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The Role of Higher Education Institutions in the Promotion of Innovation in the Triple Helix Approach

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This paper examines the contribution of a higher education institution (HEI), the Polytechnic of Guarda (PG), for the territorial dynamics of innovation within the triple helix model (THM) (Dzisah & Etzkowitz, 2009). To analyse PG's role in the triple helix approach and to promote regional innovation, an inquiry was submitted to three helices: companies, governance system and Polytechnic of Guarda. The main goal is to explore whether interaction and cooperation between helices fosters innovation and development in the region, assessing the existence of new patterns of collaboration between the helices.

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Introduction

Higher education institutions (HEI) play a key role in building a society based on knowledge and innovation development, in both the "triple helix" model (Dzisah & Etzkowitz, 2009; Pugh, 2014) and in the innovation systems approach (Lundvall, 1992; Edquist, 1997). Beyond the traditional role of teaching, they also develop research activities, knowledge transfer, business training and community development (Etzkowitz, 2002) and are responsible for economic and social dynamics as entrepreneurial institutions (Vang-Lauridsen et al., 2007).

Indeed, according to Chaminade et al. (2007), HEI' role goes beyond teaching and research, thereby increasing their importance to society. This role is the result of a sequence of revolutions: the first marks the transition from the university focused on teaching ("teaching

university") to the university focused on research ("research university"); the second revolution is characterised by the emergence of the entrepreneurial university ("entrepreneurial university"), whose mission also explicitly welcomes economic and social objectives (Etzkowitz et al., 2000).

Their activities contribute to development of the regional and national economies and allow researchers to obtain financial benefits (Leydesdorff & Etzkowitz, 1996). This task takes on great importance when we see that HEI are geographically decentralised, have a more flexible organisational nature and have human and structural resources able to perform various roles in the innovation process beyond the traditional.

This study aims to analyse the contribution of one higher education institution, the Polytechnic of Guarda (PG), for the territorial dynamics of innovation within the triple helix model (THM). To investigate whether PG is fulfilling its role within the THM (Dzisah & Etzkowitz, 2009) and helping to foster territorial dynamics of innovation, the study investigates the behaviour of three helices: HEI, companies and the governance system of the Guarda region. The goal is to explore whether relationships of interaction and cooperation between the helices foster innovation and development in the region, assessing the existence of new patterns of collaboration between the helices.

The paper is organised as follows. The second section presents a literature review regarding the THM and HEI' role in promoting innovative capacity. The third section presents the hypotheses and describes the methodology used. The last two sections illustrate the primary findings and discuss the results and their implications, acknowledging the limitations of the work and suggesting avenues for future research.

Literature Review

According to Dzisah and Etzkowitz (2009), the "heart" of innovation and economic development is the concept of triple helix circulation. The helices are the HEI, companies and the government and the interaction between them is compared to "the flow of blood." Circulation among HEI-business-government is a basic premise of economic development (Dzisah & Etzkowitz, 2009, Pugh, 2014). The interaction among HEI-companies-government in knowledge-based societies is considered the key factor needed to improve conditions for innovation (Etzkowitz, 2002). Moreover, that interaction is increasingly recognised as a source of regional innovation models once it leads to the conversion of science and technology into economic advances (Etzkowitz & Zhou, 2007).

The concept of interaction among HEI-companies-government arises in the line of thought regarding systemic approaches to innovation (Lundvall, 1992), Edquist's (1997)

systems of national innovation and Cooke et al. (1997) and Braczyk et al.'s (1998) systems of regional innovation and is framed in the THM proposed by Leydesdorff and Etzkowitz (1996).

The THM is considered the exclusive engine after the regional innovation system (Leydesdorff, 2011). This model rediscovers the concept of innovation in different territorial patterns, alerting to the fact that many countries do not demonstrate innovation dynamics supported in the regions, but have industrial clusters in different regions. Innovation is thus associated with regional clusters of resources and activities (De Bruijn, 2004). The clusters' existence tends to generate innovation, enhance productivity and promote competitiveness and prosperity.

The fundamentals of this model are based on the nonlinear perspective of innovation, interaction and the concept of circulation (Etzkowitz & Zhou, 2007). According to Etzkowitz and Zhou (2007), a triple helix has a static characteristic in which three spheres are independent and overlap and each helix has an internal core and external field space. From a dynamics point of view, they form an interactive circulatory system with vertical and horizontal linkages.

According to the model, each helix also assumes the role of the other, producing hybrid organisations such as science parks, spin-offs and enterprise incubators (Zhou, 2001). This model is based on an evolutionary perspective considering that relations between helices are in constant transformation. Thus, more recently, the THM appears as a metaphorical image comparable to a DNA chain, where the helices entwine and restructure themselves in the development of innovation (Leydesdorff & Etzkowitz, 2000; Dzisah & Etzkowitz, 2009) (Figure 1). In 2011, Leydesdorff presented an extension of the THM, considering a fourth helix in particular, the introduction of civil society, and stressing the importance of market and governance.

