From the Triple Helix model to the Global Open Innovation model a case study based on international cooperation for innovation in Dominican Republic

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Abstract

This study presents a case study research that sets out the process of designing the Dominican Republic's RDI strategy during the period 2001-2007 and the role played by international cooperation in that process. We discuss the Triple Helix model as framework, and the use of a new approach that can be transferred to other countries. The results have validated some of the model's assumptions, but they have also confirmed the existence of certain explanatory limitations in it. In order to rectify them, a new model –the Global Open Innovation model– has been proposed as alternative approach to the innovation transfer.

Keywords: R&D Strategy; international cooperation; innovation transfer; Triple Helix; case study research.

1. Introduction

University, Industry and Government: three different contexts fated to reach an understanding. The transfer of scientific and technological knowledge from universities to industry has been seen as a conditioning factor in a country's economic development, yet also as a complex problem with many and varied economic, political and cultural implications (Aghion et al., 2005; Aghion et al., 2008; Bozeman, 2000).

The need to articulate the relationship among these three very different contexts has led academics to look for models that will help facilitate this inter-relationship and the design of policies on Research, Development and Innovation (RDI). However, in light of criticisms of the lack of application of the conceptual models and the ambiguity of their assumptions (Fitriati et al., 2012; Shinn, 2002; Tuunainen, 2002), these models need to be applied to real situations, with a view to refining them and overcoming some of their limitations.

For this reason, based on a review of the theory of some of the most relevant conceptual models in the area of innovation, we have selected the Triple Helix model (Etzkowitz, 1997; Etzkowitz & Leydesdorff, 2000) as a theoretical framework, and test it against a case study as a methodology for research. The aim of this study is thus to validate and extend the Triple Helix model as a framework of reference applied to the case of the design of the RDI strategy for the Dominican Republic for 2001-2007. The results have validated some of the model's assumptions and the usefulness of the Knowledge, Consensus and Innovation Spaces, as well as highlighting some of the limitations of the model.

The case studied is that of the design of an RDI strategy for the Dominican Republic. One important virtue of the case is its originality; the design was not acquired or copied from other countries, but was the result of the joint efforts of a team made up of Dominican authorities and international experts. The value of this case study therefore lies in highlighting the importance of international cooperation in speeding up the process of transferring scientific and technological knowledge from universities to industry. The content of this case of study is related to prior experiences in Open Innovation Diplomacy (Carayannis and Campbell, 2011), that show an example of how technical knowledge can be exchanged between countries about the best ways of using sustainable sources of energy. In our case, the fact that all the agents involved (University, Industry and Government) were represented on the work group together with the international make-up of the group helped generate trust and social impact (Carayannis and Campbell, 2009, 2011). The working methodology also constitutes a process

that can be transferred to other economies without requiring major initial investment, through the use of the surveys of technological innovation and R&D, templates of meetings organization and the case study methodology as data support and previous evidences.

The results of this strategic design are relevant both because of the achievements obtained in the original context and the transferability of the model to other contexts. Such relevance sufficiently justifies this work.

2. University-Industry-Government relations and innovation strategy

The academic literature establishes different approaches to relations between science and innovation. The approach of the innovation system represents a major step forward for that of the innovation process, which no longer depends only on the activity generated within firms, but requires the interaction of agents from the environment, knowledge generators and innovation-incentivising policies. This approach is particularly relevant in stimulating University-Industry-Government relations and transferring research results, giving rise to the Triple Helix model devised by Etzkowitz & Leydesdorff (2000).

In this sense, we should not forget the contribution of the Open Innovation (OI) model, which opposes traditional models in that research and development are performed internally and later rolled out onto the market. The Open Innovation model posits that firms' internal research and development are elements that come from the market itself and from society in general. This means that valuable ideas can come from inside or outside the firm (Chesbrough, 2003). However, reducing the focus of open innovation in small and medium enterprises (SMEs) to science-driven innovations would seriously bias the understanding of open innovation for this category of firms (Van de Vrande, 2009). The Open Innovation model considers that firm is a constituent in a network, and also study the impact of institutional conditions on innovation performance (Huizingh, 2011; Samara et al., 2012). Analogously with the previous argument, valuable ideas can come from both inside and outside the national setting in which firms from the country in question operate (Elzinga, 2004).

In this sense, open innovation can be more effective in one context than in another. In economic contexts characterized by a high degree of globalization, companies are likely to use open innovation strategies and in contexts with a high level of technology intensity, and

inbound open innovation may be relevant as even large companies are able to develop technologies on their own (Gassman, 2006).

However, small companies uses open innovation practices by looking for alliances as the most effective way of conducting inbound and outbound innovative activities (Bianchi et al., 2012). In this sense, there are potential to develop a virtuous invention cycle by linking inward and outward knowledge transfer routines (Caner et al., 2014). In Bianchi´s study, the relations between universities and firms are involved in the early stage of the innovation production, and this relationship declines over time. From another approach, open innovation is more common in the latter innovation phases, especially through the commercialization of innovations stage (Lee et al., 2010).

According to the type of relation among agents for innovation transfer, previous theoretical models have proposed different approaches (Table 1):

Table 1
Theoretical models and relations for innovation transfer

Author	Theoretical model	Type of relation for innovation transfer
Bush (1945)	Linear model	SPONTANEUS: innovation is commercialized from the previous generation of knowledge. There is not any coordination through liaison agents.
Kline & Rosenberg (1986)	Chain-linked model	COMPLEX: there is a feedback system based on links between research and innovation. It generates delay and misunderstanding about who takes the lead in the process of knowledge transfer.
Gibbons et al. (1994)	Mode 2	ACTIVE: knowledge production is generated from the interdisciplinary collaboration of researchers. There are not specific mechanisms for innovation transfer.
Rothwell (1994)	Integrated model	PARTIAL: innovation is based on a process of accumulation of know-how between knowledge generators and operators. The innovation transfer needs the previous solution of problems of intellectual property management.
Callon (1994)	Techno-economic network model	PARTICIPATIVE: innovation is generated from the collaboration between Science and Technology (transfer pole), and Technology and Market (development pole).
Freeman (1987)	National Innovation System	RECEPTIVE: innovation occurs through the dynamic interaction among a network of public and private institutions with different rules of engagement. Innovative developments are responsive to the needs of the agents.
Etzkowitz & Leydesdorff (1995)	Triple Helix model	INCLUSIVE: University takes the lead of the generation and transfer of knowledge to society through reciprocal and continuing relationships with industry.
Carayannis & Campbell (2006)	Mode 3	SYSTEMIC: the knowledge production system architecture focuses on and leverages higher order learning processes and dynamics that allow for both top-down university,

		industry and government policies and bottom-up civil society priorities to interact and engage with each other.
Chesbrough (2003)	Open innovation	DYNAMIC: innovation is generated from experimentation and collaboration among firms, universities, government and final users. A model of interaction based on rules is determined for the transfer of value to all stakeholders.
Carayannis & Campbell (2009, 2010)	Quadruple Helix Model Quintuple Helix Model	ECOSYSTEMIC: the knowledge transfer includes relations with civil society (Quadruple Helix) and brings the perspective of the natural environments of society and the economy for knowledge production and the innovation systems.

The literature review shows how innovation transfer through university-industry collaboration has become a dynamic problem. From the approach that long cycles are caused by, and are an incident of the innovation process (Schumpeter, 1943), the low economic impact of University-Industry cooperation (Polt et al., 2001) can be explained if one takes into account the type of knowledge that science provides, in relation with the demand for innovation of most firms. Scientific institutions primarily offer new knowledge required by the firms in order to develop innovations that can be sold in the market. These activities take place in the early stages of the innovation process, before the entry into the market and in a context of limited competition and high uncertainty. However, most of the innovation activities of firms are developed in later stages of the innovation cycle, that is, the redesign of existing products according to market needs, the diffusion of new technologies in new areas implementation or the adoption of new technologies invented elsewhere. Additionally, research institutions and firms perceive certain aspects of collaboration differently, and it often leads to a lack of confidence and problems of communication through the innovation process.

According to previous literature, there is a lack of normative research aimed to determine the performance implications of early versus late phase of open innovation, and this research should be completed with new cases studies to contrast the effectiveness of certain open innovation practices in different environments (Huizingh, 2012). In this sense, the Triple Helix model (Etzkowitz & Leydesdorff, 2000) was regarded as a “core model” for innovation, and in the last years it has been contextualized as Quadruple Helix (Carayannis & Campbell, 2009), adding civil society, which includes the media-based and culture-based public. These authors also develop the Quintuple Helix, which brings in the perspective of the natural environments of society and the economy for knowledge production and the innovation systems (Carayannis & Campbell, 2010). However, there is a lack of studies that effectively

apply the Triple Helix model to the construction of a national strategy of R&D in emerging countries, including at the same time international cooperation as accelerator of innovation. Filling this gap will be the main goal of this work.

