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Innovation and Entrepreneurship Networks as Global Competitiveness Drivers

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Dedicatory

To my family and my true friends;
This was the real reason for my absence in these past times.

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Abstract

The main aim of this thesis is to analyze the relationship between innovation, entrepreneurship and competitiveness, following the triple helix network approach to regional economies, considering their impact on socio-economic development.

This correspondingly involved a mixed research typology, as advocated in chapters 2 to 5, alternating between quantitative methodologies, deploying descriptive statistics, structural equation modelling (SEM) and hierarchical cluster analysis; and the qualitative methodology underpinning the case studies.

The socio-economic prosperity of triple helix spaces (Academia-Industry-Political Decision regional spaces of interaction) depends on competitive advantages, including their positioning in terms of innovation and entrepreneurship factors, local endogenous resources and the development trajectories attained. The study revealed the scope for grouping the countries analyzed by the Global Competitiveness Report (GCR) and the Global Entrepreneurship Monitor (GEM) into five clusters: (1) Balanced low performance, (2) Moderate competitiveness, (3) High competitiveness, (4) High GDP per capita, and (5) Performance excellence. Making direct comparisons between European regions, and with reference to the recognized United Kingdom centre of entrepreneurship in Oxfordshire, we recommend some future paths for the Centro region of Portugal, strongly based on the opportunities arising out of the Horizon 2020 programme and RIS3. Our conclusions point to the sheer relevance of important contributions from the regional and technological clusters and the collaborative A-I research and development projects studied to the overall socio-economic development of economies. In summary, we may highlight two important theoretical contributions from this thesis: (1) the presentation of the "Regional Helix Turbine Model", clarifying the role of different actors within the context of triple helix regional spaces and their potential contribution to enhancing competitiveness; and (2) the definition of a performance measurement model appropriately adjusted to these dynamics: the "Helix Regional Scoreboard".

As recommendations and future lines of research, we would call for the completion of comparative studies on the trajectories of triple helix regional spaces across Europe featuring different levels of innovation and competitiveness as well as the "RHS" validation through the comparison of the Oxfordshire and Centro regions,, both included in this thesis.

Keywords

Innovation, Entrepreneurship, Networking, Triple Helix, Competitiveness, Regional Development.

Resumo alargado

Muita investigação tem sido conduzida sobre os temas de Inovação, Empreendedorismo e Competitividade. Neste campo, várias abordagens têm sido seguidas, visando estudar o comportamento das dinâmicas de inovação e empreendedorismo, abrangendo ainda as variáveis do crescimento económico e desenvolvimento regional.

Neste domínio, destaca-se uma primeira corrente de investigação focada na relação entre a inovação e a competitividade. Porém, são vários os estudos que relacionam a inovação e o empreendedorismo (Chandra & Leenders, 2012; Genç & Zehir, 2012; Soriano & Huarng, 2013; Timothy, 2004; Ylinenpää, 2009). Nos últimos anos, uma forte orientação empírica tem-se centrado nas relações entre a inovação, o empreendedorismo e o crescimento económico (Galindo & Méndez, 2014; Kardos, 2012; Lewrick et al., 2010; Stajano, 2009; Szabo & Herman, 2012).

Tendo como referência o nível de desenvolvimento económico dos países, a competitividade pode ser analisada a partir de três estágios de desenvolvimento das economias: (1) economias orientadas para os fatores, (2) economias orientadas para a eficiência, (3) economias orientadas para a inovação; acrescidos ainda de dois estágios intermédios de transição (Acs et al., 2008; Amorós & Bosma, 2014; Porter, 1990; Schwab, 2013). Já a atividade empresarial baseada no conhecimento é geralmente aceite como a força motriz para o crescimento económico, criação de emprego e melhoria da competitividade (Guerrero et al., 2006;. Guerrero & Urbano, 2010; Marques et al., 2010).

Em matéria de redes de cooperação e negócio, vários autores têm vindo a reforçar a importância da cooperação Academia-Indústria-Decisão política, reservando algum destaque para a transferência de conhecimento e tecnologia Academia-Indústria (Benner & Sandström, 2000; Etzkowitz et al, 2005; Etzkowitz, 2003; Leydesdorff et al, 2006; Leydesdorff & Sun, 2009; Leydesdorff, 2011; Todeva & Etzkowitz, 2014).

Uma área de estudo muito defendida no contexto das redes de cooperação, é a formação de clusters regionais (Casanueva et al., 2012, 2013; Guo & Guo, 2011; Harvey et al., 2012; Hervás-Oliver & Albors-Garrigós, 2007; Isaksen, 1997; Lin et al., 2012; Porter, 1998; Staber, 2009).

Perante este quadro de revisão da literatura, emerge uma questão de investigação central: *Em que medida as redes de inovação e empreendedorismo constituem um forte pilar para o desenvolvimento socioeconómico das economias nacionais e regionais?*

Assim, o objetivo geral desta tese consiste em analisar a relação entre a inovação, o empreendedorismo e a competitividade, seguindo uma abordagem de redes a partir dos espaços regionais da tripla hélice, considerando ainda o seu impacto para o desenvolvimento socioeconómico das regiões. A partir do objetivo geral são definidos ainda cinco objetivos específicos:

- Compreender a contribuição global da inovação e do empreendedorismo para o desenvolvimento socioeconómico das regiões;
- Compreender e comparar as trajetórias de inovação e empreendedorismo a partir de duas regiões europeias, posicionados em diferentes níveis de inovação regional;
- Estudar a contribuição competitiva das redes de inovação no contexto de um *cluster* tecnológico em Portugal;
- Analisar os processos de transferência de conhecimento e tecnologia, no âmbito da cooperação Academia - Indústria, através de projetos de I&D cofinanciados pela EU;
- Propor um modelo de suporte à medição do desempenho no contexto das redes de colaboração da tripla e/ou quadrupla hélice.