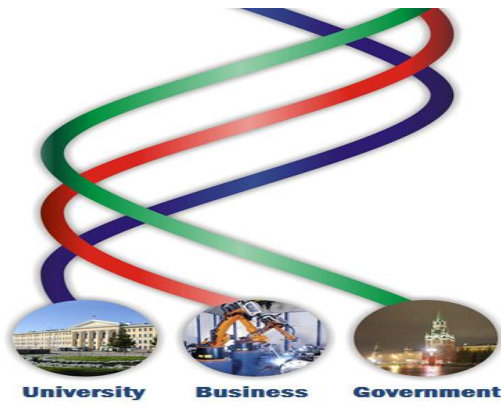


Figure 1: Triple Helix Model
Source: Etzkowitz et al. (2000)

In the triple helix model, the university (or, a broader approach, HEI), the companies, the government and especially the interaction among them play an important role in promoting innovation. The collaboration between helices is assumed to be the driving force promoting innovation. This change in the international paradigm is the starting point for promoting new patterns of collaboration among industry, universities and government agencies, with an emphasis on marketing (Leydesdorff & Etzkowitz, 2001; Asheim & Coenen, 2004; Leydesdorff, 2005).

The trilateral collaboration stimulates innovation and creative development by

providing a balance in knowledge, social benefits, profits and motivations. Moreover, it strengthens local and national partnerships by funding research programs and influences the human (and material resources) to generate solutions and new knowledge (Etzkowitz & Zhou, 2007).

Therefore, these institutions play a central role in regional development because they are regarded as the helix able to undertake socio-economic development by harmonising their basic functions of teaching and research with the role of incubator (Vang-Lauridsen et al., 2007). Likewise, Leydesdorff and Etzkowitz (1996) and Farinha and Ferreira (2013) also argued that entrepreneurial activities undertaken by HEI are important because they lead to economic development. Their activities contribute to regional and national economic development, allow researchers to obtain financial benefits and promote the competitiveness of regions. In the innovation process and development of the regions, the interaction between helices generates benefits for higher education institutions and for companies (Segatto & Mendes, 2001; Almeida, 2010; Natário et al., 2011) (see Table 1).

Table 1: Benefits for the HEI and for companies resulting from interaction and cooperation

Benefits for the HEI	Benefits for the Companies
Realisation of the social function of the university	Access to highly qualified human resources from the universities
Obtaining of practical knowledge about existing problems	Solutions for technical problems that led to the need for research
Incorporation of new information to the processes of teaching and research	Reduced costs and risks involved in Research and Development (R & D) projects
Securing of additional financial resources	Access to new knowledge developed in academics
Obtaining additional material resources	Identification of students for future recruitment
Prestige for the researcher	
Enhancement of the university’s image	

Source: Segatto and Mendes (2001), Almeida (2010), Natário et al. (2011).

The government appears as a helix that can promote the innovation system (national or regional) and thus competitiveness and economic development. This helix can enable transparent justice, cooperation, logistical support, access to information and reduced bureaucracy, as well as an investment in innovation. This sphere can play an important role in the establishment of territorial equity and in the reduction of territorial disparities.

The government under the THM is an important helix that complements other actors (companies and HEI) in regional development and competitiveness (Alberto & Ferreira, 2010). Its contribution to the promotion of innovation and the benefits it can provide to the other helices are particularly important at regional and local levels in peripheral and inland regions.

Although local governments have a key role in the defence and promotion of their territories and in regional development, the concept that best satisfies this study is governance. The emergence of governance is associated with the observation and recognition of traditional political and administrative shortcomings as well as the evolution of the role of government, modes of political regulation and a broader view of the concept of government (Le Galès, 2003).

The government is the system that directs the nation, region or city, while governance is the act, process or mode of administration (Stimson et al., 2005). Governance involves actors other than the government. The government, as an entity, is formed by the top decision-making bodies and encompasses the public sector's (political and public employees) process of decision making. Governance involves a process, but is broader, because non-governmental organisations (business organisations, civil society, individual citizens and international organisations) also participate in decision making, although the government remains the key actor.

In the context of the increasing importance of the role of regions, it is essential for good and efficient governance to improve regional competitiveness. The dynamics of the territories in terms of innovation and

competitiveness require a governance model based on network relationships among institutions that are territorially relevant, through their leadership and the decentralisation of decision making. According to Fermisson (2006), territorial governance reflects not only the administration of the territory, but also the system of relationships between institutions, organisations and individuals to ensure effective choices and their implementation.

The quality of territorial governance depends heavily on the capacity to encourage and mobilise territorial forms of partnerships and capitalise on relational portfolios (Neto, 1999). This assumes a decisive role for the construction of collective territorial strategies and promotes development and competitiveness. The robustness and sustainability of territorial development processes are based on the collective capacity for mobilisation, organisation and recovery of resources by local actors (Fermisson, 2005) and are conditioned by the institutional density and relational density of the territory.

Thus, territorial governance is based on the achievements in a particular territory of procedures and mechanisms that contribute to development of the territory. The possibility of mobilising the institutional and entrepreneurial skills that the territory offers depends on the creation of specific regional conditions for the development of new forms of relationships, which can combine the individual strategies of the multiplicity of actors and generate strategies that are sufficiently mobilised and legitimised.