3. The Triple Helix model. Lights and shadows

The spiral Triple-Helix model positions the university as a strategic actor in the whole innovation process. This model assumes that research bodies, the government and industry can contribute to a country's economic growth through the development of "generative relationships" (Etzkowitz & Leydesdorff, 2000), i.e., reciprocal relations that persist over time and induce changes in the way agents come to conceive their environment and how to act in it. But in addition, in the context concerning us here, the Triple Helix model presents a new role of the university, the promotion of the development of innovations and entrepreneurship in its socio-economic environment, in what has come to be called the "Second Academic Revolution" (Etzkowitz, 1998).

The Triple Helix model constitutes a spiral model of innovation which analyses reciprocal relations in different moments in the knowledge capitalisation process (Etzkowitz, 2003) through three dimensions: 1) internal transformation of each of the "helices" (University-Industry-Government), 2) mutual influence among the three "helices" and 3) creation of a new superimposition of trilateral networks and organisations resulting from interaction between the three "helices". Superimposition of the institutional spheres through Knowledge, Consensus and Innovation Spaces is especially useful when it comes to creating a national RDI system.

Under Etzkowitz's approach, there are three stages in the process of knowledge-based economic development. The first step in the process involves building of three "Knowledge Spaces", i.e., concentrations of related RDI activities within a close geographical area. These spaces are: 1) Knowledge Space (Casas, 2001), 2) Consensus Space (Etzkowitz, 1998) and 3) Innovation Space (Etzkowitz et al., 2001).

Leydesdorff & Meyer (2006) detected three sources of variation among the technological studies: (1) industrial sectors differ in their consideration of what the relevant technologies are, (2) different technologies induce different patterns of innovation and technological diffusion (3) systems of innovation integrate and differentiate the various functions differently. These sources of variation are functional and also institutional (agents). The functions are not observable without first specifying the institutional environment (sub-

dynamic) in which they are carried out. In this sense, prior studies of knowledge-based economic and social development at a regional level using this model (Etzkowitz et al., 2001) offers precedents for using this model following the approach of our case study.

Nonetheless, although Etzkowitz (2003) himself argued that study of the Knowledge, Consensus and Innovation Spaces is consistent with an analysis of the potential implications of the design of a RDI system on economic development at a multinational, national or regional level, it seems relevant to determine whether the model is capable of reflecting sufficiently the importance of international cooperation in the acceleration of the process of transferring scientific and technological knowledge from the bodies that generate the innovation to industry.

Indeed, some case studies criticise application of the Triple Helix as an explanatory model. Tuunainen (2002), in line with Shinn (2002), question the model's capacity to explain in any depth the University-Industry-Government relationship, in a case study analysing the difficulties of marketing the results generated by a research group. In the Tuunainen´s analysis, the Triple Helix model does not resolve the main difficulties encountered: 1) conflicts in the management of intellectual property rights, 2) common problems resulting from University-Industry collaboration and in transferring research results to the market, and 3) failed attempts to create a hybrid community between the research group and the spin-off company. These results demonstrate two limitations to the Triple Helix model (Tuunainen, 2002):

- The theoretical framework is too broad and ambiguous to provide a justified frame of reference to be directly applied to a real case. Tuunainen argues that there is a need to study specific processes that address various dimensions of the science-society interaction and contrast the results achieved with the claims of the model.
- The theoretical approach of the Triple Helix not pay enough attention to problems and contradictions related to the commercialisation of research results generated in the university. This calls into question the model's capacity to describe and understand the relationship between the three helices (University-Industry-Government).

Along similar lines, Elzinga (2004) criticises the lack of fitness of this model to the current situation of scientific research, which has to address the challenges of internationalisation and globalisation, as well as managing external financing and linking science with the commercial

interests and normative conflicts between academia and industry, all aspects that generate a new "social contract" of science.

From another perspective, Fitriati et al. (2012) review the usefulness of the Triple Helix model by comparing it to the case of the Indonesian national social security system, concluding that model as originally defined is not capable of reflecting the inter-relations between the members of the system. These authors argue in favour of completing the model with a fourth helix, the legislative body. They believe that is the only way of achieving a conceptual model capable of explaining how the Indonesian health authority seeks to achieve service innovations. In their case study, the development of a law (Act 24/2011) capable of regulating the national social security administration to a great extent affected the collaboration relations of the Triple Helix.

The existence of critical studies with empirical evidence relating to factors not sufficiently covered by the Triple Helix model mean that there is "reasonable doubt" as to the limitations of this model for all its well-proven virtues (Danell & Person, 2003; Etzkowitz et al., 2005; González de la Fe, 2009; Piqué et al., 2006; Shinn, 2002). One critical issue that we attempt to contrast in this study is whether the Triple Helix model relevantly addresses the role of international cooperation in the creation of Knowledge Spaces through the University-Industry-Government interaction.

Taking into consideration the previous review, new cases of study are needed to add evidences of the application of Triple Helix model to the design of a national RDI strategy in emerging countries. In this sense, the study of the construction of the Knowledge, Consensus and Innovation Spaces, and also the role of the legislation and international cooperation as accelerator of innovation could increase the implementation capacity of the Triple Helix model.

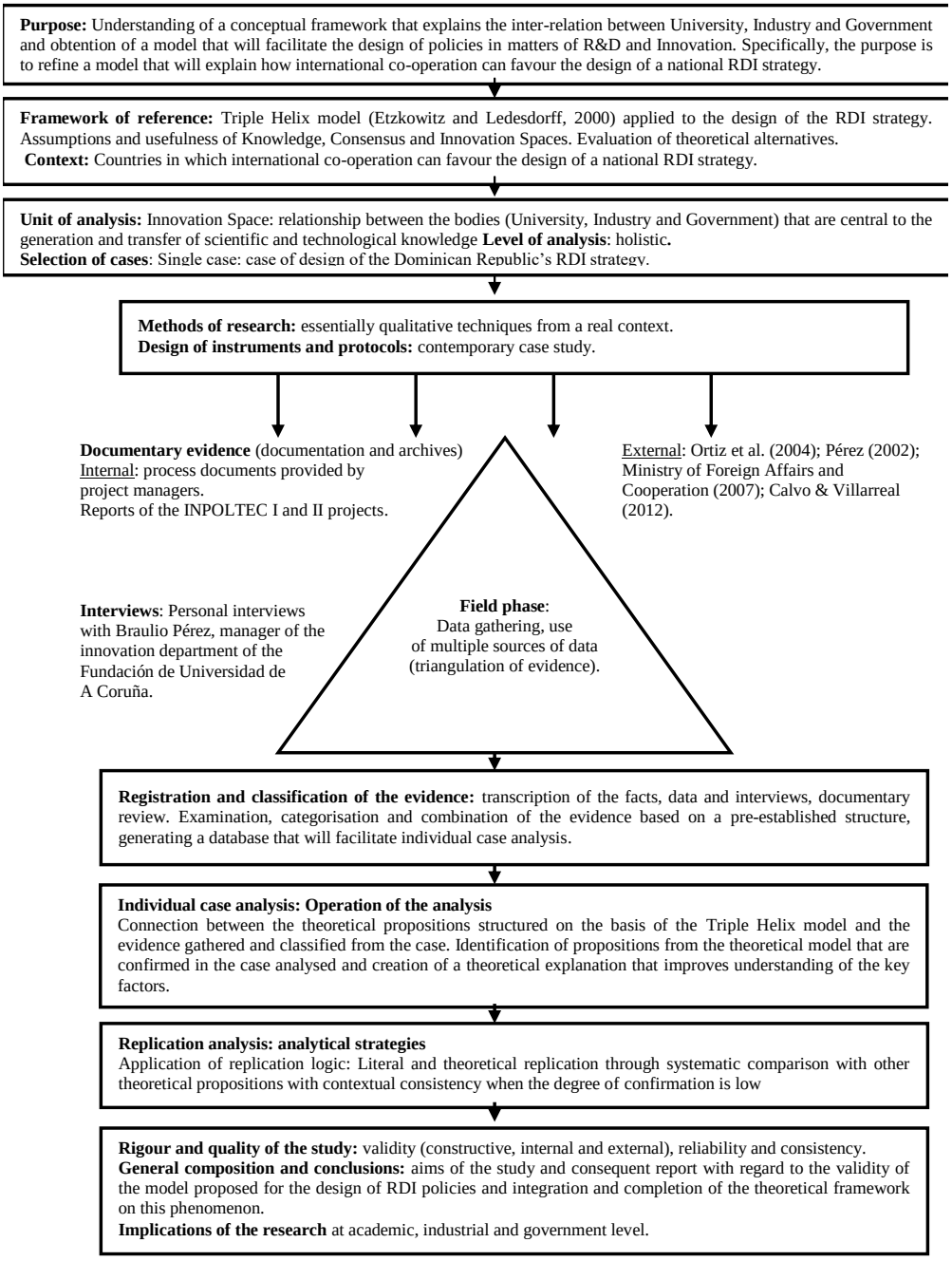
The purpose of our analysis is therefore to validate the Triple Helix model as a framework of reference applied to the case of the design of the Dominican Republic's RDI strategy for 2001-2007, and to examine whether there are limitations to the model and systemic parts of the phenomenon that it fails to address sufficiently.

