Epistemological and Methodological

Within this framework of a holism of values, Rescher accepts the presence of a plurality of values in science. However, he considers that internal values to scientific activity (above all, epistemological and methodological) are more important than the external values (social, cultural, economic, ecological, etc.). In this regard, Wenceslao J. Gonzalez notices

[1387] *The Limits of Science*, revised edition, p. 243.
[1388] Cf. GONZALEZ, W. J., "El enfoque cognitivo en la Ciencia y el problema de la historicidad: Caracterización desde los conceptos," pp. 51-80.

that "his Kantism is obvious, to the extent that the content of science is more relevant than the socio-historical context."[1389]

It is a holism of values which admits a hierarchy or scale of preferences among them. Thus, in Rescher's judgment, all the elements of value that are present in science have not the same status. In this holistic axiology of research, the internal values (epistemological, methodological, etc.) are not the only values that modulate research, but they are, in principle, more important than the external values (social, cultural, political, …). So, in the first place, it is a conception that broadens the realm of values in contrast to other proposals that are *exclusively* focused on the internal dimension;[1390] and, in the second place, this conception is clearly different form the studies of science, technology, and society, where it is more usual to highlight the external component.[1391]

On the one hand, internal values have more weight in Rescher than external values. He considers that they characterize scientific research in a better way. Above all, he focuses on epistemological values such as truth, accuracy, or coherence; and methodological values like explanatory and predictive power of theories. In turn, the results of science (mainly the development of scientific theories) that have those values can contribute decisively to the achievement of other human values, such as personal dignity, health, or sustainability. And, on the other hand, the primacy of the internal dimension has to do with a conception that emphasizes the structural aspect with regard to science. This is because Rescher is focused on what is

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[1389] GONZALEZ, W. J., *La predicción científica,* p. 269.
[1390] This can be seen in the comparison made by Wenceslao J. Gonzalez between Rescher's and Laudan's proposals. Cf. GONZALEZ, W. J., "Economic Values in the Configuration of Science," pp. 85-112.
[1391] Regarding the greater importance of the internal dimension in Rescher's axiology of scientific research, there are convergence points between his proposal and the logical empiricism and naturalism, which are two of the most influent philosophical traditions in the North American philosophy of science in the 20th century. Rescher himself notices his relation with the legacy of the logical empiricism and considers that he is a member of the "young generation" of the Berlin School, because he was a student of Hempel. Cf. RESCHER, N., "The Berlin School of Logical Empiricism and its Legacy," p. 282.

worthy regarding science as *content*, so he gives priority to the epistemological and methodological realms.

By accepting that science is *our* science, Rescher assumes that values are in science from the beginning of the activity. Thus, they are in the realm of the aims or goals of scientific research. According to the teleological character of science, two kinds of values have — in his judgment — priority: (i) values that characterize as go with the type of knowledge that science gives (epistemological values); and (ii) values that modulate the processes that lead to the achievement of that knowledge (methodological values). Within methodological values, economic values are highlighted, since science requires — for Rescher — and "economy of means."[1392]

Within epistemological values, Rescher highlights values such as coherence, consistency, generality, understandability, simplicity, accuracy, and precision.[1393] They are values that modulate the aims of the scientific research, insofar as by searching them we can effectively achieve the aims of science (among them, prediction). Moreover, they have a role in order to evaluate the results of the research (for example, accuracy and precision might be key factors in order to evaluate a scientific prediction).[1394] Rescher considers that "in this realm, we also find the values included in the management of the cognitive risk; especially, in the standards of proof and rigor."[1395]

Rescher acknowledges the diversity of values in accordance with the thematic realms. Thus, he admits that there are values that can vary in the different groups of sciences. Even more, the values that have priority in social sciences and in natural sciences are not necessarily the same. In this

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[1392] Cf. GONZALEZ, W. J., "Racionalidad científica y actividad humana. Ciencia y valores en la Filosofía de Nicholas Rescher," p. 16.
[1393] Cf. RESCHER, N., *Razón y valores en la Era científico-tecnológica*, p. 94.
[1394] Cf. GONZALEZ, W. J., *Philosophico-Methodological Analysis of Prediction and its Role in Economics*, pp. 243-245.
[1395] RESCHER, N., *Razón y valores en la Era científico-tecnológica*, p. 94.

way, he assumes that there can be different scales of preferences in sciences with regard to the epistemological values. In effect, it seems that a value such as precision can be more relevant in astronomy than in linguistics or social anthropology, where other values such as, for instance, coherence, can be more important.

But, in my judgment, Rescher's proposal should be broaden. Because there can be variations within each group of sciences (natural sciences, social sciences, or the sciences of the artificial) and within each science (astronomy, economics, physics, sociology, etc.) in accordance with socio-historical factors. These variations, that highlight the *historicity* of scientific activity, are compatible with the *objectivity* of values. In this regard, two factors should be distinguished in order to join the objectivity of values and their historical character: a) values as such; and b) the appraisal of values.

When values are considered as such, it can be seen that they have an objective basis, so it is possible to claim that coherence, accuracy, precision, simplicity, etc. are worthy factors that should accompany scientific theories. Therefore, the deliberation about what are the elements of value that should guide the aims of the research is not a merely subjective or intersubjective matter, but there is a rational basis that supports the evaluation. Meanwhile, the appraisal of values is something that can vary in accordance with different socio-cultural contexts and different historical moments.

As Javier Echeverría notices, "the criteria of evaluation of scientists themselves have varied according to the contexts, disciplines, periods, and concrete situations in which they act."[1396] Even more, the *historicity* of values cannot be just a secondary matter to axiology of scientific research, since "the most pressing issue consists in analyzing the changes in values over the history of science and within a discipline, or even during one evaluative

[1396] ECHEVERRÍA, J., *Ciencia y valores*, Destino, Barcelona, 2002, p. 185. This feature of values can be clearly seen in the case of brain studies. Cf. GÓMEZ, A., "Ciencia y valores en los estudios del cerebro," *Arbor*, v. 181, n. 716, (2005), pp. 479-492.

process."[1397] In effect, it is a crucial issue for the history of science, because "fundamental scientific controversies and large changes in the way science is practiced typically involve conflicts over, and transformations of, the value commitments that dominate genuine knowledge production."[1398]

This component of change and variation that modulates the criteria of evaluation is difficult to adapt to Rescher's structural approach. Certainly, Rescher emphasizes the issue of contextuality, so he is aware that changes occur in science, also in the realm of values.[1399] But it seems to me that his approach does not develop the three main realms where historicity can intervene: science, the agents, and the reality researched (above all, social and artificial). In my judgment, the component of change can be clearer seen within the framework of the approaches that highlight the historicity of scientific research, which is a wider notion than contextuality.[1400]

In effect, establishing the criteria to assess the acceptability of theories depends on the validities accepted by scientific community. These criteria might vary from one socio-cultural context to other (here the level of acceptation of the autonomy of science have influence) and they might depend on concrete historical moments. Certainly, the acceptation of the variability of values according to socio-historical factors does not lead us to assume an axiological relativism, because historicity is compatible with the objective character of evaluative issues.

[1397] ECHEVERRÍA, J., *Ciencia y valores*, p. 181.

[1398] DOPPELT, G., "The Value Ladenness of Scientific Knowledge," in KINCAID, H., DUPRÉ, J. and WYLIE, A. (eds.), *Value-Free Science? Ideals and Illusions*, Oxford University Press, N. York, 2007, p. 198.

[1399] "One has to accommodate general considerations with particular contexts and with variability of contexts. This has impact on normative conceptions (values, duties, etc.)," Rescher, N., *Personal Communication*, 26.5.2015.

[1400] During the sixties of the 20th century there have been a series of proposals that have acknowledged the importance of the historicity of science. Thus, the Lakatosian "research programs," the Laudan's "research traditions," and other conceptions of the advancement of science have insisted on scientific activity related to historicity (for example, Paul Thagard). On this issue and the debate about "scientific revolutions," see GONZALEZ, W. J., "Conceptual Changes and Scientific Diversity: The Role of Historicity," pp. 39-62.

Together with the epistemological values, Rescher emphasizes methodological values, which are values that have to do with scientific processes. Within these values, his attention is focused on economic values, as they are an expression of the "economy of means," because — in his judgment — "rationality and economy are inextricably interconnected. Rational inquiry is a matter of epistemic optimization, of achieving the best overall balance of cognitive benefits relative to cognitive costs."[1401] From this perspective, methodological values such as efficacy or efficiency have priority in his conception, since research requires "profitability" in terms of time and effort.

Regarding methodological values, it can be also seen how Rescher's approach is focused on the structural dimension, where the internal perspective has priority over the external aspect. Thus, even when he is interested in the nexus of science with the context (so there are external values that modulate science with regard to the aims, processes, and results), he does not develop this within a framework of *historicity*. For this reason, he insists on methodological values of economic character such as efficacy and efficiency, which are related to the achievement of other criteria, like simplicity, uniformity, regularity, etc.[1402], instead of paying more attention to the economic values that modulate science as social activity.[1403]

Two are the coordinates that modulate his axiology of scientific research and that are important for scientific prediction: (i) the primacy of the internal dimension, within a structural configuration when he address the *system* of values; and (ii) the priority of the epistemological and methodological aims over the social and operative ones. Within this

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[1401] RESCHER, N., *Cognitive Economy. The Economic Dimension of the Theory of Knowledge*, p. 13.
[1402] Cf. *Cognitive Economy. The Economic Dimension of the Theory of Knowledge*, p. 96.
[1403] The internal dimension and the external perspective with regard to economic values is developed by Wenceslao J. Gonzalez in his paper, already quoted, on "Economic Values in the Configuration of Science."

framework, Rescher addresses the study of the axiological elements of scientific prediction. In this regard, his approach goes in two different (although connected) directions. On the one hand, he addresses the *value of prediction* as such; that is, its importance within scientific activity (basic, applied, or of application); and, on the other, he analyses what *values* are or might be *characteristic of prediction* (accuracy, precision, credibility, etc.).

8.3. Prediction as Value of Science: The Problem of Predictivism

Axiologically, the problem of scientific prediction has two different dimensions. Firstly, scientific prediction can be analyzed *as value of science*; that is, the importance it has within the scientific context. Secondly, there is the problem of the *values* that should go with *scientific prediction* (accuracy, precision, etc.), which are the features that modulate its scientific appraisal. The first problem has to do, above all, with the role of prediction as one of the main goals of scientific activity. Meanwhile, the second issue has direct repercussions on the values that modulate this goal, which makes prediction be worthy.

This double dimension that affects the axiological perspective of scientific prediction — *prediction as value* of science and the *values of predction* — can be seen in Rescher's approach. On the one hand, he defends a conception of (moderately) predictivist character, since he considers that prediction has a high scientific value.[1404] On the other hand, he explicitly addresses the values that go with prediction (accuracy, precision, correctness, robustness, etc.), which he preferably analyzes from a structural perspective, where the internal values have primacy.[1405]

[1404] Cf. RESCHER, N., *Predicting the Future*, passim. On the different versions of predictivism, see HARKER, D., "On the Predilections for Predictions," pp. 429-453; and BARNES, E. C., *The Paradox of Predictivism*, *passim*.

[1405] Cf. GONZALEZ, W. J., *La predicción científica*, pp. 269-270.

The first dimension — prediction as value of science — connects with the problem of predictivism. In this regard, two main issues can be contemplated. Firstly, there is the issue of the scientific value of prediction regarding the set of the goals of science. This involves considering explanation and prediction in basic science and prediction and prescription in applied science. Afterwards, secondly, the value of scientific prediction can be considered with regard to the processes and results. This connects with the prediction-accommodation controversy, which considers which one has more methodological weight: the prediction of novel facts or the accommodation to already known facts.

8.3.1. Prediction as Value with Regard to the Aims of Science

When the value of prediction is considered with regard to the aims of science, Rescher opts for adopt a moderate position. Because he notices that "successful prediction is one of the cardinal aims of science, though not its sole objective."[1406] Thus, he considers that prediction is an important aims of scientific activity *among others*. But, at the same time, he thinks that it is an especially important aim, since "prediction is the very touchstone of science in that affords our best and most effective test for the adequacy of our scientific endeavors."[1407]

Due to the especial importance that Rescher attaches to prediction, his proposal can be classed — in my judgment — among the predictivist tradition. It is the orientation that, initially, philosophers such as F. Bacon, G. W. Leibniz and W. Whewell defend. They are authors that emphasize the value of *prediction* as a prominent aim of science. Afterwards, in the 20th century, philosophers as H. Reichenbach or economists like M. Friedman continue this tradition. Reichenbach and Friedman have in common that they

[1406] RESCHER, N., *Predicting the Future*, p. 159.
[1407] *Predicting the Future*, p. 161.

consider prediction as the highest scientific value, so other aims can be subordinated to the aim of predicting.

Karl Popper, who has been especially influential in conceptions of general philosophy and methodology of science and also in methodological issues regarding economics, has a dual approach to prediction. With regard to the general realm — with predilection for physics as the most valued science — his falsifiability emphasizes the role of prediction and its role for refutation. Thus, he puts the example of Einstein and his critical attitude: the failure of prediction can lead to neglect a scientific theory. Meanwhile, regarding socio-historical prediction, Popper addresses the problem of historicism. Thus, he rejects the scientific character of socio-historical predictions in the long run and with a broad scope, while he finally admits economic predictions that are about certain kind of phenomena.[1408] To sum up, Popper shows a predictivist approach in the general methodological level and criticizes predictivism in the special methodological level.[1409]

Afterwards, within the "historical turn" in philosophy of science, there are also philosophers who highlight the value of prediction. Thus, according to Th. S. Kuhn, "probably the most deeply held values concern predictions: they should be accurate; quantitative predictions are preferable to qualitative ones; whatever the margin of permissible error, it should be consistently satisfied in a given field; and so on."[1410] Predictivism is even clearer in Imre Lakatos, who considered that prediction of novel facts is the key factor to see a research program as progressive.[1411]

[1408] A detailed analysis of his approach to prediction is in GONZALEZ, W. J., "The Many Faces of Popper's Methodological Approach to Prediction," in CATTON, PH. and MACDONALD, G. (eds.), *Karl Popper: Critical Appraisals*, pp. 78-98.

[1409] Cf. POPPER, K. R., *The Poverty of Historicism*, Routledge and K. Paul, London, 1957 (Reprinted by Routledge, 1991).

[1410] KUHN, TH. S., "Postscript—1969," in KUHN, TH. S., *The Structure of Scientific Revolutions*, 2nd ed., p. 185. An study of Kuhn's proposal on scientific prediction is in GONZALEZ, W. J., *La predicción científica*, pp. 127-159.

[1411] Cf. LAKATOS, I., "Falsification and the Methodology of Scientific Research Programmes," in LAKATOS, I. and MUSGRAVE, A. (eds.), *Criticism and the Growth of Knowledge*, Cambridge

On this problem, Rescher's proposal is more in tune with Leibniz's than with the approaches of contemporary authors. In effect, Rescher quotes Leibniz as support[1412] to maintain that "prediction is the very touchstone of science in that it affords our best and most effective test for the adequacy of our scientific endeavor."[1413] Thus, he mainly relates the value of prediction to its role as test of theories. But prediction has other important roles in science. For this reason, besides basic science, the role of prediction in applied science and the application of science should be also considered.

In effect, the value of prediction can be related to the different roles it has: 1) In basic science, prediction can be used as a test for theories, in general, and hypotheses, in particular. 2) In the case of applied science (pharmacology, medicine, applied economics, etc.), prediction habitually is the previous step to prescription.[1414] 3) When the problema of the application of science is considered, prediction has also a role, because it can be the support for decision-making procedures.[1415]

As it is usual in his philosophy of science, when Rescher thinks of *prediction as value* with regard to the aims of science, he considers its role in

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University Press, London, 1970, pp. 91-196. Reprinted in LAKATOS, I., *Mathematics, Science and Epistemology*. *Philosophical papers, vol. 2*, edited by J. WORRALL and G. CURRIE, Cambridge: Cambridge University Press, Cambridge, pp. 128-200. For an analysis of the role of scientific prediction in Lakatos' methodology of scientific research programs, see GONZALEZ, W. J., *La predicción científica*, pp. 161-192. On his influence on the methodology of economics, see GONZALEZ, W. J., *Philosophico-Methodological Analysis of Prediction and its Role in Economics*, pp. 103-124; and GONZALEZ, W. J., "The Evolution of Lakatos's Repercussion on the Methodology of Economics," pp. 1-25.

[1412] "It may even turn out that a certain hyothesis can be accepted as physically certain [*pro physice certa*] if, namely, it completely satisfies all the phenomena which occur, as does the key to a cryptograph. Those hypotheses deserve the highest praise (after the truth), however, by whose aid predictions can be made, even about phenomena or observations which have not been tested before; for a hypothesis of this kind can in practice be accepted as truth," LEIBNIZ, G. W., *Philosophical Papers*, translation by L. E. Loemker, Reidel, Dordrecht, 1969, p. 188. This text is quoted in RESCHER, N., *Predicting the Future*, pp. 160-161.

[1413] RESCHER, N., *Predicting the Future*, p. 161.

[1414] This is especially clear in the case of economics. See SIMON, H. A., "Prediction and Prescription in Systems Modeling," *Operations Research*, v. 38, (1990), pp. 7-14. Compiled in SIMON, H. A., *Models of Bounded Rationality*. Vol. 3: *Empirically Grounded Economic Reason*, pp. 115-128; and GONZALEZ, W. J., "Prediction and Prescription in Economics: A Philosophical and Methodological Approach," pp. 321-345.

[1415] Cf. GONZALEZ, W. J., *La predicción científica*, p. 11.

basic science (above all, in natural sciences). He rarely contemplates the use of prediction in applied sciences as a guide for prescription. Even more, prescription does not appear in an explicit way when he lists the goals of science. Moreover, he barely takes into account, strictly speaking, its role for the application of science, although he is interested in the use of scientific prediction by agents in matters related to everyday life.[1416] In this way, the value of prediction appears related to its use as indicator of scientific progress in basic science, insofar as it is a test to determine the scientific character of theories.

Seen this in comparative terms, Rescher separates from the type of predictivism defended by authors such as Reichenbach or Friedman, who think of prediction as the most important aim of science. Because, in this authors, predictivism is related to methodological instrumentalism with regard to prediction. Thus, they think that predictive success is the most important thing for science, so scientific processes should be oriented towards the aim of successfully predicting the possible future.[1417] Meanwhile, the kind of predictivism defended by Rescher can be characterized as a moderated predictivism, which highlights the importance of prediction but does not subordinate other goals of science to the aim of predicting.

Even more, Rescher criticizes expressly methodological instrumentalism: "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."[1418] In this regard, it seems to me that Rescher's predictivism offers a more adequate alternative than methodological instrumentalism. On

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[1416] See, for example, RESCHER, N., *Sensible Decisions. Issues of Rational Decision in Personal Choice and Public Policy*, *passim*.
[1417] Cf. FRIEDMAN, M., "The Methodology of Positive Economics," pp. 3-43; and REICHENBACH, H., *Experience and Prediction,* passim.
[1418] RESCHER, N., *Predicting the Future*, p. 164.

the one hand, he sees prediction as a value of science, insofar as it is an important aim *among others*; and, on the other, he emphasizes its value with regard to the processes (as an indicator of scientific progress) and regarding the results (due to the knowledge it provides about the possible future).

8.3.2. The Value of Prediction in Processes and Results. The Discussion between Accommodation and Prediction

The value of prediction can be considered with regard to the processes and results of science. It is an issue that connects with the problem of scientific progress. This is because, when it is considered what the measure of the advancement of science is, scientific prediction might have a role. In this regard, the discussion between prediction and accommodation should be emphasized. It is a controversy about the methodological weight of each one of them; that is, what is more important for the evaluation of scientific contents; the prediction of novel facts or the accommodation to already known facts.[1419]

This discussion has had especial repercussions in some sciences, among them economics, where there has been an important predictivist tradition. In this regard, Friedman's proposal — that has continuity among the authors of the Chicago School — has been especially influential. In his judgment, the results of predictions are the most important feature to assess scientific progress.[1420] In this case, results have primacy (predictive success)

[1419] On this methodological controversy, see GONZALEZ, W. J., *La predicción científica*, pp. 283-288. Periodically, the prediction-acommodation controversy raises publications. During the last years, this topic has been an object of attention in ALAI, M., "Novel Predicitons and the No Miracle Argument," *Erkenntnis*, v. 79, n. 2, (2014), pp. 297-326; CARRIER, M., "Prediction in Context: On the Comparative Epistemic Merit of Predictive Success," *Studies in History and Philosophy of Science*, v. 45, (2014), pp. 97-102; HARKER, D., "On the Predilections for Predictions," pp. 429-453; HUDSON, R. G., "What's Really at Issue with Novel Predictions?," *Synthese*, v. 155, (2007), pp. 1-20; and SHMUELI, G., "To Explain or to Predict?," *Statistical Science*, v. 25, n. 3, (2010), pp. 289-310.

[1420] Cf. GONZALEZ, W. J., *Philosophico-Methodological Analysis of Prediction and its Role in Economics*, p. 152.

over the activity (the processes), so economic models should be oriented towards achieving predictive success.

Primacy of results leads him to reject the realism of the assumptions in predictive models. Thus, Friedman maintains that "the only relevant test of the validity of a hypothesis is comparison of its predictions with experience. The hypothesis is rejected if its predictions are contradicted (…); it is accepted if its predictions are not contradicted; great confidence is attached to it if it has survived many opportunities for contradiction."[1421] It is an approach that gives prediction an excessive value, since "neither scientific theories, in general, nor economic theories, in particular, can be reduced to the single goal of making predictions."[1422]

Within Friedman's philosophy and methodology of economics, an especially critical proposal with Friedman's predictivist thesis is the approach of Herbert A. Simon. Instead of results, Simon's interest is in the *processes* of decision-making, so rationality — that he addresses in terms of bounded rationality — also includes a *procedural* component (it is not merely a substantive rationality). This leads him to defend the primacy of *understanding* rather than prediction: "his interest lies in *understanding* the mechanisms that explain past and present economic phenomena rather than in the predictability of economic behavior."[1423] The rejects then that prediction is the main aim of science; and, consequently, it cannot be the only measure of scientific progress.[1424]

Currently, in philosophy and methodology of economics, the prevailing tendency consists to consider prediction as a relevant test for economics as a science, rather than being the preferential or prevailing test for economics.

[1421] FRIEDMAN, M., "The Methodology of Positive Economics," pp. 8-9.
[1422] GONZALEZ, W. J., *Philosophico-Methodological Analysis of Prediction and its Role in Economics*, p. 152.
[1423] *Philosophico-Methodological Analysis of Prediction and its Role in Economics*, p. 205.
[1424] Cf. SIMON, H. A., "The State of Economic Science," in SICHEL (ed.), *The State of Economic Science. Views of Six Nobel Laureates*, W. E. Upjohn Institute for Employment Research, Kalamazoo, 1989, pp. 97-110.

This tendency sees prediction as an important aim, but *among others*. Thus, it is more in tune with Simons' approach — not to focus the attention *only* in predictive success — than with Friedman's radical predictivism.

This means that, with regard to the role of prediction in scientific progress — its methodological value for the advancement of science, "prediction of novel facts appears now more as a sufficient condition, rather than a necessary condition, for scientific progress. Hence, it is still a relevant criterion for science, although the emphasis now is on considering prediction of novel facts as a sufficient condition of scientific evaluation of scientific research programs."[1425]

On this issue, Rescher's main interest is not in economics but in natural sciences. However, there is a criticism of Friedman's methodological instrumentalism, which he addresses in two different directions: first, with regard to the necessity of realism of the assumptions in scientific models, in general, and economic models, in particular;[1426] and, then, with regard to the primacy of the predictive success as a criterion to evaluate scientific progress.[1427] Rescher is against Friedman's radical predictivism, since he defends — in my judgment — a moderated version of predictivism, which is within the framework of his methodological pragmatism.

It seems clear that Rescher highlights the methodological role of prediction as an indicator to assess scientific progress. He considers this problem within a methodological conception that is pragmatic. Within this framework, he considers that the best criteria we have to establish the adequacy of scientific theories are the capability of the methods to obtain successful predictions and to achieve an effective control over phenomena. Thus, he does not think that successful prediction is the *only indicator* to

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[1425] GONZALEZ, W. J., "The Evolution of Lakatos's Repercussion on the Methodology of Economics," p. 16.
[1426] Cf. RESCHER, N., *Predicting the Future,* p. 109.
[1427] Cf. *Predicting the Future*, pp. 194-196.

assess the comparative theoretical adequacy of theories. Instead of this, he thinks that prediction is *the best criterion* we have.[1428]

In his judgment, the especial importance of prediction is rooted in its objectivity: prediction provides an objective criterion to confirm or disconfirm a theory. Moreover, predictive success allows us to compare the adequacy of a concrete theory with regard to other contrary or alternative theories. In that case, prediction appears as a *result*: it is a scientific statement that can be supported by experience. For this reason, besides the attention to the processes, Rescher considers that also results — above all, predictions as future statements — have value for the advancement of knowledge.

Consequently, Rescher takes into account the methodological value of prediction with regard to the aims, processes, and results. In this way, his approach on this problem is broader than the proposal of other authors, insofar as he considers the diverse elements at stake. Moreover, even when his approach is certainly *predictivist*, he clearly rejects a methodological instrumentalism. Thus, he defends a *moderate* conception of predictivism, where prediction appears as sufficient condition for scientific progress.

Concurrently, due to the fact that his approach to science is a *system*, this problem of *prediction as a value* with regard to the aims, processes, and results is closely related to the issue that has to do with the *values of prediction*. In this way, he does not consider that predictive success as such is what matters, but he thinks that prediction has a prominent place within the values of science insofar as prediction itself have a series of values, that Rescher wants to make explicit.[1429] He does this within a axiological approach to prediction that is coherent with his axiology of scientific research, so he considers, above all, the structural dimension, where internal values (above all, epistemological and methodological ones) have priority.

[1428] Cf. RESCHER, N., *Predicting the Future*, p. 164.
[1429] Cf. *Predicting the Future*, pp. 113-131.

8.4. From the Structural Perspective: Values of Scientific Prediction in Rescher's Proposal

In Rescher's phisolophy a view of values of science from the structural dimension prevails. In his judgment, "the cardinal principle of the theory of prediction is that it is not just predictions we want, and note ven just correct predictions, but predictions of high quality in the relation to the entire spectrum of relevant criteria."[1430] For this reason, he considers that it is an especially important issue to clarify what are of should be those criteria. To do this, he develops a structural approach to the values of scientific prediction, where values that have to do with prediction as *content* are highlighted. Because, in his approach, prediction is, above all, a statement about the future that is the result of a rational process. So when he addresses the problem of prediction and its relation with values, he considers prediction as an answer to a question about a future event or phenomenon.[1431]

Rescher presents a very rich framework about the structural dimension, where the relation between scientific prediction and values is addressed in several successive levels. Firstly, predictive *questions* lead to consider what elements of value have the questions we pose about future phenomena or events. Secondly, future *statements* consider what the values of prediction are, as a statement with cognitive content. Thirdly, the *task* made by the predictors or predictive methods pose the question relative to the elements that should be taken into account in the evaluation of predictive procedures or methods.[1432]

[1430] RESCHER, N., *Predicting the Future*, p. 125.

[1431] "To predict is, more or less by definition, to endeavor to provide warranted answers to detailed substantive questions about the world's future developments," RESCHER, N., *Predicting the Future*, pp. 37-38.

[1432] Rescher thinks that prediction's *quality* — if it is scientific or not — depends on the predictive questions and on the kind of processes used in order to predict. This involves that

With regard to the merit of prediction, Rescher suggests that it should be carried through according to two realms of content: (i) by the evaluation of predictive questions; and (ii) through the evaluation of the answers (that is, the statements about the future or predictions).[1433] In turn, when the relation between prediction and values is analyzed, this leads him to give primacy to the *internal dimension* over the external perspective. Certainly, he accepts an external aspect, insofar as he seeks to offer elements for the evaluation of the task made by the predictors.[1434] But, due to the primacy of the structural approach, he does not develop exhaustively this external dimension, which can be clearly seen when the axiology of research is addressed from the dynamic trait.

8.4.1. Criteria for the Evaluation of the Predictive Questions and Values of Prediction as an Answer

Within a pragmatic approach, scientific prediction can be seen as the result of an activity that seeks to achieve justified answers to meaningful questions regarding future events.[1435] From this perspective, the type of predictive question posed has a direct repercussion over the statement of future that can be achieved (generic or specific, conditional or categorical, etc.). Therefore, *the values of predictive questions* should be considered first;

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a non-scientific prediction (for example, to anticipate the choice of an individual on the basis of his tastes and inclinations) can also have values such as reliability, accuracy, precision, etc. Hence, the main difference between scientific and non-scientific prediction is rooted in the *type of processes*: it consists in the use of non-scientific procedures or properly scientific methods (such as predictive models) in order to achieve predictions. Cf. RESCHER, N., *Personal Communication*, 15.7.2014.

[1433] Cf. RESCHER, N., *Predicting the Future*, pp. 113-115.

[1434] It happens that, due to Rescher's insistence in a view of science as *our* science — that is, the result of the interaction between the researcher and the researched object — the analysis of predictors can be seen in his approach as an internal element, instead of being an external factor of prediction. In fact, he thinks that the elements for the evaluation of predictors are the same as the features that we should take into account in order to evaluate the methods of prediction. Cf. RESCHER, N., *Predicting the Future*, pp. 113-118).

On his conception of science as our science, see especially RESCHER, N., "Our Science as *our* Science," en RESCHER, N., *A System of Pragmatic Idealism.* Vol. I: *Human Knowledge in Idealistic Perspective*, pp. 110-125.

[1435] Cf. RESCHER, N., *Predicting the Future*, pp. 37-39.

and, then, *the values of prediction* should be addressed (that is, the values that have or should have the future statement).

Regarding the *predictive questions* — the first realm of content mentioned before, Rescher suggests that they should be evaluated according to what level they have several requirements.[1436] He emphasizes then four features: a) *importance*, which is assessed in terms of how much is lost — either in practical or theorical terms — if we do not have a correct answer to the predictive question; b) *interest*, which depends on personal or collective inclinations regarding the predictive problem; c) *difficulty*, which is linked with the importance of the prediction, because the most important predictions are, generally, the more complex ones[1437]; and d) *resolvability*, which is the possibility of verify or falsify the answer to a predictive question.

To assess the *importance* of the predictive question — the first criterion that Rescher's point out — the context in which the question oriented towards the future is posed must be considered. Thus, importance is not an absolute value, but it has a contextual or relational value. Consequently, the criteria important for their evaluation must be established. These criteria might be different in the realms of basic science, applied science, and the application of science. This is because basic science, applied science, and the application of science are different activities, so prediction can have different roles within each one of them.