Hypotheses and Methodology

The aim of this study is to investigate whether PG is fulfilling its role within the THM (Etzkowitz & Dzisah, 2009) and helping to promote territorial dynamics of innovation. In this sense, it is important to determine the existence of dynamic innovation and cooperation among companies, higher education institutions and the government and identify the main difficulties and main drivers of that dynamic.

Taking into account the literature review and considering the behaviour of enterprises as key elements in the innovation process, two hypotheses were defined:

H1. HEI - Industry interaction and satisfaction influence the territorial dynamics of innovation.

H2. Industry - Governance interaction and enhancement of the region influence the territorial dynamics of innovation.

To achieve the defined aim, this study analysed the behaviour of three helices: the HEI represented by the Polytechnic of Guarda, the industry represented by enterprises and the governance of the region of Guarda, an island of Portugal. An inquiry was made to the president of PG and to the four schools to collect the information necessary for analysis and to understand their interaction with the environment.

For enterprises, we used the database from the National Institute of Statistics of Portugal for 2009, from which we extracted only companies with an email address, given the social, economic and environmental costs associated with the use of surveys on paper. The tool for collecting information was also an online survey conducted through docs.google.com.

For the third helix, we used the concept of governance system (rather than just local government) considering the different actors with some decision-making power at the regional level. Thus, we considered the different institutions / organisations of the Guarda region and an inquiry by survey was the instrument used to collect information.

The survey consists of a set of questions which reflect the research variables considered relevant for this study based on the literature review performed. The inquiry is divided into three parts: the first identifies the respondents, the second is related to the topic of innovation and the third is related to the collaboration and interaction among the three helices.

The survey was personally conducted at PG and its four schools and the institutions / organisations from February through May 2012. Of the 52 institutions / organisations identified, only 26 answered the survey, thus constituting

the sample of this helix. The survey for the companies was conducted between November 2011 and February 2012 by email. Of the 3,740 enterprises obtained from the database of the Statistics Portugal only 155 had electronic mail and only 30 responded to the survey, constituting the study for enterprises.

Data and Results

Triple Helix Model in Guarda Region

This study emphasises the role of PG and its higher schools in development of the Guarda region. The universe of this helix is constituted by five organisations: four higher schools and PG as a whole. PG's main activity is administering higher education in fulfilment of the traditional role of this kind of institution.

Of the sample of enterprises that responded to the survey (30), 40% belongs to the services sector, 33% to industry, 13% to commerce and 7% to both agriculture and construction. The vast majority was enterprises with more than 5 years of operations (over 90%).

The other MTH helix, the governance system of the district of Guarda, is composed of 26 public and private institutions with some power of decision making in the region; 31% was linked to local government institutions, 23% to the corporate sector and 27% to the health sector. The remaining surveyed institutions were linked to employment (4%), social security (4%) and protection (4%) as their main activity.

The vast majority of the enterprises under study (43%) had fewer than 10 employees, 40% had between 11 and 49 employees and only 3% had more than 250 employees. Regarding the governance system, most institutions had between 11 and 49 workers, followed by those with between 100 and 250 workers.

Importance of PG for Society and for the Region

The Polytechnic of Guarda plays a key role in building a society based on knowledge, in the development of innovation and hence in the

development of the region. On average, the surveyed companies agree with this statement. The results show that about 60% considers that PG has an important or very important influence in the Guarda region. Also, the helix system of governance supports the decisive role of PG in the region, giving it an average of 4.4 (scale of 1 to 5, where 1 = not important, 5 = very important). Indeed, about 90% of the institutions of the region considers the PG influence in the region important or very important (Table 2).

Table 2: Influence of Polytechnic of Guarda in the Region

	Mean	N
Schools of Polytechnic of Guarda	4,8	4
Firms	3,6	30
Governance Institutions	4,4	25

Source: Survey applied to Firms, Institutions and Polytechnic of Guarda

In the traditional role of education and training, the importance of PG to the business sector and community development through the transfer of knowledge and business training (Etzkowitz, 2002) can be seen by the high percentage of companies that have workers trained by this institution (60%) and by the satisfaction and high satisfaction with the work performed by these professionals (about 90% of the sample). We did not find companies that expressed dissatisfaction. This result is further confirmed by the high percentage of institutions of the governance system (73%) employing workers trained by PG and the high satisfaction obtained with these professionals (Table 3). Note that PG and its organisational units have on staff employees who trained at this institution and teachers who began their training at PG.

Table 3: Workers of Enterprises and Governance System Graduates in Polytechnic of Guarda

Professionals graduates Polytechnic of Guarda		Firms	Governance Institutions	Satisfaction with Workers	Firms	Governance Institutions	
No	N	11	7	Neither satisfied / Not dissatisfied	N	2	2
	%	40	27		%	10	11
Yes	N	19	19	Satisfied	N	8	10
	%	60	73		%	40	56
Total	N	30	26	Very Satisfied	N	8	6
	%	100	100		%	40	33

Source: Survey applied to Firms and Institutions

The majority of companies (about 60%), over more than seven years, employed professionals trained at PG, 40% of them being senior technicians. Also, the vast majority of local institutions and organisations (88%), over more than seven years, employed professionals trained at PG, 60% of them as senior technicians, also including here PG and its schools.