In order to contrast the Triple Helix model with this case of study, we defined five propositions, which are described in section 5.

4. Methodology

We have used a single holistic case study design, adapted from Villarreal (2007) and Villarreal & Landeta (2010). This design has been drawn up using the most relevant contributions (Eisenhardt, 1989; Yin, 1994, 2012, 2014; Maxwell, 1996) taken from a review of the literature. This has allowed us to implement a series of protocols to contrast the theoretical framework with the real case studied (Figure 1 and Table 2).

Fig. 1. Methodological design of the case study



Source: adapted from Villarreal (2007; 2008) and Villarreal & Landeta (2010).

Table 2
Case study data

Purpose of research	Understanding of a conceptual framework that explains the inter-relation between University, Industry and Government and obtention of a model that will facilitate the design of RDI policies. Specifically, the purpose is to refine a model that will explain how international co-operation can favour the design of a national RDI strategy. This identification will make it possible to establish potential means of improving on the model overcoming any limitations.
Methodology of research	Single holistic Case study (single analysis unit). Exploratory and partially explanatory study.
Single analysis unit	Innovation Space: relationship between the bodies (University, Industry and Government) that are central to the generation and transfer of scientific and technological knowledge
Geographical coverage	Worldwide.
Universe	Countries in which international co-operation can favour the design of a national RDI strategy.
Type of sample	Logical and theoretical sample (capacity for analytical generalisation of the phenomenon studied), non-random (sampling and statistical generalisation).
Sample	Single case: case of design of the Dominican Republic's RDI strategy.
Evidence-gathering methods	Documentary review (documentation and archives). Multiple interviews with open and closed questions. Use of physical, technological and cultural evidence.
Information sources	Internal: reports, internal reports and studies, publications from innovation support programmes. External: publications, databases, media, government websites and other reports.
Key informers	Agents participating actively and directly in the case studied.
Methods of analysing the evidence	Essentially qualitative: - Identification and structural classification of key dimensions. - Search for key factors. - Search for critical difficulties. - Creation of theoretical explanation (comparison by replication analysis). - Analysis of critical decisions.
Scientific approach	Analytical induction through replication logic (analytical generalisation). Deductive processes insofar as they arise from the theoretical propositions of theory review.
Evaluation of the methodological rigor and quality	Validity (constructive, internal and external), reliability, consistency (contextual and theoretical - interpretative).
Date conducted	2010-2013

Primary data were obtained from surveys and interviews developed in the framework of the international project INPOLTEC (2001-2007). However, the finalization of the economic support of the project in 2007 prevented the evidences collection about the final implementation of the R&D strategy, which is a limitation of the study.

Table 3 shows the rigour and quality assessment tests used in this case study.

Table 3
Assessment of the rigour and quality of the case study. Case study assessment tests.

Test	Tactical	Research phase
Constructive validity	Prior analysis of the conceptual context and theoretical framework (*theoretical triangulation*).	Review of the literature
	Structural design of main conceptual elements based on the *Triple Helix model* (theoretical model).	Design of the research
	Synthesis of main explanatory factors in said original model.	Design of the research
	Use of different methods for gathering the evidence (*methodological triangulation*):	Evidence gathering
	- Documentary review.	
	- Multiple in-depth interviews.	Evidence gathering
	- Use of physical, technological and cultural artefacts.	
	Use of multiple sources of information. (*data triangulation*) to confirm evidence in different sources:	
	- Internal and external, direct (primary) and indirect (secondary).	
	- Varied typology: documentation, files, interviews, questionnaires, databases, real physical context.	Evidence gathering and analysis
	- Diversity of key informers faced with the same questions.	Design and gathering
	- Critical assessment of evidence compared by source.	Gathering and analysis
	Quasi-simultaneous and unified process of evidence gathering and analysis.	Composition
	Establishment of chain of evidence.	All
	Feedback and interactive contact with informers.	
	Review of case report by key informers.	
	General and instrumental flexibility of the research through cyclical review of the field study and the original structural model.	
Internal validity	Pattern matching (support in theoretical propositions).	Individual and replication analysis
	Creation of explanation (systematic comparison of the structured literature in the theoretical model).	Individual and replication analysis
External validity	Eclectic and inclusive approach to the theoretical perspectives and focuses on innovation.	Design of the research
	Use of rival theories in original model (*theoretical triangulation*).	General design
	Establishment of unit of analysis and selection of the case based on the potential of knowledge on the phenomenon studied (international cooperation in innovation).	Identification of unit of analysis and selection of case
	Selection of evidence-gathering methods (*methodological triangulation*) and information sources (*data triangulation*) based on the potential for understanding the phenomenon under study.	General design and evidence gathering
	Use of key explanatory factors of rival theories in the case.	Individual analysis
	Application of *replication logic* (analysis of other case studies) to arrive at *analytical generalisation*.	Replication analysis and conclusions
	Consideration of the results of the research as an initial hypothesis for studies in future lines of research.	Composition and conclusions
Reliability	Creation of a *study protocol* and monitoring of guidelines as a guide for action.	General design and data gathering
	Preparation of a *database* that will organise, integrate and synthesise the information obtained from the different sources of evidence.	General design and data gathering
	Ethical commitment on effort, time, dedication and specific activities of the key informers involved.	General design and data gathering
	Rigorous assessment of ethical aspects in obtaining and analysing the evidence.	General design, gathering and analysis
Theoretical-interpretative consistency	Prior understanding of perspectives and terminology of the phenomenon and the context according to key informers (high degree of empathy with the frameworks of reference of the sources of information).	General design and data gathering
	Use of techniques (starting protocol, open questions, semi-structured interviews) that will allow dialectic initiative by key informers.	General design and data gathering
	Systematic critical comparison between the theoretical propositions structured in the theoretical model and those assumed and obtained from the sources of evidence.	Data gathering and analysis
	Critical filtering of the contextual knowledge based on relevant conceptual and theoretical elements established in the theoretical model.	Data gathering and analysis

Contextual consistency	Attention to relevant contextual elements for explaining the phenomenon to be studied, even those not explicitly set out in the original model.	Evidence gathering
	Consideration of the generic environment of the unit of analysis and critical assessment of the evidence based on this (macro) context.	Data gathering and analysis
	Consideration of the specific environment of the case and critical assessment of the evidence based on this (micro) context.	Data gathering and analysis

Adapted from Yin (1994) and Villarreal & Landeta (2010).

5. Assumptions of the Triple Helix model: propositions for the case study

In order to allow the Triple Helix model established by Etzkowitz and Leydersdorff to be contrasted with the case study, we applied the propositions listed below to explain the phenomenon analysed in the real context of the design of the Dominican Republic's RDI strategy. These propositions include both the main bases of the model (propositions A, B and C) and those related to certain deficiencies inferred from other studies (Propositions D and E):

PROPOSITION A: The Triple Helix bases multiple reciprocal University-Industry-Government relations on different points in the process of knowledge capitalisation (Knowledge, Consensus and Innovation Spaces).

PROPOSITION B: The Regional Innovation Environment concept consists of a set of political, industrial and academic institutions which, either in a planned or a spontaneous manner, work to favour improvements in local conditions that will favour innovation (Knowledge Space).

PROPOSITION C: The concepts of social capital and rootedness refer to the density of social relations and trust existing in interpersonal relations. These concepts can be extended across institutional borders, by investigating the production conditions of social and relational capital in the different institutional spheres, allowing for both hierarchical and horizontal coordination (Consensus Space).

PROPOSITION D: The Triple Helix correctly and sufficiently supports the importance of international cooperation in accelerating the process of transferring scientific and technological knowledge from Universities to Industry (Innovation Space).