When the importance of a predictive question is assessed in the realm of basic science, epistemological values of the possible answer — with regard to the cognitive content it can provide — can be emphasized, as well as its methodological value (to what extent the answer to this question can be a test for the scientific character of a theory). Meanwhile, in applied

[1436] Cf. *Predicting the Future*, pp. 113-118.

[1437] "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 component of importance," RESCHER, N., "The Problem of Future Knowledge," p. 152.

science the main values to assess the importance of a predictive question are practical criteria, which have to do with its importance to make the subsequent prescription. Moreover, in the case of the application of science practical values have, in principle, more weight than the cognitive values, insofar as the answer to a predictive question can be the basis for decision-making.

In contrast to importance (that can be assessed on the basis of objective criteria in different contexts), *interest* (the second criterion) provide a weaker evaluation, because it depends on the inclinations (either personal or collective) towards the problems posed. Even more, to the extent that Rescher defends the objectivity of values, it can be considered that interest is not, strictly speaking, a value of predictive questions, since it depends of subjective or intersubjective factors. Thus, even when he expressly mentions interest as one of the criteria to evaluate predictive questions, it does not seem that it can have the same status as other criteria that do have an objective basis.

Regarding *difficulty* as a factor to evaluate predictive questions — the third criterion in his list — there are several issues at stake. a) Within the framework of values that Rescher's proposes, difficulty is related to importance. This is because he usually relates the importance of a prediction to its informativeness (accuracy, precision, etc.) and maintains that the more informative predictions are generally the most difficult to achieve.[1438] b) Evaluating the difficulty of a predictive question involves — in my judgment — taking into account the economic values, since the more difficult a predictive question is, the more resources we need, in principle, in order to solve it.

With regard to the fourth criterion to value a predictive question — *resolvability*, it is a criterion Rescher associates with "its definitive verifiability

[1438] Cf. RESCHER, N., "The Problem of Future Knowledge," p. 152.

or falsifiability in due course."[1439] In principle, it seems that it is, in effect, a relevant criterion when a predictive question is posed in the realm of basic science, because it is required for the role of prediction as a test of theories. However, it has lesser relevance — in my judgment — in applied science and in the application of science.

Both in applied science and in the application of science it is seek that prediction serves as a guide for a subsequent action. Thus, on the one hand, prediction is the previous step to prescription in applied science; and, on the other, it is the starting point of practical decision-making in the application of science. In this case, the possibility of confirming or falsifying the prediction is not something pressing. Even more, it could happen that, on the basis of the obtained prediction, action is design in order to avoid that the predicted thing happens. Thus, for example, in the case of design sciences, it is usual to use prediction in order to anticipate the possible problems of design, so prescription is oriented to avoid that, in the future, the predicted problem occur.

Rescher also notices values with regard to relevance of the *answers* or *statement about the future* (the second level of content that he contemplates), to the extent that they have or not the different worthy factors.[1440] He points out six criteria: 1) relevance with regard to the predictive answer; 2) correctness, which cannot be guaranteed in the moment when prediction is made,[1441] but that can be estimated according to its credibility; 3) accuracy, which consists in the level the content of prediction reflects specific facts in the future; 4) precision, which has to do with the level

[1439] RESCHER, N., *Predicting the Future*, p. 115.
[1440] Cf. *Predicting the Future*, pp. 119-125.
[1441] "In the end, only the course of experience can inform us about the extent to which the phenomena of a particular domain are predictable," RESCHER, N., "Leaping in the Dark and Other Aspects of Rational Inquiry," in RESCHER, N., *The Pragmatic Vision. Themes in Philosophical Pragmatism*, p. 44.

of detail the prediction reaches;[1442] 5) credibility, which is based in the evidence and the probability that supports the predictive statement; and 6) robustness, which is the cohesion between the prediction and other predictions achieved or methods used within a concrete field.

According to these values suggested by Rescher, it can be considered that his main interest is in the *content* of prediction. This has direct consequences for his proposal about the values of scientific prediction. In the first place, the internal dimension clearly has primacy over the external axiological perspective, to the point that external values (social, political, economic, ecological, etc.) are not explicitly in the framework he proposes about the values of scientific prediction. In the second place, among the internal values, the main values are the cognitive ones (accuracy, precision, correctness, etc.), which are related to scientific prediction as cognitive content (and have incidence on the methodological processes).

In the third place, on the basis of the primacy of internal values and the priority of cognitive values, it can be claimed that Rescher is generally thinking of the evaluation of the statement of future in a context of basic science. Consequently, there can be problems if we try to transfer his proposal to the realm of applied science or to a context of the application of science. This is because, in basic science, prediction is evaluated on the basis of the increase of the available knowledge, so it is important that the cognitive content of the prediction can be tested. In this way, prediction can serve as a test for theories. To do this, values such as accuracy, precision, correctness, or robustness — that are the values that Rescher habitually notices — are especially important.

[1442] Regarding the level of precision of predictions, there is an important problem: the more informative a predictive statement is, the less secure it is. Thus, generally, the more generic predictions are also the more secure ones. Cf. RESCHER, N., "Communicative Pragmatism," pp. 1-48; especially, pp. 19-24.

But, in applied sciences, prediction is usually the previous step to prescription. Its main role is to anticipate problems and contribute to design possible solutions. For this reason, the evaluation of prediction in this realm has a more pragmatic dimension: it is made on the basis of its contribution to the solution of the concrete problem posed. Thus, on the one hand, it is usual to considerate cognitive values in applied scientific activity as less important than in basic science; and, on the other, the presence of external values (social, political, economic, ecological, etc.) is clearer than in basic science.

From this perspective, criteria suggested by Rescher (correctness, accuracy, precision, etc.) are only some values of prediction *among others*. Thus, it seems clear that cognitive values are not the only values in scientific activity, neither they are necessary the most important ones. Even more, the problems that applied science seeks to solve (for example, in applied economics, pharmacology, medicine, etc.) are usually related to the wider human experience, so the external axiological dimension should be taken into account. This is even clearer in the application of science, where prediction serves aims that, in turn, are modulated by the context, which is changeable.

8.4.2. Elements for the Evaluation of Predictors and Predictive Methods

Besides the values that have to do with the predictive questions and predictive answers (that is, predictions as statements of future), there is another level that Rescher considers: the task made by predictors and the methods of prediction. He proposes a variety of criteria for the *evaluation of predictors*. In this regard, he notices that "predictive *methods* can themselves also be looked upon as being predictors and can be evaluated as such by exactly the same standards."[1443] This issue is related to his approach to predictive processes, which he classifies in two large types: (i) *unformalized or judgmental procedures* and (ii) *formalized or discursive methods*.

Unformalized or judgmental processes are based on the personal estimations of experts (for example, the Delphi procedure)[1444], while formalized methods follow a series of rules or inferential principles (as in the case of the current predictive models).[1445] Hence, when Rescher is focused on the axiology of prediction, his proposal is valid both for the estimative procedures — where the evaluation is focused on the agents — and for the formalized methods, where the evaluation is made with regard to scientific procedures, without taking into account the subjects.[1446]

Rescher considers that there are nine worthy factors for the evaluation of predictors and predictive methods. 1) Reliability, which is established with regard to the record of predictive results of the past and that can be estimated either in an absolute way or in a comparative way. 2) Range or versality, which has to do with the extent of the thematic range. 3) Daring, which is the ability to succeed with difficult or complex issues. 4) Perceptiveness, which deals with the detail and definiteness of the achieved predictions.

[1443] RESCHER, N., *Predicting the Future*, p. 130.

[1444] Rescher, together with Olaf Helmer and Norman Dalkey, contributed to the creation of Delphi procedure. It is an estimative procedure of prediction that seeks to achieve one forecast form the individual predictions of a group of experts, avoiding the direct interaction among them. The aim is to achieve an "aggregate prediction" through the consensus of the different predictions. On this predictive procedure, see RESCHER, N., *Predicting the Future*, pp. 91-96).

[1445] Cf. *Predicting the Future*, chapter 6, pp. 85-112; especially, pp. 86-88.

[1446] According to Rescher, the quality of predictions does not depend on their scientific character, because there might be non-scientific predictions more reliable than some scientific predictions. Thus, he considers that the difference between scientific and non-scientific predictions is mainly methodological; that is, it is rooted in the type of processes that are used in order to predict the future. For this reason, in order to evaluate the quality of predictions, the values of predictive questions (importance, interest, …) and the values of the answers or statements about the future (accuracy, precision, …) are especially important. Moreover, the quality of the predictions achieved will depend on the type of reality prediction is about (for example, predictions about natural phenomena are usually more reliable than predictions about the social reality). RESCHER, N., *Personal Communication,* 15.7.2014.

5) Foresight, which is characterized by Rescher as the timespan over which a predictor or predictive method is able to function.[1447] 6) Consistency, which is considered from the perspective of regularity; that is, the capacity to perform at a uniform level of competence over time. 7) Self-criticism, that has to do with the accuracy of the evaluation that the predictor makes about his own task. 8) Knowledgeability, which is the ability to provide nonpredictive information within the thematic realm of the prediction. 9) Coherence, which requires that the predictions achieved by the predictor or the predictive method are compatible among them.[1448]

This proposal by Rescher about the values of prediction, which is focused on the structural dimension — where the epistemological and methodological realms have primacy — has repercussions on his preference for the *internal* values of prediction (mainly, cognitive ones) over the *external* values. However, he defends a position of *holism of values*, which is related to his view of science as a *system*. In this way, the distinction between internal values and external values does not allow us to separate them. He considers that values form a set of interdependent elements within that system.[1449]

Now then, the primacy of the structural dimension, which in the case of Rescher is linked to the priority of the internal values (where above all the cognitive values are emphasized) poses problems when this approach is transferred to the realms of applied science and application of science, which are different form basic science. In this regard, it seems to me that it is important to address the dynamic perspective of the axiology of prediction, which has into account the aims, processes, and results of the three kinds of

[1447] *Sensu stricto*, the notion of "foresight" refers to a scientific prediction which achieves an effective control of the relevant variables. Therefore, it is the most reliable type of prediction, irrespective of its temporal projection (that can be in the short, medium, or long run). Cf. FERNÁNDEZ VALBUENA, S., "Predicción y Economía," pp. 385-405; especially, p. 388.

[1448] Cf. RESCHER, N., *Predicting the Future*, pp. 125-130.

[1449] Cf. GONZALEZ, W. J., "Racionalidad científica y actividad humana. Ciencia y valores en la Filosofía de Nicholas Rescher," p. 22.

activities (basic, applied, and of application), so it highlights the historical dimension of scientific activity.

8.5. Values from the Dynamic Perspective: Prediction in Basic Science, Applied Science, and the Application of Science

As science is a human activity of a teleological character, it has aims, processes, and results. Concerning scientific knowledge about the future, the evaluation of these aims, processes, and results is the main objective of the axiology of prediction from the dynamic perspective. This perspective involves taking into account the differences between basic science and applied science, because those differences have to do with the aims, processes, and results of both kinds of activities.[1450] In addition, the realm of the application of science can be also considered. In this field, prediction can be the basis of decision-making (for example, in the context of policy).

Concurrently, it happens that scientific activity — which articulates aims and processes that can produce some results — is carried through within a context (historical, social, cultural, political, economic, ecological, …), which is changeable. This external dynamics of scientific activity involves that, together with the internal values of scientific activity itself (for example, cognitive values), there are also external values. These values affect science according to its nexus with other human activities (social, political, economic, ecological, etc.). This external component especially affects applied sciences, where prediction is usually the previous step to prescription, and also the application of science, where scientific prediction can be de basis of decision-making.

[1450] 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," p. 158; and GONZALEZ, W. J., "The Roles of Scientific Creativity and Technological Innovation in the Context of Complexity of Science," pp. 17-18.

8.5.1. Evaluation of Aims and Processes in the Three Cases

Certainly, the presence of values in science is clear insofar as they modulate the aims that orientate scientific research and the processes that seek to achieve these aims. But the aims and processes of scientific research can be different in basic science and applied science. The third step — the application of science — has, in turn, its own aims and processes, which are modulated by context.[1451] Thus, the differences between basic research and applied research have repercussions on the configuration of the values in both kinds of sciences, both from an internal viewpoint and from an external perspective. This can be seen regarding the values of science, in general, and the values of scientific prediction, in particular.

From the perspective of the *aims* or *goals* of research, there is basic science when scientific activity seeks to achieve new knowledge or to enlarge the available knowledge. Thus, basic research is mainly oriented towards providing answers to cognitive questions. Meanwhile, there is applied science when knew knowledge is sought with a specific purpose, which can be either solve a concrete problem or solve it in a more efficient way.[1452] In that case, practical factor is usually present when scientific research is applied research. This involves that, in applied science, besides cognitive values there are practical values, which should be taken into account when an applied discipline is evaluated.[1453]

[1451] Cf. GONZALEZ, W. J., “Value Ladenness and the Value-Free Ideal in Scientific Research,” pp. 1503-1521; especially, pp. 1511-1513; 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.

[1452] Cf. NIINILUOTO, I., "The Aim and Structure of Applied Research,” pp. 1-21; especially, pp. 3-5. See also 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, p. 32. 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*, p. 71.

[1453] Cf. NIINILUOTO, I., “Values in Design Sciences,” *Studies in History and Philosophy of Science*, v. 46, (2014), pp. 11-15.

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 enlargement of the available knowledge. So a critical feature is the search for empirical support for the theories and hypotheses suggested. 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)."[1454]

According to these differences with regard the aims and processes, it seems clear that cognitive values have primacy in basic science; while in applied science there is a pragmatic or instrumental feature, which is more emphasized.[1455] This affects the axiology of prediction in two different senses: (i) *prediction as a value* in basic science and applied science; and (ii) *values of prediction* in both types of sciences. With regard to the first sense mentioned (prediction as a value of science), prediction can be considered as a valuable aim in itself.[1456] This can be seen both in basic science and applied sciences.

Undoubtedly, in Rescher's philosophical account, prediction is a *value* of science according to the teleological character of scientific research.[1457] However, the roles of prediction are different in basic science and in applied science. In basic science, aims, processes, and results of the research are oriented towards the enlargement of the available knowledge, so cognitive

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[1454] 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,* p. 338.

[1455] Cf. GONZALEZ, W. J., "Value Ladenness and the Value-Free Ideal in Scientific Research," pp. 1511-1513.

[1456] This claim do not has to do in a direct way with the controversy about the methodological weight of prediction versus accommodation. But it should be acknowledge that Rescher manifests a preference for prediction.

[1457] Cf. RESCHER, N., *Razón y valores en la Era científico-tecnológica*, p. 106.

values related to explanation and prediction have priority.[1458] In this regard, prediction provides knowledge about the possible future that can be used as a test for scientific theories.[1459]

Meanwhile, in applied sciences (pharmacology, medicine, applied economics, information sciences, etc.) the aims, processes, and results of scientific investigation are oriented towards solving specific problems within a concrete domain. Thus, "the natural sciences, the social sciences and the sciences of the artificial require prediction of the possible events and prescription on how to perform."[1460] Consequently, the main values in applied sciences are those related to prediction and prescription, where the practical dimension is important.

Within this framework, in basic science the value of prediction has to do, on the one hand, with the type of knowledge it offers about the possible future; and, on the other, it is related to its use as a test for the scientific character of theories. Meanwhile, prediction is linked to prescription in applied sciences. This feature is because prediction is required in order to prescribe (that is, in order to suggest how to perform when the aim is the resolution of a specific problem). Thus, in the realm of applied science, prediction is the previous step to prescription. For this reason, prediction can be considered as a methodological tool in applied sciences: we need to predict the possible future in order to establish next how to perform.[1461]

[1458] Cf. GONZALEZ, W. J., "Value Ladenness and the Value-Free Ideal in Scientific Research," p. 1513.

[1459] "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. 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. Predictive success thus functioning as the pivotal controlling factor for quality control in scientific theorizing," RESCHER, N., *Predicting the Future*, p. 161.

[1460] GONZALEZ, W. J., "The Roles of Scientific Creativity and Technological Innovation in the Context of Complexity of Science," p. 17.

[1461] 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.

These differences, that have to do with prediction as a value in the context of basic science and in the realm of applied science, have repercussions on the second sense mentioned before regarding the axiology of scientific prediction: the values that predictions have or should have. In basic science, the values of prediction with regard the aims, processes, and results are mainly of an internal character. Since prediction in basic science can be a test for the scientific character of theories, the *values* of prediction have to do above all with the quality of the knowledge about the future (accuracy, precision, etc.). In this way, if the predictive content is confirmed, prediction can provide empirical support for theories.

Meanwhile, in applied science prediction has also an instrumental value, insofar as it can be the basis for problem-solving. Due to this instrumental component, it is usual to consider the cognitive values of prediction (accuracy, precision, etc.) as less important than in basic science. This can be seen in Herber A. Simon's approach to the sciences of the artificial.[1462] For the Nobel Prize winner in economics, prescription do not require predicting the future with accuracy and precision, but the main concern is to shape the future through designs.[1463] In this way, it can be good enough to have a forecast — the least reliable kind of scientific prediction — instead of having a foresight in the strict sense.[1464]

From this perspective, the evaluation of prediction in applied science is carried through on pragmatic basis, which has into account to what extent prediction allows us to anticipate problems and to design possible solutions. However, the more accurate and precise the prediction is, the highest the

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[1462] Cf. SIMON, H. A., *The Sciences of the Artificial*, 3rd ed., passim.

[1463] Cf. 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*, pp. 233-266; especially, p. 248.

[1464] On the different types of predictions (forecast, prediction, foresight, …) see véase FERNÁNDEZ VALBUENA, S., "Predicción y Economía," pp. 385-405; and GONZALEZ, W. J., *La predicción científica. Concepciones filosófico-metodológicas desde H. Reichenbach a N. Rescher*, pp. 261-263.

prescription's probability of success will be (at least in principle). For this reason, it is desirable — in my judgment — that applied sciences are oriented towards the search of predictions more and more reliable and informative (that is, detailed, precise, etc.), so it facilitates the task of selecting among alternative courses of action.[1465]

But, besides the internal values of science (accuracy, precision, coherence, efficacy, efficiency, …), the dynamic trait of the axiology of research involves the attention to the external values (social, political, economic, ecological, esthetic, …). Thus, in addition to the "internal" dynamics of scientific research (aims, processes, and results), there is also a "external" dynamics, which has to do with the relations between science and the socio-historical context.[1466]

Commonly, the presence of external values to science can be clearer seen in the case of applied science than in basic science. The reason for this higher visibility is clear: results of applied science and their possible consequences have frequently more incidence in the society's life. Those external values can modulate the aims of applied research and they can even have a role regarding the processes, which eventually lead to some results.

Among the external values there are the exogenous ethical values (that complement the endogenous ethical values). They are values that affect science as a human activity linked with other human activities (for instance, solidarity, social responsibility, etc.). These exogenous ethical values might have a role in the selection of the aims and processes of the research, above all when it is an applied research (for example, in medicine, demography,

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[1465] Cf. GUILLÁN, A., "Analysis of Creativity in the Sciences of Design," in GONZALEZ, W. J. (ed.), *Creativity, Innovation, and Complexity in Science*, pp. 125-139; especially, pp. 128-129.

[1466] 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*, pp. 7-30.

etc.). However, they are usually more relevant for the evaluation of the results and their possible consequences, to the extent that they can have incidence for the individuals, the society, or the environment.[1467]

The relation between scientific prediction and the external values (among them, the exogenous ethical values) can be also seen — in my judgment — in a context of application of science; because prediction can be the basis for agents' decision-making (for example, in the realm of policy, as can be seen in the decisions about climate change). This involves that the application of science is always contextual; that is, it depends on a socio-historical context. Furthermore, it is more conditioned than the cases of basic science and applied science, due to its practical repercussions, that are more direct than in the realms of the basic or applied knowledge (this feature leads to strongest connections with national or international legislations).

8.5.2. Criteria for the Evaluation of the Results in the Three Realms

The orientation of scientific research towards aims leads to select some processes that, in turn, produce some results. The task of evaluating the results of the research, which is carried through according to values, can follow two different orientations: a) the internal perspective and b) the external viewpoint. The internal perspective addresses to what extent the achieved results correspond to the previously established aims. Meanwhile, form the external viewpoint, the focus is on the relation with the context (social, cultural, political, economic, ecological, etc.), where it is usual that changes occur.

[1467] On Rescher's approach to the ethics of science, see RESCHER, N., *Razón y valores en la Era científico-tecnológica*, passim; and RESCHER, N., "The Ethical Dimension of Scientific Research," in RESCHER, N., *Studies in the Philosophy of Science*, Ontos Verlag, Heusenstamm, 2006, pp. 201-218. On the relation between science and ethical values (endogenous and exogenous), see 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," pp. 139-171.

When the internal orientation is followed in the analysis of the results, criteria for the evaluation of the obtained results are different in basic science and in applied science. Thus, in basic science, results are evaluated on the basis of the enlargement of the available knowledge, without taking into account — in principle — the possible concrete uses for these results.[1468] For this reason, the values that have primacy in basic science are commonly values related to explanation and prediction. Among them, cognitive values such as accuracy, precision, novelty, simplicity, coherence, etc., are highlighted, as well as values related to the problem of truth understood as agreement with reality.

It happens that, in the more specific case of scientific prediction, its use as test for theories is also relevant. In this regard, there might be a hierarchy of values on the basis of the empirical support that prediction provides for theories in basic research (for example, detail is especially important for prediction, since specific predictions are preferable to generic predictions as test for theories). This case of prediction as test has being of great importance in the case of economics.

Meanwhile, in applied sciences there is a more active component. For this reason, the evaluation of results can be made according to cognitive criteria (the adequation of the obtained knowledge in order to solve the concrete problem raised) or it can be made following practical criteria (efficacy and efficiency in the resolution of that problem).[1469] Thus, besides the cognitive values, there are values such as the economic ones, which also have an important role for the evaluation of the results of applied research. So cognitive values (accuracy, precision, etc.) are usually considered as less important than practical values when prediction in applied sciences is

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[1468] 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," pp. 158-159.
[1469] Cf. "Ciencia y valores éticos: De la posibilidad de la Ética de la Ciencia al problema de la valoración ética de la Ciencia Básica," pp. 158-159.

analyzed. From this perspective, the practical value of prediction as a guide for the resolution of concrete problems is emphasized.

In addition, the prescriptive task of applied science — which is usually oriented to suggest how to perform in order to deal with issues that we cannot effectively control — should be considered. Here, it is usual to search for the best possible adaptation to the predicted problems.[1470] Therefore, the evaluation of the results would be positive if they facilitate the adaptation to the context. In this regard, the values of prediction are also relevant, because achieving satisficing results in applied science depends, to a great extent, on the achievement of reliable predictions in order to anticipate the problems and consider the feasibility of the possible solutions.

Besides the internal orientation — which values involved the achieved results considering if they adjust or not to the previously established aims — results can be also evaluated following an external viewpoint. From the external viewpoint, the focus is on the relation with the context (social, cultural, political, economic, ecological, etc.). Those relations with the context are clearer in applied science, which has more incidence on the whole human experience. Furthermore, applied science serves as a guide for social action (for example, in economics, so external or contextual values have more weight than in basic science).[1471]

The relevance of external values in applied science is especially clear in the case of ethical values, above all when the attention goes to the practical consequences of the research and their possible repercussions on society, instead of highlighting the epistemic content.[1472] There is a relation between exogenous ethical values and scientific prediction, which appears insofar as

[1470] Cf. SIMON, H. A., "Prediction and Prescription in Systems Modeling," *Operations Research*, v. 38, (1990), pp. 7-14. Compiled in SIMON, H. A., *Models of Bounded Rationality*. Vol. 3: *Empirically Grounded Economic Reason*, p. 122.
[1471] Cf. GONZALEZ, W. J., "Value Ladenness and the Value-Free Ideal in Scientific Research," p. 1513.
[1472] Cf. "Value Ladenness and the Value-Free Ideal in Scientific Research," p. 1513.

the predictions achieved in applied science can be the basis for problem-solving. Those problems might have incidence on the individuals, the society, or the context (for example, in the case of pharmacology or ecology).

Concurrently, the dimension of analysis that deals with the research's results opens another perspective. This perspective has to do with the use that agents make of those results in practical contexts of decision-making (political, economic, ecologic, etc.). This leads to the distinction between applied science and application of science. In this regard, according to Niiniluoto, "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)."[1473]

Frequently, the applications of science are made by agents in institutions (for example, in hospitals, economic organizations, etc.). Due to this application in variable contexts, the results of scientific research can be used in the wider socio-historical context. In this regard, values are especially important when matters such as risk management appear.[1474] From this perspective of the application of science, prediction has to do with the decision-making in professional contexts (as it commonly happens, for example, in medicine or in policy issues in cases such as a hurricane, an earthquake, or a tsunami).[1475]

Due to the importance of the context for the applications of science, the external dimension of the axiology is crucial. Thus, the applications of sciences in realms such as economics, medicine, pharmacology, etc., have to do with matters of public interest, insofar as they can affect the individuals, the society, or the environment (either in a positive or in a negative way).

[1473] NIINILUOTO, I., "The Aim and Structure of Applied Research," p. 9.
[1474] Cf. GONZALEZ, W. J., "Value Ladenness and the Value-Free Ideal in Scientific Research," p. 1516.
[1475] For Rescher, a main issue regarding prediction is the fact that our ideas about what will happen in the future have a clear influence on our present decisions. Cf. RESCHER, N., *Predicting the Future*, p. 64.

Ethical values have here a highlighted role, above all, those values related to social responsibility. Moreover, "insofar as the consequences are more manifest for citizens and society as a whole, the legislation (regional, national or international) can show up."[1476]

To sum up, the elements offered by Rescher for the axiology of prediction are coherent with his axiology of scientific research, which is within the coordinates of a pragmatic Kantism. Thus, the structural dimension has primacy, due to his view of values as a system.[1477] From this perspective, above all the internal values to scientific activity are emphasized. If this approach is transferred to the axiological study of scientific prediction, epistemological and methodological values of prediction have a manifest primacy over other kind of values. Thus, he thinks of the relation between prediction and values in three successive levels: predictive questions, answers or statements about the future, and the task made by the predictors or the methods of prediction.[1478]

In my judgment, Rescher's proposal can be complemented with the attention to the dynamic trait in the relation between science and values. Through the dynamic component — that addresses the aims, processes, and results of the research ("internal" dynamics) and the relations with the environment ("external dynamics) — it seems clear that, besides the internal values, external values have also importance. They are important insofar as science is a human activity linked with other human activities, so there are

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[1476] GONZALEZ, W. J., "Value Ladenness and the Value-Free Ideal in Scientific Research," p. 1508.
[1477] 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; 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; and RESCHER, N., *Razón y valores en la Era científico-tecnológica*, passim.
[1478] Cf. RESCHER, N., *Predicting the Future*, cap. 7, pp. 113-131.

values that have to do with the relations between scientific activity and the context (social, political, economic, ecological, etc.).[1479]

Although Rescher gives primacy to the estructural dimension of science, his approach is not reduced to something sectorial, because his starting point is the acknowledgement of a holism of values. In this way, he proposes *de facto* “a broad axiology of research according to his conviction that sciences are related to values from diverse angles (cognitive, social, etc.). These values in science are related to other human values and rooted in human needs.”[1480] Within this framework, the distinctions regarding the different realms or types of values (“structural” versus “dynamic,” “internal” as different from “external”) do not properly admit a *separation*, but they are interconnected in the system of values mentioned before.

To conclude, Rescher’s axiology of scientific research — which follows preferentially a structural perspective — can be compatible with a dynamic approach. However, he does not develop in an articulate way this dynamic trait regarding the relation between prediction and values, which emphasizes the *historicity* of scientific activity. Consequently, his approach do not especially notices the external values that go with science, in general, and with scientific prediction, in particular. For this reason, although his approach is broader than other axiological proposals, it lacks — in my judgment — the due attention to the dynamic trait (internal and external).[1481] Within the dynamic trait, prediction and the connected values have a key role for the evaluation of the aims, processes, and results of scientific prediction.

[1479] 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,” pp. 139-161; and GONZALEZ, W. J., “Value Ladenness and the Value-Free Ideal in Scientific Research,” pp. 1503-1521.

[1480] GONZALEZ, W. J., “Value Ladenness and the Value-Free Ideal in Scientific Research,” p. 1512.

[1481] On W. J. Gonzalez’s analysis of this issue, mainly in “Value Ladenness and the Value-Free Ideal in Scientific Research,” there are elements for the comparison of Rescher’s approach to the axiology of scientific research with other proposals, such as Larry Laudan’s conception.

Moreover, this can be seen in three cases: in basic science, in applied science, and in the application of science.

CHAPTER 9

ANALYSIS OF PREDICTION FROM ETHICS OF SCIENTIFIC RESEARCH

Over the last decades, the axiological perspective in the analysis of science has emphasized how science, in general, and scientific prediction, in particular, are modulated by values. In effect, a turn has occurred in the contemporary philosophy and methodology of science, from a dominant view of science as value-free (*Wertfrei*) to the opposite conception, according to which science is value-laden.[1482] These values can be either *internal* values to scientific activity (cognitive, methodological, etc.) or *external* values, which are those that modulated science as an activity related to other human activities (social, cultural, political, economic, etc.).

This change of perspective has motivated the development of the ethics of science, which studies the more specific realm of ethical values (honesty, credibility, social responsibility, etc.) that are present in scientific activity.[1483] Thus, science is susceptible of ethical evaluations "insofar as science is a free human activity, whose values are related to the processes of research (honesty, originality, etc.) or to its nexus with other activities of human life (social, cultural, political, etc.)."[1484] From this perspective, ethics of science can follow two different angles of analysis: the endogenous view and the exogenous perspective.

From the endogenous point of view, ethics of science deals with the ethical values that have to do with *scientific activity* by itself, so they are values that can be found in the aims, processes, and results of the scientific activity. Meanwhile, the exogenous perspective of analysis involves paying

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[1482] Cf. GONZALEZ, W. J., "Value Ladenness and the Value-Free Ideal in Scientific Research," pp. 1503-1521; especially, pp. 1504-1506.

[1483] These values are analyzed in RESNIK, D. B., *The Ethics of Science. An Introduction*, Routledge, London, 1998, pp. 53-73.

[1484] GONZALEZ, W. J., *Philosophico-Methodological Analysis of Prediction and its Role in Economics*, p. 12.

attention to *science as an activity* that is related to others, which means emphasizing that there are ethical values that have to do with the context (social, cultural, political, economic, ecological, etc.) where the activity is carried through.[1485]

Therefore, the ethics of science — endogenous and exogenous — considers the activity carried through by free human agents within a socio-historical context. From this perspective, the analysis of the ethical factors that affects scientific prediction must separate two different aspects of prediction: (i) the cognitive content, which is oriented towards the future (real or possible); and (ii) the human activity that leads to obtain or to use this knowledge about the future.