Profile of the Guarda Region

The attractiveness profile of the region and its innovation dynamics can be analysed taking

into account variables such as the spirit of enterprise initiative, the logistical infrastructures (access and digital networks, among others) and the pro-activity with public institutions, business associations and ease of cooperation with HEI.

In the perspective of entrepreneurs, using a Likert scale from 1 to 5, the region presents itself with little attractiveness in its profile across various dimensions, looking ahead to a very negative scenario; the same is happening in the opinion of actors in the governance system (Table 4). Note, however, that, according to the latter group, the ease of

cooperation with HEI is presented as the most positive factor, which already denotes some openings with these institutions. Regarding HEI, in the PG perspective, the region has reasonable infrastructure, although in the spirit

of entrepreneurship, entrepreneurial associations and ease of cooperation with HEI are reported as having poor or low attractiveness.

Table 4: Profile of the Guarda Region

	Firms		Governance Institutions		Polytechnic of Guarda	
	Mean	St. Deviation	Mean	St. Deviation	Mean	St. Deviation
Entrepreneurship initiative	2,04	0,518	2,52	0,730	2,50	0,89
Logistics infrastructure (access, digital networks, business fairs, parks)	2,30	0,724	3,00	0,756	3,75	0,75
Pro-activity of public institutions	1,85	0,602	2,73	0,456	3,00	0,55
Business associations	2,11	0,698	2,64	0,848	2,50	0,52
Easiness of cooperation with university	2,31	0,736	3,05	1,090	2,75	0,58

Source: Survey applied to Firms, Institutions and Polytechnic of Guarda

Performance of Innovation

Analysing the innovative behaviour of firms, the governance system and PG, positive behaviour emerges in the set of organisations surveyed (Table 5). Most of companies' innovations were introduced in the market, mainly in health and safety, in new or improved products or processes and in cost reductions. Also, the institutions of governance demonstrated positive innovative behaviour, verifying that most innovations introduced in the market are

new or improved products or processes and organisational innovations in health and safety.

PG is an innovative institution of excellence, not only contemplating ecological innovation. The innovation process covers the various types of innovation from those in products and processes to organisational innovations and reductions in materials and energy (Table 5).

Table 5: Types of Innovation in the Helix

	Firms		Governance Institutions		Polytechnic of Guarda	
	Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation
Introduction innovation in last 3 years	,87	,346	,84	,374	1	0,00
Innovation_improvement_Products	,70	,466	,76	,436	1	0,00
Innovation_improvement_Process	,70	,466	,72	,458	1	0,00
Innovation_Reorganization	,57	,504	,64	,490	0,8	0,45
Innovation_Marketing	,27	,450	,44	,507	0,4	0,55
Innovation_Ecology	,27	,450	,32	,476	0	0,00
Reducing Labor Costs	,70	,466	,44	,507	0,6	0,55
Reducing the use of materials and energy	,70	,466	,60	,500	1	0,00
Health and Safety	,73	,450	,64	,490	0,6	0,55

Source: Survey applied to Firms, Institutions and Polytechnic of Guarda

Thus, the results show that for the three helices of THM the innovation processes are a concern that is reflected in their behaviour, characterised by a strong commitment to generate innovation. Then, what is failing? According to Etzkowitz and Zhou (2007), from the static point of view the three spheres are independent and overlap each other and each helix has an internal core and external field space; in a dynamic point of view, in the vertical dimension each helix develops independently; in the horizontal dimension, they form an interactive circulatory system. The question that arises is whether the three helices are effectively acting in this dynamic perspective and if they are stimulating the circulatory system between the institutional spheres.

Interaction, Cooperation and Dynamics of the Circulatory System

The interaction of PG-companies-governance system is regarded as the key factor for improving innovation conditions in the region. From Table 6, one can conclude that companies generally have introduced innovations in the last three years, although most did so alone. Indeed, only 24% of companies said they established cooperation agreements (formal

and informal) with other firms and institutions to access information and resources.

Cooperation with HEI was very low (about 17%) and even lower with PG (7%) (Table 6). The preference is for collaboration with customers / suppliers, followed by business associations, as the collaboration with universities / polytechnics is very small and with institutions of local public administration even smaller.

The governance system and its institutions in general have introduced innovations in the last three years but not altogether individually. About 84% said they have established cooperative agreements (formal and informal) with companies or other institutions (for access to information and resources). The cooperation with HEI was satisfactory (about 67%) and with PG was positive (30%). The preference of governance actors is for collaboration with HEI, followed by consultants and local public administration. PG and its schools develop cooperative relationships with companies and other local institutions. All said they have established cooperation agreements (formal and informal) with firms and other institutions to access information and resources. Innovation is not a practice carried out in isolation, but in partnership with companies (80%) and other local institutions (80%).