PROPOSITION E: The Triple Helix correctly and sufficiently supports the importance of the legislative institution in freely associated reciprocal relations established between University, Industry and Government.

6. Design of the Dominican Republic's RDI strategy

In 1961, the Dominican Republic had only one university, educating 3,600 students (Pérez, 2002). Given the country's economic vulnerability and development problems combined with its small size, the only means of ensuring progress in human development and improving the living conditions of its people through innovation was through regional integration with other nations. Throughout the 1990s, the Dominican Republic underwent a process in which the legal and institutional bases of higher education, science and technology were upgraded. The State Secretariat for Higher Education, Science and Technology (SSHEST) was created, taking over the functions of the former National Council for Higher Education with additional competences in the area of science and technology.

The first stage of the INPOLTEC project (2001-2003) arose as an international cooperation agreement between the SSHEST, the Dominican Institute of Technology (INDOTEC), the Pontificia Universidad Católica Madre y Maestra (PUCMM) and the Spanish public institution Xunta de Galicia (regional government of Galicia), which delegated the running of the project to the Fundación de la Universidad de A Coruña (FUAC) (A Coruña University Foundation). The goal of the project was to design and implement the Dominican Republic's RDI strategy for the following decade, and with it to endow the country with a powerful instrument of economic and social development.

The first task of the INPOLTEC project was to establish the Dominican Republic's initial position in the context of RDI. This required introducing a conceptual framework agreed upon by all the experts. It also entailed identifying the primary characteristics of the scientific and business community of the Dominican Republic, and positioning the country in terms of RDI in relation to its benchmark neighbours (Bravo-Juega et al., 2004).

To achieve such ambitious objectives, leading representatives from the Dominican scientific community were invited to two important seminars in 2001 and 2002.

In presenting the RDI concepts, the aim of the team of international experts was that key social partners from the Dominican Republic would share a common language with the team of experts. However, despite sharing a common language, innovation did not mean the same thing to Spaniards and Dominicans. They needed a standard from which to work and generate a "Consensus Space" among the agents in the innovation system. For this purpose, they took the OECD manuals (1993, 1996) as their conceptual base. Thus the work of building the Dominican RDI plan was oriented along the lines set out in the Frascati and Oslo manuals (international standards). However, given the geographical context of the project, particular

emphasis was placed on the considerations of the Bogotá Manual (RICYT/OEA/CYTED, 2001). This document contained reflections on the specific characteristics of innovation in developing countries.

This approach sought to avoid the distortions that could be caused by applying procedures that were valid in countries with a greater RDI tradition but at a distant from the real position of science and technology in the Dominican Republic.

Having reached consensus on RDI concepts, the team of international experts compiled and analysed the existing information on the Dominican Innovation system, according to the OCDE model (1999), generating a "Knowledge Space" amongst all the agents involved in that system. The actions carried out consisted of conducting: a) a "Census of Researchers" in the Dominican Republic, b) a "Survey of R&D in Research Centres" and c) a "Survey of technological innovation in Firms".

These tasks helped to consolidate initial confidence in the team of international experts, and made it possible to design a system of innovation indicators for the Dominican Republic, which were compared against those of other Latin American countries and presented to local public authorities. In addition, the lines of support for international cooperation in innovation were set out; these came both from the European Union and also from Spain.

The initial results[1] of the first stage of INPOLTEC (2001-2003) were not encouraging. However, the ultimate goal was to start a discussion on the strategic lines that needed to be implemented in order to improve the Dominican situation, generating a Knowledge Space in which local and international experts could identify innovation niches with potential to become development poles in the future. The country's RDI strategy should then focus on these issues.

A. Situation of Dominican firms in RDI

The international experts designed a survey targeted at a sample group of Dominican firms, with the aim of determining the role of the firms in the Dominican Innovation System (Table 4). The innovations surveys employed the international methodology set out in the OECD's Oslo Manual, and a sample group of 1,000 representative Dominican firms was surveyed. The procedure used in the survey involved personal interviews in the offices of the firm with the

[1] These results are presented in extended form in Calvo and Villarreal (2012) and Pérez (2002).

person who had information on the situation of the firm´s innovation. The fieldwork was carried out in the last quarter of 2001, and a total of 971 valid responses were generated.

Table 4
Innovating firms in the Dominican Republic (% of respective totals)

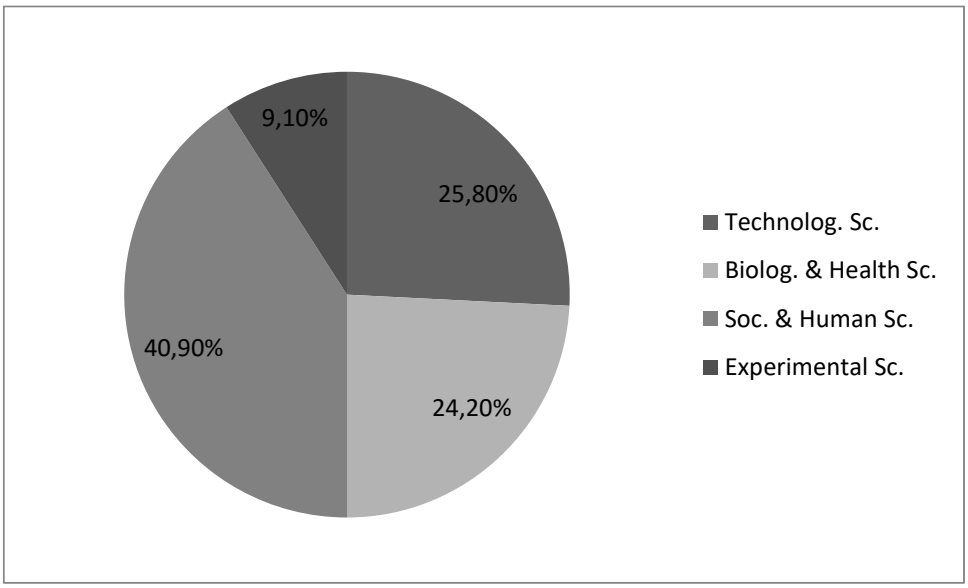
	Innovating (%)	R&D (%)	Number of companies surveyed
Geographical orientation			
Santo Domingo	42.7	6.3	726
Multinational	59.6	0.6	178
Free Trade Zone	50.4	0.4	224
Sectorial orientation:			
Agri-food industry;	37.4	2.3	214
Chemical industry	60.3	36.2	58
Traditional industrial sector	47.6	2.8	502

Adapted from Pérez (2002).

B. Situation of the scientific and technological community of the Dominican Republic

In order to get a clearer idea of the scientific and technological situation in the Dominican Republic, a "Who's Who" of science and technology in the Dominican Republic was drawn up in order to extend the contents of the "Knowledge Space" in the country. A survey was conducted among researchers from higher education, science and technology institutions to establish a direct contact with the scientific and technological community in the country and determine its basic characteristics. Answers were received from 132 researchers responsible for research teams (Figure 2).

Fig. 2. Percentage of researchers by scientific and technological area (2001)



The data obtained suggested that research potential in Dominican higher education, science and technology institutions justified the work of organising and utilising their capacities in an RDI Strategy Plan.

C. Situation of the Dominican Republic in science and technology compared to other Latin American countries

The RICYT data provided a reliable estimate of the number of people working in R&D in the Dominican Republic, giving an initial idea of the country's "Innovation Space". Researchers accounted for 0.13 per thousand of the Dominican workforce, putting the country in last place among all Latin American countries (RICYT, 2000) with data for this indicator (Table 5).