In effect, on the one hand, it does not seem that the cognitive content as such can be susceptible of an ethical valuation (that is, scientific knowledge is not something morally adequate or inadequate).[1486] But, on the other hand, this cognitive content is the result of a human *activity* oriented towards achieving knowledge about the possible future, and there are aims, processes and results, as well as relations with context (social, cultural, political, etc.). Consequently, prediction is linked with the ethics of science "through the presence of prediction in the *research activity*, mainly when the ethical limits of science are discussed."[1487]

Within this framework of the ethics of science, where there are a double dimension of analysis — endogenous and exogenous — this chapter seeks to clarify the ethical factors that modulate prediction in the context of *scientific activity* and *science as activity*. Rescher does not develop this aspect of the philosophical analysis of prediction when he suggests his theory of

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[1485] Cf. GONZALEZ, W. J., *Philosophico-Methodological Analysis of Prediction and its Role in Economics*, p. 19.

[1486] Cf. RESCHER, N., *Razón y valores en la Era científico-tecnológica*, pp. 159-162.

[1487] GONZALEZ, W. J., *Philosophico-Methodological Analysis of Prediction and its Role in Economics*, p. 20.

prediction.[1488] However, his philosophy of sciences pays much attention to the ethics of scientific research.[1489] Thus, the starting point of this study is his proposal about the ethical features of scientific research.

In this regard, several steps are followed. Firstly, the attention goes to pragmatic idealism as a framework for ethics, in general, and ethics of science, in particular. Secondly, the analysis seeks to go more deeply in the double dimension of analysis regarding the relation between science and ethical values: the endogenous component and the exogenous perspective. This involves paying attention to three realms: basic science, applied science, and the application of science, which are different due both to endogenous considerations (the aims, processes, and results) and to exogenous factors (the relations with the context).

Thirdly, the problem of the ethical limits of scientific research is considered, as well as its incidence on prediction both from the endogenous dimension and form the exogenous perspective. Finally, the dynamic perspective of the relation between ethical values and scientific prediction is considered. It is an angle of analysis that is difficult to introduce in Rescher's framework, where the structural dimension has primacy, so he does not grasp the features related to the historicity of the human activity carried through in a social context. This activity involves paying attention to the "internal" dynamics (the aims, processes, and results)[1490] and the "external" dynamics (the relations with the context).[1491] Both the internal and external

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[1488] Cf. RESCHER, N., *Predicting the Future*, *passim*.
[1489] This feature can be seen in the large number of publications that Rescher has devoted to the study of the ethics of science. Among then, some can be highlighted here: RESCHER, N., *Razón y valores en la Era científico-tecnológica*, passim; RESCHER, N., *Public Concerns. Philosophical Studies of Social Issues*, Rowman and Littlefield, Lanham, MD, 1996; and RESCHER, N., *Sensible Decisions. Issues of Rational Decision in Personal Choice and Public Policy*, Rowman and Littlefield, Lanham, MD, 2003.
[1490] Cf. GONZALEZ, W. J., "Value Ladenness and the Value-Free Ideal in Scientific Research," pp. 1503-1521.
[1491] 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*

dynamics of science have incidence on the ethical values that accompany prediction in three different cases: basic science, applied science, and the application of science.

9.1. Pragmatic Idealism as the Framework of the Ethics of Science

The ethics of science proposed by Rescher falls within the framework of his philosophical system, which he characterizes as "pragmatic idealism," but which is in fact open to elements of other philosophical orientations, also in the case of ethics.[1492] On the one hand, the Kantian influence is present insofar as he wants to based moral in mind and seeks universal ethical principles and values. And, on the other hand, he thinks that science is modulated and conditioned by ethical values, insofar as it is a free human activity, which is oriented towards ends.

Through the combination of these two background lines — one general and other more oriented towards scientific practice — Rescher shows Kantian and pragmatic elements in his thought about the ethics of scientific research. Thus, he proposes an ethics of science which has two main features: 1) it is an ethics of a normative character, so it is about what *ought to be*, according to values and principles that are universally valid; and 2) it is a teleological ethics, where the ethical adequacy of human actions — actual or potential — always considers their validity with regard to the sought aims.

9.1.1. The Grounding of Moral in Mind: The Cognitive Basis as a Support of the Ethical Dimension of Our Science

When Rescher addresses the ethics, in general, and the ethics of science, in particular, he commonly uses indistinctly the terms "ethics" and

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Ciencias de la Complejidad: Vertiente dinámica de las Ciencias de Diseño y sobriedad de factores, pp. 7-30; especially, pp. 8-9.

[1492] This feature of Rescher's approach does not involve that he is an eclectic philosopher, but rather that he has his own system of thought.

"moral," so he does not make an explicit differentiation between both notions. This distinction can be found in Evandro Agazzi's work. In his judgment, "moral" consists of the set of norms and principles that regulate human behavior; while "ethics" has to do with rational justification of moral, so one of its tasks is lay the foundations of the norms and moral principles.[1493] According to this characterization, it can be seen that ethics, in general, and ethics of science, in particular, are a part of philosophy.

In this chapter, the term "ethics" is used in the sense suggested by Agazzi; that is, as a philosophical discipline that makes a critical analysis of the moral norms and principles. In this case, it seems clear that ethics cannot be reduced to a simple description of those norms and principles (even if the description is very detailed). On the contrary, it includes a prescriptive or normative dimension, so it is always open to the realm of the "ought to be." In this regard, there is in Rescher a distinction between "mores" and "moral." He suggests this distinction in order to emphasizes the normative character of ethics.[1494]

On the one hand, "mores" have to do with the costumes and convections that — either implicitly or explicitly — are accepted by a community. Meanwhile, "moral" or "morality" has a universal support, because — in Rescher's judgment — it is founded in needs that human beings have in common. He highlights, therefore, the pragmatic dimension, which sees the human activity oriented towards ends. Thus, he thinks that "morality is a functional enterprise whose aim is to channel people's actions toward realizing the best interests of everyone. This makes morality into something quite different from mere mores geared toward communal

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[1493] Cf. AGAZZI, E., *Il bene, il male e la scienza. Le dimensioni etiche dell'impresa scientifico-tecnologica*, Rusconi, Milan, 1992. Vers. cast. de Ramón Queraltó: *El bien, el mal y la Ciencia. Las dimensiones éticas de la empresa científico-tecnológica*, Tecnos, Madrid, 1996, pp. 332-336. See 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," p. 145.
[1494] Cf. RESCHER, N., "Moral Objectivity," *Social Philosophy and Policy Foundation*, v. 25, n. 1., (2008), pp. 393-409; especially, pp. 397-400.

uniformity and predictability. (After all, morality is not a matter of anthropology; it addresses what people *should* do rather than what they *actually* do.)"[1495]

Therefore, the characterization of moral suggested by Rescher configures ethics of science on the basis of two main characteristics: a) it is normative, so it deals with the *ought to be*, instead of being about what those things that, in fact, are;[1496] and b) it is teleological, because the "functional" character of morality is understood by Rescher as it is a human endeavor oriented towards ends.[1497] On the one hand, the normative character of ethics involves that the grounding of morality cannot be about costumes or conventions (*mores*), which are intrinsically variable; and, on the other hand, the configuration of ethics as teleological involves expressly addressing the ends of the human activity, instead of considering just the means.[1498]

On this philosophical basis, the grounding of moral that Rescher suggests combines Kantism with pragmatism, which are the mainstays that support his philosophy, in general, and his philosophy of science, in particular. Kantism can be seen, above all, when he links the conception of "morality" with *human rationality*.[1499] This leads to an ethical intellectualism, because he thinks that there are cognitive roots as a support for ethics, in general, and the ethics of science, in particular.[1500]

[1495] RESCHER, N., "Moral Objectivity," p. 393. "Anthropology" here might refer to social anthropology, so the goal of ethics is not merely the description of social uses and traditions.

[1496] See, for example, RESCHER, N., "Moral Objectivity: The Rationality and Universality of Moral Principles," in RESCHER, N., *Objectivity. The Obligations of Impersonal Reason*, pp. 151-171.

[1497] Cf. RESCHER, N., "Against Moral Relativism," in RESCHER, N., *Objectivity. The Obligations of Impersonal Reason*, pp. 124-150; especially, pp. 127-130.

[1498] See RESCHER, N., *Moral Absolutes. An Essay on the Nature and Rationale of Morality*, Peter Lang, N. York, 1989.

[1499] Cf. RESCHER, N., "Moral Objectivity: The Rationality and Universality of Moral Principles," in RESCHER, N., *Objectivity. The Obligations of Impersonal Reason*, pp. 151-171; especially, pp. 160-163.

[1500] 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*, p. 13.

Rescher expressly maintains this ethical intellectualism: he claims that "the problem of the *rational grounding* of morality has deep cognitive ramifications. Here knowledge, mind, and even science intervene."[1501] In this regard, he thinks that H. A. Prichard was right when he noticed that, one we know what is morally adequate (the "correct" thing), we do not need another subsequent reason about why we should do that.[1502]

But, even when he considers that this line of thought is correct, Rescher seeks other line of argumentation, one not completely internal to morality itself. Then he proposes an *ontological* support of morality, which is rooted in the characterization of human beings as *rational* agents. He does this from a perspective that takes into account the individual agents, instead of being oriented towards social agents. There is then a philosophical anthropology with a metaphysical background, which has links with the improvement of the agent as a human being.[1503]

In effect, Rescher points out that "the mandatory character of morality is ultimately rooted in an *ontological* imperative of making values with regard to the self and the world, and imperative to which free agents as such are subjected. From this ontological perspective, the ultimate basis of the moral duty is rooted in the obligation we have as rational agents (towards ourselves

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1501 RESCHER, N., *Razón y valores en la Era científico-tecnológica*, p. 61.
1502 PRICHARD, H. A., "Does Moral Philosophy Rest on a Mistake?," *Mind*, vol. 21, (1912), pp. 21-37. Cf. RESCHER, N., *Razón y valores en la Era científico-tecnológica*, p. 62.
1503 Regarding this issue, the pragmatic aspect of his thought prevails, insofar as it goes from the actions to the subjects of those actions. He thinks of the person as who unifies the processes, which are developed in the "personhood," which makes the features of that entity possible. In effect, he maintains that "once we conceptualize the core 'self' of a person as a unified manifold of actual and potential process—of action, and of capacities and dispositions to action (both physical and psychic)—then we have a concept of personhood that renders the self or ego experientially accessible. (After all, experiencing itself simply consists of such processes.)," RESCHER, N., "Philosophy in Process," in RESCHER, N., *A System of Pragmatic Idealism.* Vol. III: *Metaphilosophical Inquires,* p. 178.

On the concept of "personhood" in Rescher, see MOUTAFAKIS, N. J., *Rescher on Rationality, Values, and Social Responsibility. A Philosophical Portrait*; especially, chap. 2, pp. 63-83; and chap. 6, pp. 139-160. An analysis of the concept of "person" is in GONZALEZ, W. J., "La primitividad lógica del concepto de persona," *Anales de Filosofía*, v. 1, (1983), pp. 79-118.

and towards the world in general) of making the most of our opportunities of self-development."[1504] This leads to the promotion of agents from values.

Rescher links this ontological grounding of morality, which takes into account human agents as rational agents, to an ethical approach of teleological character. He suggests this from a pragmatic perspective, according to which "morality as such consists in the pursuit, through variable and context-relative means, of invariant and objectively implementable ends that are rooted in a commitment to the best interests of people in general."[1505] It happens that, in his approach, the adequate ends are those that contribute to universal human needs, so they are oriented towards achieving the best interests of people. In this way, he considers that there are ethical principles and values that are universal, such as dignity, respect, freedom, or safety.[1506]

This acknowledgement of the universal character of certain ethical values involves the acceptation of certain elements of realism with regard to values.[1507] Thus, once again, his system of pragmatic idealism is open to realism. This feature can be seen insofar as he accepts the notion of "moral fact," which is about what is morally adequate or correct in an objective way. In that case, there is an objective support to morality, which leads Rescher to reject any form of relativism regarding ethics and to accept a "moral realism."[1508]

[1504] RESCHER, N., *Razón y valores en la Era científico-tecnológica*, pp. 65-66.
[1505] RESCHER, N., "Moral Objectivity," p. 408.
[1506] The Kantian influence is highlighted here. As Rescher admits, "this aspect of the present account is thoroughly Kantian. The governing idea of Kant's moral theory is that of *universality*; that when an action is wrong or right it is so always and for everyone," RESCHER, N., "Moral Objectivity: The Rationality and Universality of Moral Principles," p. 167.
[1507] Cf. RESCHER, N., "Moral Objectivity (Are There Moral Facts?)," in RESCHER, N., A System of Pragmatic Idealism. Vol. II: *The Validity of Values: Human Values in Pragmatic Perspective*, pp. 173-186.
[1508] Cf. RESCHER, N., "Moral Objectivity," pp. 393-396. See, in this regard, RESCHER, N., "Moral Values as Immune to Relativism," in RESCHER, N., *A System of Pragmatic Idealism.* Vol. II: *The Validity of Values: Human Values in Pragmatic Perspective*, pp. 187-205.

But Rescher does not think that "moral facts" are *properties*, either non-natural or supervenient. Instead of that, he considers that moral acts have a relational character. In his judgment, "the moral status of an act is not the sort of thing that is a property or quality at all, but a relational feature whose determination involves a wide variety of contextual issues: agents, circumstances, motives, alternatives, and the like."[1509] Again, this feature links his conception of "morality" with *human rationality*.[1510] Thus, in his approach, rationality — which is not independent from the context — involves an evaluative dimension, so it should be oriented towards adequate ends, and the adequacy of the ends should be also considered from an ethical viewpoint.[1511]

Thus, Rescher considers that the direction of human action towards morally adequate ends according to ethical values is a *rational* task. But it happens that the ability of human agents to exert rationality is *limited* and is conditional on factors that depend on the context.[1512] In this way, his approach acknowledges that, even when "morality" has a support of a universal character, there is variability according to socio-cultural factors. For this reason, "the universal of morality not only permit but *require* adjustment to local conditions, and at the local level we are concerned not with the validation of morality as such, but with the justification of a particular moral code for a particular group in particular circumstances."[1513]

Therefore, the universal character of moral principles and values should be combined with the variability — due to socio-historical factors — of the concrete moral codes. To do this, Rescher suggests a "hierarchy of morality."

[1509] Cf. RESCHER, N., "Moral Objectivity," p. 396.
[1510] Cf. RESCHER, N., "Moral Rationality: Why Be Moral?," in RESCHER, N., *A System of Pragmatic Idealism.* Vol. II: *The Validity of Values: Human Values in Pragmatic Perspective*, pp. 206-232.
[1511] Cf. RESCHER, N., *Rationality. A Philosophical Inquiry into the Nature and the Rationale of Reason*, pp. 92-106.
[1512] Cf. RESCHER, N., *Rationality. A Philosophical Inquiry into the Nature and the Rationale of Reason*, pp. 115-118.
[1513] RESCHER, N., "Moral Objectivity," pp. 406-407.

Within this hierarchy, he distinguishes five levels.[1514] 1) *Defining aims of morality*, which are the aims that identifies morality as such. In his judgment, they consist of supporting the best interest of people and avoiding cause them harm. 2) *Fundamental principles or controlling values*, which are the moral virtues (such as fairness, generosity, probity, honesty, etc.).

3) *Governing rules*, which are the rules that guide human deliberations and decisions according to moral principles (for instance, do not kill, do not lie, or do not steal). 4) *Operating directives*, which give us standards and criteria according to the context, so they specify concrete situations that have to do with level 3 (like, for example, 'killing in self-defense is justifiable'). 5) *Concrete rulings*, which are individual resolutions with respect to specific issues in specific cases (for example, 'it is justifiable that X has killed Y in self-defense').

According to this "hierarchy of morality," there are some moral principles that are invariable, because they are grounding in universal features related to *human activity* and they have a rational support. The activity demands the best interest of the agents, who should orient their actions to the achievement of ethically adequate ends. Thus, he thinks that the aims characteristic of morality are in the highest level of the moral principles. In this way, the other levels are justified on the basis of their relation with these principles. However, levels 4) and 5) introduce in the ethics a factor of variability. Because, in his approach, the operating directives and the concrete rules take into account the context (cultural, social, political, etc.), which is changeable.[1515]

When this approach is transferred to the area of *scientific activity*, there are clear repercussions for the ethics of science. Because, for Rescher, there

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[1514] Cf. "Moral Objectivity," p. 403.
[1515] Cf. RESCHER, N., "Moral Objectivity," pp. 404-405.

are ethical values in science insofar as it is *our* science.[1516] Science is our science due to two reasons: in the first place, it is the result of an activity carried through by human agents; and, in the second place, science corresponds with our *conceptual* framework, which is different from the conceptual framework that other agents may have. Thus, when he characterizes science as *our* science, the two mainstays of his system of thought are present: pragmatism and Kantism.

On the one hand, he considers that there are ethical values in science as *human activity* oriented to ends. For Rescher, values, in general, and ethical values, in particular, are mainly placed in the ends of the *scientific activity*. In his judgment, "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."[1517] The goals of scientific activity connect with the evaluative dimension of (human and scientific) rationality, which deals with the ends that should be preferred or values.[1518] Consequently, the ends of scientific activity prevail over the means and over the finally achieved results (and their possible consequences). These features lead Rescher to distance from ethical utilitarianism, in general, and ethical consequentialism, in particular.[1519]

And, on the other hand, Rescher usually focuses his attention on basic science, so he commonly thinks of the kind of scientific activity that seeks to enlarge or improve *knowledge*, instead of being more concerned about applied science or the application of science. For this reason, in his approach, ethical values in science refer to the cognitive dimension. Thus, he

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[1516] 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.
[1517] RESCHER, N., *Razón y valores en la Era científico-tecnológica*, p. 95.
[1518] Cf. RESCHER, N., *Rationality. A Philosophical Inquiry into the Nature and the Rationale of Reason*, pp. 92-106.
[1519] On ethical consequentialism there is an influential paper by Elisabeth Anscombe. Cf. ANSCOMBE, G. E. M., "Modern Moral Philosophy," *Philosophy*, v. 33, (1958), pp. 1-19, reprinted in WALLACE, G. and WALKER, A. D. M. (eds.), *The Definition of Morality*, Methuen, London, 1970, pp. 211-234.

notices that "although the search for knowledge is not our only adequate task, it is however an activity whose normative level is high, because knowledge serves to facilitate the fulfillment of any other legitimate good: each and every one of these goods are cultivated in most effective way by someone who pursuits their fulfillment by means of knowledge."[1520]

From this perspective, science — as expression of knowledge — connects with the first level of the "hierarchy of morality" proposed by Rescher.[1521] Scientific knowledge can contribute to the achievement of the *defining aims of morality* (to contribute to the best interests of people and to avoid harms to others). To do that, scientific activity should be modulated by ethical values, which are in the second level of the hierarchy. They are values such as honesty, respect, safety, heath, etc. These ethical values (endogenous and exogenous) should be present in the three successive steps of the scientific research: the aims of the research, the means oriented to achieve those aims, and the results achieved (with the due attention to the consequences that those results might have).

On the basis of the ends that, for Rescher, are characteristic of morality — the level 1 — and the presence of ethical values that modulate the aims, means, and results of the research — the level 2 —, a series of governing rules should be established (the level 3). These rules seek to orientate human activity towards morally adequate aims, according to ethical values which are universally valid. In this regard, there are ethical rules that regulate scientific activity (such as, for example, 'do not plagiarize' or 'do not perform nonconsensual experiments on human beings'). The presence and the acceptation of this kind of rules can be seen in the deontological codes of some scientific professions (for example, in medicine).

[1520] RESCHER, N., *Razón y valores en la Era científico-tecnológica*, p. 105.
[1521] Cf. RESCHER, N., "Moral Objectivity," p. 403.

Finally, there are other two levels: 4 and 5. They are about operating directives and concrete rulings, respectively. Within these two levels there might be variability in the ethics of science, due to concrete situations and contexts. This variability can appear due to *internal* factors to science. Thus, it is possible to think that the operating directives and the concrete rulings about what is ethically adequate can vary according to different contexts; those of basic science, applied science, and the application of science. They are different activity, so their aims, processes, and results also have specific characteristics. Concurrently, there can be variations according to external determining factors that are due to the different socio-historical contexts. Thus, the ethics of science must take into account the context (social, cultural, economic, political, etc.) where scientific activity is developed.

This framework about the "hierarchy of morality," where there are different levels, has — in my judgment — two main consequences for the ethics of science. In the first place, Rescher's approach involves that the ethical issues are not something "added" to science. This means that ethical values and problems do not affect science "from outside," since the scientific human activity is itself value-laden. In the second place, it involves that the ethics of science cannot be addressed as something isolated, since it is connected with the whole human experience. Thus, there are ethical values in science as such (endogenous values) and there are ethical values that modulate science as it is an activity connected with others (exogenous values).[1522]

In effect, Rescher thinks that scientific knowledge is an important good, but it is a good *among others*.[1523] Thus, on the one hand, even when Rescher gives priority to the aims of scientific activity, the means and the

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[1522] On the theoretical framework of the ethics of science, see 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," pp. 147-151

[1523] Cf. RESCHER, N., *Razón y valores en la Era científico-tecnológica*, pp. 162-165.

results of the research (basic or applied) are also subjected to ethical evaluation, insofar as they can interfere or obstruct the cultivation of other legitimate goods.[1524] And, on the other hand, besides the attention to the values which modulates *scientific activity*, the ethical issues which affects *science as activity* should be also considered, insofar as science is an activity connected with the whole human experience (social, cultural, political, economic, ecological, etc.). These considerations provide a broad framework for the ethics of science, where there are two dimensions of analysis: a) the endogenous ethics (which takes into account the scientific activity) and b) the exogenous ethics (which analyses science as activity).

9.1.2. Science and Ethical Values in Rescher's Approach

Rescher considers that there is an ethical dimension of scientific research insofar as science is a *human creation and activity*.[1525] As human activity, he sees science as *our science*. Thus, on the one hand, it is a human endeavor with its own characteristics; and, on the other, is an activity connected with others. In this regard, in his philosophy of science, in general, and his ethics of science, in particular, there is a clear preference for emphasizing the internal factors; those which characterizes the very scientific activity as such.

Usually, Rescher sees the relation between science and ethical values within the framework of *scientific research*. It has three successive steps — with ethical relevance — within its internal dynamics: (i) the choice regarding the possible research goals, which configure the objectives sought, (ii) the selection of the means in order to achieve those goals, which configure the

[1524] Cf. RESCHER, N., *The Limits of Science*, revised edition, p. 243.
[1525] Cf. RESCHER, N., "The Ethical Dimension of Scientific Research," in RESCHER, N., *Studies in the Philosophy of Science*, p. 218.

processes chosen, and (iii) the results achieved, which are important within this framework of teleological activity.[1526]

But, besides the internal factors, the external factors to science should be acknowledged and taken into account. Thus, scientific research is developed within an institutional framework (public or private) and in a socio-historical context, which is changeable. From this perspective, there are ethical values that modulate science as it is an activity connected with other activities (social, cultural, political, economic, ecological, etc.). Rescher gives priority to the internal factors to scientific activity and he gives less weight to the external factors.

In his approach, he rules out that science can be neutral with regard to values and, therefore, he rejects the possibility that science can be isolated from ethical evaluations. In effect, science is a human activity carried through by *human agents*, so "the scientist does not, and cannot, put aside his common humanity and his evaluative capabilities when he puts on his laboratory coat."[1527] From this perspective, Rescher's ethics of science is primarily centered on the *person*; and from the person the social and institutional levels are finally reached.

But, even when Rescher is above all interested in persons, he acknowledges that the attention to the individual level of the agents is not good enough. There is a social dimension that is ethically important, and it leads to take into account the institutional modulation. So "phenomena of the collectivization and increasing social diffusion of modern science are the main forces that have resulted in making a good deal of room for ethical consideration within the operational framework of modern science."[1528]

[1526] These are the three steps that configure 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*, pp. 8-9.
[1527] RESCHER, N., "The Ethical Dimension of Scientific Research," p. 201.
[1528] "The Ethical Dimension of Scientific Research," p. 203.

Within this framework — which highlights human actions as free: from the individual actions to the social ones — Rescher suggests that scientific research is connected with ethical problems from several viewpoints:[1529] 1) The choice of research goals; 2) the staffing of research activities; 3) the selection of research methods; 4) the specification of standards of proof; 5) the dissemination of research finding; 6) the control of scientific misinformation; and 7) the allocation of credit for research accomplishments.

Rescher thinks that this issues are *internal* to science, insofar as they involve moral choices related to persons: either the scientists themselves take part of the decision or they directly affect the work scientists develop. Thus, in his approach, those actions which directly imply the scientists and their investigations are "endogenous" (the *internal* dimension of science from an ethical point of view). Meanwhile, he sees as "exogenous" — the ethical features *external* to science — the issues related to the use of results; that is, the questions that are about "what is *done with* scientific discoveries once they have been achieved"[1530].

1) In order to analyze his proposal, the presence of ethical problems in each one of the steps of the dynamics of scientific activity should be acknowledged, where there are ends, means, and consequences in line with the aims, processes, and results of basic science, applied science, and the application of science.[1531] In the case of the ethics of science, Rescher is

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[1529] Cf. RESCHER, N., "The Ethical Dimension of Scientific Research," pp. 201-218.

[1530] "The Ethical Dimension of Scientific Research," p. 202. The external dimension is addressed by Rescher in several publications. Among them, it can be highlighted RESCHER, N., *Public Concerns. Philosophical Studies of Social Issues*, Rowman and Littlefield, Lanham, MD, 1996.

[1531] It should be emphasized that each one of those steps poses ethical questions. This involves that science should not be reduced to "general" ethical problems, since there are specific problems within each one of those realms (basic, applied, and of application). Ethics of science must be able to go in depth in each one of them, taking into account how are those realms interrelated. In this regard, ethics is not reduced to the structural dimension of scientific research, since it also affects the dynamics over time. Thus, there are ethical factors in the historicity that has to do with the relation of the agent with the context (natural, social, or artificial) and other factors that deal with the historicity of the very relations among the researchers (for example, in the research centers). GONZALEZ, W. J., *Personal Communication*, 2.1.2015.

usually focused on the first case and takes into account some aspects of the others; especially, the third one. As his ethics is primarily of teleological character, the problems related with the choices regarding the aims of the research are especially important.

Regarding the problem of the choice of the aims, Rescher has into account three possible levels: individual, institutional, and national. The *individual* level has to do with the choices that the scientists do regarding those aims of research that might have an ethical component (for example, when they decide to do applied research oriented to the development of chemical weapons for military ends).[1532]

The *institutional* level affects the laboratories, departments, or institutes of research; that is, it has to do with the organization where science is developed. Rescher thinks that ethical problems can arise at the institutional level when the orientation of the research is considered. Thus, when a topic of research is selected, an ethical problem could be whether it is ethically adequate to give priority to funding facilities, instead of having into account the benefit the investigation would have for society or its contribution to the advancement of science.[1533]

Then, the *national* level also intervenes. This level has to do with the systems of scientific and technological policy in the different countries. In this regard, Rescher thinks that the decision about the distribution of founding among the different research problems can have ethical implications, because it involves deciding what researches will have priority.[1534] This framework proposed by Rescher is even more complex if other levels are considered. Thus, in the case of Spain, for example, scientific and technological policy do not have only a national level, but also a regional

[1532] Cf. RESCHER, N., “The Ethical Dimension of Scientific Research,” pp. 205-206.
[1533] Cf. “The Ethical Dimension of Scientific Research,” pp. 204-205.
[1534] Cf. RESCHER, N., “The Ethical Dimension of Scientific Research,” pp. 203-204.

level (Autonomous Communities) and a supranational level (the European Union).

2) A second group of ethical problems that Rescher takes into account are those related to the staff that makes the research. It is an issue that he relates to the increasing collectivization of science; that is, with the need for bigger scientific communities in order to carry through the research. Since laboratories, research groups, research centers, etc., consist of a large number of persons, there are a series of administrative issues that have to do with the management of those entities. Those problems did not appear before (or at least they do not have the same importance as now). In this regard, Rescher thinks that, in decision making, there is the risk of giving primacy to *administrative* issues over strictly *scientific* matters.[1535]

3) There are also ethical issues related to the research methods.[1536] Rescher thinks that there are procedures of research that are ethically inadequate or questionable. In this regard, he considers that the most visible and pressing problems are those related to experimentation, above all in sciences such as biology, medicine, or psychology. Thus, among the examples of ethically inadequate research procedures, the nonconsensual experiments on human beings or the consensual experimentation that puts the life or well-being of the subjects at risk can be pointed out.

4) Other kind of ethical problems is that related to the standards of proofs. It is an issue that has to do "with the amount of evidence that a scientist accumulates before he deems it appropriate to announce his findings and put forward the claim that such-and-so may be regarded as an established fact."[1537] In Rescher's judgment, besides the epistemological and methodological components, there is an ethical dimension related to this problem, because "in presenting his own results, a researcher may be under

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[1535] Cf. "The Ethical Dimension of Scientific Research," p. 206.
[1536] Cf. RESCHER, N., *Razón y valores en la Era científico-tecnológica*, pp. 157-158.
[1537] RESCHER, N., "The Ethical Dimension of Scientific Research," p. 208.

a strong temptation to fail to do justice to the precise degree of certainty and uncertainty involved."[1538] For this reason, the decisions regarding the standards of proof should be modulated by ethical values such as honesty or credibility.

5) The dissemination of information can be also problematic. In this regard, Rescher thinks that "ethical problem of favoritism in the sharing of scientific information has come to prominence (…) in our day."[1539] This happens when the scientists or the laboratories share information about the results of their researches following reasons ethically questionable, like the mere personal benefit. Problems can also arise with regard to information dissemination because of the content of the information (for example, how to proceed once a prediction is achieved about the end of the world in few years' time, due to the impact of a meteorite on Earth).[1540]

6) Other problem — related to information dissemination — is the issue of the "control, censorship, and suppression of scientific misinformation."[1541] About this matters, Rescher thinks that scientists have the duty to protect their colleges and society in general from the dangers that can derive form the publication of the research results that are manifestly false (in this sense, truth can be also seen as an ethical value).[1542]

Rescher considers that this way of acting is especially necessary in sciences like medicine, since it has direct repercussions over the public health and well-being. This is an especially complex issue, because there are epistemological, methodological, and ethical issues that must be taken into

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[1538] "The Ethical Dimension of Scientific Research," p. 208.
[1539] RESCHER, N., "The Ethical Dimension of Scientific Research," p. 209.
[1540] Cf. RESCHER, N., *Razón y valores en la Era científico-tecnológica*, p. 156.
[1541] RESCHER, N., "The Ethical Dimension of Scientific Research," p. 211.
[1542] The view of truth as an ethical value appears in philosophers like Karl Popper. On this topic, see MARTINEZ SOLANO, J. F., *El problema de la verdad en K. R. Popper: Reconstrucción histórico-sistemática*, Netbiblo, A Coruña, 2005, pp. 282-294.

account.[1543] Thus, on the one hand, mechanisms of control should be established in order to evaluate the results of the research (for example, through the review procedures established by scientific journals, where values such as reliability and honesty are at stake); and, on the other hand, novelty and innovation in scientific research should be also accepted.[1544]

7) The last group of ethical problems that Rescher admits is that related to the allocation of credit or authorship of the research results.[1545] On this issue, he notices that "the allocation to individuals of credit for the research accomplishments resulting from conjoint, corporate, or combined effort"[1546] can be problematic from an ethical viewpoint. This problem is especially pressing nowadays, due to the phenomenon of the "collectivization" of scientific research, which is carried through in laboratories, research groups and institutions with a large number of researchers.[1547]

When Rescher develops these seven aspects of scientific research in which ethical problems can arise, he expressly maintains that they are *internal* issues to science, so the ethical dimension is not something "supervenient" to scientific activity. He acknowledges that he is little interested in the external issues, since he will not analyze the ethical problems that are outside science and that, in his judgment, have to do

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[1543] A good example of the combination of these factors is provided by John Worrall when he analyses the crinical trials. See, in this regard, WORRALL, J., "Why Randomize? Evidence and Ethics in Clinical Trials," in GONZALEZ, W. J. and ALCOLEA, J. (eds.), *Contemporary Perspectives in Philosophy and Methodology of Science*, pp. 65-82.