Table 6: Cooperation between the Helix: Firms and Governance Institutions (%)

	Firms	Governance Institutions
Introducing innovations in collaboration with IES	7	20
The Firms/Institutions has established a cooperation agreement	24	84
Cooperation with Universities / Polytechnics	17	67
Cooperation with Polytechnic of Guarda	7	30
Cooperation with Business Associations	33	29
Cooperation with Consultants	23	50
Cooperation with Customers / Suppliers	50	13
Cooperation with Research Centers	7	13
Cooperation with Other Firms/Institutions	27	17
Cooperation with Local Government	10	33
Not applicable	17	4

Source: Survey applied to Firms and Institutions

In this sense, the preference for cooperation in innovation of this higher education institution is focused on collaboration with other HEI, followed by business associations and local public administration, which assume the same importance in terms of cooperation. This is followed by cooperation with customers / suppliers and research centres (both with the same importance). The Polytechnic of Guarda and its schools do not include consultant firms as local actors in terms of cooperation.

Based on analysis of these results, one can see a near absence of interaction between companies of the Guarda region and the PG and between business and local government

(excluding here the business associations of the local governance system). However, between the governance system and PG, there is already greater proximity between these two helices of the THM. From PG's point of view (helix HEI), there is high openness to cooperation and interaction with other helices and an overall stimulation of the circulatory system between the spheres of the model. Note that companies consider collaboration with the university / polytechnic as contributing positively to innovation (average 4.3 on a Likert scale of 1-7), and the main form of collaboration between companies and PG is through the provision of services followed by the use of equipment (Table7).

Table 7: Types of Cooperation between Firms/Governance Institutions and Polytechnic of Guarda

	Firms		Governance Institutions	
	Mean	Std. Deviation	Mean	Std. Deviation
Quantify the Contribution of Cooperation for Innovation	4,33	1,826	4,47	1,19
Services	0,17	0,379	,43	,507
Research studies	0,07	0,254	,39	,499
Employee training	0,07	0,254	,17	,388
Use of equipment	0,13	0,346	,09	,288
Trainee recruitment	0,07	0,254	,39	,499
Registration of Patents and Other Intellectual Property Rights Protection	0	0	,04	,209
Promotion, Dissemination and Public Relations	0	0	,13	,344
Promoting Partnerships and Networking Opportunities	0,07	0,254	,22	,422
Consulting support	0,07	0,254	,13	,344
Negotiations support	0	0	,00	,000
Defining Strategies for Technology Transfer	0,07	0,254	,09	,288
Participation in Business Incubation and Technology Parks	0	0	,04	,209
Sponsorship and restructuring of courses	0	0	,04	,209

Source: Survey applied to Firms and Institutions

Other governance actors agree that collaboration with the university / polytechnic contributes decisively to innovation (average 4.47 on a Likert scale of 1-7), and the main forms of collaboration with PG are through the provision of services, recruitment of trainees and research studies (Table 7). It must be emphasised that approximately 45% of institutions in the region and companies still do

not have knowledge of the PG training offered and have even less information about provided services (Appendix, Table 1a).

In what concerns the Polytechnic of Guarda, collaboration with other HEI and the governance system is considered a good contribution to innovation, but with companies that contribution is reduced. The main way of collaboration between PG and business / local

institutions is the training of employees, followed by the use of equipment, the provision of services, employing trainees, research studies and sponsorship and restructuring of courses. However, PG and its schools do not have real knowledge of the demand / needs of enterprises and local institutions, which is an obstacle to the achievement of the third mission: economic and social dynamisation (Appendix, Table 2a).

In the firms' perspective (Table 8), the interaction and cooperation between helices lead to benefits for PG, mainly in terms of obtaining practical knowledge of the available problems, incorporation of new information to the processes of teaching and research and dissemination of the HEI image. Note that the possibility of obtaining resources (financial and material) this way is not altogether accepted.

From the point of view of local institutions (the governance system), the interaction and cooperation between helices lead to benefits for PG, mainly at the level of promoting the image of the HEI, obtaining practical knowledge about available problems, prestige for the investigator and institution and the incorporation of new information into the processes of teaching and research (Table 8). From PG's point of view, interaction and cooperation between helices lead to benefits, mainly at the level of promoting PG's image, achieving the social function of HEI and incorporating new information into the teaching and research processes to increase knowledge about the needs of business. Cooperation as a means of obtaining financial and material resources is still not used by this helix (Table 8).

Table 8: Polytechnic of Guarda Benefits Arising from the Cooperation with others Helix

	Viewpoint Polytechnic of Guarda	Viewpoint of Firms	Viewpoint of Governance Institutions
	Mean	Mean	Mean
Fulfillment of Polytechnic of Guarda's social function	3,8	3,63	3,82
Practical knowledge of existing problems	3,6	4,15	4,00
Incorporation of new knowledge to teaching and research practices	3,8	3,95	3,76
Additional financial resources	2,75	3,47	3,05
Acquisition of extra material resources	2,5	3,37	3,00
Prestige for the researcher	3	3,89	3,95
Publicity for the Polytechnic of Guarda	4,25	3,94	4,14

Source: Survey applied to Firms, Institutions and Polytechnic of Guarda

For companies, the most important benefits of cooperation with HEI are access to highly skilled resources and new knowledge developed in an academic environment. However, companies do not consider access to

specialised market studies an important benefit. The distance between the productive system and the institutions of knowledge is still visible in the value assumed by the introduction and development of new products as a result of cooperation (Table 9).