Table 5
Researchers and Science Citation Index publications in Latin American countries

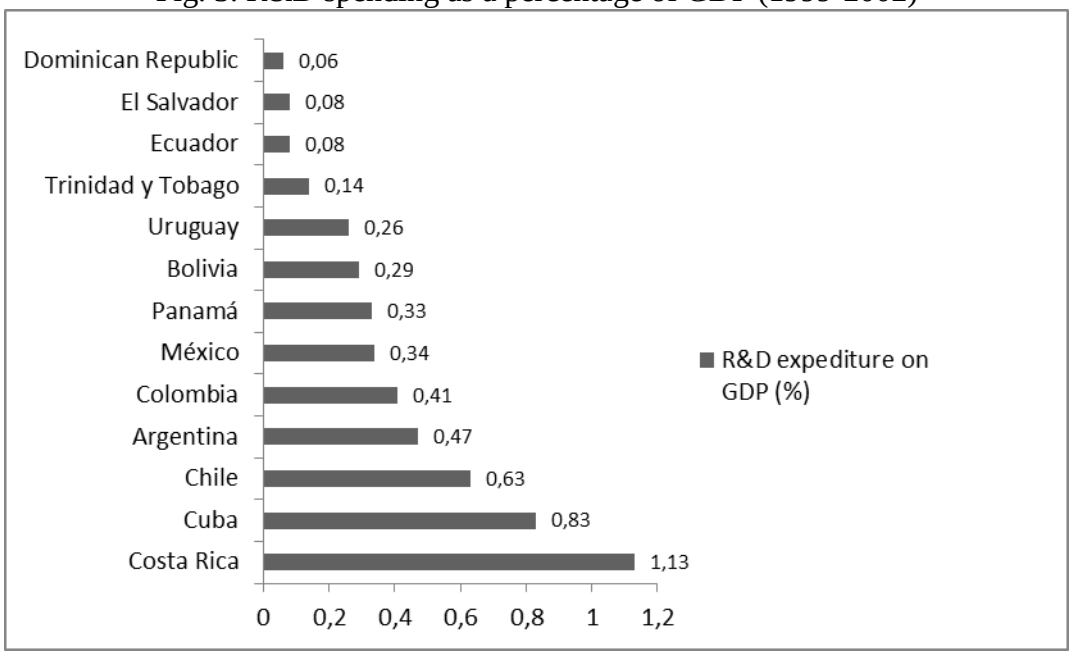
	Researchers as a proportion of workforce (*1000)	SCI publications per population (*1000)
ARGENTINA	2.10	1.24
COSTA RICA	1.53	0.63
URUGUAY	1.52	1.07
CHILE	1.22	1.25
CUBA	1.18	0.49
PANAMA	0.78	0.50
MEXICO	0.74	0.48
BRAZIL	0.67	0.61
TRINIDAD AND TOBAGO	0.66	0.83
COLOMBIA	0.47	0.14
BOLIVIA	0.35	0.11
ECUADOR	0.31	0.09
EL SALVADOR	0.20	0.01
DOMINICAN REPUBLIC	**0.13**	**0.03**
LATIN AMERICA	0.82	0.55

All figures on researchers are from 1999, except for Colombia, Ecuador and Panama (1998); Trinidad and Tobago (1997); Costa Rica (1996) and Brazil and Mexico (1995). Figures on SCI publications are from 1998.
Pearson's correlation coefficient for the 14 countries = 0.847 (significant correlation at level 0.01, (bilateral))

RICYT (2000)

The various science and technology indicators analysed also placed the Dominican Republic last among Latin American countries. To a great extent, its expenditure on R&D as a percentage of GDP also reflected this weak position (Figure 3).

Fig. 3. R&D spending as a percentage of GDP (1999-2002)



The results showed that Dominican Republic had less RDI development than other countries in the region. A great effort was required of all parties to advance RDI and make use of the Triple Helix dynamic to favour the development of knowledge niches supported by the local economy. The next steps in the INPOLTEC project needed to be oriented towards the organization of possible actions that would allow this challenge to be addressed and favour the design of an "Innovation Space".

The success of the first stage of the INPOLTEC project stimulated a continuation of the cooperation begun between Spain and the Dominican Republic, even after a change in the Dominican government in 2003. The trust and good relations between the group of international and local experts extended the "Consensus Space" to an international dimension. The second stage of INPOLTEC project was developed from 2004 to 2007, and it was focused on the formulation of the RDI strategy of the Dominican Republic.

D. Formulation and strategic design

The survey of key social partners allowed an itemised list to be drawn up of the problems affecting the Dominican Republic. Classification of these problems showed that they were of a dual nature (Bravo-Juega et al., 2004): a) *Socio-economic problems*, which affected the

Dominican Republic's possibilities for social and economic development and which could be addressed through investment in RDI; b) *Problems related to science and technology management* which hindered the development of RDI in the Dominican Republic.

In this second phase of the INPOLTEC project (2004-2007), the socio-economic problems were classified by economic sector (Table 6).

Table 6
Socio-economic problems

Sector	Problem
Agricultural	- Low competitiveness
	- Migration from the countryside to the city
Industrial	- Low adaptation to a global knowledge-based market
	- Lack of harnessing of competitive opportunities
Energy	- Difficulties in power generation and distribution
Education	- Shortfalls in primary education and medium-level technical education
	- Lack of qualified professionals in industry
Environment	- Environmental threats resulting from atmospheric emissions, discharges and waste
	- Need to implement environmental management standards among businesses
Health	- Problems of management and qualification of health personnel
Construction	- Lack of town planning
Infrastructures	- Need to improve transport to rural areas of tourist development
	- Need to develop telecommunications infrastructures

INPOLTEC II project. Adapted from Bravo-Juega et al. (2004).

Issues related to science and technology management were classed in two groups: those related to the government's science and technology actions and those due to the institutions of higher education, science and technology themselves.

These problems were used as the basis for determining elements to be taken into account in planning RDI-related actions, and represented the challenges to be addressed in the actions of the State Secretariat for Higher Education, Science and Technology.

In October 2004, the team leading the project organised a communication session in order to offer the Dominican government a strategic design with which to orient public action in RDI over the coming years. In developing this design, they once again received input from the key social partners in the Dominican Republic (university and industry), to which the Spanish experts brought European experience in planning (conveyed via the INPOLTEC project work team).

The opinions of the key social partners from the Dominican Republic were taken into account in determining the nature of the proposed RDI Plan. The methodology used consisted of a presentation of the alternatives by the INPOLTEC project work team, and a discussion and selection, through a majority process, by the group of key social partners from the Dominican Republic. Out of this interaction emerged the bases for design of the Proposed RDI Plan.

a. Institutional management base

The key social partners ranked science and technology promotion very high in a list of the Dominican government's policies. They also felt that it should be built on a solid institutional base; this entailed giving it the status of a State Policy.

The science and technology promotion plan would have to be set out in a multiannual RDI Plan, representing the Dominican government's long-term commitment to developing science and technology in the country. The plan would seek to encourage creative aspects of scientific and technological activity, as outlined in the list of RDI concepts. Through this action, an "Innovation Space" would be formed. This would be an organisational mechanism capable of meeting the innovation commitments acquired in the "Consensus Space", with sources of financing, technical assistance and systems of support for business creation.

Given that legislation was already in place to allow public actions of support for science and technology to be taken, (Act 139-01), the key social partners felt that the State Secretariat for Higher Education, Science and Technology should be the body within the Dominican government responsible for launching and managing the RDI Plan.

b. Core activity and actors

According to the key social partners surveyed, the RDI Plan for the Dominican Republic should prioritise actions of scientific and technological adoption, with a form of RDI that would be oriented towards adapting the knowledge elsewhere in the world to the specific needs of the Dominican Republic. In view of the preliminary diagnosis of the "Knowledge Space", any support for scientific and technological creation that sought to advance international frontiers in scientific and technological knowledge should be limited to specific actions within the Dominican RDI Plan, only where some promising opportunity was detected.

As for the agents of execution, the institutional context of support action of the RDI Plan should be the institutions of higher education, science and technology and all matters

within them related to private enterprise. As a result, the plan was targeted at the higher education, science and technology institutions, as established in Act 139/01. At the same time, there were already other bodies in the Dominican government proposing to take action in the area of business innovation. It was therefore necessary to prevent the RDI Plan from coming into competition with these initiatives and breaking the "Consensus Space". Technological Innovation therefore had to be included in the plan through the encouragement of a linking between higher education, science and technology institutions and industry.

c. Attention to the problems of the Dominican Republic

Design of the RDI Plan would have to be structured taking into account the problems of different kinds affecting the Dominican Republic, both social and economic, and those related to institutions of higher education, science and technology.

Finally, it was important to bear in mind that plan could not address all issues, nor resolve them immediately. A list of priorities had to be drawn up, constituting a political decision with implications for budgetary allocation.

D. Proposed RDI Plan for the Dominican Republic

Based on the above recommendations debated within the group of key social partners, a Proposed RDI Plan was drafted by the INPOLTEC II project work team. It was structured identifying objectives, periods, participants, systems of participation, blocks of activity and programmes, financing and ways of assessment.

It was proposed that the following list of agents should be eligible participants in the Dominican RDI Plan: a) institutions of higher education, science and technology from the Dominican Republic with research groups in operation, b) firms from the Dominican Republic and any other geographical area that could provide financing and clients or users of the research results, c) interface units, which would promote a rapprochement between higher education, science and technology institutions and industry, d) individual researcher –experienced or still in education, e) social institutions and f) civil servants and work units from the State Secretariat for Higher Education, Science and Technology.