[1544] Cf. RESCHER, N., "The Ethical Dimension of Scientific Research," pp. 211-212. It is a problem that also has implications regarding the limits of science as barriers (*Shranken*), insofar as the distinction beween science an non-science (or pseudoscience) is at stake. Cf. RESCHER, N., "The Ethical Dimension of Scientific Research," p. 215.

See, in this regard, GONZALEZ, W. J., "Rethinking the Limits of Science: From the Difficulties for the Frontiers to the Concern on the Confines," forthcoming.

[1545] Cf. RESCHER, N., "Credit for Making a Discovery," in RESCHER, N., *Studies in the Philosophy of Science*, pp. 181-200.

[1546] RESCHER, N., "The Ethical Dimension of Scientific Research," p. 216.

[1547] Ethical problems that have to do with the publication, dissemination, and authorship of the research results are analyzed in RESNIK, D. B., *The Ethics of Science. An Introduction*, pp. 96-121.

above all with the use and the applications of the research results. Expressly he maintains that “such questions of what is done with the fruits of the tree of science, both bitter and sweet, are not problems that arise *within* science, and are not ethical choices that confront the scientist himself. This fact puts them outside of my limited area of concern. They relate to the exploitation of scientific research, not to its pursuit, and thus they do not arise *within* science in the way that concerns us here.”[1548]

In order to assess his approach, it should be pointed out, in the first place, that Rescher seems to accept a distinction regarding the ethical problems, to the extent that he assumes a difference between the cases of scientific research as such (either basic or applied) and the application of science, which consists of the use that agents make of the results obtained through scientific research.[1549] In the second place, he is usually interested in basic science, although he admits that the most visible ethical issues are those related to applied science, because it has a higher social incidence that basic science.[1550]

Because he usually thinks of a context of basic science, he normally highlights the *endogenous* ethical values, which are those that have to do with scientific activity as such (for example, honesty, reliability, or truthfulness). But, in his approach, he expressly notices that, since science is a human activity, “it must be ultimately subject to the same standards of moral evaluation we use with regard with any other human activity.”[1551] This involves paying attention to the *exogenous* ethical values, which are those

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[1548] RESCHER, N., “The Ethical Dimension of Scientific Research,” p. 202.

[1549] His interest in ethical problems related with the application of science can be seen in several of his publications. Among them, RESCHER, N., *Public Concerns. Philosophical Studies of Social Issues*, Rowman and Littlefield, Lanham, MD, 1996; and RESCHER, N., *Sensible Decisions. Issues of Rational Decision in Personal Choice and Public Policy*, Rowman and Littlefield, Lanham, MD, 2003.

[1550] Cf. RESCHER, N., “The Ethical Dimension of Scientific Research,” p. 202.

[1551] RESCHER, N., *Razón y valores en la Era científico-tecnológica*, p. 163.

values that modulates science insofar as it is an activity connected with others (social, cultural, political, economic, ecological, etc.).

Consequently, even when Rescher's philosophy of science gives usually primacy to the internal dimension of analysis, his proposal offers an adequate framework to make an ethical analysis of science from two different levels: the endogenous ethics and the exogenous ethics. They have to do with the *scientific activity* as such and *science as an activity* connected with others, respectively.[1552] From this perspective, his ethics of science is open to a dynamic approach, which has an internal dimension — the aims, processes, and results of the research — and an external component, which has to do with the relations with the context.[1553]

However, he scarcely pays attention to the *historicity* of the human activity, so he does not develop how the historical character of science — by itself and with regard to its relations with other activities — has incidence on the ethical values, both from the endogenous dimension and from the exogenous perspective. And this historicity has to do with ethical issues in the relations with the context (natural, social, or artificial), as well as with the different ethical issues that arise in the relations with the other researches over time (mainly in decision-making). So the historicity of science should not be reduced to one ethical vector (the "extrinsic" one) since it also has into account the other vector (the "intrinsic" one), which deals with the interactions among the researcher agents over time.[1554]

[1552] 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," pp. 147-151.

[1553] 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*, pp. 8-9.

[1554] This means that, in this regard, agents' historicity is twofold: the relations among the researches have features of variability over time that are different from the relations between the agents and the context (natural, social, or artificial). Frequently, the relations of the former case are intense and revisable, possible to a larger extent than in the latter case. This type of variability can be seen in the changes in the groups of research and in the internal dynamic of the research centers. History of science selects the representative actions of

9.2. Two Levels of Ethical Analysis of Science: The Endogenous Ethics and the Exogenous Ethics

Regarding the ethical study of science, there is, in principle, a double dimension of analysis. In the first place, the endogenous ethics considers scientific activity as such; that is, without taking into account the relation with the context where research is carried through. From this perspective, it is highlighted how science, as a free and social human activity, is value-laden. Values considered here are endogenous values, since they modulate scientific activity as such. In this endogenous dimension, the presence of ethical values such as honesty, reliability, personal dignity, the acknowledgment of other's contributions, etc. is highlighted.[1555]

Meanwhile, from the second dimension of analysis — the exogenous ethics — it can be seen that science is a human activity *among others*. This orientation contemplates "scientific activity 'towards the outside,' so it is interested in the set of problems posed by the ethical limits of scientific research, according to the incidence for the people, human society in general (and the environment, insofar as it has repercussions on people or on the social life)."[1556] From this perspective, there are exogenous ethical values in science, insofar as science is related to the whole human experience (for example, solidarity, legality, or social responsibility).

9.2.1. Endogenous Ethical Values in Scientific Activity

The endogenous ethics of science considers scientific activity by itself, so it addresses the values that have to do with the very process of research

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both types of historicity, insofar as they are important for the development of the scientific activity. GONZALEZ, W. J., *Personal Communication*, 2.1.2015.

[1555] 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," p. 147.

[1556] "Ciencia y valores éticos: De la posibilidad de la Ética de la Ciencia al problema de la valoración ética de la Ciencia Básica," p. 149.

(either in basic science or in applied research). It is a perspective that contemplates "scientific activity 'towards the inside' with the consequent interest in issues such as the honesty of scientific endeavor (reliability in the publication of the data really obtained; the originality of the work, insofar as it has to do with the credibility of the researcher, etc.) or the appropriateness of addressing certain ends or means, according to the moral rules of behavior."[1557]

Within the framework of a teleological conception of ethics as that proposed by Rescher, the role of the ends of scientific research is emphasized. In principle, they are more relevant than the means and, in addition, they prevail over the results and their possible consequences. In this way, the ethical evaluation of the ends of scientific research is a critical issue. In this regard, his philosophical approach clearly differentiates two realms with regard to their ethical implications: the aims of basic science and the goals of the applied scientific research.

In accordance with his ethical intellectualism, scientific knowledge is, for Rescher, a good (as they are, for example, justice, health, or well-being).[1558] For this reason, it is possible to think that basic science seeks a goal that is itself ethically adequate, to the extent that it is a type of research oriented towards increasing or improving the available knowledge. Meanwhile, "the applications of science and technology present a different setting, since there are more questions involved in them than the simple increase of knowledge."[1559]

It happens that, when Rescher addresses how science is affected by ethical issues, his analysis usually gives primacy to the endogenous ethics; above all, insofar as he thinks of scientific knowledge as a *good*. Thus, he

[1557] 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," p. 149.
[1558] Cf. RESCHER, N., *Razón y valores en la Era científico-tecnológica*, pp. 105-106.
[1559] *Razón y valores en la Era científico-tecnológica*, p. 165.

sees knowledge as a good in itself, which also has an instrumental component, since it contributes to the achievement of other human goods. In his judgment, "whatever other projects we may have in view—justice, health, environmental attractiveness, the cultivation of human relations, and so on—it is pretty much inevitable that their realization will be facilitated by the knowledge of relevant facts."[1560]

This feature emphasizes that his interests is usually in basic science, where scientific research seeks either to increase our knowledge — hence the importance of prediction as an aim — or improve the knowledge available now (which emphasizes prediction as scientific test). Thus, in the case of Rescher, the preference for the endogenous dimension of analysis goes hand in hand with the higher interest in basic scientific research, where exogenous ethical values have less presence than in the case of applied science. In this way, "he assumes that ethics of science is directly connected with epistemology (that is, with the cognitive component of science) when he wonders if knowledge as such can be ethically inadequate."[1561]

In this regard, it is possible to consider that Rescher gives to truth an ethical value, besides its cognitive value, since the *goodness* of scientific knowledge is linked with its truth value. Karl Popper expressly did this. In his approach, "ethical principles form the basis of science. The idea of truth as the fundamental regulative principle — the principle that guides our search — can be regarded as an ethical principle. The search for truth and the idea of approximation to the truth are also ethical principles; as are the ideas of intellectual integrity and of fallibility, which lead us to a self-critical attitude and to toleration."[1562]

[1560] RESCHER, N., *The Limits of Science*, revised edition, p. 243.

[1561] 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*, p. 13.

[1562] POPPER, K. R., *Auf der Suche nach einer besseren Welt*, Piper, Munich, 1984, p. 226. English translation by Laura J. Bennett and reviewed K. Popper and M. Mew: *In Search of a*

In Rescher's approach, the value of true knowledge is emphasized. So, in his judgment, "we cannot work in this world without an adequate cognitive accommodation. Our mind needs each piece of information as much as our body needs food."[1563] In this regard, scientific prediction, as *cognitive content*, can also have an ethical role, within the context of the human activity.[1564] This can be seen when he notices that the anticipation of the future is a *human need*: "to act, to plan, to survive, we must anticipate the future."[1565] Therefore, scientific prediction carries a cognitive content that directly serves the best interest of people.

But, although Rescher's approach has characteristic features of ethical intellectualism — where there is a cognitive support for ethics, in general, and for the ethics of science, in particular — he expressly acknowledges that "inquiry is a human activity. It must, in the final analysis, be subject to the same general standards of moral appraisal that we use in relation to any other human activity."[1566] Therefore, the activity displayed by scientists when developing research must be regulated by the fundamental principles or controlling values that Rescher places in the second level of his "hierarchy of morality." Those ethical principles and values are the following:[1567]

(i) Do not cause people needless pain (*gentleness*); (ii) do not endanger people's lives or their well-being unnecessarily (*care for safety*); (iii) honor your genuine commitments to people; in dealing with people, give them their just due (*probity*); (iv) help others when you reasonably can (*generosity*); (v) do not take improper advantage of other (*fairness*); (vi) treat other with

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Better World, Routledge, London, 1992, p. 199. See 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," pp. 155-156.

1563 RESCHER, N., *Razón y valores en la Era científico-tecnológica*, p. 166.

1564 In Rescher's approach, the cognitive content of basic science as such (that is, considered by itself) is not susceptible of ethical evaluation. Ethical evaluation appears when basic science is seen as related with human activity (where ends, means, and consequences are at stake).

1565 RESCHER, N., *Predicting the Future*, p. 64.

1566 RESCHER, N., *Public Concerns. Philosophical Studies of Social Issues*, p. 150.

1567 Cf. RESCHER, N., "Moral Objectivity," p. 403.

respect; (vii) do not violate the duly established rights and claims of others; (viii) do not unjustly deprive others of life, liberty, or the opportunity for self-development; and (ix) do not deliberately aid and abet others in wrongdoing.

These are ethical principles and values that scientists must assume when they are carrying through their research activity. Hence they regulate the human processes of making science, also in the case of basic scientific research. Thus, there are a series of endogenous ethical values in science (honesty, gentleness, care for safety, probity, fairness, etc.). These values modulate the aims and the means of research, as well as the behavior of the researchers, insofar as science is a human activity. From this perspective, an ethical problem is whether certain aims and means are ethically adequate in accordance with endogenous criteria.

Consequently, Rescher's ethical intellectualism — which can be seen, above all, when he addresses ethical problems related to basic science — does not involve a view of scientific activity as ethically well-oriented (or as an activity that is neutral with regard to ethical issues). So, although he thinks of the possession of scientific knowledge as something neutral with regard to ethical values (that is, having knowledge is not something morally adequate or inadequate in itself)[1568], *scientific activity* (basic or applied) is certainly value-laden, and it is conditional on ethical values (both endogenous and exogenous).

From the endogenous perspective, it can be seen that there might be ethically inadequate behaviors in scientific research (such as, for example, in the cases of plagiarism or when fraud is committed in the publication of the achieved results). In order to evaluate those behaviors, Rescher usually gives primacy to the personal level — the agent's responsibility — over the institutional component. For this reason, he is focused on the individual actions and choices that can be subject to an ethical analysis (for example,

[1568] Cf. RESCHER, N., *Razón y valores en la Era científico-tecnológica*, pp. 159-162.

when a scientist has to decide if he will use information that was obtained by ethically reprehensible means, such as the experimentation on prisoners of war).[1569]

But Rescher's approach is not reduced to the endogenous dimension of analysis, but it also contemplates science as an activity connected with others, so there is interdependence with exogenous factors. This relation with the context is more important in applied science (where the relation with technology is also more relevant) and, above all, in the application of science, insofar as the *use* of scientific knowledge can be oriented towards issues questionable form an ethical viewpoint. In a clearer way than in the case of the endogenous ethics, the exogenous ethics of science involves paying attention to the institutional level (the laboratories, companies, research centers, etc.), where problems arise such as the credit for the results, allocation of responsibilities, or corporate interests.

9.2.2. Science and Exogenous Ethical Values: Science as Activity

Besides the endogenous ethics — which is oriented towards *scientific activity* as such — there is the exogenous dimension of analysis. From the exogenous dimension, ethics of sciences addresses *science as activity*, so the relations with the whole human experience (social, cultural, political, economic, ecological, etc.) are emphasized. Thus, there are more elements at stake in the ethics of science than those circumscribed to the specific realm of scientific activity. In this way, when science is considered as an activity among others, "there is, in effect, a linkage with ethical concerns of the general realm (social responsibility, solidarity, promotion of personal dignity, equal rights, …)."[1570]

[1569] Cf. *Razón y valores en la Era científico-tecnológica*, p. 155.

[1570] 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," p. 150.

This perspective is expressly assumed by Rescher, since he insists on the search for scientific knowledge as a human project *among others*.[1571] For this reason, he thinks that science "must, in the final analysis, be subject to the same general standards of moral appraisal that we use in relation to any other human activity."[1572] However, he does not develop in an exhaustive way the problems that arise in the exogenous dimension of the ethics of science, because he is usually focused on the realm of basic science, instead of paying attention to questions that affect more specifically the applied research.

In effect, "it is in the *exogenous realm* where many of the reflections about the ethical valuations of applied science should be situated, because they have a direct social incidence (not only in the direct field of the human life, but also in what has to do with the environment — for example, contaminant chemicals — or what might have technological projection, above all when it is clearly inadvisable — for example, bacteriological weapons)."[1573]

Thus, the exogenous ethics goes further than the simple attention to scientific activity as such, since it sees science as an activity that is developed in a wider context (social, cultural, political, economic, ecological, etc.). In this regard, an especially important problem is that related to social responsibility, both of the individual agents and of the groups of agents. In effect, scientific activity can affect the social life, above all when the activity is applied (medicine, applied physics, applied economics, etc.).

This is even clearer when applied science has technological projection,[1574] because the social incidence of the technological devices is

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[1571] Cf. RESCHER, N., *Razón y valores en la Era científico-tecnológica*, chapter 4, pp. 99-121.
[1572] RESCHER, N., *Public Concerns. Philosophical Studies of Social Issues*, p. 150.
[1573] 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," p. 151.
[1574] This projection has been clear during the last decades in the realm of communications (for example, between the signal theory and mobile telephony devices). But this feature does

even more direct for citizens (for instance, in the areas of transport, communications, domestic devices, etc.). In addition, this social repercussion can be seen in the case of the application of science (for example, in issues of policy, like it happens with the Intergovernmental Panel of Climate Change).[1575] Thus, applied science, application of science, and technology, can affect people, society, and environment, either in a positive or in a negative way from an ethical viewpoint.

On this issue of ethical responsibility, although Rescher is usually focused on questions related to basic science, there is in his approach a concern about the problems that have to do with collective responsibility (that is, the responsibility of the groups of agents). This is a crucial problem for the ethics of science in its exogenous dimension, since scientific activity (basic, applied, or of application), as well as technological doing, are usually developed in institutions (companies, laboratories, research centers, etc.), so there is a social dimension that is characteristic of science as human activity.

In order to address this problem, Rescher thinks that "the natural step is to begin by basing our understanding of group responsibility upon that of individual responsibility."[1576] Since his ethical proposal is focused on the person, he considers the problem of the social responsibility as related to scientists as individuals, so the set is reached from the individual agents. Thus, the ethical evaluation of entities is possible (in the case of science, laboratories, research centers, etc.) to the extent that ethical characteristics can be attributed to the individuals who form those entities.

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not involve reducing technology to applied science or considering that technology is a pure application of science. The relation between science and technology was emphasized in chapter one of this Ph.D. research and it is described by Rescher as two legs of the same body. Cf. *Razón y valores en la Era científico-tecnológica*, p. 100.

[1575] This can be seen in the successive international meetings on climate change, where the meeting in Río de Janeiro (1992), Kyoto (1997), and Copenhagen (2009) can be highlighted.

[1576] RESCHER, N., "Collective Responsibility," in RESCHER, N., *Sensible Decisions. Issues of Rational Decision in Personal Choice and Public Policy*, p. 125.

Regarding this issue, Rescher considers that, besides the element of "causality," the notion of "intentionality" is crucial in order to have a genuine *collective responsibility*.[1577] Thus, the fact that the actions of a group of individuals are the cause of a certain result is a *necessary* condition to consider the group as ethically responsible of this result, but it is not sufficient condition to attribute responsibility. So, in his judgment, "without a normative responsibility that transcends mere causality, there can be no actual guilt."[1578]

Seen from an ethical perspective, science has intentionality.[1579] As an intentional human activity it is oriented towards the search of aims (theoretical or practical), which can be ethically adequate (the research for the development of a new vaccine) or clearly inadequate (the research oriented to the subsequent development of bacteriological weapons).[1580] From this point of view, it seems clear to me that laboratories, research centers, etc. can be "moral subjects," since the individual members who form the group actively and intentionally seek a previously established goal.

But, different from the intentionally of individuals, the intentionality of a group requires some kind of coordination among the individual members of that group. Thus, "when the products of group activity are concerned, it only makes sense to speak of group intentions in the case of coordinated productions. Without the synthesis or unification of actions there is no meaningful collective intention."[1581] In the case of science (either basic or applied), coordination and cooperation among scientists is usually present,

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[1577] Cf. RESCHER, N., "Collective Responsibility," p. 126.
[1578] "Collective Responsibility," p. 130.
[1579] The concept of "intentionality" is understood as a feature of a human activity, a feature which is developed in the action of an agent or a group of agents, so it is not equivalent to "intention" as a simple mental act (and, therefore, unobservable). On this issue, see ELSKAMP, R. G., "Intención e intencionalidad: Estudio comparativo," *Anales de Filosofía*, v. 4, (1986), pp. 147-156.
[1580] 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," p. 143.
[1581] RESCHER, N., "Collective Responsibility," p. 130.

since scientific activity is commonly developed by communities within an institutional framework (companies, laboratories, research centers, etc.).

In this regard, Rescher notices that "there are principally two kinds of teams: those that are leader directed and/or hierarchical and those that are purely cooperative and unstructured."[1582] The kind of coordination that appears among the members that form a group has consequences for the allocation of ethical responsibilities. Because, in the framework that Rescher expressly suggests, a group of agents can be ethically responsible to the extent that its individual members are responsible. So, in order to attribute social responsibility to a group, from an ethical viewpoint, the individual agents that form the group must be responsible to some extent for the activity carried through and for the result finally achieved.

Consequently, Rescher thinks that, when the group has a hierarchical structure, the allocation of responsibility is, in principle, easier than when the group works in a cooperative way, without a well-delimited hierarchy or without a leader who guides the activity.[1583] The same happens when the issue is to allocate credit or authorship of a result obtained through the research.[1584] Thus, the institution where research is developed can be considered either responsible for an ethically reprehensive result (for example, the pollution of the environment) or can receive credit for the positive results achieved by its researchers (for example, a new vaccine).

But, in order to specify to what extent there is an ethical responsibility, we have to determine the concrete individuals who have cooperated in the activity carried through and their contribution to the final result. In principle, this task is easier when there is a leader or a hierarchical structure within the

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[1582] "Collective Responsibility," p. 137.
[1583] Cf. RESCHER, N., "Collective Responsibility," pp. 137-138.
[1584] Cf. RESCHER, N., "The Ethical Dimension of Scientific Research," p. 216.

group, while responsibility and credit tend to fade when the group works through the cooperation of its members, without a clear internal structure.[1585]

Regarding this problem, the distinction between "moral responsibility" and "legal responsibility" is important. For Rescher, "groups can be *legal* persons and thus bear legal responsibility. Legal responsibility is alienable and capable of transfer and delegation."[1586] Meanwhile, moral responsibility is, in his judgment, inalienable. Thus, "groups can only bear [moral] responsibility derivately—either by way of aggregation (consensus) or by way of delegation (via representation)."[1587] Moreover, the existence of moral responsibility — either individual or of a group — does not necessarily involve legal responsibility, and vice versa.

However, the legal features have repercussions on the ethics of science; because science is developed within legal frameworks (autonomic or regional, national, and international) that have consequences for the scientific research. The legal framework affects, for example, issues such as the funding of science, insofar as it can provide the conditions for allowing or prohibiting ethically questionable researches (for instance, those oriented toward the development of chemical weapons).[1588] In this regard, Rescher seems to assume that the legal realm is more variable; whereas the ethics has more stable basis, since it is supported by universal ethical principles and values.

Due to Rescher's insistence in the ethical features that are universal, his approach to ethics, in general, and to the ethics of science, in particular, does not grasp adequately the variability in the field of human values (among them, ethical values). In my judgment, when the ethics of science is analyzed

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[1585] Cf. RESCHER, N., "Collective Responsibility," pp. 137-138.
[1586] "Collective Responsibility," pp. 132-133.
[1587] RESCHER, N., "Collective Responsibility," pp. 132.
[1588] Cf. BALMER, B., "The Social Dimension of Technology: The Control of Chemical and Biological Weapons," in GONZALEZ, W. J. (ed.), *New Perspectives on Technology, Values, and Ethics: Theoretical and Practical Discussions*, Boston Studies in the Philosophy of Science, Springer, Dordrecht, forthcoming.

from the exogenous perspective, we can clearly see how there might be variability in the ethical values, insofar as science is a *human activity* with a dynamic component. The dynamic component of science has an internal dimension (the articulation in aims, processes, and results) and an exogenous component, which has to do with the relations with the socio-historical context where scientific activity is developed.[1589]

From this perspective, the exogenous values (solidarity, legality, social responsibility, etc.), which regulate or should regulate science according to its social incidence, are — in principle — more variable than the endogenous ethical values (honesty, coherence, etc.). In effect, the exogenous ethical values modulate science as an activity developed in a context — social, cultural, political, economic, ecological, etc. — that is changeable. This feature involves that the ethics of science is open to the historicity of human activity, which is compatible with the acknowledgement of the objectivity of values.[1590]

However, Rescher's approach is more static. Thus, in the first place, he gives primacy to the idea of a system. The idea of a system is important both in his conception of human values, in general, and ethical values, in particular, which are structured into a hierarchy of values. Hence, the universal values, which are absolute and inalienable, are in the first level of the hierarchy; whereas those issues that are subject to variation are in the lowest levels of the hierarchy.[1591] And, in the second place, he is interested in

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[1589] 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*, pp. 8-9.

[1590] The problem of how historicity can be compatible with objectivity is analyzed in GONZALEZ, W. J., "El enfoque cognitivo en la Ciencia y el problema de la historicidad: Caracterización desde los conceptos," pp. 51-80.

[1591] Cf. RESCHER, N., "Moral Objectivity," p. 403.

reject the ethical relativism, so he usually insists on the universality of values.[1592]

Consequently, although Rescher acknowledges that there are variations in values, he sees this problem in contextual terms. So, in his judgment, there are contextual matters that affect concrete ethical codes. But this is not an acceptation of the historicity (of science, the agents, and the reality itself that is researched). In my judgment, the acknowledgement of a genuine *historicity* is required in order to address the ethical analysis of science, both from the endogenous dimension and — above all — from the exogenous perspective. It is a critical issue when the problem of the limits of science, where historicity allows us to address the factors of variability, both of scientific activity as such (the endogenous dimension) and of science as activity related to other activities (the exogenous perspective).

9.3. The Ethical Limits of Scientific Research: Their Incidence for Scientific Prediction

When the ethical limits of scientific research are considered, there is a double perspective of analysis. On the one hand, the ethical limits can be *internal* to scientific activity, where the aims, processes, and results are addressed. And, on the other hand, the ethical limits can be *external*. They appear insofar as science is an activity related to other activities (social, cultural, political, economic, ecological, etc.). These limits — internal and external — have incidence for scientific prediction, insofar as prediction is the result of an *activity* that seeks to achieve justified answers to meaningful questions regarding future events.[1593]

As activity, scientific prediction might be subjected to an ethical evaluation of its aims, processes, and results. Here there can be limits

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[1592] See, for example, RESCHER, N., "Against Moral Relativism," in RESCHER, N., *Objectivity. The Obligations of Impersonal Reason*, pp. 124-150.
[1593] Cf. RESCHER, N., *Predicting the Future*, pp. 37-39.

according to ethical considerations. In this regard, the differences between the basic scientific activity, applied scientific research, and the application of science should be taken into account, insofar as they affect the articulation of the aims, processes, and results (and their possible consequences. These differences have repercussions on the ethical values linked with prediction in each one of the three contexts — basic science, applied science, and application of science — both from the internal perspective and from the external viewpoint.

9.3.1. Approaches to the Ethical Limits of Scientific Research: Importance for Ends and Means

Regarding the problem of the ethical limits of scientific research, Rescher thinks that, in principle, three different approaches are available: a) panregulation, which considers that scientific knowledge should be completely under control and regulated; b) *laissez-faire*, which considers that controlling or limiting knowledge is never adequate; and c) centrism or moderate option, whose starting point is a view of scientific knowledge as a good among others. [1594]

Panregulation — the first possible option — consists of a totalitarian view of scientific knowledge. According to this approach, "knowledge is power, and the use of power in a community *always* should be controlled and regulated. Moreover, knowledge belongs to that especial category of things that require a particular treatment, and should be regulated with exceptional rigor."[1595] Thus, the advocates of this approach maintain that every aspect of scientific research must be subject to an external control, so science loses its autonomy.[1596]

[1594] Cf. RESCHER, N., *Razón y valores en la Era científico-tecnológica,* pp. 152-154.
[1595] *Razón y valores en la Era científico-tecnológica,* p. 152.
[1596] Niiniluoto is a philosopher who has especially insisted in the autonomy of science as a characteristic feature of what science is or should be. In his judgment, "the community of

Meanwhile, the second approach noticed by Rescher — the *laissez-faire* — maintains that scientific knowledge should never be limited, since it "belongs to the especial ethical category of things that — such as life or freedom — are subject to a fundamental right that is inalienable."[1597] On this basis, limits cannot be set to scientific research, since scientific knowledge is considered as a supreme good. Therefore, science would be completely autonomous and any other attempt to set limits to scientific activity would be considered as something ethically inadequate.

These are extreme approaches that — in Rescher's judgment — are unacceptable. Thus, he opts for the third approach (centrism or moderate option) according to which scientific knowledge should be considered as a good among others. On this basis, it is possible to preserve the autonomy of science and to acknowledge, at the same time, that there are ethical limits that should be respected.[1598] From this perspective, the search for knowledge should be subjected to ethically grounded considerations of general interest. Thus, "exactly in the same way as it happens with other activities, public interest is a potential source of adequate restrictions [to scientific research]."[1599]

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investigators ceases to be a scientific community if it gives up—or is forced to give up—this principle of autonomy," NIINILUOTO, I., *Is Science Progressive?*, Reidel, Dordrecht, 1984, p. 6.

On the concept of "autonomy," see GONZALEZ, W. J., "Progreso científico, autonomía de la Ciencia y realismo," pp. 91-109; especially, pp. 100-104 and 108-109; GONZALEZ, W. J., *Philosophico-Methodological Analysis of Prediction and its Role in Economics*, pp. 25-28; and O'NEILL, O., "Autonomy: The Emperor's New Clothes," *Proceedings of the Aristotelian Society*, 77, (2003), pp. 1-21.

[1597] RESCHER, N., *Razón y valores en la Era científico-tecnológica,* p. 152.

[1598] Rescher considers that the autonomy is a defining feature of science. In his judgment, "the acceptability of the scientific proposals is an issue that should be completely resolved at the level of internal considerations to scientific endeavor. A 'science' subject to external criteria of correctness is simply not worthy of that name," RESCHER, N., *Razón y valores en la Era científico-tecnológica,* p. 115.

The search for a balance between the autonomy of science and the limits due to ethical issues is a main concern in the recent literature on the ethics of science. See, for example, DOUGLAS, H., "Rejecting the Ideal of Value-Free Science," in KINCAID, H., DUPRÉ, J. and WYLIE, A. (eds.), *Value-Free Science? Ideals and Illusions*, Oxford University Press, N. York, 2007, pp. 120-139; especially, pp. 126-131.

[1599] RESCHER, N., *Razón y valores en la Era científico-tecnológica,* p. 152.

Rescher considers the three options regarding the problem of the ethical limits of science — panregulation, *laissez-faire*, and the moderate option — as conceptions of general character about scientific knowledge, which has also incidence for the problem of the ethical limits of scientific research. In this regard, it seems clear that his ethics of science is supported by epistemology. In this way, when he thinks of the ethical limits of scientific research (either in the realm of basic science or in the context of applied science), he usually gives primacy to the cognitive component of science.