Table 9: Business and Governance Benefits through Interaction and Cooperation with HEI

	Viewpoint of Firms	Viewpoint of Governance Institutions	Viewpoint Polytechnic of Guarda
	Mean	Mean	Mean
Introduction of new products	3,29	3,50	3,4

Improvement of production processes and innovation	3,52	3,74	3,8
Access to highly qualified people from the universities	3,90	3,89	4
Solution of technical problems that require research	3,50	3,28	3
Reduction of costs and risks involving R&D projects	3,15	3,35	2,6
Access to knowledge obtained in the educational field	3,90	3,86	3,8
Identification of students for future hire	3,60	3,70	3,8
Access to specialized market studies	3,22	3,40	2,2

Source: Survey applied to Firms, Institutions and Polytechnic of Guarda

For institutions of the governance system, the most important benefits are access to highly skilled resources of higher education institutions, access to new knowledge developed in an academic environment, improvement of production processes / innovation and identification of students for further recruitment (Table 9).

From the point of view of PG and its schools, for companies and institutions of the governance system, the most important benefits are access to highly skilled resources of institutions of higher education, access to new knowledge developed in academics, improvement of production processes / innovation and identification of students for future recruitment (Table 9).

The Polytechnic of Guarda does not consider as one of the most important benefits

abroad (companies / local institutions) the access to specialised market studies. The distance between the productive environment and the institutions of knowledge is then visible in the value assumed for access to specialised market studies and for sharing of costs and risks involved in research and development projects.

Note that the main reason companies give for not hiring the services of HEI relates to the lack of these services, but also to a high lack of need (we stress here again the isolated thought). In governance systems, the main reason for not hiring the services of HEI is related to the absence of need, although the emphasis here is on "not applicable" as the highest percentage among reasons for not using the services of HEI (Table 10).

Table 10: Reasons for not Hiring Services of HEI

	Firms		Governance Institutions	
	Frequency	%	Frequency	%
Unfamiliarity	10	40,0	2	11,8
No need	7	28,0	3	17,6
Not Adapted	2	8,0	2	11,8
Complexity of the process	2	8,0	-	-
Not applicable	4	16,0	10	58,8
Total	25	100,0	17	100

Source: Survey applied to Firms and Institutions

Given the results obtained, one can conclude that the interaction between HEI-companies-governance systems leads, as Etzkowitz and Zhou (2007) mentioned, to the conversion of scientific and technological

progress for economic activity. Thus, the Polytechnic of Guarda plays a crucial and innovative role in society because it fulfils its traditional role of teaching and at the same time develops research activities, knowledge

transfer, business training and community development (Etzkowitz, 2002). However, the helices within the framework of the Guarda THM do not intertwine or restructure in the development of innovation as advocated by Leydesdorff and Etzkowitz (2000) and Dzisah and Etzkowitz (2009), thus the difficulty in dynamisation of the circulatory system spheres of the "triple helix" and sustainable development of the region.

Additionally, PG now includes the third mission of Vang-Lauridsen et al. (2007): the economic and social dynamics of an entrepreneurial institution and assumption of the role of incubator. Indeed, this can be seen from "Policasulos" and other activities under entrepreneurship ("Poliemprende" contest, seminars on this theme, entrepreneurship curricular units in some courses and master's degree in innovation and entrepreneurship) in the complete openness and predisposition to comply with this third mission with explicit economic and social objectives.

Business Dynamics of Innovation and Polytechnic of Guarda Influence

To evaluate PG's performance under the THM and its influence on regional dynamics of innovation, we tried to classify the behaviour of firms in terms of innovation and identify which factors are associated with the most innovative companies' profiles, verifying whether interactions and relationships exist between these companies and the Polytechnic of Guarda.

To detect behavioural patterns or innovation profiles of companies, cluster analysis was used to group firms in terms of their perception of the level of innovation dynamics. This clustering analysis considered evaluations of firm managers regarding the variables of different types or forms of introduction of innovation. The use of cluster analysis proved adequate and the variables used to classify the companies were all significant for the final solution estimated, as we can verify by the results of the analysis of variance (ANOVA) presented in Table 11.

Table 11: ANOVA Analysis

	Cluster		Error		F	Sig.
	Mean Square	df	Mean Square	df		
Innovation_improvement_Products	1,461	2	,125	27	11,672	,000
Innovation_improvement_Process	,999	2	,159	27	6,270	,006
Innovation_Reorganization	1,295	2	,177	27	7,317	,003
Innovation_Ecology	1,395	2	,114	27	12,240	,000
Reducing the use of materials and energy	1,211	2	,144	27	8,427	,001
Health and Safety	1,842	2	,081	27	22,800	,000

Source: Survey applied to Firms

The application of cluster analysis allowed the distinction of three behavioural patterns of firms regarding their innovation dynamics (Table 12). Cluster 1 comprises 11 companies with low levels of evaluation for all classification variables considered because the companies only introduced product innovation.