The RDI Plan was structured into blocks of activity that are deployed in programmes. The blocks of activity were defined on the basis of strategic objectives as follows (Table 7):

Table 7
Structure of the RDI Plan

Activity block	Strategic Aim	Programmes
Activity Block 1	Convert science and technology into sustainable-development solutions for the Dominican Republic	- Agricultural Production Programme - Energy Programme - Environment Programme - Health Programme - Construction Programme - Communication Infrastructures Programme - Information Society Programme
Activity Block 2	Structure the Dominican Republic's higher education, science and technology system	- General Knowledge Promotion Programme - Human Resources Programme - Scientific and Technological Infrastructures Programme - Research and Innovation Liaison Programme - Education Programme
Activity Block 3	Reinforce public management of R&D and technological innovation in the Dominican Republic	- Information and Communication Programme - Coordination Programme - Internationalisation Programme

INPOLTEC II project. Adapted from Bravo-Juega et al. (2004)

The financing section included the financial instruments and resources of the RDI Plan, which would make up the "Innovation Space".

Assessment was considered to be a very important phase in the RDI Plan. As far as possible, it was essential to ensure that decisions on applications for grants were taken objectively and to allow the plan to be adapted to changes occurring over time. Two assessment procedures were proposed: a) *ex-ante assessment*: grading of applications by panels of expert assessors and b) *strategic assessment*: decision making for reorientation of the plan, which required building indicators of science and technology in the country. It was therefore proposed that these procedures should be implemented by the State Secretariat for Higher Education, Science and Technology, in coordination with the statistical services of the Dominican Government.

In conclusion, the results of the INPOLTEC projects, developed through international cooperation between Spain and the Dominican Republic, demonstrated that it was possible to undertake initiatives of support for science and technology not only from the isolated perspective of the individual state, but through cooperation between countries within the Central American and European area.

7. Results: application of the Triple Helix model to the case study

In order to favour contrast of the Triple Helix model with the actual situation analysed, we have proceeded to apply its principal propositions to the case study:

PROPOSITION A: The Triple Helix bases multiple reciprocal University-Industry-Government relations on different points in the process of knowledge capitalisation (Knowledge, Consensus and Innovation Spaces).

In the case in question, the process of designing the Dominican Republic's RDI strategy was based on the relations between the SSHEST (Dominican government), the country's university directive, a representative sample from the business world and a group of international experts.

Throughout the process, individual inputs from each helix were specified as well as actions stimulating the relationship between them (Table 8).

Table 8

Reciprocal relations between helices

Process phases	Individual input from each helix	Relations between helices
1. Diagnosis of the R&D situation in the Dominican Republic	- R&D situation of Dominican firms - R&D situation of the university - The country's relative R&D position	- Linguistic consensus in innovation. Agreement on definition of: o R&D concepts o Concepts of technological innovation
2. Detection of problems	- Socio-economic problems of a sectorial nature (Government and Industry) - Problems of science and technology management (Government and University)	- Conflict of competences between government bodies - Lack of information between helices - Lack of personnel with liaison functions between helices
3. Formula of the R&D Strategy	- Design of objectives (Administration) - Proposal of systems of incentives (Government and University) - Financial regulation (Government)	- Creation of interface bodies - Design of liaison programmes between research and innovation - Design of information and communication, coordination and internationalisation programmes

PROPOSITION B: The Regional Innovation Environment concept consists of a set of political, industrial and academic institutions which, either in a planned or a spontaneous manner, work to favour improvements in local conditions that will favour innovation (Knowledge Space).

Construction of the Regional Environment favouring innovation in the Dominican Republic involved the following national and international institutions (Table 9):

Table 9
Institutions participating in the Regional Innovation Environment

Type of institution	Bodies	Description
Political	- SSHEST	Local institutions
	- INDOTEC	
	- Government of Galicia	International institution
Industrial	Multi-sectorial sample of firms	No leadership as an institution
Academic	PUCMM	Local academic institutions
	INDOTEC	
	FUAC	International management institution

Throughout the process of designing the RDI Strategy Plan, the Knowledge Space was configured as a set of actions of a formal and informal nature (Table 10).

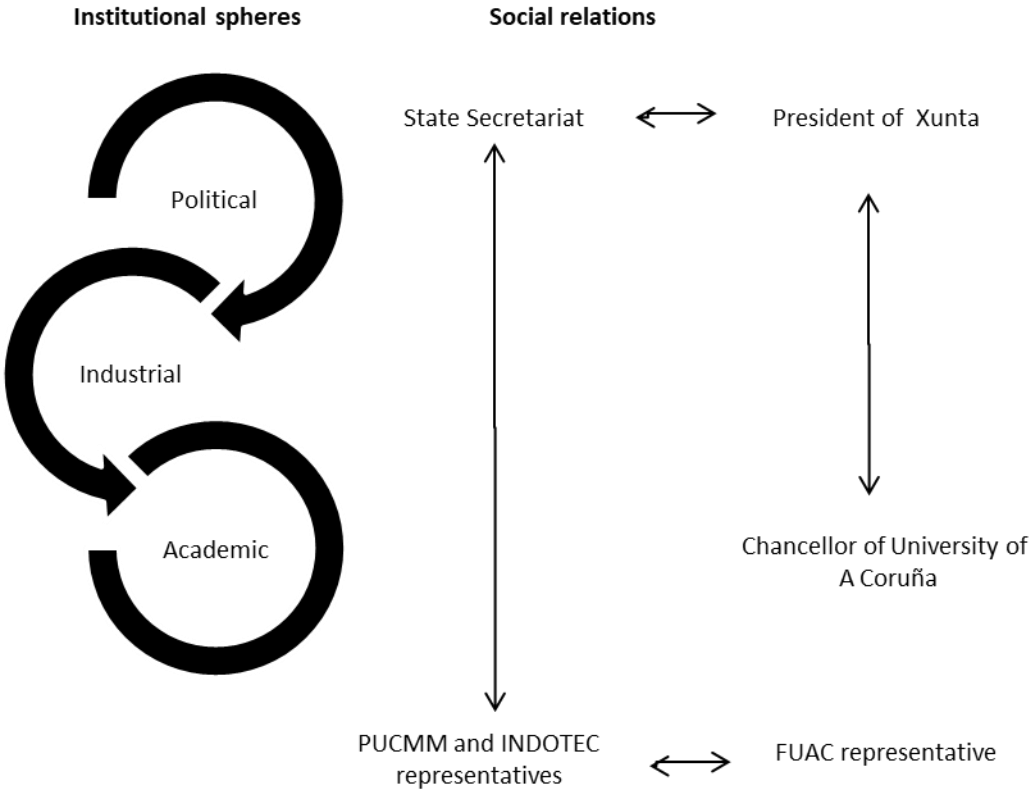
Table 10
Knowledge Space

Formal planning	Spontaneous relations
Seminars on Innovation Strategy and Technological Policy	Initial contacts between representatives from the SSHEST, INDOTEC, the PUCMM, the Government of Galicia and the FUAC
Interviews with firms	
Interviews with research groups	Continuity of the project thanks to the trust established between the interlocutors from the SSHEST, INDOTEC, the PUCMM and the FUAC

PROPOSITION C: The concepts of social capital and rootedness refer to the density of social relations and trust existing in interpersonal relations. These concepts can be extended across institutional borders, by investigating the production conditions of social and relational capital in the different institutional spheres, allowing for both hierarchical and horizontal coordination (Consensus Space).

In the process of designing the RDI Strategy Plan for the Dominican Republic, three institutional spheres were detected (political, industrial and academic), although relations were only coordinated between the political and academic institutions (Figure 4).

Fig. 4. Consensus Space.



PROPOSITION D: The Triple Helix correctly and sufficiently supports the importance of international cooperation in accelerating the process of transferring scientific and technological knowledge from universities to industry (Innovation Space).

The Triple Helix model establishes two propositions directly related to globalisation: and international relations (Etzkowitz, 2003). The first of these states that innovation management is decentralised in a global environment, and takes place through regional networks among universities, as well as through multinational corporations and international organisations. These new configurations become the basis of a continuous process of business development, diversification and collaboration between competitors. Developing countries and regions have the possibility of making rapid progress by basing their development strategies on the construction of niche knowledge sources, supported by the local political economy.

In the case in question, only through collaboration between the group of international experts and local university and government leaders was it possible to design the RDI Plan for the Dominican Republic in agreement with the agents in the innovation system, supported by international innovation standards and previous successful experiences. In addition, particular importance was given to the fact that RDI actions backed by sources of public financing must be related to the needs and capacities of the local economy. The INPOLTEC project, and its continuation in the INPOLTEC II project is a clear example of a "generative relationship" (Leydersdorff & Etzkowitz, 1997), i.e. a joint initiative that persists over time and induces changes in the way agents come to conceive their environment and how to act in it.