Certainly, his approach to the limits of science is in accordance with his ethical intellectualism, insofar as there is a cognitive support for the ethics of science. But, in Rescher's approach, scientific knowledge is a good among others. This involves taking into account the *activity* developed by science, which should not hinder other human goods (freedom, safety, well-being, etc.) when it tries to increase or improve the available knowledge (basic science) or to solve concrete problems (applied science).

Therefore, the centrist approach to the problem of the limits of science involves, on the one hand, considering knowledge as a good in itself; because obtaining knowledge is a human need, due to the kind of creatures we are. This feature is especially clear when scientific knowledge is about the possible future, since the ability to anticipate the future is a crucial aspect of human survival.[1600] Due to the high value of knowledge, Rescher thinks that we should adopt a wary attitude regarding the issue of the ethical limits. In this judgment, "the idea of 'ethical limits' should be always implemented with care. Free research is a delicate and vulnerable plant, which should be fed and protected as much as we can."[1601]

But, on the other hand, Rescher insists that knowledge is not a supreme good, so he sees the search for scientific knowledge as a valuable

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[1600] Cf. RESCHER, N., *Predicting the Future*, p. 64.
[1601] RESCHER, N., *Razón y valores en la Era científico-tecnológica*, p. 166.

human goal *among others*. This means that "*there are* ethical limits to research that legitimate *can* be implemented in some cases."[1602] Therefore, we should find a balance between the value of free research — and the due care and respect for the autonomy of science — and the acknowledgement of other values, which can lead to establishing limits to scientific research on the basis of ethical considerations.[1603]

This involves considering the activity developed by science, both by itself and according to its relations with other human activities. From this perspective, it seems clear that there is a double dimension of analysis when the ethical limits of science are considered: (i) *scientific activity*, where there is an articulation of aims, processes, and results; and (ii) *science as activity*, which is oriented towards the relations between science and the context (social, cultural, political, economic, ecological, etc.).

Too often, Rescher gives primacy to the internal dimension of analysis. On the one hand, his preference for the internal dimension is due to his structural conception about science, where the idea of a system prevails. And, on the other hand, he is more interested in basic research than in applied science, which has more repercussions in the social milieu. But, to the extent that he defends a holism of values, the external dimension cannot be omitted, because the scientific values and the other human values are interrelated (also in the case of the ethical values).

Within this framework, Rescher thinks that the most important ethical limits that can be put on scientific research are those related to three aspects of knowledge:[1604] I) empirical information, because the use of information can be restricted when it is known information was obtained or fund through illegitimate means; II) topics of research, insofar as there are some topics

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[1602] *Razón y valores en la Era científico-tecnológica*, p. 167.
[1603] 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," pp. 154-155.
[1604] Cf. RESCHER, N., *Razón y valores en la Era científico-tecnológica*, pp. 154-159.

that can lead to damaging applications to people, society or the environment; and III) research methods or procedures, because some methods of research can be ethically inadequate (for example, nonconsensual experimentation on human beings).

Undoubtedly, ethical limits can be put on scientific activity regarding these aspects of knowledge. But, in my judgment, the ethical limits of science can be better seen when the internal dynamics of *scientific activity* is considered. This perspective involves that the ethical limits — when they are contemplated from the internal dimension to science — have to do with the aims, processes, and results of scientific research, which are different in the context of basic science from the realm of applied science.[1605] From this perspective, which is oriented towards the three successive steps in the internal dynamics of scientific activity, the ethical problems related to prediction and prescription are also clearer.

Regarding the aims of research, a question is whether there are scientific goals that should be limited according to ethical values. Rescher's concern about the ethically inadequate topics of research can be placed in this level. But, in this regard, a distinction should be made between the goals of basic science and the aims of applied science. So, to the extent that basic science is directed to increasing or improving the available knowledge, it seems that the goals of this kind of research are not ethically problematic by themselves.

From this perspective, basic research cannot be limited on the basis of its aims, which usually are the explanation and prediction of phenomena and events. Furthermore, insofar as it is oriented towards these aims, basic research provides knowledge, which is valuable by itself and in addition can

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[1605] On the differences 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.

contribute to cultivate other human goods.[1606] Meanwhile, in the case of applied research, the aims sought have a more practical character. Therefore, it can be seen how applied research, according to the sought aims, can have direct repercussions (either beneficial or damaging) on people, society, and the environment.

On the one hand, according to the *aims* sought (for example, the development of a new vaccine), applied research can contribute to human well-being to a greater extent than basic science (for instance, astronomy).[1607] But, on the other, there are aims of the applied research that are ethically questionable, due to their negative repercussions on people, society, or the environment (for example, the research about certain chemicals). In some cases it is clear whether the aim sought is ethically inadequate (an example could be human cloning), but there are cases where the search for a goal lead to an unexpected unfavorable result.

In this regard, prediction has a role for the anticipation of the possible unfavorable effects of a research, also in the case of basic science. So, although the aims of basic research (mainly, explanation and prediction) are not problematic from an ethical viewpoint, they can lead to undesired or undesirable applications. Thus, prediction can contribute to reduce uncertainty about future phenomena, so it might be crucial in order to minimize the problem of risk (above all, in applied research).[1608] It must be noticed, however, the difficulty in making predictions in the scientific realm, so it might be difficult to predict that a certain research will lead to damaging

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[1606] Cf. RESCHER, N., *Razón y valores en la Era científico-tecnológica*, pp. 105-106.

[1607] This is expressly accepted by Rescher. In his judgment, "one very pervasive problem at this institutional level is the classical issue of pure, *or* basic, versus applied, *or* practical, research. This problem is always with us and is always difficult, for the more 'applied' the research contribution, the more it can yield immediate benefits to man; the more 'fundamental', the deeper is its scientific significance and the more it can contribute to the development of science itself," RESCHER, N., "The Ethical Dimension of Scientific Research," p. 204.

[1608] Cf. SHRADER-FRECHETTE, K. S., *Ethics of Scientific Research*, Rowman and Littlefield, Lanham, MD, 1994, chap. 6, pp. 101-117; especially, pp. 111-117.

applications in the future.[1609] For this reason, Rescher thinks that we should be especially wary if we limit scientific research due to the concrete aim sought.[1610]

Once the aim of the research is established, *processes* must be selected to achieve that aim. In this regard, Rescher maintains that there should be limits to scientific research according to the processes or methods, since there might be ethically inadequate research methods. He provides several examples of ethical limits regarding the processes, such as the nonconsensual experimentation on human beings, or the experimentation that inflicts excessive or avoidable harm on animals.[1611] Ethical limitations regarding the processes also include the use of information obtained by ethically questionable procedures (for example, the experimentation on prisoners of war).[1612]

After establishing the aims and selecting the processes, scientific research leads to a *result*, which can be also evaluated from an ethical perspective (mainly according to its consequences). This evaluation of the results can be either internal or either external to scientific activity. Form the internal perspective, the adjustment of the achieved result to the previously established aim is assessed. Here, endogenous ethical values such as honesty or reliability are taken into account. According to these values, it can be claimed that there are questionable practices, like fraud in the publication of the results, which are out of the limits of scientific research.

In addition, an external evaluation of the results can be done. This leads to the exogenous dimension regarding the limits of scientific research, which takes into account that the results of scientific research (and their possible

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[1609] Cf. RESCHER, N., *Razón y valores en la Era científico-tecnológica*, pp. 158-159. On the problems related to the prediction of future science, see RESCHER, N., "The Problem of Future Knowledge," pp. 149-163.
[1610] Cf. RESCHER, N., *Razón y valores en la Era científico-tecnológica*, p. 163.
[1611] Cf. *Razón y valores en la Era científico-tecnológica*, p. 157.
[1612] Cf. RESCHER, N., *Razón y valores en la Era científico-tecnológica*, p. 155.

consequences) can have negative repercussions on people, society, or the environment, so they interfere with other human values (social, cultural, ecological, etc.). This feature can be clearer seen in the case of applied science — where the relations with technology are more important — than in the realm of basic science, where the endogenous factors often have primacy.

But, besides basic science and applied science, the application of science must be also considered (the use of scientific knowledge by agents; for example, in professional contexts such as medical practice).[1613] The perspective of the application of science highlights how also basic research — besides applied science — might lead to undesired or undesirable applications. In this regard, there are ethical elements that modulated scientific prediction in the application of science, since prediction can serve as a guide for agent's decision-making when they apply scientific knowledge (for example, in issues related to climate change).

9.3.2. From the Internal Perspective to the External Dimension

Undoubtedly, over the last decades the external dimension of analysis has motivated the development of the ethics of science, in general, and the concern about the ethical limits of scientific research, in particular. In effect, "one of the reasons for the increasing interest in the ethics of science is the existence of a negative social perception regarding some recent scientific developments, above all in their technological projection (especially in the realm of the genetic engineering and in the cases of environmental damage due to industrial products)."[1614]

[1613] 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, pp. 17-18.

[1614] 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," p. 152.

Therefore, the need to establish external ethical limits to scientific activity seems to be clear when science is contemplated as an activity connected with other human activities. From this perspective, the relations with the context (social, political, cultural, economic, ecological, etc.) must be considered. Then, it can be seen how the results of the scientific activity (and the possible consequences of those results) can have repercussions on people, society, and the environment, either in a positive or in a negative way.

Certainly, science can have a *positive* effect in other realms of human experience, above all when it is applied science (for example, medical research has decisively contributed to health, which is a human good). But scientific research can have also a *negative* effect for people, society, and the environment, to the extent that it can interfere with other human values, such as safety, well-being, or sustainability. Thus, it seems clear that, besides the endogenous limits to scientific activity, there are also exogenous limits, which have into account the repercussions of science in the whole human experience. These are clearer in applied science — which usually has technological projection — than in the context of basic research, where the internal factors have usually primacy.

Insofar as the external ethical obstacles limit *science as activity* (that is, due to its relations with the context), they are, in principle, more variable than the limits due to internal factors (such as honesty, reliability, or truthfulness). In this regard, Agazzi's proposal is interesting. He highlights the variability that has to do with contextual factors and that has incidence for the problem of the limits of science. In his judgment, besides de aims, processes, and results, the analysis of the ethical limits of science must take into account the *conditions* (those factors that make an action possible) and the *circumstances* (the context where the action is developed).[1615]

According to Agazzi, "in order to evaluate an action from a moral viewpoint it is almost always needed to take into account its *conditions* and *circumstances*. Sometimes, the concrete conditions that would make an action possible (fair by itself) will not be morally acceptable: in this case, the mentioned action should not be performed."[1616] Among conditions, it is possible to highlighted, in my judgment, the means and resources required to develop the research, which can be ethically questionable. An example in this regard is that of a research illicitly funded. Thus, although the aims, processes, and results of a concrete research are adequate from an ethical viewpoint, the research should not be developed if, for example, the funding has been achieved in an ethically inadmissible way.

Agazzi also notices that "other times circumstances surrounding action must be considered: it is possible that a course of action morally allowed under 'normal' circumstances becomes morally reprehensible under 'exceptional' circumstances, or vice versa."[1617] This might happen, for example, when priorities must be established in the systems of scientific and technological policy (at the regional, national, and international levels) in order to support research problems. In this regard, circumstances can be crucial and they have incidence for the consideration of the economic distribution as adequate or inadequate from an ethical viewpoint (for example, when a country is at war, giving many resources to researches oriented to military ends might be considered as correct).

[1615] See AGAZZI, E., "Límites éticos del quehacer científico y tecnológico," in GONZALEZ, W. J. (ed.), *Ciencia y valores éticos*, p. 255. On Agazzi's proposal, see 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," pp. 160-161.

[1616] AGAZZI, E., "Límites éticos del quehacer científico y tecnológico," p. 255.

[1617] "Límites éticos del quehacer científico y tecnológico," p. 255.

Rescher also pays attention to the context in which human activity is developed, and he is aware that context introduces elements of variability in ethics, in general, and in ethics of science, in particular. In an explicit way, this feature appears in his “hierarchy of morality,” where the values of the lowest levels vary according to contextual factors.[1618] Thus, his ethics of science combines the existence of universal ethical values with issues open to changes due to context-dependent factors. Moreover, regarding the ethical limits of scientific research, he notices that issues such as the means or resources that make scientific research possible should be also taken into account[1619], so his approach — in some sense — is open to considering the “conditions” and “circumstances” of actions.

However, although Rescher’s approach is open to variable elements regarding ethical values, which have repercussions on the variability of the limits of science (at least, when they are considered from the external dimension), he is usually more concerned with ethical values and principles that are stable, insofar as they have features of universality. This is related to his rejection of a moral relativism, either of social or historical character.[1620] In effect, in his proposal, the objectivity of values, in general, and of ethical values, in particular, is crucial, to the extent that it allows the rational deliberation about problems that have to do with value matters.[1621]

From this perspective, ethical limits to scientific research — internal and external — have *rational* basis, which is directed to what is objectively preferable, instead of being merely focused on what is preferred. In this way, the ethical limits of science are not something constructed neither the result of consensus (explicit or implicit), but they are established through a rational deliberation that seeks optimal solutions taking into account the concrete

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[1618] Cf. RESCHER, N., “Moral Objectivity,” pp. 403-405.
[1619] Cf. RESCHER, N., *Razón y valores en la Era científico-tecnológica*, pp. 155-156.
[1620] On the different types of relativism, see GONZALEZ, W. J., “El realismo y sus variedades: El debate actual sobre las bases filosóficas de la Ciencia,” pp. 27-28.
[1621] See RESCHER, N., “Moral Objectivity,” pp. 393-409

circumstances and the context.[1622] Thus, in his approach, Rescher combines the objectivity of values — grounded in universal human needs — with the contextual character of the human activity performed in a social milieu.

But, although Rescher takes into account the context (social, cultural, political, economic, ecological, etc.), he does not pay attention to the concept of *historicity* that, in my judgment, is required to adequately develop the dynamical component of the ethics of science. Instead of being a conception open to historicity, Rescher's approach is more static. Thus, on the one hand, his analysis is mainly structural, so ethical values are part of the wider system of human values. And, on the other hand, he searches for invariable ethical values and principles, so there can be objective basis for the rational deliberation about ethical issues.

In this regard, it should be noticed that historicity is compatible with the objective character of the problems of evaluation, so the acknowledgement of historicity (of science, agents, and the reality researched) does not necessarily lead to ethical relativistic conceptions.[1623] Furthermore, the objectivity of the issues of ethical evaluation that have to do with science require, in my judgment, taking into account the internal dynamics of scientific activity — the changes regarding the aims, processes, and results of the research — and the external dynamics (the relations with the context, which is also changeable).

Concurrently, the relation of scientific prediction with ethical problems can be best seen — in my judgment — when historicity is acknowledged. This aspect of the philosophico-methodological analysis of scientific prediction is not developed by Rescher. In effect, in his main book about

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[1622] Cf. RESCHER, N., *Razón y valores en la Era científico-tecnológica*, pp. 90-96; y RESCHER, N., *Rationality. A Philosophical Inquiry into the Nature and the Rationale of Reason*, pp. 169-175.

[1623] On how historicity is compatible with objectivity, see GONZALEZ, W. J., "El enfoque cognitivo en la Ciencia y el problema de la historicidad: Caracterización desde los conceptos," pp. 51-80.

prediction, there is no specific attention to the study of scientific prediction from the viewpoint of the ethics of science.[1624] In my judgment, in order to develop an ethical analysis of scientific prediction, the dynamical component (both internal and external) of the scientific activity must be considered, paying attention to the notion of historicity. Moreover, this should be done regarding three cases: basic science, applied science, and the applications of science.

9.4. Prediction and Ethical Values from the Dynamic Perspective: Evaluation of the Aims, Processes, and Results

Ethics of science can be addressed in relation to three different realms: basic science, applied science, and the application of science. The relation between science and ethical values has different characteristics in each one of these realms, since they are different activities. This feature can be seen from the dynamic perspective, which has an internal dimension (the articulation in aims, processes, and results) and an external viewpoint, which has to do with the relations with the context. The different internal configuration of the three types of activities (basic, applied, and of application) as well as their own features regarding the external dynamics lead to considering their specific ethical problems. However, they have also some aspects in common, since they are free human activities of a social character.

These differences have repercussions on the relation between prediction and the ethical values in basic science, applied science, and the application of science. In effect, prediction has different roles, according to the context where it is made.[1625] 1) In basic science, prediction is usually used as a test for theories and hypotheses. 2) In applied science, prediction

[1624] Cf. RESCHER, N., *Predicting the Future*, passim.
[1625] Cf. GONZALEZ, W. J., *La predicción científica*, p. 11.

is usually the previous step to prescription, which is oriented towards the resolution of concrete problems. 3) In the application of science, prediction can be the basis for the procedures of decision-making, since it allows us to anticipate the problems and the consequences of the proposed solutions. From this perspective, the study of scientific prediction from the ethics of science must take into account the internal dynamics of scientific activity (basic, applied, and of application), both from the internal dimension — the aims, processes, and results — and from the external perspective (the relations with the context).

9.4.1. Ethical Values and Prediction in the Realm of Basic Science

Commonly, basic science is considered as the type of scientific activity directed to increasing or improving the available knowledge. For this reason, within the ethical concern with basic science, one problem which has received especial attention is that related to whether the possession of knowledge can be ethically inadequate as such. In this regard, as Wenceslao J. Gonzalez notices, the aspect of the cognitive content should be distinguished from the dimension of the free human activity.[1626]

In effect, "from the point of view of the very *content* of knowledge (as its truth value, for example, is considered), ethics does not have a realm where it can work on (*campo alguno de actuación*): ethics does not evaluate the cognitive content as such. Meanwhile, to the extent that knowledge is connected with a *free human activity*, which has some goals or aims, some means, and some results — and can have also links with other free human activities — then the situation is different. From this perspective, the ethical evaluation is possible, which is not oriented towards the possession of

[1626] 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," p. 161.

information *per se*, but towards the human activity that leads to information search, its acquisition, and its use."[1627]

When Rescher takes into account the problem of the ethical evaluation of basic science, his approach follows this very direction. Thus, on the one hand, he sees scientific knowledge as neutral with regard to ethical values. In this way, he insists that the possession of knowledge cannot be valued as something morally adequate or inadequate in itself.[1628] But, insofar as science is a free human activity, he considers that basic scientific research is value-laden and conditional on ethical values, which are mainly endogenous.[1629]

Thus, although scientific knowledge as such can be considered as neutral regarding ethical values, the ethical evaluation of basic science is possible when the free and intentional human activity is considered. This involves taking into account the three successive steps of the internal dynamics of scientific activity, where ethical values can intervene: the concrete aims of the research, the processes oriented towards achieving those aims and the result finally achieved (and its consequences).[1630]

Regarding the aims of the basic research, scientific prediction has an important role. On the one hand, basic research is oriented to increase our knowledge, so prediction is a relevant aim; and, on the other, it seeks to improve the available knowledge, so it emphasizes prediction as scientific test. Insofar as it provides knowledge about the possible future, scientific prediction as an aim of science does not pose any ethical problems.

Moreover, it is possible to think — as Rescher does — that knowledge about the future can raise a positive ethical evaluation. Thus, on the one

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[1627] "Ciencia y valores éticos: De la posibilidad de la Ética de la Ciencia al problema de la valoración ética de la Ciencia Básica," p. 161.
[1628] Cf. RESCHER, N., *Razón y valores en la Era científico-tecnológica*, pp. 159-162.
[1629] Cf. *Razón y valores en la Era científico-tecnológica*, pp. 162-165.
[1630] 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," pp. 139-171; especially, pp. 155-164.

hand, it allows us to knowledge the reality better; and, on the other, it favors agent's adaptability and survival.[1631] However, basic scientific activity (also when it is oriented towards knowing the possible future) requires some means, which can be reprehensible form an ethical viewpoint. This is expressly maintained by Agazzi. In his judgment, "the problem of the moral judgment regarding the *means* refers also to pure science and not only to applied science."[1632]

Thereafter, the means generate some results that can also have inadvisable consequences. In this regard, Rescher's reflection on the ethical problems related to the standards of proof can have repercussions for the problem of the ethical values of prediction and the realm of basic science. According to Rescher, "in presenting particular scientific results, and especially in presenting his own results, a researcher may be under a strong temptation to fail to do justice to the precise degree of certainty and uncertainty involved"[1633].

Uncertainty is one of the main obstacles to scientific prediction.[1634] Furthermore, to the extent that prediction is about the future (something that is not yet), it is seems that there is always certain degree of uncertainty that accompanies a prediction. Thus, the temptation to improperly reduce the degree of uncertainty that accompanies the results can appear when those results are about the possible future. Regarding this issue, there are endogenous ethical values that should be present in the presentation and communication of the scientific results, such as reliability or credibility.

Moreover, the results of basic science can have consequences that might be evaluated from an ethical perspective. In order to address this

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[1631] Cf. RESCHER, N., *Predicting the Future*, p. 64.
[1632] AGAZZI, E., *Il bene, il male e la scienza. Le dimensioni etiche dell'impresa scientifico-tecnologica*. Spanish version by Ramón Queraltó: *El bien, el mal y la Ciencia*. *Las dimensiones éticas de la empresa científico-tecnológica*, Tecnos, Madrid, 1996, p. 247.
[1633] RESCHER, N., "The Ethical Dimension of Scientific Research," p. 208.
[1634] Cf. RESCHER, N., *Predicting the Future*, p. 135.

problem, the distinction between "non-oriented basic research" and "oriented basic research" is certainly important.[1635] The former is a type of research that is not connected with applied research, even in the long run; while the latter does lead to an applied dimension, at least potentially. This distinction can be useful to evaluate prediction, because "it seems obvious that some predictions belong to 'non-oriented basic research' (for example, predictions about 'black holes' in distant galaxies) and others fall within the 'oriented basic research,' which is the most frequent case in economic predictions."[1636]

According to this distinction, it seems clear that scientific prediction in basic science, from the point of view of the consequences, can be subjected to an ethical evaluation, above all when the basic research is connected with applied science. In this regard, anticipating the possible objectionable consequences of a research is especially important, science it they can lead to limiting a research or to make changes regarding the aims of the means in order to minimize those possible negative consequences. However, as Rescher notices, anticipating the development of future science is something especially difficult.[1637]

On this issue, Agazzi also notices that the possible negative consequences of the results of basic science are not themselves foreseeable neither necessary, since they depend on the free and conscious choices of the agents.[1638] Consequently, when ethical evaluation is regarding the consequences of scientific research, a wary attitude seems the best option. In effect, as Rescher maintains, "the aspirations of unrestrained research are essential. They have weight enough and are valid enough so they never

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[1635] Cf. GONZALEZ, W. J., "La contribución de la predicción al diseño en las Ciencias de lo Artificial," p. 191.
[1636] "La contribución de la predicción al diseño en las Ciencias de lo Artificial," p. 191.
[1637] Cf. RESCHER, N., "The Problem of Future Knowledge," pp. 149-163.
[1638] Cf. AGAZZI, E., *Il bene, il male e la scienza. Le dimensioni etiche dell'impresa scientifico-tecnologica*, Rusconi, Milán, 1992. Spanish version by Ramón Queraltó: *El bien, el mal y la Ciencia*. *Las dimensiones éticas de la empresa científico-tecnológica*, p. 258. Cf. also 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," pp. 161-162.

should be put aside because of something that lacks clear and actual dangers."[1639]

9.4.2. Ethical Elements of Prediction in Applied Science and Repercussions on Scientific Prescription

Certainly, ethical problems that have to do with science, in general, and with scientific prediction, in particular, are more visible in applied science than in the realm of basic research. This higher visibility of the ethical matters in applied science is because, in comparison with basic research, the social repercussions of applied research are greater. Thus, there are values and ethical problems related to the *exogenous* dimension of analysis (the relations with the context), since applied scientific research can directly affect people, society, and the environment.

Furthermore, within this scientific realm, prediction has a direct relation with prescription, since the applied scientific activity is oriented towards solving concrete problems, so it needs guides for action in order to achieve its aims.[1640] Thus, ethical values that affect scientific prediction in applied science can be seen, above all, when its relation to *prescription* is considered. Prescription involves a normative aspect — it suggest the guides for action that *should* be followed in order to solve some concrete problem — that is connected with the realm of values, were ethical values can have an important role.

In this regard, as A. Sen has emphasized in the case of applied economics, the prescriptive dimension always leads to an ethical component. In his judgment, "any prescriptive activity must, of course, go well beyond pure prediction, because no prescription can be made without evaluation and

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[1639] RESCHER, N., *Razón y valores en la Era científico-tecnológica*, p. 166.
[1640] Cf. GONZALEZ, W. J., *Philosophico-Methodological Analysis of Prediction and its Role in Economics*, p. 317.

an assessment of the good and the bad."[1641] In turn, the evaluative aspect, which encompasses an ethical component — endogenous and exogenous — involves that "the 'normative' domain cannot be filled completely by prescriptions, insofar as prescriptions are made after an evaluation of the goals to be achieved by them."[1642] Thus, the prescriptive activity of applied science (that need knowledge about the possible future) requires an evaluation of ends, where ethical criteria (endogenous and exogenous) intervene.

This approach involves assuming a rationality of ends, so scientific rationality is not a simple instrumental rationality. In the case of applied economics, Wenceslao J. Gonzalez notices that "rationality of ends would take charge of drawing the aims of economic prescriptions. This includes several levels: first, the selection of possible *aims*; second, the elaboration of *priorities*, either in terms of a hierarchy of ends within a delimited field or through a consideration of the realms which are or should be priorities; and third, evaluation of the *consequences* which derive from those aims (in economic terms or in other terms: social, cultural, political, etc.)."[1643] This approach is valid for any applied science, so it is not confined to the realm of economics.

In effect, within the sphere of applied science, prediction is related methodologically to the future. Thus, the prediction about the possible future is needed for establishing what should be done.[1644] Thus, prescription seeks to offer solutions in order to resolve the concrete problems posed, so it is of a clear teleological character, In this regard, firstly, the concrete aims are

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[1641] SEN, A. "Prediction and Economic Theory," in MASON, J, MATHIAS, P. and WESTCOTT, J. H. (eds.), *Predictability in Science and Society*, The Royal Society and The British Academy, London, 1986, p. 3.
[1642] GONZALEZ, W. J., *Philosophico-Methodological Analysis of Prediction and its Role in Economics*, p. 327.
[1643] *Philosophico-Methodological Analysis of Prediction and its Role in Economics*, p. 333.
[1644] 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.

selected; secondly, priorities are established regarding the aims; and, thirdly, the possible consequences are evaluated. Certainly, ethical values and problems intervene within each one of these levels.

Regarding the aims, it seems clear that applied science is more connected with the context than basic science, so its social repercussions are also higher. Social incidence of applied research can be either positive (prescription can lead to solutions that provide a social or environmental benefit, for example, the research about renewable energy), or negative or questionable from an ethical viewpoint (for example, the research with military ends). This feature is acknowledged by Rescher, although he is above all interested in the specific problems of basic research.

As Rescher notices, the individual level — the decisions of the scientists — should be distinguished from the institutional level (the research centers where science is developed). Since his ethics of science is focused on persons, he thinks that, at the individual level, "the ethical question of research goals and the allocation of effort—namely that of the individual himself—can arise and present difficulties of the most painful kind."[1645] Thus, when the scientists choose the aims of the research, the decision-making can take into account ethical criteria (for example, "in the choice of a military over against a nonmilitary problem context—A-bombs versus X-rays, poison gas versus pain killers"[1646]).

Meanwhile, at the institutional level, the research centers (public or private) should select the research lines and the concrete ends. In this regard, Rescher notices that, frequently, the choice "is resolved in favor of the applied end of the spectrum by the mundane, but inescapable, fact that

[1645] RESCHER, N., "The Ethical Dimension of Scientific Research," p. 205.
[1646] "The Ethical Dimension of Scientific Research," p. 205.

this is the easier to finance,"[1647] instead of taking into account the social benefit that the research can produce.

Once the realm of the investigation and the concrete aims have been decided, it is possible to order them according to a hierarchy of priorities. Again, here decision-making of scientists themselves and of the institutions where science is developed, as well as the systems of scientific and technological policy (regional, national, and international), intervene. These decisions can be guided by ethically adequate criteria (for example, giving priority to research that can contribute to the common good or can motivate the progress of the discipline) or other criteria, which might be questionable from an ethical viewpoint (for instance, the search for personal or institutional prestige, economic benefit, etc.).

Finally, prescription requires an evaluation of the possible consequences of the results eventually achieved. In this regard, prediction is crucial; because, as Simon notices "we construct and run models because we want to understand the consequences of taking one decision or another."[1648] Thus, in applied science, prediction allows us to anticipate the possible problems, so it precedes and serves as a basis for the prescriptive task of science (for example, the research about the climate change). But prediction has also a role for the anticipation of the possible consequences of the solutions offered. In this way, it also contributes in order to avoid or, at least, to minimize the negative consequences of prescription.

Where the ethical problems posed by applied science are more pressing is — in my judgment — at the level of the consequences; above all, due to exogenous considerations, which have to do with the relation between science and the wider context. Thus, the consequences of the applied research can produce harm to people, society, and the environment. This

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[1647] RESCHER, N., "The Ethical Dimension of Scientific Research," p. 205.
[1648] SIMON, H. A., "Prediction and Prescription in Systems Modeling," *Operations Research*, v. 38, (1990), p. 10.

feature has links with the problem of social responsibility, both of the individual agents (the scientists) as of the groups of agents (laboratories, research groups, etc.).

The problem of social responsibility also affects the means of the research, above all, when the experimentation on human subjects is required. A good example in this regard is provided by clinical research in medicine and pharmacology, where "the fundamental ethical challenge posed by clinical research is whether it is acceptable to expose some to research risks for the benefit of others."[1649] Prediction also has a role here since, in order to weigh adequately the risks and the potential benefits, we need a reliable anticipation of the risks that will be assumed by the experimental subjects and the benefits that will be obtained once the investigation is finished.

Again, the difficulties to make prediction regarding the development of science must be noticed. For this reason, it seems to me that Agazzi is right when he proposes that we should "study the 'reasonably foreseeable' consequences of our choices and select those that do not involve seriously negative consequences, even in the long run."[1650] Regarding this issue, Agazzi's approach has links with Rescher's proposal, which insists that scientific research should be only limited on the basis of serious and actual dangers.[1651]

However, when the research has social incidence (as it is usually the case in applied science), an especially important issue is that related to who should participate in decision-making about the risks that can be considered assumable. Thus, on the one hand, science itself can inform us about the

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[1649] WENDLER, D., "The Ethics of Clinical Research," in ZALTA, E. N. (ed.), *The Stanford Encyclopedia of Philosophy* (fall edition, 2014), *http://plato.stanford.edu/archives/fall2012/entries/clinical-research/*, sec. 9, (access on 20.1.2015).

[1650] AGAZZI, E., "Límites éticos del quehacer científico y tecnológico," p. 258.