Cluster 2 comprises 6 companies with dynamic innovation classified at an average level and among the types of innovation presented; they do not introduce ecological and product innovation. Cluster 3 (with 13 companies) is constituted by companies with the best results in the dynamics of innovation, considered the most innovative and proactive cluster.

Table 12: Cluster Constitution

	Cluster		
	1	2	3
	N=11	N=6	N=13
Innovation_improvement_Products	1	0	1
Innovation_improvement_Process	0	1	1
Innovation_Reorganization	0	1	1
Innovation_Ecology	0	0	1
Reducing the use of materials and energy	0	1	1
Health and Safety	0	1	1

Source: Survey applied to Firms

Following this analysis, an independent chi-square test was used to assess the association between the groups and the influence of the variables relating to the institution (Polytechnic of Guarda): some employees of the companies studied at PG; the company employs graduates of HEI other than PG; the company is interested in hiring trained professionals at PG; the company is aware of

PG's educational offer and the professional category occupied by the professionals from PG.

The results show the existence of this relationship in terms of the variables related to the company that employs graduates from other and not from PG, whether the company is interested in hiring professionals trained at PG and the professional category occupied by professionals from PG (Table 13).

Table 13: Results of Chi-square Test

Chi-square	X ²	df	Prob.	Observations
Graduates in Polytechnic of Guarda (PG)	,589	2	,745	X
Employs graduates from other higher education institutions than the PG	5,595	2	,061	V
Interested in hiring professionals graduated in PG	10,730	2	,005	V
Do you know the training PG offer	6,287	8	,615	X
Professional category of professionals from the PG	14,580	2	,024	V

Source: Survey applied to Firms

Note that companies belonging to the less innovative clusters are those that contract professionals trained in other HEI and not in PG. In turn, the most innovative company cluster is the most interested in hiring professionals trained at PG. It is also the most innovative cluster that has employees trained in PG, which denotes a larger / better

understanding of the training supplied by this higher education institution (Table 13).

A positive relationship also exists between the most innovative clusters and monthly gross income earned by graduates of PG, as well as the professional category occupied by professionals from PG. Cluster 3 has the best averages for these variables (Table 14).

Table 14: Crossing of Variables by Cluster

Means	Cluster			Total
	1	2	3	
Do you know the training PG offer	2,30	3,33	2,77	2,72
The company introduced in the last three years new product or service in the market	0,73	0,83	1,00	87
Marketing Innovations	18	33	31	27
Reducing Labor Costs	64	67	77	70
Professional category of professionals from the PG	2,20	2,50	2,00	2,18
What is the gross monthly income earned by these professionals	2,17	2,50	3,13	2,67

Source: Survey applied to Firms

To interpret the relationship between the explanatory variables and the dependent variable of firms' innovative behaviour, multiple means comparison tests were used to find differences among the variables considered in the hypotheses.

Based on Table 15, one can conclude that the most innovative cluster, which is more satisfied with the work performed by professionals trained at PG, most highly values the contribution to innovation resulting from cooperation and collaboration with universities / polytechnics.

Table 15: Anova -Means Differences among Groups: The Region and the PG Reputation

	Sum of Squares	df	Mean Square	F	Sig.	
Assess satisfaction with the work done by the professionals	5,292	2	2,646	14,654	0,000	3>1,2
For you, what is the influence of the PG in the region of Guarda	2,665	2	1,333	1,422	0,259	
Entrepreneurship initiative	0,13	2	0,065	0,228	0,798	
Logistics infrastructure (access, digital networks, business fairs, parks)	1,053	2	0,526	1,004	0,381	
Business associations	4,333	2	2,167	6,24	0,007	2>3>1
Pro-active public institutions	1,651	2	0,825	2,554	0,099	2,3>1
Easiness of cooperation with university/polytechnics	3,608	2	1,804	4,178	0,028	2,3>1

Source: Survey applied to Firms

The most innovative cluster also places the most value on the important benefits for companies arising from cooperation with HEI, with regard to both introduction and development of new products, such as the identification of students for future recruitment (Table 16).

Table 16: Anova -Means Differences among Groups: Benefits for Firms of cooperation with HEI

	Sum of Squares	df	Mean Square	F	Sig.	
Quantify the contribution of cooperation for innovation	17,833	2	8,917	4,261	0,05	3>2>1
Benefits of cooperation for the development and introduction of new products	5,104	2	2,552	3,026	0,074	3>2>1
Benefits of cooperation: Improvement of production processes / innovation	2,018	2	1,009	0,945	0,407	

Benefits of cooperation: Access to highly skilled resources of Higher Education Institutions	0,941	2	0,47	0,322	0,729	
Benefits of cooperation: Solving technical problems that led the need for research	2,564	2	1,282	0,672	0,524	
Benefits of cooperation: Reducing costs and risks involved in projects Research and Development (R&D)	5,805	2	2,902	2,632	0,101	
Benefits of cooperation: Access to new knowledge developed in academia	0,6	2	0,3	0,22	0,805	
Benefits of cooperation: Access to new knowledge developed in academia	6,85	2	3,425	2,653	0,099	3>2>1

Source: Survey applied to Firms

The cluster with average behaviour in terms of innovation and the most innovative cluster are those that value the region in terms of business associations, pro-activity with public institutions and ease of cooperation with HEI. The remaining variables showed no significant differences in the constitution of clusters or influence on the results.