Nonetheless, the model's somewhat vague and ambiguous approach did not give sufficient relevance to the key factor of this proposition (international cooperation) and it is therefore insufficiently precise in this regard.

PROPOSITION E: The Triple Helix correctly and sufficiently supports the importance of the legislative institution in freely associated reciprocal relations established between University, Industry and Government.

The Triple Helix model states that political and social arrangements based on principles of equity and transparency lay the groundwork for rapid development in a stable environment (Etzkowitz, 2003).

With regard to this proposition, the case analysed demonstrates the need to extend the model, with particular stress on legislative development in the specific context. Of key importance in this regard were the Higher Education, Science and Technology Act (Act 139-01) and the creation of the State Secretariat for Higher Education, Science and Technology, with capacity to lead the government's role in designing the RDI Plan and laying the foundations for the action programmes and their financial backing.

Based on the above analysis, we may determine the degree to which the case study confirms the propositions of the model (Table 11).

Table 11
Degree of confirmation of propositions

	Propositions	Degree of Confirmation
A.	*The Triple Helix bases multiple reciprocal University-Industry- Government relations on different points in the process of knowledge capitalisation.*	Confirmed to a high degree. Identification of the three helices facilitated coordination and participation of all those involved in design of the R&D Strategy Plan. However, the conceptual framework does not include certain points of relationship between the university and industry.
B.	*The Regional Innovation Environment concept consists of a set of political, industrial and*	Confirmed to a high degree. Formal relations were led by representatives of the political and academic

	academic institutions which, either in a planned or a spontaneous manner, work to favour improvements in local conditions that will favour innovation (Knowledge Space).	institutions and coordinated by the international experts. The city of Santo Domingo is configured as a development pole, given the concentration of firms and research groups. However, the lack of an interlocutor from the business institution suggests potential problems in adapting the innovation environment to business needs.
C.	*The concepts of social capital and rootedness refer to the density of social relations and trust existing in interpersonal relations. These concepts can be extended across institutional borders, by investigating the production conditions of social and relational capital in the different institutional spheres, allowing for both hierarchical and horizontal coordination (Consensus Space).*	Confirmed. The fact that the Secretary of Status has remained in her post reduces the delay in institutional decision-making. The trust established between the local and international academic authorities favours the continuance of the project and broadens its scope.
D.	*The triple helix correctly and sufficiently supports the importance of international cooperation in accelerating the process of transferring scientific and technological knowledge from the bodies that generate it to industry (Innovation Space).*	Partial confirmation. Starting from the Consensus Space created between the team of international experts and the local interlocutors, it has been possible to continue the project of strategic RDI design over a period of nearly a decade. Design of the RDI Strategy Plan focuses on those niches in which the Dominican innovation system may be competitive, avoiding setting innovation targets in all fields. However, the Triple Helix model, although recognising the relevance of international innovation management, does not provide instruments that establish the role of international cooperation in the process of innovation transfer.
E.	*The triple helix correctly and sufficiently supports the importance of the legislative institution in freely associated reciprocal relations established between University, Industry and Government.*	Unconfirmed. The model does not support this relationship. In line with other recent studies (Fitriati et al., 2012), the conceptual framework does not include the legislative institution as a necessary fourth helix in the model. The case presents evidence of the importance of legislative development in the Dominican innovation process.

8. Conclusions

Etzkowitz defined Innovation Space as an organizational mechanism that attempts to realize the goals articulated in the Consensus Space. For this, the capture of sources of financing, technical assistance and support for business creation are determinant to the success of the environment. The case study discussed here reflects how the Triple Helix model constitutes a conceptual framework capable of articulating University-Industry-Government relations when it comes to establishing a national RDI Strategy Plan.

However, an in-depth analysis of the Knowledge, Consensus and Innovation Spaces has confirmed the existence of certain limitations to the model. In essence, the model's capacity adequately to handle the globalised environment of innovation systems, through international cooperation, needs further specification. In addition, the importance of the legislative institution is not adequately considered in the model. In the case study, the development of

the Higher Education, Science and Technology Act (Act 139-01) had an enormous effect on the creation of the regional innovation space.

Based on the evidence found in this case study, we propose an extension to the Triple Helix model, incorporating the legislative institution, and including the role of international cooperation as an accelerator of the process of scientific and technological knowledge transfer from the bodies that generate it to industry. This will make it possible to relate the Triple Helix to the Open Innovation model from a global perspective (Figure 5).

Fig. 5. From the Triple Helix model to the Global Open Innovation model.

The proposed model posits the existence of a linking mechanism between the four institutional spheres of innovation (political, legislative, industrial, academic), making it possible to draw lessons from other local innovation systems while at the same time integrating the reality of the case study. The role of the interface structures as key elements of the Triple Helix model is particularly relevant in this case, favouring international financial support for this type of initiative (the INPOLTEC project was financed with European and Dominican capital), the transfer of legislative standards that served as a guide for drafting Act 131-01, and especially in the work of identifying potential researchers who met the international requirements, not only from the local area but from across the wider region.

Based on the strategic diagnosis of the Dominican innovation system, it will in the future be necessary to make a more in-depth identification of the functional and jurisdictional profile of professionals from the interface structures, as well as technological innovation supply and demand matching systems with the capacity to create cross-overs between research organisations from one country and the demands of another.

The process employed in the case of the strategic design for the Dominican Republic generates a methodology that can be transferred to other countries, and opens up new conceptual possibilities in the context of University/Industry innovation transfer.

Although the type of single case study used here allows considerable quality and depth of information, it must be accepted that it constitutes a relevant limitation to any wider application of the conclusions, and it is also a limitation from the lack of evidences of the final implementation of the R&D strategy from 2007 forward. The single case study reduces the chance of using Yin's replication logic, compared with the multiple-case study. From this perspective, the observation and analysis of the case generate new theoretical explanations, through an inductive approach that complements the deductive approach. The methodology

used in this paper also considers this value. However, the creation of the new theoretical explanations (comparison by replication analysis) should be validated through new observations. In this regard, it is proposed as line of future research to use Yin's replication logic, both in other cases with a similar context (literal replication) and in different contexts (theoretical replication), with a view to achieving a greater degree of transferability (Maxwell, 1996).

Finally, it is also proposed new studies based on national RDI strategies in emerging countries, through the construction of the Knowledge, Consensus and Innovation Spaces, and their comparison with RDI strategies in developed countries could be also new lines of research, in order to validate the model proposed in this paper.

References

Aghion, P., Bloom, N., Blundell, R., Griffith, R., & Howitt, P., 2005. Competition and innovation: An inverted-U relationship. The Quarterly Journal of Economics 120 (2), 701-728.

Aghion, P., Dewatripont, M. and Stein, J., 2008. Academic freedom, private sector focus, and the process of innovation. Rand Journal of Economics 39 (3), 617-35.

Autio, E.; Hameri, A-P; Nordberg, M., 1996. A Framework of Motivations for Industry-Big Science Collaboration: A Case Study. Journal of Engineering and Technology Management 13, 301-314.

Bianchi, M., Cavaliere, A., Chiaroni, D., Frattini, F., Chiesa, V., 2012. Organisational modes for open innovation in the bio-pharmaceutical industry: an exploratory analysis. Technovation 31, 22-33.

Bozeman, B., 2000. Technology transfer and public policy: a review of research and theory. Research Policy 29, 627-55.

Bravo-Juega, A.; Pérez, B., Mejía, R., 2004. Estrategia de innovación y política tecnológica para la República Dominicana. Proyecto INPOLTEC II. Mimeo, Santo Domingo.

Bush, V., 1945. Science the Endless Frontier: A Report to the President. United States Government Printing Office, Washington DC.

Callon, M., 1994. Is science a public good? fifth mullin lecture, virginia politec institute, 23 march 1993. Science, Technology, and Human Values, 19(4), 395-424.

Calvo, N. and Villarreal, O., 2012. Innovation and development cooperation in Central America and Caribbean: Mission impossible?. Emerging Markets Case Studies Collection 2 (8), 1-17.

Caner, T.; Sun, J. and Prescott, J.E., 2014. When a firm's centrality in R&D alliance network is (not) the answer for invention: The interaction of centrality, inward and outward knowledge transfer. Journal of Engineering and Technology Management, 33 (in progress, DOI: 10.1016)

Carayannis, E. G. and Campbell, D. F. J., 2006. "Mode 3": meaning and implications from a knowledge systems perspective. In Knowledge Creation, Diffusion, and Use in Innovation Networks and Knowledge Clusters (pp. 1–25). Westport, CN: Praeger.