[1651] Cf. RESCHER, N., *Razón y valores en la Era científico-tecnológica,* p. 163.

risks and their scope. This feature involves that the standards of proof in applied research should be established taking into account ethical principles and values. In effect, as Carl F. Cranor notices, “otherwise we risk imposing the consequences of poor information, uncertainty, small samples, and scientific skepticism on an innocent public.”[1652]

But, on the other hand, when science is considered as an activity connected with other human activities (social, cultural, political, economic, ecological, etc.), it does not seem adequate that only scientists or experts intervene in the decision-making, because their decisions can affect the wider human experience. For this reason, Rescher is right, in my judgment, when he maintains that “the competing interests should be weighed here: the value of knowledge against people’s well-being. (Those who develop a research are not necessarily the most qualified and the best situated to do the indispensable analysis.)”[1653]

This feature involves that it is indispensable that we find a balance between the autonomy of science and the respect for the exogenous ethical limits, which involve that science should take into account external considerations to scientific activity itself. Thus, on the one hand, “the acceptability of the scientific proposals is an issue that should be completely resolved at the level of internal considerations to scientific endeavor,”[1654] so science is autonomous regarding the criteria of correctness of knowledge. And, on the other hand, it seems clear that society as a whole — and not only the scientists — should participate in decision-making regarding the ethical limits of scientific research (above all, if it is applied research).

[1652] CRANOR, C. F., “Public Health Research and Uncertainty,” in SHRADER-FRECHETTE, K. S., *Ethics of Scientific Research*, p. 185.
[1653] RESCHER, N., *Razón y valores en la Era científico-tecnológica,* p. 163.
[1654] *Razón y valores en la Era científico-tecnológica,* p. 115.

9.4.3. The Problem of the Application of Scientific Prediction: The Variability of Contexts and the Adaptability of the Agents

Besides basic science and applied science, the problem of the application of science must be also considered. Application of science "is concerned with the use of scientific knowledge and methods for the solving of practical problems of action (e.g., in engineering or business)."[1655] In this context of the application of science by agents (either in an individual or in a collective way), prediction has also a role, because it can serves as support for decision-making. This is what usually happens in professional contexts (for example, in medical practice) and in the realms of policy (in economic matters, environmental policy, public health, etc.).

Certainly, the applications of science have clear ethical applications, insofar as the decision-making can affect people, society, and the environment. This feature has to do with three successive levels of the application of science: aims, processes, and results (and their possible consequences). Thus, there are ethical values and criteria at the three levels, so the selection of aims and processes, as well as the evaluation of the results (and the possible consequences) must take into account ethical values and principles.[1656] Because the application of science is directly connected with science as activity (that is, it deals with the relations between science and the context), the values related to social responsibility (that can even lead to a legal responsibility) are especially important.

When the application of science is developed in professional contexts, the existence of deontological codes is especially relevant, since they regulate the professional practices according to ethically adequate criteria at the three mentioned levels (aims, processes, and results). However, "like all rules (…) those in professional codes of ethics will never specify how to apply

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[1655] NIINILUOTO, I., "The Aim and Structure of Applied Research," p. 9.
[1656] Cf. GONZALEZ, W. J., "The Philosophical Approach to Science, Technology and Society," p. 26.

them in all situations. Thus, professional codes of ethics often provide no clear way to distinguish priorities among conflicting obligations (e.g., to employers versus the public), even though they proscribe certain behavior."[1657]

Then, the criterion of the professionals prevails, which transcends the structural dimension of the research and its applications, because it involves a dynamic component, which is oriented towards the free human activity of a social character that is developed in a changing context. In this way, deontological codes might not grasp all the situations, since the decisions with an ethical component have to do, on the one hand, with the relations between the agent or the groups of agents with the context (natural, social, or artificial) and are open to changes; and, on the other, there are variations because of the historicity of the very relations of the researchers, which have interactions among them when developing their professional activity (in business, hospitals, etc.).[1658]

This features are even clearer when the application of science deals with problems related to public health, since in this case there are more agents involved and the relations with the context are also broader, so there are a large number of variables that are not easily predictable. The interest of Rescher in the application of science is at this level, because he is mainly focused on the use of the knowledge about the future in matters related to policy, instead of being focused on professional practices.[1659]

Rescher admits that there might be complexity regarding knowledge when decision-making is at stake. Thus, he notices that "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

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[1657] SHRADER-FRECHETTE, K. S., *Ethics of Scientific Research*, p. 41.
[1658] GONZALEZ, W. J., *Personal Communication*, 2.1.2015.
[1659] Cf. RESCHER, N., "Political Pragmatism," in RESCHER, N., *Pragmatism. The Restoration of its Scientific Roots*, pp. 205-215.

application of 'scientific principles.'"[1660] From this perspective, the application of science, in general, and of scientific predictions, in particular, must deal with the problem of complexity, which has incidence on phenomena in the short, middle, and long run.

However, Rescher does not relate the complexity of the application of scientific knowledge with the *historicity of the human activity*. In effect, he does not address how ethical factors are modulated by the relations with the context (natural, social, or artificial) and by the interactions among the agents themselves who apply scientific knowledge. This is, in my judgment, an indispensable element in order to understand the problems that have to do with the application of science; especially, when those problems are of an ethical character.

In effect, when the applications of science have to do with complex systems (as it is usual the case in the context of policy), the obstacles that make prediction difficult are often related with the historical character of those systems. Thus, prediction and the subsequent prescription — with its expression in terms of planning in order to solve practical problems — should deal with many variables that are open to changes because of the historicity.

This feature poses problems for the application of science, which can also have an ethical component (for example, in issues related to public health, as it happens when there is risk of an epidemic, or in questions related to climate change).[1661] In effect, knowledge about the possible future — the prediction — is required in order to anticipate the possible problem and the consequences of the solutions that might be adopted. However, it is not an easy task, because, as Rescher notices, "the eventual effects of the

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[1660] RESCHER, N., "Political Pragmatism," p. 205.

[1661] See, in this regard, MEARNS, L. O., "Quantification of Uncertainties of Future Climate Change: Challenges and Applications," *Philosophy of Science*, v. 77, n. 5, (2010), pp. 998-1011; PARKER, W. S, "When Climate Models Agree: The Significance of Robust Model Predictions," *Philosophy of Science*, v. 78, n. 4, (2011), pp. 579-600; and PARKER, W. S, "Values and Uncertainties in Climate Prediction, Revisited," *Studies in History and Philosophy of Science, Part A*, v. 46, (2014), pp. 24-30.

measures we take to address the challenges become lost in a fog of unpredictability."[1662]

The lack of reliable predictions that serve as a guide in order to search solutions to the practical problems poses clear difficulties for the process of decision-making. Thus, in this way, the agents' action prevails. They, on the basis of the same applied knowledge, might apply knowledge in different ways taking into account different contexts. So, in the first place, faced with the same problem (for example, risk of epidemic), the different experts or entities which manage an issue might suggest different solutions. And, in the second place, it is also possible that the experts have opposite opinions regarding the consequences of the solutions suggested.[1663]

On this problem, Rescher thinks that very often it is not possible a direct transfer of the solutions suggested by the scientists in order to solve practical problems. For this reason, he notices that "we very much need them [the experts] to indicate alternatives, clarify issues, assess consequences, evaluate assets and liabilities, and generally work to inform the public debate on the issues. But we emphatically do *not* need them to decide matters. By all means let them [the experts] do their work and have their say about it. But when this is said and done, then by all means let the people decide."[1664] Here, the main problem is the allocation of responsibility, because, when the decisions are collectively made, responsibility (both moral and legal) tends to fade.[1665]

In my judgment, Rescher suggests a rejection of a naive view regarding the ability of science to offer solutions to practical problems of action. Thus, he thinks that the rational procedure in decision-making regarding issues of

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[1662] RESCHER, N., "Technology, Complexity, and Social Decision," p. 89.

[1663] These kind of problems are also frequent in professional practices (for example, when several physicians disagree about the best way of treating a patient).

[1664] RESCHER, N., "Risking Democracy (Some Reflections on Contemporary Problems of Political Decision)," in RESCHER, N., *Sensible Decisions*. *Issues of Rational Decision in Personal Choice and Public Policy*, p. 121.

[1665] Cf. RESCHER, N., "Collective Responsibility," pp. 137-138.

public interest "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."[1666] Therefore, scientific knowledge, in general, and knowledge about the future, in particular, can serve as a guide for decision-making, but they do not offer univocal solutions to the problems.

All these considerations emphasize the importance of the ethical values and principles to address the problems related to the application of science. But this task requires taking into account the historicity of the human activity developed within a context (social, cultural, political, economic, ecological, etc.), which is open to changes. Thus, on the one hand, historicity makes prediction difficult, so it hinders its role as a guide for the solution of practical problems; and, on the other, historicity modulates the ethical factors that intervene in the application of science according to the aims, processes, and results (and their possible consequences). Due to his lack of attention to historicity, Rescher's approach does not encompass — in my judgment — all the elements at stake when the ethical problems posed by prediction in the realm of the application of science are analyzed.

[1666] RESCHER, N., "Political Pragmatism," p. 212.

CONCLUSIONS

There have been two the axes of this research. First, the philosophico-methodological characteristics of scientific prediction in Nicholas Rescher's account have been investigated in this Ph.D. research according to different thematic realms. There have been seven perspectives of the philosophical analysis: semantic, logical, epistemological, methodological, ontological, axiological, and ethical. These perspectives have been frequently used by Wenceslao J. Gonzalez for philosophical reflection on science. Second, in connection with the philosophical analysis of each one of these thematic realms of scientific prediction, a critical reconstruction of Rescher's philosophy of science has been made, which can be characterized as pragmatic idealism. Generally, it must be emphasized that there are many adequate proposals within his characterization of scientific prediction, but there are also some points that — in my judgment — are unsatisfactory.

1) When Rescher addresses the problem of scientific prediction, his proposals are modulated by his own system of thought. Thus, the aspects of scientific prediction — semantic, logical, epistemological, methodological, ontological, axiological, and ethical — are interrelated, since they are integrated within a *system* of thought. This system is a pragmatic idealism open to elements of realism. He configures it in a way that avoids a merely eclectic approach. In effect, he achieves a coherent articulation of a version of *conceptual idealism*, which is combined with a pragmatic proposal that follows Charles S. Peirce's tradition, which is in turn compatible with realistic elements (above all, those that have to do with the notions of "objectivity," "fact," and "truth").

However, when Rescher is concerned with philosophical realism, he does not adequately grasp some realist proposals, such as the current conception of scientific realism; in particular, critical scientific realism. Thus, his view reduces scientific realism to a naïve realism, so he thinks that this philosophical doctrine is not compatible with fallibilism. In this way, he rejects a realist approach that, to a large extent, is a version constructed by him, instead of being a genuine approach of current scientific realism.

But, at the same time, Rescher accepts notions and proposals that are clearly realist, since he seeks to connect his approach with real science. I consider that this background component — the nexus with scientific practice — is quite interesting and, furthermore, is crucial in his philosophy of science. Moreover, it is especially important for the problem of prediction. In fact, a thorough approach to scientific prediction requires, in my judgment, accepting the existence of an extramental reality, whose properties are accessible to the knowing subjects, so the scientific knowledge about the possible future can be objective and, on this basis, can become true.

2) Within his philosophical system — pragmatic idealism open to elements of realism — Rescher offers a characterization of scientific prediction. His approach is coherent with the general coordinates that modulate his thought. His proposal about prediction is certainly sound, since in his approach there is explicit attention to the different components of scientific prediction (semantic, logical, epistemological, methodological, ontological, axiological, and, to a lesser extent, ethical). However, although Rescher notices that he seeks to configure a broad theory of prediction, his proposal is certainly limited, insofar as he does not take into account some aspects that I think that are important.

In this regard, several aspects should be noticed. (i) Usually his attention goes to the realm of natural science, without paying enough attention to other fields of the empirical sciences. (ii) Moreover, he is mainly focused on basic science, where he highlights the role of prediction as a test for scientific theories, since he insists in prediction as an indicator of scientific progress. This makes it possible to broaden his approach, in order to consider prediction in applied science and in the application of science. (iii) There are also problems that have to do with the social sciences and the sciences of the artificial, which Rescher does not take into account. Thus, he does not go more deeply into some issues (for example, the use of prediction as a test in economics). (iv) He pays no attention to the historicity (of science, the agents, and the reality itself researched, above all, social and artificial). I think that this is an important gap in his approach to prediction in the different realms considered.

3) When Rescher analyses prediction from language, his starting point is a pragmatic conception, where the view of meaning as use has primacy. However, he admits that language can be evaluated in terms of objectivity and truth (or, at least, truthlikeness). In my judgment, this is a wise choice in his approach, since he avoids reducing meaning to a mere intersubjective use of language, insofar as he admits an objective basis in its content. From this perspective, his approach makes it possible to characterize scientific prediction as a statement that can have an *objective content*.

From the idea of prediction as statement that is about non-observed (or now unobservable) phenomena, Rescher suggests four main features in order to characterize a prediction: (i) it is oriented towards the future; (b) it is correct or incorrect; (c) it is meaningful; and (d) it is informative. In my judgment, it is possible to broaden this characterization if it is highlighted that prediction has to do with *something expected*, so it is related to novelty. From this viewpoint, scientific prediction is connected with the notion of "novel facts," which involve novelty in some relevant sense (ontological, epistemological, or heuristic).

4) Although Rescher tries to offer an exhaustive characterization of the concept of "prediction," the barriers between scientific prediction and non-scientific prediction are not always clear in his approach. He does distinguish prediction from mere prophecy, but there is not a clear differentiation

between scientific prediction and other kinds of rational predictions (for example, those that an agent can make on the basis of his experience). Undoubtedly, the demarcation between “scientific prediction” and “non-scientific prediction” is necessary.

In this regard, Rescher thinks that the difference is in the processes used in order to predict, so scientific prediction is that obtained through the use of scientific methods of prediction (for example, predictive models). Therefore, he does not take into account the differences regarding language, which can be also crucial. Thus, in order to distinguish a scientific prediction from a non-scientific prediction, the rigor in language should be also considered (for example, the precision and accuracy in the sense and reference of the terms used).

5) Furthermore, in order to achieve a comprehensive account of prediction, a higher rigor regarding language is required. Thus, in my judgment, the distinction between the different possible types of scientific prediction is necessary. In this point, Rescher’s approach can be revised in order to go more deeply. In effect, he contemplates some distinctions that have to do with the language of prediction. In this regard, he distinguishes qualitative and quantitative prediction, as well as generic and specific prediction.

But these distinctions are not good enough in order to encompass the entire possible field. In effect, it is also important to differentiate the types of prediction, such as “foresight,” “prediction,” “forecasting,” and “planning.” In my viewpoint, it is desirable to achieve a typological variety in the realm of scientific prediction, which has been already achieved in the field of scientific explanation. For this reason, Rescher’s approach to the semantic features of prediction should be broadened in the direction mentioned.

6) Seen from the logic of science, where the attention goes to the structural aspects of the scientific theories, Rescher is right when he

maintains that there is a *logical asymmetry* between explanation and prediction, so a structural equivalence between both processes can be rejected. Moreover, his criticism to the symmetry thesis goes further than the logical realm, so he also gives reasons that show asymmetry in the semantic, epistemological, methodological, and ontological levels. In this regard, he thinks that predicting and explaining are coordinated processes, so science should search for a harmony between explanation and prediction. In this way, Rescher rejects the instrumentalist predictivism too, and he adopts a moderate version of predictivism, which is — in my judgment — a more adequate approach to scientific practice.

Furthermore, the perspective of *temporality* — the temporal anisotropy between explanation and prediction — may give more elements in favor of the asymmetry thesis than those suggested by Rescher. On the basis of this perspective, there is an adequate framework in order to analyze other two questions of logical character that are not exhaustively considered by Rescher: (i) the possible equivalence between "retrodiction" and scientific explanation; and (ii) the problem of the logical equivalence between prediction and "retrodiction," which is usually connected with the acceptance of a genuine "prediction of past." According to the research made, rejecting both logical equivalences is — in my judgment — the most acceptable position.

7) Among the logical components of scientific prediction, its nexus with the problem of *induction* should be emphasized. Regarding this issue, Rescher offers a characterization of induction as an estimative procedure, instead of being properly a form of inference. On this basis, he develops pragmatic reasons for the justification of induction. This involves a change in the approach, since it means the abandonment of the strictly logical perspective — which was influent over decades — in favor of a

epistemological approach to induction, which also has clear methodological repercussions.

From a pragmatic perspective, Rescher offers a solution that — in my judgment — is coherent with his philosophy of science, in general, and his methodological pragmatism, in particular. His proposal is oriented toward problem-solving, so the justification of induction as a predictive procedure appears in practical terms. It is ultimately rooted in the capacity of those procedures — that are supported by induction — to obtain successful prediction. By insisting on the pragmatic justification of induction, it is highlighted that the different constitutive elements of science are interrelated as a system in Rescher's approach.

8) The express acceptance of induction for prediction leads to the problem of the limits of deductivism for prediction. This issue is especially important for Rescher, since his methodological pragmatism cannot be supported by only deductive bases. In effect, his methodological pragmatism needs to use the performance of the processes (among them, the inductive procedures) in the past as a predictive indicator of their success in the future. This involves an element of induction, since making an inference that goes from the past to the future is one of the modes of inductive inference contemplated by Rescher.

This feature is an important contribution, because it seems to me that the elements offered by Rescher — and Wesley Salmon's criticism in this regard — emphasize the insufficiency of deductivism to solve the problems posed by scientific prediction. Therefore, a logical-methodological approach to scientific prediction of an exclusively deductive character — as that suggested by Karl Popper — does not allow us to grasp all the elements that are at stake when prediction is analyzed from a logical perspective.

9) Epistemologically, scientific prediction is related to the theory of rationality in Rescher's approach. In this regard, his approach is broader than

the proposals of other philosophers, such as Herbert A. Simon. The main difference between them is the evaluative rationality, which Rescher expressly assumes. With evaluative rationality the preferability of the ends is taken into account, instead of only considering what is preferred or just accepting the ends as given. The attention to the rationality of ends or evaluative rationality is connected with the axiology of research, since the selection of ends must be made according to values (internal and external). Thus, the epistemological and axiological realms are closely related in Rescher's philosophy of science.

On the one hand, Rescher sees scientific knowledge as the result of a goal oriented activity, and these goals are selected according to values. On the other hand, his axiology of research gives primacy to cognitive values. When this approach is applied to scientific prediction, the most important aspect is — in his proposal — the cognitive content of the prediction, which should have a series of epistemological values (coherence, accuracy, precision, etc.). But he is certainly aware of the difficulties in predicting the possible future in a reliable way. Thus, his approach is in no way naïve, but he maintains a fallibilistic view of scientific knowledge, especially when this knowledge is about the future, which, in principle, has many possibilities.

10) Within a fallibilistic epistemological framework, Rescher defends the possibility of obtaining true (or, at least, truthlike) predictions. For this reasons, he emphatically rejects the "non-reasoned predictions:" these do not make science. However, he excessively highlights the pragmatic dimension, since he maintains that the main difference between reasoned and non-reasoned predictions is rooted in the fact that the second ones have not practical utility. In this respect, he disregards, to some extent, the theoretical dimension of prediction. This means that the demarcation between scientific predictions and non-scientific predictions is not always clear in his approach.

His fallibilism has distinctive features. Rescher has his own conception of truth as "coherence," but he also assumes a realist approach to truth as correspondence, when statements about natural phenomena are considered. His fallibilism is also pragmatic, so there is an interaction with nature that leaves research processes open. For this reason, his view of prediction — which admits the possibility of achieving true statements — does not accept a "perfect science," where all our questions can be solved. This involves an intrinsic revisability of our predictive knowledge. But again his approach is limited to the realm of basic science; he scarcely pays attention to prediction in applied science or its role regarding the application of science, although he is aware that agents use prediction for decision-making in practical contexts.

11) Besides the importance of the rational bases in order to achieve successful predictions, Rescher highlights the epistemological obstacles to prediction. In effect, the analysis of the limits to predictability is one of his main contributions to the problem of scientific prediction. In this regard, he highlights the epistemological and ontological limits, which he tries to make explicit. Undoubtedly, this is a crucial problem in the study of prediction, since it allows us to illuminate the difficulties of the predictive task.

However, two limitations should be mentioned. On the one hand, Rescher is mainly focused on the natural sciences within a context that is directed, above all, to basic research. A more exhaustive approach to the epistemological limits to predictability should take into account — in my judgment — all the empirical sciences, as well as the different types of scientific activity (basic, applied, and of application). On the other hand, his perspective on the epistemological limits is mainly structural, so he does not take into account the problems related to the historicity of knowledge. This feature can be seen, above all, when he considers the problems related to the prediction of the future advancement of science.

12) The most sound contributions of Rescher to the problem of scientific prediction are placed — in my judgment — in the methodological realm. His methodological proposal is in the framework of a methodological pragmatism, which highlights the importance of prediction for scientific practice, above all since predictive success can be used as an indicator to evaluate scientific progress. Thus, his methodological approach involves an instrumental approach to prediction, which emphasizes the value of predictive success as a criterion to assess the comparative theoretical adequacy of theories.

But his predictivism is a moderate version that explicitly rejects the instrumentalist predictivism without realism in the assumptions, which was the version defended by M. Friedman. In this regard, Rescher develops a proposal that — in my judgment — is assumable, but that needs some qualifications. Certainly, Rescher's methodological pragmatism does not grasp the entire scientific realm. In effect, there are theories only oriented towards explaining past phenomena, so their truthlikeness cannot be evaluated on the basis of pragmatic criteria, such as the predictive success of the efficacy in controlling phenomena. This can be seen in human and social sciences such as history, which mainly seek the explanation of past events, instead of providing predictions about future events.

13) Moreover, the view of prediction as a cognitive tool does not involve that it is used in the same way in every context. We have to distinguish, in this regard, the roles of prediction in the realms of basic science, applied science, and the application of science. In the context of basic science, scientific prediction can be seen as an indicator to evaluate the truthlikeness of the hypotheses and theories. This is because in basic science, prediction can be used as a scientific test. But the role of prediction in applied science and in the application of science must be also considered.

Rescher scarcely pays attention to the role of prediction as a guide for prescription in applied sciences. This is because, in Rescher's thought, pragmatism goes hand in hand with a Kantian approach, so prediction is mainly a cognitive content that is valuable by itself. At the same time, he is interested in the nexus between prediction and human action. But he does not offer an exhaustive analysis of prediction as a guide for the problem-solving task developed by the applied science. Meanwhile, he is more interested in researching the use of prediction by agents (that is, the application of science), both in an individual way — in the everyday actions — and in a collective way (in policy issues).

14) There are also methodological differences that affect prediction according to the variety of realms of reality (natural, social, and artificial). Moreover, within each group of sciences as well as within each science there are variations in the methods according to the questions posed and the phenomena that we want to predict. This feature is admitted by Rescher, so he clearly rejects the methodological universalism and is in favor of a methodological pluralism. This is, in my judgment, the most assumable approach in this regard.

But it should be emphasized again that Rescher's interest in prediction is preferentially centered in the realm of the natural sciences, so he does not go more deeply into certain specific issues of the methodology of the social sciences. Moreover, he does not take expressly into account the science of the artificial. On the one hand, this means that his approach to prediction should be broadened in order to grasp other realms that he does not contemplate. And, on the other hand, it highlights that his research into some issues needs more development. This can be seen, for example, when he addresses the problem of complexity in the social sciences. In this regard, he offers an analysis that is too generic, against the thoroughness that is characteristic of his proposals about the methodological repercussions of complexity in the natural sciences.

15) Although Rescher is preferentially focused on the natural sciences and basic scientific activity, there is in his approach a clear concern to clarify the common bases of the different predictive procedures. Thus, one of his most valuable contributions to the problem of prediction must be placed in the methodological realm. This contribution deals with the "preconditions for rational prediction," which are the *previous* and *necessary* conditions for the processes oriented toward predicting: data availability, pattern discernability, and pattern stability.

This is an adequate synthesis — in my judgment — of the necessary preconditions for predictive success, which involves the different relevant factors from a methodological perspective. Moreover, from the viewpoint of the preconditions for rational prediction, it is possible to go more deeply into the study of the limits to predictability. In effect, the analysis of these preconditions has highlighted the methodological repercussions of the epistemological and ontological obstacles to scientific prediction, where factors such as anarchy, volatility, chaos, chance, or uncertainty must be highlighted.

16) Besides the common bases of the predictive processes, Rescher offers a very detailed framework of the different predictive processes, which involves attention to their specific features. He classifies the predictive processes into two main groups: (i) *estimative* or *intuitive procedures* and (ii) *formalized* or *discursive methods*. The former are developed on the basis of the personal estimations of the experts, such as in the case of the Delphi procedure (which Rescher contributed to design). Nevertheless, the formalized methods follow a series of well-articulated rules of inferential principles. In turn, these can be divided into two types: a) *elementary* discursive processes, such as trend projection or the use of analogies; and b) *scientific* discursive processes, as the inference from laws and the predictive models.

Rescher's framework about the predictive processes is relevant. It allows us to highlight the reliability and characteristics of the different predictive *procedures* and *methods*. Certainly, the level of rigor and sophistication in the processes is different in each case, and it varies from the lowest level — the estimation by experts — to highest level of rigor, which is achieved when properly scientific methods are used (as in the case of the predictive models or the inference form laws). Furthermore, the rigor in the processes has repercussions in the reliability of the predictions. From this perspective, predictions obtained through estimative procedures (where some cognitive biases can intervene) seem to be, in principle, less reliable than the predictions that are the result of the use of genuinely scientific methods.

17) The highest level possible of rigor is achieved by the discursive scientific methods. Rescher considers some of these scientific methods of prediction: a) the use of correlations as predictive indicators, b) the inference from scientific laws, and c) the use of models oriented towards predicting. Although his analysis in this regard is certainly broad-ranging, it seems to me that a crucial element is absent: the attention to parsimonious factors. This important gap in his approach especially affects the study of the predictive models, above all when these have to deal with problems of complexity.

In effect, the attention to the methodological conception of parsimonious factors can be the basis to overcome the limits that can lead to designing non-realist models. In my point of view, parsimonious factors allow us to focus on the necessary and sufficient factors in order to encompass a system. This is also very important in order to deal with complexity, which is a feature that often makes prediction about some systems (for example, in biology or economics) very difficult.

18) Ontologically, the study of scientific prediction must take into account the characteristics of the reality prediction is about, which can be a

natural, social, or artificial reality. For Rescher, the characteristics of the phenomena that we want to predict have epistemological and methodological repercussions on prediction. In this regard, he considers that natural phenomena are generally more stable than social phenomena. Consequently, the unreliability of prediction is a more frequent problem in social sciences than in natural sciences.

But his analysis rarely goes further. Rescher does not go deeply into the specific characteristics of the social reality and he does not consider the artificial realm. In this regard, he does not pay attention to a crucial element for prediction in these realms: *historicity*. In effect, both social and artificial realities are historical by themselves: historicity is a key feature of social and artificial systems. Thus, there is a component of variability that adds complexity to prediction in these realms of social reality and artificial reality (where creativity also pays a role).

19) It seems clear to me that *complexity* is a crucial aspect for the study of the ontological characters of scientific prediction. Certainly, complexity (both epistemological and ontological) has relevance for the analysis of scientific prediction and its characteristics. So, to the extent that prediction has to do with a complex reality (natural, social, or artificial), two problems appear: 1) complexity has repercussions on the very possibility of predicting, and 2) it has also repercussions on the kind of prediction that is achievable (in relation to its reliability, accuracy, precision, etc.). This is clearer when complexity is seen as a twofold notion: it has a structural dimension and a dynamic component.

Certainly, Rescher's approach to complexity is more thorough than other authors' conceptions. However, his proposal is too focused on the structural dimension of complexity and he frequently disregards the dynamic component. In my judgment, a broader approach to complexity should take also into account complex dynamics, which is connected with the notion of historicity. In effect, as Wenceslao J. Gonzalez has emphasized, historicity allows us to characterize the chance in complex dynamics (both “internal” and “external”) as well as to recognize its repercussions in scientific prediction, in general, and in prediction in social sciences and the sciences of the artificial, in particular. In Rescher’s ontology of prediction, there is no such acknowledgement of the role of historicity, which is a crucial feature of science, the agents, and the reality researched (above all, social and artificial).

20) A thorough conception of scientific prediction must consider (i) the diversity of the reality (natural, social, and artificial) that is studied by science, and (ii) the acknowledgement of its complexity, both according to its structure and its dynamics. In this thematic context, the ontological obstacles to prediction (due to the very character of the phenomena) are a crucial issue. It must be noticed that one of Rescher’s main contributions to the problem of scientific prediction is — in my judgment — the identification and analysis of the obstacles to predictability (above all, epistemological and ontological). Within the ontological obstacles, he considers several of them: (i) anarchy and volatility; (ii) chance, chaos, and arbitrary choice; and (iii) creativity.

Although Rescher’s framework about the ontological obstacles to predictability is broad, there should be — in my judgment — a further development of the problem of human creativity. In order to make this analysis, it seems to me that two successive dimensions of creativity should be taken into account: a) *creativity* as an element that *configures the subject matter* of science (the economic, social, cultural, or political reality), where the activity of the agents might generate changes that involve novelty; and b) creativity as a factor that *intervenes in the scientific activity of research* (either basic or applied), which is important both from a structural viewpoint and from a dynamic perspective. In the first case, creativity can be a clear obstacle to prediction (above all, in the social and artificial realms); while, in the second level of analysis, agents' creativity can contribute to overcome the not-predictability of certain phenomena and events.

21) When prediction is addressed from the axiology of research, it can be seen that Rescher follows preferentially a structural approach. The internal values have primacy, above all, the epistemological and methodological ones. Regarding the structural dimension, his approach to the relation between scientific prediction and values is certainly broad. In fact, he takes into account three successive levels: a) the values of the predictive questions; b) the values of the statements about the future; and c) the elements in order to evaluate the task developed by predictors and predictive methods.

Although Rescher clearly gives primacy to the structural dimension, his proposal has original features: he offers an approach of holism of values. This feature allows him to configure a *broad* axiology of research, in which the internal dimension and the external component of analysis are interrelated. Within this framework, the distinction regarding values ("structural" versus "dynamic," "internal" versus "external") does not properly allow a *separation*: there is only a distinction. In effect, he thinks that all the values are interrelated within the system of values.

22) Insofar as Rescher's conception is offered as a pragmatic idealism, his view on values is idealistic to the extent that it is a *system*, and its pragmatic component leads him to think in terms of activity and *primacy of practice*. Prediction — in his approach — is related with this system of values and, furthermore, it appears as a necessity of the scientist in order to address different problems. Moreover, prediction as such has value in his system, but his predictivism is moderate, instead of being purely instrumental. Also, prediction has value for the processes and the results: it is important for the human activity of addressing problems.

From this perspective, Rescher's axiology of scientific research can be compatible with a dynamic approach. However, he does not develop in an articulate way that dynamic dimension of the relation between prediction and values, precisely because he does not highlight the *historicity* of the scientific activity. Consequently, his approach does not emphasize the external values that accompany science, in general, and scientific prediction, in particular. For this reason, although his approach is broader than other axiological proposals, the attention to the dynamic component (internal and external) is, in my judgment, required.