Conclusions

The analysis of PG's performance under the THM and its influence on regional innovation dynamics evidences a belief, widely shared by the three helices (Polytechnic of Guarda, companies and governance system), that this institution has a key role in building a knowledge-based society, in the development of innovation and in the development of the region. Its important role in the business dynamics and community development through knowledge transfer and entrepreneurship training (in its traditional role of education and training) is reflected in the high proportion of businesses and institutions of the governance system that have workers trained in this institution and by the satisfaction (medium and high) with the work performed by professionals trained at PG.

Although the profile of the region is seen by different actors as unattractive in various dimensions, the actors highlight as positive elements the available infrastructures and some ease of cooperation with HEI in the region. The interaction between HEI-companies-governance systems leads, as Etzkowitz and Zhou (2007) mentioned, to the conversion of scientific and technological progress for economic activity. Thus, the Polytechnic of Guarda plays a crucial and

innovative role in society because it fulfils its traditional role of teaching and at the same time develops research activities, knowledge transfer, business training and community development (Etzkowitz, 2002) contributing to promote the innovation in Guarda region. However, the helices within the framework of the Guarda THM do not intertwine or restructure in the development of innovation as advocated by Leydesdorff and Etzkowitz (2000) and Dzisah and Etzkowitz (2009), and for this reason don't allow the dynamisation of the circulatory system spheres of the "triple helix" and sustainable development of the region.

Regarding the performance in terms of innovation, one can conclude that for the three helices of the THM the innovation processes are a concern that is reflected in their behaviour. They are engaged in the generation of innovation, although independently, assuming the static characteristic in which three spheres are independent and overlap and each helix has an internal core and external field space as at present (Etzkowitz & Zhou, 2007). The results in Guarda Region reflect similar conclusions obtained by Pugh (2014) in Wales namely: "according to the Triple Helix model the three spheres of university, business and government are all required to work together to drive innovation, and the model might not work if one of these three helices is too weak, or the links between them are lacking".

There was almost no interaction between the companies and PG or between the companies and the institutions of governance, although a closer relationship existed between local institutions of governance and PG. The main way of collaboration between companies and PG is through the provision of services and

the use of equipment, and from the institutions of governance with PG, it is the provision of services and the recruitment of trainees.

The benefits to PG from cooperation are obtaining practical knowledge about existing problems, incorporating new information into the processes of teaching and research and disseminating the image and reputation of the investigator and the institution. For companies / institutions of governance, the most important benefits from cooperation are access to highly skilled resources of higher education institutions, access to new knowledge developed in academics and identification of students for future recruitment. Note that the main reason companies pointed out for not hiring PG services was the lack of information about these services; the governance system cited the absence of need.

Given the behavioural profiles of the companies, derived by quantitative methods, in terms of the dynamics of innovation, we can draw conclusions about the conditions associated with a more innovative approach and therefore with a best innovation dynamic:

- The group of companies with better results in terms of innovation dynamics incorporate workers trained at PG and show more interest in hiring graduates of PG. In turn, the companies show bigger / better knowledge of the training offered at this higher education institution and their employees earn the highest gross monthly income. In contrast, groups of companies with a lesser dynamic in terms of innovation rely on professionals trained at HEI other than PG;

- The most innovative cluster has greater satisfaction with the work performed by professionals trained at PG and values most

highly the contribution to innovation resulting from cooperation and collaboration with universities / polytechnics; it also gives more value to benefits for enterprises of cooperation with HEI regarding the introduction and development of new products and the identification of students for future recruitment;

- The most innovative clusters are also those that most value the region in terms of business associations, pro-activity with public institutions and ease of cooperation with HEI.

Thus, the main differences in dynamic innovation in the Guarda region are associated with employment and interest in hiring professionals trained at PG, satisfaction with the work of the best professionals as well as the gross monthly income they earn, a higher / better understanding of the training offered at this institution, greater appreciation of the contribution to innovation resulting from cooperation and collaboration with universities / polytechnics regarding the introduction and development of new products, the identification of students for future recruitment and the increase of business associations, pro-activity with public institutions and ease of cooperation with institutions of higher education.

As limitations of the study, we must point out the number of surveys answered by businesses and institutions, which limits certain aspects that could be tested and the fact that the study is focused on only one region. This analysis would be more complete if it were extended to other regions of the country. In that sense, future research can use administrative databases, which can address the problems arising from the use of surveys.

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Appendix I

Table a1: Knowledge of PG training offer

		No	Little	Less or mor	Mean	very
Knowledge of PG training offer by firms	N	7	6	7	6	3
	%	24	21	24	21	10
Knowledge of PG training offer by institutions	N	2	8	6	0	6
	%	9	36	27	0	27

Source: Survey applied to Firms and Institutions

Table a2: Knowledge of the Territory requirements by PG (%)

	No	Little	Less or mor	High	Very high
Empresarial needs		40	20	40	
Local Institutions needs		20	40	40	