Carayannis, E. G. and Campbell, D. F. J., 2009. 'Mode 3' and 'Quadruple Helix': toward a 21st century fractal innovation ecosystem. International Journal of Technology Management, 46(3), 201-234.

Carayannis, E. G. and Campbell, D. F. J., 2010. Triple Helix, Quadruple Helix and Quintuple Helix and How Do Knowledge, Innovation, and Environment Relate to Each Other? International Journal of Social Ecology and Sustainable Development, 1(1), 41-69.

Carayannis, E. G. and Campbell, D. F. J., 2011. Open Innovation Diplomacy and a 21st Century Fractal Research, Education and Innovation (FREIE) Ecosystem: Building on the Quadruple and Quintuple Helix innovation Concepts and the "Mode 3" Knowledge Production System. Journal of the Knowledge Economy 2(3), 327-372.

Casas, R., 2001. La formación de redes de conocimiento. Una perspectiva regional desde México. Antropos, UNAM, México.

Chesbrough, H., 2003. Open Innovation: How Companies Actually Do I. Harvard Business Review, 81 (7), 12-14.

Danell, R. and Persson, O., 2003. Regional R&D activities and interactions in the Swedish Triple Helix. Scientometrics 58 (2), 203-218.

Eisenhardt, K.M. 1989. Building Theories from Case Study Research. Academy of Management Review, 14(4), 532-550.

Elzinga, A., 2004. The new production of reductionism in models relating to research policy, in: Grandin, Wormbs and Widmalm (Eds.), The Science-Industry Nexus, Science History Publications, USA, pp. 277-303.

Etzkowitz, H., 1997. The Triple Helix: academy-industry-governement relations and the growth of neo-corporatist industrial policy in the U.S., in S. Campodall'Orto (Ed.), Managing Technological Knowledge Transfer, EC Social Sciences COST A3, Brussels.

Etzkowitz, H., 1998. The norms of entrepreneurial science: Cognitive effects of the new university-industry linkages. Research Policy 27, 823-833.

Etzkowitz, H., 2003. Innovation in innovation: the Triple Helix of university- industry-government relations. Social Science Information 42 (3), 293-337.

Etzkowitz, H. and Leydesdorff, L., 1995. The Triple Helix University-Industry-Government Relations: A Laboratory for Knowledge-Based Economic Development. EASST Review 14, 14-19.

Etzkowitz, H. and Leydesdorff, L., 2000. The dynamics of innovation from national systems and 'Mode 2' to a Triple Helix of university – industry – government relations. Research Policy 29, 109-123.

Etzkowitz, H., M. Gulbrandsen and J. Levitt, 2001. Public Venture Capital. Aspen 2nd Ed, New York.

Etzkowitz, H.; Carvalho de Mello, J. M. and Almeida, M., 2005. Towards 'metainnovation' in Brazil: The evolution of the incubator and the emergence of a Triple Helix. Research Policy, 34, 411-424.

Fitriati, R.; Rahmayanti, K. P. and Salomo, R. V., 2012. Critical review of Triple Helix to quanto-tuple helix: lesson learned from social security system act implementation. Procedia Social and Behavioral Sciences 52, 217-225.

Freeman, C., 1987. Technology policy and economic performance: Lessons from Japan. London: Pinter.

Fundación COTEC para la Innovación Tecnológica, 2009. COTEC Report 2009. Madrid.

Gassman, O., 2006. Opening up the innovation process: towards an agenda. R&D Management 36 (3), 223-228.

Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P., Trow, M., 1994. The new production of knowledge: The dynamics of science and research in contemporary societies. London: Sage.

González de la Fe, T., 2009. El modelo de Triple Hélice de relaciones universidad, industria y gobierno: un análisis crítico. Arbor Ciencia, Pensamiento y Cultura, 738, 739-755.

Huizingh, E., 2011. Open innovation: state of the art and future perspectives. Technovation 31, 2-9.

Kline, S. and Rosenberg, 1986. An overview of innovation. Landau and Rosenberg (Eds), National Academy Press, Washington.

Lee, S.; Park, G.; Yoon, B.; Park, J., 2010.Open innovation in SMEs. An intermediated network model. Research Policy 39, 290-300.

Leydersdorff, L. and Etzkowitz, H. (Eds.), 1997. A Triple Helix of University-Industry-Government relations. The future location of Research,.Book of Abstracts, Science Policy Institute, New York.

Leydesdorff, L. and Etzkowitz, H., 1998. The Triple Helix as a model for innovation studies. Science and Public Policy 25, 195-203.

Leydesdorff, L. and Meyer, M., 2006. Triple Helix indicators of knowledge-based innovation systems: Introduction to the special issue. Research Policy 35, 1441-1449.

Maxwell, J. A., 1996. Qualitative Research Design: An Interactive Approach. Sage Publications, Thousand Oaks.

Nelson, R. and Rosenberg, N., 1993. Technical innovation and national systems, in: Nelson, R. (Ed). National innovation systems: a comparative analysis. Oxford, Oxford University.

OECD, 1993. Proposed Standard Practice for Surveys of Research and Experimental Development. Frascati Manual. OECD, Fifth Edition. Paris.

OECD, 1996. Proposed Guidelines for Collecting and Interpreting Technological Innovation Data. Oslo Manual. OECD, Second Edition, Paris.

OECD, 1999. Managing National Innovation Systems OECD, Paris.

Pérez, B., 2002. Proyecto INPOLTEC I. Fundación Universidade da Coruña. Santo Domingo.

Piqué, J. M.; González, S.; Bellavista, J. and Alves, V., 2006. Parques científicos y tecnológicos y universidades en el sistema de incubación de empresas de base tecnológica:

contribución desde el modelo de la Triple Hélice. Coneixement i Societat: Revista d'Universitats, Recerca i Societat de la Informació, 11, 32-47.

Polt, W., Rammer, C., Gassler, H., Schibany, A., & Schartinger, D., 2001. Benchmarking Industry-Science Relations – the Role of Framework Conditions. Research Project commissioned by the EU (DG Enterprise) and BMWA, Vienna.

RICYT, 2000. El estado de la Ciencia. Principales indicadores de Ciencia y Tecnología Iberoamericanos/Interamericanos. Buenos Aires, Argentina.

RICYT/OEA/CYTED, 2001. Normalización de Indicadores de Innovación Tecnológica en América Latina y el Caribe. Manual de Bogotá. Colombia.

Rothwell, R., 1994. Towards the fifth-generation innovation process. International Marketing Review, 11(1), 7-31.

Samara, E.; Georgiadis, P. and Bakouros, I., 2012. The impact of innovation policies on the performance of national innovation systems: A system dynamics analysis. Technovation 32, 624-638.

Shinn, T., 2002. The Triple Helix and New Production of Knowledge: Prepackaged Thinking on Science and Technology. Social Studies of Science 32 (4), 599-614.

Schumpeter, J., 1934. The Theory of Economic Development. Harvard University Press. Cambridge, Mass.

Tuunainen, J., 2002. Reconsidering the mode 2 and the Triple Hélix: a critical comment based on a case study. Science Studies, 15 (2), 36-58.

Van de Vrande, V.; De Jong, J.P.J.; Vanhaverbeke, W. and De Rochemont, M., 2009. Open innovation in SMEs: Trends, motives and management challenges. Technovation 29, 423-437.

Villarreal, O., 2007. La Estrategia de Internacionalización de la Empresa. Un Estudio de Casos de Multinacionales Vascas. Ph.D. Dissertation, Universidad del País Vasco-Euskal Herriko Unibertsitatea, Bilbao.

Villarreal, O., 2008. El caso de CIE Automotive: el crecimiento de un grupo empresarial mediante la internacionalización. Ekonomiaz 68 (2), 231-263.

Villarreal, O. and Landeta, J., 2010. El estudio de casos como metodología de investigación científica en dirección y economía de la empresa. Una aplicación a la

internacionalización. Investigaciones Europeas de Dirección y Economía de la Empresa 16, 31-52.

Yin, R. K., 1994. Case Study Research. Design and Methods. Applied Social Research Methods Series, 5, Second Edition, Sage Publications

Yin, R. K., 2012. Applications of Case Study Research. Third Edition. Sage Publications, Thousand Oaks.

Yin, R. K., 2014. Case Study Research. Design and Methods. Applied Social Research Methods Series, 5, Fifth Edition, Sage Publications, Thousand Oaks.