23) This leads — in my view — to the need of broadening his proposal. This should be done through the analysis of prediction and the connected values in a conception open to the dynamic perspective, both internal and external. To do this, the differences between three types of activities must be taken into account: basic science, applied science, and the applications of science. When the attention goes to the internal dynamics, it can be seen how prediction and the connected values have a crucial role in the evaluation of the scientific activity (basic, applied, or of application), where there is an articulation of aims and processes, which can lead to some results.

Moreover, the scientific activity is carried through within a context (historical, social, cultural, political, ecological, etc.), which is changeable. This external dynamics of the scientific activity involves that, besides the internal values to scientific activity by itself (for example, cognitive values), there are also external values. These external values affect science according to its connection with other human activities (social, political, economic, ecological, etc.). Since Rescher is mainly interested in basic science, external values are not exhaustively considered in his approach. In effect, the external component especially affects the applied sciences, where prediction is usually the previous step to prescription, and it also has to do with the application of science, where prediction can be the basis of decision-making.

24) His philosophy of science pays special attention to the ethics of scientific research. But when Rescher suggests his theory of prediction, he does not develop the study of scientific prediction from the ethics of science. In this regard, his ethical proposal regarding scientific practice is coherent with his pragmatic idealism open to elements of realism. On the one hand, Kantian influence is highlighted, insofar as he proposes that morality should be grounded in the mind; and, furthermore, he seeks universal ethical values and principles. And, on the other hand, he thinks that science is modulated and conditioned by ethical values, since it is a human and free activity, which is oriented towards ends.

Again, the acceptance of elements of realism allows him to configure an assumable approach, where the ethical values have objective bases. In this way, ethical relativism is rejected, and he also avoids reducing the ethics of science to a merely descriptive discipline. However, Rescher gives an excessive primacy to the internal factors to scientific activity, and gives less weight to the external factors to science. A broader approach to the ethics of science should take into account, in my judgment, two dimensions of analysis: a) the endogenous ethics, which is oriented towards *scientific activity* by itself, so it can be seen that there are values in the aims, processes, and results of the scientific endeavor; and b) the exogenous ethics, which analyses *science as activity*, so it highlights that there are ethical values that connect science with the context (social, cultural, political, economic, ecological, etc.).

25) When this double dimension of analysis is taken into account, a more exhaustive study of the relation between scientific prediction and ethical values is possible. From this perspective, it seems clear that when the problem of the ethical limits of scientific research and their repercussions on

prediction is addressed, there are more questions at stake than those considered by Rescher. In effect, in his approach, the ethical limits are mainly oriented towards scientific activity. In this way, he usually disregards the external dimension, where science as activity is considered.

This is because, on the one hand, Rescher is above all interested in basic science, where the external factors are usually less important than in the cases of applied science and the application of science. And, on the other hand, it has to do with the primacy of the structural approach, which involves a static perspective about the relation between science and ethical values, in general, and about the problem of the ethical limits of research, in particular. For this reason, although he takes into account the context (social, cultural, political, economic, ecological, etc.), he does not highlight the notion of *historicity*, which — in my judgment — is required in order to adequately develop the dynamic component of the ethics of science.

26) The dynamic component of analysis involves diversity in the approach. Thus, the study of the relations between science and ethical values should take into account three different realms: basic science, applied science, and the application of science. In effect, in each one of these realms, the ethics of science has special characteristics, since these are different kinds of activities. The relation between scientific prediction and ethical problems (which has specific features in each one of these human activities) is modulated by the different internal configuration of each one of the three activities (basic, applied, and of application), as well as their own features regarding the external dynamics.

If the relation of prediction to ethical values is addressed in a context of basic science, the aspect of the cognitive content by itself should be distinguished from the dimension of the human and free activity. Thus, regarding the cognitive content, it does not seem that prediction is susceptible of ethical evaluation. But, from the viewpoint of the consequences, prediction can be an object of ethical evaluation, above all when the basic research is connected with applied science, because it can have a negative incidence on the persons, the society, and the environment.

In the cases of applied science and the application of science, the relation of prediction with ethical values is clearer. Above all, this can be seen regarding the external dimension of analysis, because the nexuses with the context are more direct. In the applied sciences, prediction can pose ethical problems because of its relation with prescription, which is oriented towards suggesting solutions to concrete problems. Meanwhile, in the application of science, prediction can be the basis for the decision-making of the agents (individual or social), where issues of ethical character must be considered. Regarding these realms, Rescher's analysis does not achieve the same level of detail as his reflections oriented towards basic science.

27) Following the two axes of this research — the philosophico-methodological analysis of scientific prediction in Rescher's account and the critical reconstruction of his philosophy of science using his approach to prediction — an overall result seems clear to me. On the one hand, he has made a real contribution to the topic of prediction seen in philosophico-methological terms. But some aspects can be improved (e.g., the role of applied sciences), while others, in principle, cannot be reached because of his explicit conceptual idealism (such as the relevance of historicity for scientific prediction, mainly in social and artificial sciences). On the other hand, Rescher has been able to construct his own system of thought instead of being focused on a parcel of the philosophical enterprise. Nevertheless, although his vision is wide and the number of topics discussed is broad, there are elements missing in his system, such as the genuine dynamic factors of complexity or the relevance of contextual aspects (social and institutional). Once again, he has quite interesting ideas but his system cannot cover the whole field at stake.

BIBLIOGRAPHY

This bibliography is organized in three sections, according to the importance of the different publications for the present Ph.D. research. I) *Sources* includes papers, books, and chapters of books that have been more relevant in the present philosophical research regarding the two central objectives of the research: Nicholas Rescher's conception of scientific prediction and the reconstruction of his philosophy taking into account this perspective. Thus, there are publications related to his views (mainly on scientific prediction and Rescher's system of philosophy) or in order to broaden his approach. II) *Complementary publications* lists a set of important resources in this study, but that are not as relevant as the sources. III) *Secondary bibliography* offers additional pieces of information, especially on collateral aspects regarding this research as well as topics that are addressed here just in an indirect way.

I. Sources

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ANEXO

Resumen de la Tesis Doctoral *Scientific Prediction in Nicholas Rescher's Conception: Philosophico-Methodological Analysis* (*La predicción científica en la concepción de Nicholas Rescher: Análisis filosófico-metodológico*)

El problema de la predicción científica es, sin duda, un tema central para la Filosofía y Metodología de la Ciencia. Lo es a tenor de su relevancia para la práctica científica en las diversas Ciencias Empíricas (de la Naturaleza, Sociales o de lo Artificial), donde la predicción científica cubre varios cometidos, como ha resaltado Wenceslao J. González. Así, la predicción puede ser un test acerca de la índole científica de las hipótesis y teorías (Ciencia Básica), antecede a la prescripción orientada a resolver problemas concretos (Ciencia Aplicada) o sirve de apoyo para la toma de decisiones en contextos prácticos de actuación (aplicación de la Ciencia).

Sucede que, cuando se piensa en los objetivos de la investigación científica básica, es habitual que se destaquen dos: (i) la explicación de los fenómenos del pasado (sucesos, eventos, …), y (ii) la predicción del futuro posible (los acontecimientos del futuro). En el caso de los objetivos de la investigación científica aplicada, se resalta primero la predicción de posibles acontecimientos (sucesos, eventos, tendencias, etc.), como paso previo a la prescripción de las pautas de actuación. Y, cuando se trata de la aplicación de la Ciencia, los agentes necesitan pensar en el futuro posible antes de decidir cómo actuar en un contexto dado.

Pero, pese a la triple relevancia filosófico-metodológica de la predicción científica, se le ha dedicado mucha menos atención a la predicción científica que al estudio de la explicación científica. Esto se aprecia en el número de publicaciones al respecto, que es manifiestamente superior en el caso de la explicación científica. Ahora bien, con frecuencia la predicción aparece como un concepto clave para el estudio de otras cuestiones que atañen a la Filosofía y Metodología de la Ciencia, tales como el progreso científico, la complejidad o los límites de la Ciencia.

I. Contexto temático de la investigación y objetivos fundamentales

Dentro del panorama contemporáneo, ocupa la contribución de Nicholas Rescher un lugar destacado en la reflexión filosófica acerca del problema de la predicción. Porque, por un lado, la predicción científica aparece como un concepto clave dentro de su Filosofía de la Ciencia. Así, su idealismo pragmático pone de relieve la importancia de la predicción científica como tema de reflexión para la Filosofía de la Ciencia. Por otro lado, tiene trabajos en los que analiza la predicción científica desde diversos ángulos (donde destaca habitualmente las vertientes epistemológica y metodológica). De este modo, ofrece una concepción rigurosa de la predicción, donde el análisis alcanza una gran profundidad de detalle y una inequívoca riqueza de matices.

Tanto por la importancia de la predicción como por la relevancia del planteamiento de Rescher, resulta pertinente llevar a cabo un análisis filosófico-metodológico de su concepción de la “predicción científica”. Está claro que es uno de los autores que más han contribuido a la reflexión acerca de este asunto, que es clave para la Ciencia. Además, Rescher ha desarrollado un planteamiento filosófico propio: el idealismo pragmático. Así, aunque la investigación que se enfoca aquí desde la Filosofía de la Ciencia, también se presta atención a sus aportaciones a la Filosofía en general. Se hace, en primer lugar, en la medida en que conectan con su Filosofía de la Ciencia y pueden ser relevantes para el estudio de la predicción científica. Y, en segundo término, para reconstruir críticamente su concepción filosófica.

Dentro de este marco —un tema relevante visto clave filosófico-metodológico y en un pensador contemporáneo influyente— la presente

Tesis Doctoral tiene dos objetivos fundamentales. 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: el semántico, el lógico, el epistemológico, el metodológico, el ontológico, el axiológico y el ético. Estos ámbitos temáticos para el análisis de la predicción científica, propuestos por Wenceslao J. González, se fundamentan en que los diversos componentes de la Ciencia (el lenguaje, la estructura, el conocimiento, los procesos, la actividad, los fines y los valores) pueden orientarse a lo futuro, de modo que tienen relevancia para el concepto de predicción.

En segundo término, la investigación se orienta a reconstruir críticamente la Filosofía de la Ciencia de Rescher, que cabe caracterizar como un idealismo pragmático, que está abierto a elementos relevantes de realismo. Esta segunda línea se desarrolla de manera paralela a la primera —los rasgos filosófico-metodológicos de la predicción científica—, puesto que, en el planteamiento de Rescher, el idealismo pragmático modula los caracteres de la predicción. Esto se debe a que su Filosofía de la Ciencia mira a un *sistema*, de manera que los ámbitos temáticos para el análisis de la predicción científica están interconectados dentro de un sistema de Pensamiento.

Conviene resaltar que Nicholas Rescher, nacido en Alemania en 1928 y afincado en Estados Unidos desde los nueve años, ha desarrollado una importante contribución filosófica en múltiples campos, entre los que destacan sus aportaciones al problema de la predicción científica. A este respecto, sus aportaciones han sido teóricas —al abordar un buen número de problemas— y prácticas, pues es uno de los creadores del procedimiento predictivo Delphi. Entre sus contribuciones teóricas cabe mencionar su trabajo de 1958 “On Prediction and Explanation”, donde cuestiona la simetría lógica entre explicación y predicción, entonces dominante, y su libro

Predicting the Future, donde por vez primera se ofrece un estudio sistemático filosófico-metodológico sobre la predicción científica, a partir de varias vertientes relevantes (en especial, la epistemológica, la metodológica y la ontológica).

Además de atender al problema de la predicción científica en distintas vertientes, Rescher ha ofrecido un *sistema de Pensamiento*; esto es, ha proporcionado una concepción propia de la Filosofía, en general, y de la Filosofía de la Ciencia, en particular. Su postura —el idealismo pragmático— comprende elementos contemporáneos influyentes —como el pragmatismo—, pero su postura idealista hace que tenga rasgos bien distintos al frecuente naturalismo de las últimas décadas. Con frecuencia, su posición tiene el sello de la originalidad.

Hay, por tanto, dos ejes en este estudio, que son complementarios: el análisis filosófico-metodológico de la predicción científica en Rescher y la reconstrucción crítica su sistema de idealismo pragmático a partir de su concepto de "predicción". Para desarrollar estos dos ejes de manera que se puedan apreciar las relaciones entre ambos, la Tesis Doctoral se estructura en tres partes, a tenor de un criterio temático. Esas tres partes son las siguientes: I) Coordenadas generales, rasgos semánticos y caracteres lógicos de la predicción científica; II) Conocimiento de predicción y procesos predictivos en el pragmatismo metodológico; y III) De la realidad a los valores: Rasgos ontológicos, elementos axiológicos y caracteres éticos de la predicción científica.

Cada capítulo, en la medida de lo posible, tiene de alguna manera "entidad propia," puesto que el foco de análisis es distinto (semántico, lógico, epistemológico, metodológico, ontológico, axiológico y ético). No obstante, los capítulos están conectados entre sí y lo están en las dos direcciones que sigue la investigación: el estudio sobre la predicción científica y la reconstrucción crítica del Pensamiento de Rescher. Así, en principio, cada capítulo busca dar todas las claves para abordar los problemas, aunque esto pueda comportar alguna repetición, que cuando se da está pensada para facilitar el hilo conductor del presente estudio.

II. Configuración de la investigación: De los problemas al análisis filosófico-metodológico

Se orienta la primera parte de la Tesis al estudio de tres cuestiones: en primer lugar, se analiza el marco general que ofrece Rescher para la reflexión sobre la predicción científica; en segundo término, se enfoca el estudio de la predicción desde la Semántica de la Ciencia; y, en tercera instancia, la indagación se lleva a cabo desde Lógica de la Ciencia. Después, en la segunda parte, el estudio de la predicción se centra en la Epistemología y la Metodología de la Ciencia, que son los dos ámbitos donde cabe ubicar buena parte de las contribuciones de Rescher al análisis de la predicción científica. Ya en la tercera parte el foco de atención se dirige a la Ontología de la Ciencia y, más tarde, al ámbito de los valores, donde la predicción científica se estudia desde la Axiología de la investigación y la Ética de la Ciencia.

Sirve el capítulo 1 como marco para los capítulos siguientes. Así, por un lado, el capítulo se dirige a aclarar las coordenadas generales del sistema de idealismo pragmático de Rescher; y, por otro lado, busca ofrecer una caracterización de los elementos filosófico-metodológicos de la predicción científica; esto es, afronta el problema de los factores constituyentes de la "predicción científica". Esto comporta realizar un estudio que tiene dos vertientes: una dimensión histórica y una perspectiva temática. Respecto de la dimensión histórica, se estudia la relevancia de la trayectoria académica e intelectual de Rescher, tanto para la articulación de su sistema de Pensamiento como para el desarrollo de su interés inequívoco por el problema de la predicción.

Tras este marco histórico se indaga en el cuadro temático: el idealismo pragmático de Rescher. Ahí se consideran dos aspectos fundamentales: a) el papel que atribuye a los conceptos para la articulación del conocimiento y b) su propuesta acerca del progreso científico, que conecta directamente con la noción de "predicción". Esto lleva a completar el cuadro temático mediante la atención a los caracteres filosófico-metodológicos de la predicción —que se desarrollan en los siguientes capítulos— y los problemas que plantea cada uno de ellos. Por último, se analiza cuál es el lugar que ocupa el idealismo pragmático de Rescher en el contexto actual.

Se acomete en el capítulo 2 la indagación acerca la predicción científica desde el lenguaje, de forma que se plantea el problema de cómo concebir adecuadamente la predicción científica a partir del lenguaje. Esta perspectiva lleva a reflexionar sobre los rasgos del planteamiento de Rescher acerca del lenguaje, que es de índole pragmática. Lo es en cuanto que las condiciones de uso tienen primacía sobre las condiciones de verdad en su propuesta acerca del significado. A este respecto, se acomete el estudio acerca de cuáles son las repercusiones de este planteamiento pragmático acerca del lenguaje para la noción de predicción científica.

Después, se puede profundizar en el lenguaje de "predicción". Esta ruta lleva a abordar el problema de los rasgos del concepto de "predicción científica" y la demarcación respecto a la predicción no científica. A este respecto, se trata de alcanzar rigor en cuanto al lenguaje empleado para la predicción. Esto comporta indagar en otras distinciones, como son el deslinde entre predicción genérica y predicción específica; predicción cuantitativa y predicción cualitativa; y los diversos tipos de predicción científica posibles, en cuanto a su fiabilidad u otras características. Conecta esto con los límites de la predicción en cuanto al lenguaje, de manera que también se puede reflexionar acerca de la dualidad entre "no predecibilidad" e "impredecibilidad".

A continuación, en el capítulo 3, se lleva a cabo la indagación acerca de la predicción científica desde el ámbito de la Lógica de la Ciencia, que comporta afrontar el problema de las relaciones lógicas entre la predicción y la explicación científica. Esto supone tener en cuenta dos tesis que se han mantenido al respecto: (i) la tesis de la simetría lógica entre explicar y predecir; y (ii) la tesis de la asimetría, de la que es partidario Rescher. El estudio de ambas tesis lleva a resaltar el factor de la temporalidad, que plantea otros interrogantes de índole lógica. A este respecto, es preciso reflexionar acerca de la noción de "retrodicción" y su posible equivalencia lógica respecto de la explicación científica, primero, y respecto de la predicción científica, después.

Hay otros dos problemas que tienen especial relevancia para aclarar los rasgos lógicos de la predicción científica. El primero atañe a los nexos con la inducción, mientras que el segundo mira al papel de la Lógica deductiva. Respecto del primer problema, se puede reflexionar sobre dos cuestiones distintas aunque conectadas: a) la caracterización de la inducción; y b) la justificación de la inducción. Sobre esta base, se acomete el estudio de la relevancia de la inducción para la predicción científica, donde cabe abordar su papel en el contexto de descubrimiento y en el contexto de justificación. Esto lleva al segundo problema, que atañe al cometido de la deducción. Acerca de este asunto, se consideran los posibles límites del deductivismo para la predicción científica.

Corresponde al capítulo 4 el estudio acerca de los factores epistemológicos de la predicción científica en el planteamiento de Rescher, de manera que se indaga en el tipo de *contenido cognitivo* que ofrece la predicción y en los problemas conexos. A tal efecto, cabe conectar su Epistemología de la predicción con su Teoría de la Racionalidad, donde concede primacía a la práctica. Desde esta perspectiva, la indagación acerca de la predicción científica se puede llevar a cabo a tenor de los tipos de racionalidad que expresamente contempla: la racionalidad cognitiva, la racionalidad práctica y la racionalidad evaluativa.

Respecto del conocimiento que proporciona la predicción, un problema central atañe a la fiabilidad de los enunciados predictivos. Este foco de estudio lleva a profundizar en el falibilismo y sus repercusiones para la predicción en la Ciencia Básica, la Ciencia Aplicada y la aplicación de la Ciencia. La falibilidad del conocimiento de predicción conecta con los límites epistemológicos para la predecibilidad. De este modo, se puede reflexionar acerca de problemas como la incertidumbre, que afectan al tipo de conocimiento alcanzable mediante la predicción y tienen incidencia en cuestiones como la gestión del riesgo.

Para profundizar en los aspectos metodológicos de la predicción científica están los capítulos 5 y 6. La indagación acerca de la Metodología de la predicción requiere dos capítulos, debido a que es en este ámbito donde se sitúan buena parte de las contribuciones de Rescher al problema de la predicción científica (y algunas de las que han sido más influyentes). Así, el capítulo 5 tiene una orientación más general, de manera que la investigación se dirige a aclarar el marco conceptual de la Metodología de la predicción de Rescher.

Como los problemas los afronta desde la primacía de la práctica, se acomete el estudio del planteamiento que ofrece Rescher de pragmatismo metodológico. Esto lleva a profundizar en las funciones de la predicción científica en los distintos tipos de investigación científica (Básica, Aplicada o de aplicación) y su cometido en diversas Ciencias Empíricas (de la Naturaleza, Sociales y de lo Artificial). Después, se puede reflexionar acerca de las precondiciones del proceso racional de predicción, que son las condiciones necesarias para los procesos predictivos.

Dentro de los caracteres metodológicos de la predicción científica, el foco de indagación del capítulo 6 tiene un carácter más particular. En él se encara el estudio de los métodos de predicción y su relevancia científica. A este respecto, se indaga en los procesos de predicción a partir del cuadro que propone Rescher. Esto conlleva distinguir entre los procedimientos estimativos de predicción y los procesos discursivos, que pueden ser o bien procedimientos elementales o bien métodos científicos. Esta ruta lleva a profundizar en la fiabilidad y las características de los procedimientos y métodos predictivos, dentro de un enfoque que asume *de facto* un pluralismo metodológico en cuanto a la predicción.

Ya en el capítulo 7 el estudio se dirige a las cuestiones relacionadas con los rasgos ontológicos de la predicción científica. Planteado desde la Ontología de la Ciencia, el problema de la predicción conecta con la realidad de los fenómenos. Esto comporta indagar acerca de las características específicas que pueden tener los fenómenos que se inscriben en distintos ámbitos de la realidad (natural, social o artificial). Desde esta perspectiva, se acomete el estudio de las repercusiones (sobre todo, epistemológicas y metodológicas) de la realidad de los fenómenos para la predicción científica. Junto a los ámbitos de realidad —en su triple vertiente empírica—, está el problema de la caracterización de los fenómenos futuros, que conecta con el horizonte temporal de la predicción y con la posibilidad de control de los fenómenos.

También desde la Ontología de la Ciencia se puede indagar en los obstáculos ontológicos a la predicción científica. Se trata un asunto especialmente relevante en el planteamiento de Rescher. Una manera de plantear el problema de los límites ontológicos a la predecibilidad es desde la perspectiva de la complejidad. A este respecto, se indaga en las variedades y formas relevantes de complejidad, que llevan a poner de relieve la noción de *historicidad*. Así, se puede reflexionar acerca de la complejidad desde la perspectiva de la historicidad, que tiene especial relevancia para las Ciencias Sociales y las Ciencias de lo Artificial.

Más tarde, en el capítulo 8, se acomete la indagación acerca de los problemas relacionados con los elementos axiológicos de la predicción científica. Esto lleva a analizar, en primer lugar, la propuesta de Rescher respecto de la Axiología de la Ciencia, para ver cómo modula los rasgos axiológicos de la predicción. Esto comporta atender a los valores en cuanto sistema, donde hay una doble perspectiva de análisis: la interna y la externa. La perspectiva interna mira a la Ciencia como actividad en sí misma considerada; mientras que la perspectiva externa se ocupa de las relaciones de la Ciencia con el entorno. En la Axiología de Rescher, que es preferentemente estructural, tiene primacía la componente interna de análisis, donde destacan los valores epistemológicos y metodológicos.

En segundo término, se indaga en los caracteres axiológicos de la predicción. Para ello, se acomete, por un lado, la investigación acerca de la predicción como valor de la Ciencia; y, por otro lado, se profundiza en los valores que acompañan a la predicción. A este respecto, hay dos vertientes de análisis: la perspectiva estructural y la componente dinámica. La propuesta de Rescher es preferentemente estructural. Esto lleva a ampliar su propuesta mediante la atención a la componente dinámica. A tal efecto, se puede reflexionar en cómo la predicción y los valores conexos modulan los objetivos, procesos y resultados de la investigación científica (Básica, Aplicada o de Aplicación), tanto desde una perspectiva interna como desde un punto de vista externo.

Por último, en el capítulo 9, la indagación en la predicción científica se lleva a cabo desde la Ética de la Ciencia. A tal efecto, se pueden considerar dos perspectiva de análisis: a) la Ética endógena, que mira a la actividad científica en sí misma considerada; y b) la Ética exógena, que analiza la Ciencia como una actividad conectada con otras (sociales, culturales, políticas, económicas, ecológicas, etc.). El punto de partida de este capítulo es el estudio de la Ética de la Ciencia de Rescher, donde tiene primacía la perspectiva endógena. Esto lleva a profundizar en la perspectiva exógena, que también tiene relevancia para la predicción.

Ya para finalizar, el estudio se orienta a reflexionar sobre los problemas que plantea la relación entre la predicción científica y los valores éticos. A este respecto, en primer lugar, se indaga en la incidencia de los límites éticos de la Ciencia para la predicción científica. En segundo término, se acomete el estudio de los valores éticos de la predicción científica desde la perspectiva dinámica, que atiende a la evaluación de los objetivos, procesos y resultados de la investigación. Para ello, hay que tener en cuenta las diferencias entre la Ciencia Básica, la Ciencia Aplicada y la aplicación de la Ciencia.

III. Conclusiones alcanzadas

Tras la configuración de la investigación —con su despliegue en 9 capítulos—, corresponde ahora detallar las conclusiones alcanzadas. Se sitúan dentro del contexto temático señalado al principio y reflejan los dos ejes que surcan los objetivos buscados.

1) Cuando Rescher se ocupa de la predicción científica, sus posiciones están moduladas por un sistema de Pensamiento propio. Así, los caracteres de la predicción científica —semánticos, lógicos, epistemológicos, metodológicos, ontológicos, axiológicos y éticos— están interrelacionados, puesto que aparecen integrados en un *sistema* de Pensamiento. Se trata de un idealismo pragmático que está abierto a elementos relevantes de realismo. Lo configura de manera que evita caer en un planteamiento meramente ecléctico. En efecto, consigue articular de manera coherente una versión de *idealismo conceptual*, que combina con un planteamiento pragmático que sigue la tradición de Charles S. Peirce, que a su vez es compatible con elementos realistas (fundamentalmente, los que atañen a las nociones de “objetividad”, “hecho” y “verdad”).

Sin embargo, cuando se ocupa del realismo, Rescher no llega a captar adecuadamente algunas propuestas realistas, como la concepción actual de realismo científico; en particular, el realismo científico crítico. Así, su visión reduce el realismo científico a un realismo ingenuo, de manera que piensa que es incompatible con el falibilismo. Llega a rechazar una propuesta realista que, en buena medida, es una versión que él mismo construye, en lugar de ser una genuina postura de realismo científico actual.

Asimismo sucede que Rescher acepta nociones y propuestas netamente realistas. Esto se debe a que busca conectar su enfoque con la Ciencia real. Considero que esta componente de fondo —el nexo con la práctica científica— es un acierto y es, además, clave en su Filosofía de la Ciencia. Asimismo, tiene especial relevancia para el problema de la predicción. Porque una propuesta cabal acerca de la predicción científica requiere, a mi juicio, la aceptación de la existencia de una realidad extramental, cuyas propiedades sean accesibles a los sujetos cognoscentes, de manera que el conocimiento científico acerca del futuro posible pueda ser objetivo y, sobre esta base, pueda llegar a ser verdadero.

2) Dentro de su sistema filosófico —el idealismo pragmático abierto al realismo—, Rescher ofrece una caracterización de la predicción científica. Su planteamiento es coherente con las coordenadas generales que modulan su Pensamiento. Su enfoque acerca de la predicción es ciertamente sólido, puesto que llega a dar forma a una concepción de la predicción científica donde hay una atención expresa a sus diversos componentes (semánticos, lógicos, epistemológicos, metodológicos, ontológicos, axiológicos y, en menor medida, éticos). Sin embargo, aun cuando Rescher señala que busca dar forma a una concepción amplia de la predicción, su planteamiento es ciertamente limitado. Lo es porque no contempla algunos aspectos que considero que son relevantes.

Cabe señalar, a este respecto, varios aspectos: (i) su atención suele estar centrada en el ámbito de las Ciencias de la Naturaleza, sin prestar suficiente atención a otros campos de la Ciencia empírica. (ii) Paralelamente, se vuelca con frecuencia en la investigación básica, donde destaca el cometido de la predicción como test de las teorías científicas, de manera que insiste en la predicción como indicador del progreso científico. Esto lleva a que se puede ampliar su propuesta, para llegar a considerar la predicción en la investigación científica aplicada y en la aplicación de la Ciencia. (iii) También hay problemas que atañen a las Ciencias Sociales y las Ciencias de lo Artificial, que habitualmente Rescher no contempla. Hay así algunos asuntos (por ejemplo, el uso de la predicción como test en Economía) en los que no profundiza. (iv) Como laguna en su planteamiento, me parece más relevante la falta de atención a la historicidad (de la Ciencia, los agentes y la propia realidad investigada, sobre todo, social y artificial). Aunque Rescher atienda a elementos contextuales, pienso que es una laguna que presenta su concepción acerca de la predicción en los diversos ámbitos que se han considerado.

3) Cuando analiza la predicción desde el lenguaje, Rescher parte de una concepción pragmática, donde prima la visión del significado como uso. Sin embargo, admite que se puede evaluar el lenguaje en términos de objetividad y verdad (o, cuando menos, de verosimilitud). Se trata, a mi juicio, de un acierto en su planteamiento, puesto que evita reducir el significado a un mero uso intersubjetivo del lenguaje, en cuanto que admite una base objetiva en su contenido. Desde esta perspectiva, su propuesta permite caracterizar la predicción científica como un enunciado que puede ser portador de un *contenido objetivo*.

A partir de la idea de la predicción como enunciado que versa sobre fenómenos no observados (o, en su caso, ahora inobservables), Rescher propone cuatro rasgos principales para caracterizar una predicción: (a) mira al futuro; (b) es correcta o incorrecta; (c) es significativa; y (d) es informativa. A mi juicio, es posible ampliar esta caracterización si se pone de relieve que la predicción tiene que ver con *algo esperado*, de modo que se relaciona con la novedad. Desde esta perspectiva, la predicción científica aparece vinculada a la noción de "hechos nuevos" (*novel facts*), que comportan novedad en algún sentido relevante (ontológico, epistemológico o heurístico).

4) Sucede que, aun cuando Rescher trata de ofrecer una caracterización exhaustiva del concepto de "predicción", las fronteras entre la predicción científica y la predicción no científica no siempre están claras en su planteamiento. Sí distingue la predicción respecto de la mera profecía; pero no hay un deslinde claro entre la predicción científica y otro tipo de predicciones racionales (por ejemplo, las que hace un agente sobre la base de su experiencia). Esa delimitación entre la "predicción científica" y la "predicción no científica" es, sin duda, necesaria.

A este respecto, Rescher piensa que la diferencia está en los procesos utilizados para predecir, de manera que la predicción científica es la que se obtiene mediante el uso de métodos científicos de predicción (por ejemplo, los modelos predictivos). No tiene en cuenta, por tanto, las diferencias en cuanto al lenguaje, que también pueden ser claves. Así, para distinguir una predicción científica de una predicción no científica, uno de los asuntos a considerar es el rigor en el lenguaje (por ejemplo, la precisión y exactitud del sentido y la referencia de los términos utilizados).

5) Paralelamente, si se desea lograr una concepción cabal de la predicción, hace falta un mayor rigor en cuanto al lenguaje empleado. Así, a mi juicio, resulta necesaria la distinción entre los diversos tipos de predicción científica posibles. En este punto, el enfoque de Rescher se puede revisar para lograr más profundidad. Esto ha de hacerse a tenor de un análisis filosófico del lenguaje más sofisticado. Así, su enfoque contempla algunas

distinciones que atañen al lenguaje de predicción. Distingue, a este respecto, la predicción cualitativa y la predicción cuantitativa, además de diferenciar la predicción genérica y la predicción específica.

Pero estas distinciones no son suficientes para cubrir todo el espectro posible. En efecto, también es relevante deslindar los tipos de predicción, tales como “previsión” (*foresight*), “predicción” (*prediction*), “pronóstico” (*forecasting*) y “planificación” (*planning*). A mi modo de ver, es deseable lograr una variedad tipológica en el terreno de la predicción científica, que es algo que ya se ha alcanzado en lo que atañe a la explicación científica. Por eso, la propuesta de Rescher en cuanto a los rasgos semánticos de la predicción debe ampliarse en la dirección señalada.

6) Vista la predicción desde la Lógica de la Ciencia, donde la atención está en los aspectos estructurales de las teorías científicas, Rescher tiene razón cuando mantiene que hay una *asimetría lógica* entre explicar y predecir, de manera que cabe descartar una equivalencia estructural entre ambos procesos. Además, su crítica a la tesis de la simetría no se queda únicamente en el plano lógico, sino que ofrece razones que muestran su asimetría también en los planos semántico, epistemológico, metodológico y ontológico. A este respecto, piensa que predecir y explicar son procesos coordinados, de manera que la Ciencia ha de aspirar a alcanzar una armonía entre explicación y predicción. De este modo, Rescher descarta también el predictivismo instrumentalista. Lo hace en favor de una versión moderada de predictivismo, que es una postura —a mi juicio— más adecuada a la práctica científica.

Al mismo tiempo, la perspectiva de la *temporalidad* —la anisotropía temporal entre explicación y predicción— ha permitido aportar más elementos en favor de la tesis de la asimetría que los expuestos por Rescher. Sobre la base de esta perspectiva hay un marco adecuado para el análisis de otras dos cuestiones de índole lógica, pero en las que Rescher no profundiza: (i) la posible equivalencia de la "retrodicción" y la explicación científica; y (ii) el problema de la equivalencia lógica entre la predicción y la "retrodicción", que va habitualmente unido a la aceptación de una genuina "predicción de pasado". A tenor del estudio realizado, la postura más asumible es —a mi juicio— el descartar ambas equivalencias lógicas.

7) Entre los componentes lógicos de la predicción científica, destaca su nexo con el problema de la *inducción*. Ofrece a este respecto Rescher una caracterización de la inducción como un procedimiento de estimación, en lugar de ser propiamente una forma de inferencia. Sobre esta base, desarrolla razones pragmáticas para la justificación de la inducción. Esto conlleva un cambio de enfoque, puesto que supone abandonar la perspectiva estrictamente lógica de la inducción —que fue influyente durante décadas— en favor de un planteamiento epistemológico de la inducción, que además tiene repercusiones metodológicas claras.

Desde una perspectiva pragmática, Rescher da una solución que —a mi juicio— es coherente con su Filosofía de la Ciencia, en general, y con su pragmatismo metodológico, en particular. Su postura mira a la solución de problemas, de modo que la justificación del uso de la inducción como procedimiento predictivo está en términos prácticos. Se enraíza, en último término, en la capacidad de esos procedimientos —que se apoyan en la inducción— para obtener predicciones con éxito. Al insistir en la justificación pragmática de la inducción, se pone de relieve que los distintos elementos constitutivos de la Ciencia están interrelacionados como un sistema en la propuesta de Rescher.

8) La aceptación expresa de la inducción para la predicción lleva a plantear el problema de los límites del deductivismo para la predicción. Se trata de un asunto especialmente relevante para Rescher, pues su pragmatismo metodológico no se puede sostener sobre una base exclusivamente deductiva. En efecto, su pragmatismo metodológico necesita

utilizar la actuación (*performance*) de los procesos (entre ellos, los procedimientos inductivos) en el pasado como indicador predictivo acerca de su éxito en el futuro. Esto comporta un elemento de inducción, puesto que se realiza una inferencia que va de lo pasado a lo futuro, que es uno de los modos de inferencia inductiva que Rescher contempla.

Hay en esto una aportación, pues considero que los elementos que ofrece Rescher —y la crítica de Wesley Salmon al respecto— ponen de relieve la insuficiencia del deductivismo para resolver los problemas que plantea la predicción científica. Por tanto, una propuesta lógico-metodológica acerca de la predicción científica de índole expresamente deductivista, como la que propuso Karl R. Popper, no permite abarcar todos los elementos en liza cuando se analiza la predicción desde una perspectiva lógica.

9) Epistemológicamente, la predicción científica conecta con la Teoría de la Racionalidad en la propuesta de Rescher. A este respecto, su enfoque es más abarcante que el expuesto por otros filósofos, como Herbert A. Simon. La diferencia principal está en la racionalidad evaluativa, que Rescher asume de manera expresa. Con ella se atiende a la preferibilidad de los fines, en lugar de quedarse en el ámbito de lo preferido o, simplemente, aceptar los fines como ya dados. Esta atención a la racionalidad de fines o evaluativa conecta con la Axiología de la investigación, puesto que la selección de fines se ha de realizar de acuerdo con valores (internos y externos). Así, los ámbitos epistemológico y axiológico están estrechamente relacionados en la Filosofía de la Ciencia de Rescher.

Por un lado, Rescher ve el conocimiento científico como el resultado de una actividad orientada a fines, que se seleccionan según valores. Y, por otro lado, su Axiología de la investigación da prioridad a los valores cognitivos. Llevado este planteamiento al ámbito de la predicción científica, lo más relevante es —en su enfoque— el contenido cognitivo de la predicción, que ha de reunir una serie de valores epistémicos (coherencia, exactitud, precisión, etc.). Pero ciertamente es consciente de las dificultades para predecir de manera fiable el futuro posible. Así, su planteamiento no es en modo alguno ingenuo, sino que mantiene una visión falibilista acerca del conocimiento científico; en especial, es falibilista cuando ese conocimiento versa sobre un futuro que, en principio, cuenta con múltiples posibilidades.

10) Dentro de un cuadro epistemológico falibilista, Rescher defiende la posibilidad de obtener predicciones verdaderas o, cuando menos, verosímiles. Para ello, descarta rotundamente las "predicciones no razonadas": no hacen Ciencia. Sin embargo, resalta en exceso la vertiente pragmática, pues llega a afirmar que la principal diferencia entre las predicciones razonadas y las no razonadas radica en que las segundas carecen de utilidad práctica. A este respecto, desatiende la vertiente teórica de la predicción. De ahí que, en su planteamiento, no siempre esté clara la demarcación entre las predicciones científicas y las no-científicas.

Su falibilismo tiene un sello propio. Es sabido que Rescher tiene una concepción propia de la verdad en cuanto "coherencia", pero asume también la postura realista de verdad como correspondencia, cuando se trata de enunciados científicos respecto de fenómenos de la Naturaleza. Su falibilismo es también pragmático, de modo que hay una interacción con la Naturaleza para que el proceso de investigación siempre esté abierto. Por eso, su visión de la predicción, que admite poder llegar a enunciados verdaderos, también se concibe como ajena a una "Ciencia perfecta", donde todas nuestras preguntas pueden ser respondidas. Esto supone una revisabilidad congénita de nuestro conocimiento predictivo. Pero, de nuevo, se limita a la Ciencia Básica, apenas hay nada en sus textos de predicción ante la Ciencia Aplicada o su papel en cuanto a la aplicación de la Ciencia, aun cuando Rescher es consciente del uso que hacen los agentes de la predicción para tomar decisiones en contextos prácticos.

11) Junto a la importancia de las bases racionales para obtener predicciones con éxito, Rescher destaca los obstáculos epistemológicos para la predicción. En efecto, una de sus principales contribuciones al problema de la predicción científica está en el análisis de los límites a la predecibilidad, donde destaca los límites epistemológicos y ontológicos, que busca hacer explícitos. Sin duda, se trata de un aspecto fundamental para el estudio de la predicción, puesto que permite dar cuenta de las dificultades que entraña la tarea de predecir.

Sin embargo, hay que señalar dos limitaciones. Por un lado, Rescher se centra excesivamente en las Ciencias de la Naturaleza, dentro de un contexto que mira, sobre todo, a la investigación científica básica. Una propuesta más exhaustiva acerca de los límites epistemológicos para la predecibilidad ha de tener en cuenta, a mi juicio, el conjunto de las Ciencias Empíricas, así como los distintos tipos de actividad desplegada por la Ciencia (básica, aplicada y de aplicación). Por otro lado, su perspectiva acerca de los límites epistemológicos es fundamentalmente estructural, de manera que no tiene en cuenta los problemas que atañen a la historicidad del conocimiento. Esto se aprecia, sobre todo, cuando se ocupa de las dificultades para predecir el avance futuro de la Ciencia.

12) Es en el plano metodológico donde, a mi juicio, las contribuciones de Rescher al problema de la predicción científica son más sólidas. Sitúa su planteamiento en el marco de un pragmatismo metodológico, donde la importancia de la predicción para la práctica científica aparece resaltada, sobre todo en cuanto que el éxito predictivo se puede utilizar como un indicador para evaluar el progreso científico. Así, su planteamiento metodológico comporta un enfoque instrumental respecto de la predicción, donde se destaca el valor del éxito predictivo como criterio para evaluar la adecuación teorética comparativa de las teorías.

Se trata de una versión de predictivismo moderado, que rechaza de manera explícita el predictivismo instrumentalista sin realismo de los supuestos que defendió M. Friedman. A este respecto, Rescher desarrolla una propuesta que es —a mi juicio— asumible, pero que requiere algunos matices. Porque un planteamiento de pragmatismo metodológico como el que propone no cubre, ciertamente, todo el ámbito científico. En efecto, hay teorías orientadas únicamente a la explicación de los fenómenos, donde no puede evaluarse su verosimilitud sobre la base de criterios pragmáticos como el éxito en la predicción o la eficacia en el control. Esto se puede apreciar en Ciencias Sociales como la Historia, que buscan fundamentalmente la explicación de eventos del pasado, en lugar de proporcionar predicciones acerca de sucesos del futuro.

13) Paralelamente, que la predicción sea un instrumento cognitivo no quiere decir que siempre funcione igual en todos los contextos. Hay que diferenciar, a este respecto, los cometidos de la predicción en los ámbitos de la Ciencia Básica, la Ciencia Aplicada y la aplicación de la Ciencia. Es en el contexto de la investigación básica donde cabe ver la predicción científica como indicador para evaluar la verosimilitud de las hipótesis y las teorías. Porque, en la Ciencia Básica, se puede utilizar la predicción como test científico. Pero también hay que atender al cometido de la predicción en la Ciencia Aplicada y en la aplicación de la Ciencia.

Rescher apenas se ocupa del papel de la predicción como guía para la prescripción en el marco de la Ciencia Aplicada. Esto se debe a que, en el Pensamiento de Rescher, el pragmatismo va unido a un enfoque kantiano, de manera que la predicción es, fundamentalmente, un contenido cognitivo en sí mismo valioso. Sí le interesan, en cambio, los nexos entre la predicción y la acción humana. Por tanto, no llega a ofrecer un análisis exhaustivo de la predicción como guía para la actividad de resolución problemas que llevan a cabo las Ciencias Aplicadas. En lugar de eso, le interesa más indagar acerca del uso de la predicción por parte de agentes (esto es, la aplicación de la Ciencia), tanto de manera individual —en las acciones cotidianas— como de forma colectiva (en cuestiones de actuación pública [*policy*]).

14) También hay, en rigor, diferencias metodológicas que afectan a la predicción según los distintos ámbitos de la realidad (natural, social y artificial). Asimismo, tanto dentro de cada grupo de Ciencias como en cada Ciencia concreta hay variaciones en los métodos a tenor de las cuestiones planteadas y de los fenómenos que se quiere predecir. Esto lo admite Rescher, de manera que descarta claramente el universalismo metodológico y es partidario de un pluralismo metodológico. Se trata, a mi juicio, de la postura más cabal a este respecto.

Pero hay que destacar, de nuevo, que el interés de Rescher en la predicción se centra, preferentemente, en el ámbito de las Ciencias de la Naturaleza, de manera que no llega a profundizar en las cuestiones más específicas acerca de la Metodología de la predicción en las Ciencias Sociales y, ciertamente, no se ocupa en modo alguno de la Metodología de la predicción en las Ciencias de lo Artificial. Por un lado, esto hace necesario ampliar sus reflexiones acerca de la predicción, para abarcar otros ámbitos que no contempla. Y, por otro lado, pone de relieve que su estudio de algunas cuestiones requiere una mayor profundidad. Esto se puede apreciar, por ejemplo, cuando se ocupa de la complejidad de la predicción en Ciencias Sociales. A este respecto, su análisis es, ciertamente, excesivamente genérico, frente a la amplia riqueza de matices que caracterizan sus estudios acerca de las repercusiones metodológicas de la complejidad en las Ciencias de la Naturaleza.

15) Aun cuando Rescher se centra preferentemente en las Ciencias de la Naturaleza y en la actividad científica básica, hay en su enfoque una clara preocupación por hacer explícitas las bases comunes a los diversos procesos predictivos. Así, es en el plano metodológico general donde hay

que situar una de sus aportaciones más valiosas al problema de la predicción. Se trata de las “precondiciones del proceso racional de predicción”, que son las condiciones *previas* y *necesarias* para los procesos orientados a predecir: (i) la disponibilidad de la información, (ii) la discernibilidad de las pautas, y (iii) la estabilidad de esas pautas.

Constituyen las tres una síntesis adecuada —a mi juicio— de las precondiciones necesarias para el éxito predictivo, que abarca los diversos factores que son relevantes desde una perspectiva metodológica. Además, desde la perspectiva de las precondiciones del proceso racional de predicción, es posible profundizar en el estudio de los límites a la predecibilidad. En efecto, el análisis de estas precondiciones ha puesto de relieve las repercusiones metodológicas de los obstáculos epistemológicos y ontológicos para la predicción científica que Rescher contempla, donde destacan factores como la anarquía, la volatilidad, el caos, el azar o la incertidumbre.

16) Junto a las bases comunes de los procesos predictivos, Rescher ofrece un cuadro muy rico acerca de los distintos métodos de predicción, lo que supone atender a los rasgos distintivos de cada proceso concreto. Clasifica los procesos predictivos en dos grandes grupos: (i) los *procedimientos estimativos* o intuitivos (*judgmental*) y (ii) los *métodos formales* o discursivos. Los primeros se llevan a cabo sobre la base de las estimaciones personales de expertos, como el procedimiento Delphi, que Rescher contribuyó a elaborar. Mientras tanto, los métodos formales siguen una serie de reglas o principios inferenciales bien articulados. A su vez, estos últimos pueden ser de dos tipos: a) los métodos discursivos *elementales*, tales como la extrapolación o el uso de analogías; y b) los métodos discursivos *científicos*, que son, normalmente, la inferencia a partir de leyes y los modelos predictivos.

Este cuadro de Rescher acerca de los procesos de predicción es relevante: permite poner de relieve la fiabilidad y características de los diversos *procedimientos* y *métodos* predictivos. Ciertamente, hay un diferente grado de rigor y sofisticación en los procesos, que varía desde el nivel más bajo —la estimación de los expertos— hasta el máximo rigor posible, cuando se utilizan métodos propiamente científicos (como en el caso de los modelos de predicción o la derivación de leyes). Asimismo, el rigor en los procesos repercute en la fiabilidad de las predicciones. Desde esta perspectiva, cabe pensar que las predicciones que se obtienen mediante procedimientos estimativos —donde pueden intervenir una serie de sesgos cognitivos— son, en principio, menos fiables que las predicciones que son el resultado del uso de métodos propiamente científicos.

17) Cabe afirmar que son los métodos discursivos científicos los que reúnen el mayor nivel de rigor posible. Rescher se ocupa de varios de esos métodos científicos de predicción: a) el uso de las correlaciones como indicadores predictivos, b) la inferencia a partir de leyes científicas y c) el empleo de modelos orientados a la predicción. Aun cuando ciertamente su análisis al respecto es exhaustivo, considero que falta un elemento clave: la atención a la sobriedad de factores (*parsimonious factors*). Se trata de una laguna relevante en su planteamiento, que afecta especialmente al estudio de los modelos predictivos, sobre todo cuando tienen que afrontar problemas de complejidad.

Porque la atención a la concepción metodológica de sobriedad de factores —propuesta por Herbert Simon— puede ser la base para superar las deficiencias que pueden llevar al diseño de modelos no-realistas. A mi modo de ver, la sobriedad de factores hace posible el centrarse en los factores necesarios y suficientes para abarcar un sistema, de manera que puede contribuir a aumentar la exactitud y precisión de los modelos predictivos. Esto, además, es muy relevante para lidiar con la complejidad que con frecuencia dificulta la predicción acerca de algunos sistemas (por ejemplo, en Biología o Economía).

18) Ontológicamente, el estudio de la predicción científica ha de atender a las características de la realidad sobre la que versa la predicción, que puede ser natural, social o artificial. Sucede que, para Rescher, las características de los fenómenos que se quieren predecir tienen repercusiones epistemológicas y metodológicas para la predicción. A este respecto, Rescher considera que los fenómenos naturales son generalmente más estables que los fenómenos sociales. En consecuencia, la falta de fiabilidad en las predicciones afecta en mayor medida a las Ciencias Sociales que a las Ciencias de la Naturaleza.

Pero Rescher no suele ir más lejos. En rigor, no llega a profundizar en las características que son específicas de la realidad social y, ciertamente, no se ocupa del ámbito de lo artificial. A este respecto, falta la atención a un elemento central para la predicción en estos campos: la *historicidad*. Porque tanto la realidad social como la realidad artificial son, en sí mismas, históricas. La historicidad es un rasgo ontológico clave de los sistemas sociales y los sistemas artificiales. Hay así un componente de variabilidad que añade complejidad a la predicción en estos ámbitos de la realidad social y la realidad artificial (donde interviene además la creatividad).

19) Parece claro que la *complejidad* es un rasgo clave para el estudio de los caracteres ontológicos de la predicción científica. Ciertamente, la complejidad, tanto epistemológica como ontológica, tiene relevancia cuando se analiza la predicción científica y sus características. Porque, en la medida en que la predicción versa sobre una realidad (natural, social o artificial) que es compleja, hay dos problemas: 1) la complejidad incide en la posibilidad misma de predecir y 2) repercute en el tipo de predicción alcanzable (en cuanto a su fiabilidad, exactitud, precisión, etc.). Esto se refuerza si se tiene

en cuenta que la complejidad es una noción dual: comporta una vertiente estructural y una componente dinámica.

Ciertamente, la propuesta de Rescher acerca de la complejidad es más rica en matices que las concepciones de otros autores. Sin embargo, su postura se centra excesivamente en la vertiente estructural de la complejidad y, habitualmente, desatiende la componente dinámica. Un enfoque más abarcante acerca de la complejidad debe —a mi juicio— prestar también atención a la dinámica compleja, que conecta con la noción de historicidad. Porque, como ha puesto de relieve Wenceslao J. González, la historicidad permite dos tareas: a) caracterizar el cambio en la complejidad dinámica ("interna" y "externa") y b) apreciar su incidencia en la predicción científica, en general, y en la predicción en Ciencias Sociales y Ciencias de lo Artificial, en particular. En la Ontología de la predicción de Rescher falta ese reconocimiento del papel de la historicidad. Porque la historicidad es un rasgo fundamental de la Ciencia, los agentes, y de la propia realidad investigada (sobre todo, social y artificial).

20) Una concepción cabal de la predicción científica ha de apoyarse en dos aspectos: (i) la diversidad de la realidad (natural, social y artificial) que estudia la Ciencia y (ii) en el reconocimiento de su complejidad, tanto a tenor de su estructura como con respecto a su dinámica. En este entorno temático, un asunto crucial es el estudio de los límites ontológicos a la predicción científica, que son aquellas dificultades para la predicción que se derivan de la propia índole de los fenómenos. Hay que señalar que una de las principales contribuciones de Rescher al estudio de la predicción científica está, a mi juicio, en la identificación y análisis de los obstáculos a la predictibilidad (sobre todo, epistemológicos y ontológicos). Dentro de los obstáculos ontológicos, se ocupa Rescher de varios de ellos: 1) la anarquía y la volatilidad; 2) el azar (*chance*), el caos y la elección arbitraria; y 3) la creatividad.

Aun cuando el cuadro que ofrece Rescher acerca de los obstáculos ontológicos a la predecibilidad es amplio, falta —a mi juicio— un mayor desarrollo del problema de la creatividad humana. Para acometer este análisis, me parece necesario atender a dos planos sucesivos donde interviene la creatividad: a) la *creatividad* como elemento que *configura el campo de estudio* de la Ciencia (la realidad económica, social, cultural, política, etc.), donde la actividad de los agentes puede dar lugar a cambios que conllevan novedades; y b) la creatividad como factor que *interviene en la propia actividad científica* de investigación (sea Básica o Aplicada), que es relevante tanto desde un punto de vista estructural como desde una perspectiva dinámica. En el primer caso, la creatividad puede ser un obstáculo claro para la predicción (sobre todo, en el ámbito social y artificial). Mientras tanto, en el segundo plano de análisis, la creatividad de los agentes puede contribuir a superar una coyuntural no predecibilidad de ciertos fenómenos y eventos.

21) Cuando se enfoca la predicción científica desde la Axiología de la investigación, se aprecia que Rescher sigue preferentemente un enfoque estructural. Tienen primacía los valores internos, sobre todo, los epistemológicos y los metodológicos. En cuanto a la dimensión estructural, su planteamiento acerca de la relación entre la predicción científica y los valores es, ciertamente, muy amplio. Porque tiene en cuenta tres planos sucesivos: a) los valores de preguntas predictivas, b) los valores de los enunciados de futuro y c) los elementos para la evaluación de la tarea que realizan los predictores y los métodos de predicción.

Aunque Rescher prima claramente la dimensión estructural, su postura tiene un sello propio: ofrece un planteamiento de holismo de los valores. Esto es lo que le permite configurar una Axiología de la investigación *amplia*, donde la vertiente interna y la componente externa de análisis están interrelacionadas. Dentro de este marco de conjunto, las distinciones acerca de los diversos planos o tipos de valores (“estructural” frente a “dinámico”, “interno” como distinto de “externo”) no admiten propiamente una *separación*: solo hay distinción. Porque piensa que todos están interconectados dentro del sistema de valores.

22) Como la concepción de Rescher se ofrece como un idealismo pragmático, su visión de los valores conserva el sello idealista en cuanto a que es un *sistema* y su componente pragmático le lleva a pensar en términos de actividad y de *primacía de la práctica*. La predicción —en su enfoque— se relaciona con ese sistema de valores y, al mismo tiempo, aparece como una necesidad del científico para afrontar diversos problemas. Además, como tal, la predicción tiene un valor en su sistema, pero su predictivismo es moderado, en lugar de puramente instrumental. También la predicción tiene un valor para los procesos y los resultados: forma parte de afrontar problemas de una actividad humana.

Desde esta perspectiva, la Axiología de la investigación científica de Rescher puede ser compatible con un planteamiento dinámico. Sin embargo, no llega a desarrollar de un modo articulado esa vertiente dinámica acerca de la relación entre predicción y valores, precisamente porque no pone de relieve la *historicidad* de la actividad científica. En consecuencia, su postura tampoco llama la atención respecto de los valores externos que acompañan a la Ciencia, en general, y a la predicción científica, en particular. Por eso, si bien su enfoque es más rico que otros planteamientos axiológicos, falta —a mi juicio— la debida atención a la componente dinámica (interna y externa).

23) Esto lleva —a mi juicio— a tener que ampliar su propuesta. Se ha de hacer a través del análisis de la predicción con sus valores conexos en una concepción abierta a la componente dinámica, tanto interna como externa. Para ello, es preciso tener en cuenta las diferencias entre tres tipos de actividades: la Ciencia Básica, la Ciencia Aplicada y las aplicaciones de la Ciencia. Cuando la atención se dirige a la componente dinámica interna, se

aprecia como la predicción y los valores que la acompañan tienen un cometido clave en la evaluación de la actividad desplegada por la Ciencia (básica, aplicada o de aplicación), donde hay una articulación de objetivos y procesos, que pueden dar lugar a unos resultados.

Paralelamente, sucede que la actividad científica se lleva a cabo dentro de un entorno (histórico, social, cultural, político, económico, ecológico, ...), que es cambiante. Esta dinámica externa de la actividad científica comporta que, junto a los valores internos a la actividad científica misma (p. ej., valores cognitivos), hay también valores externos. Son los que afectan a la Ciencia a tenor de su conexión con otras actividades humanas (sociales, políticas, económicas, ecológicas, etc.). Puesto que el interés prioritario de Rescher está en la Ciencia Básica, los valores externos aparecen únicamente en segundo plano. En efecto, la componente externa afecta especialmente a las Ciencias Aplicadas, donde la predicción es habitualmente el paso previo para la prescripción, y también atañe a la aplicación de la Ciencia, donde la predicción científica puede ser la base para la toma de decisiones.

24) Su Filosofía de la Ciencia presta una gran atención a la Ética de la investigación científica. Pero, cuando propone su teoría de la predicción, Rescher no llega a desarrollar el estudio de la predicción científica desde la Ética de la Ciencia. A este respecto, su propuesta ética de la práctica científica es coherente con su idealismo pragmático abierto a elementos de realismo. Por un lado, destaca la influencia kantiana, en cuanto que propone fundamentar la Moral en el entendimiento y, además, busca principios y valores éticos que son universales. Y, por otro lado, piensa que la Ciencia está modulada y condicionada por valores éticos, puesto que es una actividad humana libre, que está orientada a fines.

De nuevo, la aceptación de elementos de realismo le permite configurar un enfoque asumible, donde los valores éticos tienen una base objetiva. De este modo, se descarta el relativismo ético y evita reducir la Ética de la

Ciencia a una disciplina meramente descriptiva. Sin embargo, Rescher da una preferencia excesiva a los factores internos a la actividad científica y concede menos peso a los factores externos a la Ciencia. Un enfoque más amplio para la Ética de la Ciencia ha de tener en cuenta, a mi juicio, dos vertientes de análisis: a) la Ética endógena, que mira a la *actividad científica* en cuanto tal, de manera que se constata que hay valores que se encuentran en los objetivos, procesos y resultados del quehacer científico mismo; y b) la Ética exógena, que analiza la *Ciencia como actividad*, lo que pone de relieve que hay valores éticos que conectan la Ciencia con el entorno (social, cultural, político, económico, ecológico, etc.)

25) Atendiendo a esta doble vertiente de análisis es posible llevar a cabo un estudio más exhaustivo acerca de la relación entre la predicción científica y los valores éticos. Desde esta perspectiva, parece claro que, cuando se plantea el problema de los límites éticos de la investigación científica y su incidencia para la predicción, hay más cuestiones en liza que las que Rescher contempla. Porque, en su enfoque, los límites éticos miran, sobre todo, a la actividad científica. De este modo, desatiende habitualmente la vertiente externa, donde se atiende a la Ciencia como actividad.

Esto se debe, por un lado, a que le interesa sobre todo la Ciencia Básica, donde los factores externos tienen habitualmente menos peso que en el caso de la Ciencia Aplicada y la aplicación de la Ciencia. Y, por otro lado, tiene que ver con la primacía de un enfoque estructural, que conlleva una perspectiva estática acerca de la relación entre la Ciencia y los valores éticos, en general, y sobre el problema de los límites éticos de la investigación, en particular. Por eso, aun cuando Rescher atiende al contexto (social, cultural, político, económico, ecológico, etc.), no lo hace dentro de un marco de *historicidad* que, a mi juicio, es necesario para desarrollar adecuadamente la componente dinámica de la Ética de la Ciencia.

26) Comporta la vertiente dinámica de análisis una diversidad de enfoque. Así, el estudio de las relaciones entre la Ciencia y los valores éticos ha de tener en cuenta tres ámbitos diferentes: la Ciencia Básica, la Ciencia Aplicada y la aplicación de la Ciencia. Porque, en cada uno de estos ámbitos, la Ética de la Ciencia tiene características propias, puesto que se trata de actividades diferenciadas. La distinta configuración interna de las tres actividades (Básica, Aplicada y de aplicación), así como sus rasgos propios en cuanto a la dinámica externa, modulan la relación entre la predicción científica y los problemas éticos, que tiene rasgos específicos en cada una de esas actividades humanas.

Si la relación de la predicción con los valores éticos se plantea en un contexto de Ciencia Básica, conviene distinguir el aspecto del contenido cognitivo mismo y la dimensión de actividad humana libre. Así, en cuanto contenido cognitivo, no parece que la predicción sea susceptible de una valoración ética. Pero, desde el punto de vista de las consecuencias, la predicción puede ser objeto de valoración ética, sobre todo cuando la investigación básica está conectada con la Ciencia Aplicada, en cuanto que puede tener una incidencia negativa sobre la persona, la sociedad o el medio ambiente.

En los casos de la Ciencia Aplicada y de la aplicación de la Ciencia, la relación de la predicción con los valores éticos es más clara. Lo es, sobre todo, a tenor de la componente externa de análisis, debido a que los nexos con el entorno son más directos. En las Ciencias Aplicadas, la predicción puede plantear problemas éticos a tenor de su relación con la prescripción, que se orienta a proponer las pautas de actuación para resolver problemas concretos. Mientras tanto, en la aplicación de la Ciencia, la predicción puede ser la base para la toma de decisiones por parte de los agentes (individuales o sociales), donde hay que considerar cuestiones de índole ética. Respecto de estos ámbitos, el análisis de Rescher no alcanza, ciertamente, la profundidad y riqueza de matices que tienen sus reflexiones orientadas a la Ciencia Básica.

27) Siguiendo los dos ejes de esta investigación —el análisis filosófico-metodológico de la predicción científica en la propuesta de Rescher y la reconstrucción crítica de su Filosofía de la Ciencia a partir de su concepto de "predicción"— me parece que hay un resultado de fondo claro. Por un lado, Rescher ha hecho una contribución real al estudio de la predicción desde una perspectiva filosófico-metodológica. Pero hay algunos aspectos que pueden mejorarse (por ejemplo, el cometido de las Ciencias Aplicadas); y otras cuestiones, en principio, no pueden abarcarse desde su idealismo conceptual (como la relevancia de la historicidad para la predicción científica, fundamentalmente en Ciencias Sociales y las Ciencias de lo Artificial). Por otro lado, ha construido su propio sistema de Pensamiento en lugar de centrarse en una parcela del análisis filosófico. Sin embargo, aunque su visión es amplia y el número de problemas que afronta es también elevado, hay algunos elementos que no están presentes en su sistema, como los factores genuinamente dinámicos de la complejidad o la relevancia de los aspectos contextuales (sociales e institucionales). De nuevo, sus ideas son realmente interesantes, pero su sistema no cubre todos los elementos en liza.