Em termos epistemológicos, e de forma a dar cumprimento aos objetivos traçados, é seguido no presente estudo o processo de raciocínio dedutivo, baseado numa cadeia de reflexão em ordem decrescente, a partir do quadro teórico geral para os casos particulares da investigação (Mahootian & Eastman, 2009). É definida uma metodologia de investigação mista, alternando entre a metodologia quantitativa, com recurso à estatística descritiva, à modelação de equações estruturais e à análise de *clusters*, prevalecendo a aplicação da metodologia qualitativa aos estudos de caso apresentados.

A partir do problema central do nosso estudo, e procurando dar cumprimento ao nosso primeiro objetivo específico, através da identificação da variável dependente "competitividade", e assumindo como a variável de controlo o "PIB *per capita*", os resultados obtidos no Capítulo 2 desta tese demonstram que as economias mais avançadas apresentam uma forte estabilidade entre os pilares "Inovação" e "sofisticação de negócios", em comparação com a tendência do índice global de competitividade (GCI), contrariamente às restantes economias. O Estudo confirma ainda que a competitividade das economias é fortemente explicada através dos fatores "inovação" e "sofisticação dos negócios", destacando-se uma forte associação entre o estágio de desenvolvimento de cada economia e seu nível de competitividade. O resultado da aplicação da análise de clusters permitiu confirmar a inovação e o empreendedorismo como fatores de competitividade, aglomerando os países em cinco grupos: (1) Países de baixo desempenho equilibrado; (2) Países moderadamente competitivos; (3) Países de elevada competitividade, (4) Países com elevado PIB *per capita*, e (5) Países de excelente desempenho.

Partindo do 2º objetivo desta tese *"compreender e comparar as trajetórias de inovação e empreendedorismo a partir de duas regiões europeias, posicionadas em diferentes níveis de inovação regional"*, e tomando como referência o reconhecido centro de empreendedorismo de Oxfordshire no Reino Unido, são recomendados alguns caminhos a seguir, para a região Centro de Portugal, decorrentes das oportunidades que poderão emergir dos programas Horizonte 2020 e RIS3, definidos pela Comissão Europeia. Os resultados obtidos neste campo apontam para que cada região deve apostar nos seus pontos fortes e nos seus recursos endógenos, trilhando sempre um caminho de excelência para a Academia, de modo a fazer valer novos e mais ambiciosos padrões de competitividade.

O terceiro objetivo da nossa investigação centra-se *"na análise da contribuição competitiva das redes de inovação no contexto de um cluster tecnológico em Portugal"*. Analisando cluster português inserido no setor dos moldes e ferramentas especiais, a partir das suas iniciativas e redes empreendedoras, constatámos a presença de um importante impacto socioeconómico na economia regional e nacional, confirmado através do seu volume de negócios médio superior a 500 milhões de euros, do qual cerca de 80% destinado ao mercado de exportação, fazendo do nosso país um dos 10 maiores exportadores mundiais no setor. O setor, quase exclusivamente constituído por micro e pequenas empresas (cerca de 94% no total), emprega cerca de 8.000 pessoas, onde cerca de 70% desta força de trabalho é conduzida na fabricação de componentes para a indústria automóvel.

Um forte grupo de autores defende que as políticas de investigação e inovação tendem a concentrar-se no contexto das relações Academia-Indústria, deixando de estar apenas inseridas em grandes centros de I&D alojados em grandes organizações (Bennett et al., 2012; Bjerregaard, 2010; Perkmann et al., 2013, 2011; Petruzzelli, 2011; Plewa et al., 2013; Soete & Stephan, 2004; Vaz et al., 2014).

De acordo com o nosso objetivo nº4 *"analisar os processos de transferência de conhecimento e tecnologia, no âmbito da cooperação Academia-Indústria, através de projetos de I&D cofinanciados pela EU"*, o Capítulo 5 desta tese destaca o surgimento de novos produtos transacionáveis com valor de comercialização para o mercado internacional, contribuindo assim para a valorização socioeconómica dos territórios. Neste contexto, é seguida a conceção e desenvolvimento de uma máquina de colheita de azeitona em contínuo, resultante da colaboração entre a Universidade de Évora e uma PME do setor metalomecânico, sedeada na região Centro do país.

Visando facilitar a compreensão do leitor a partir da revisão da literatura em matéria de redes de inovação, empreendedorismo e competitividade, e dos resultados da investigação empírica conduzida, desenvolvemos um novo modelo conceptual, a que chamámos de *"Regional Helix Turbine"*, auxiliando assim o cumprimento do nosso objetivo nº5 *"encontrar*

um modelo de suporte à medição do desempenho no contexto das redes de colaboração da tripla e/ou quadrupla hélice". Com base nos resultados da investigação realizada ao longo cos capítulos 2 a 5, é apresentado um novo modelo conceptual de avaliação de desempenho, ao qual chamámos de *"Regional Helix Scoreboard"*. O modelo tem como objetivo medir o impacto do desempenho competitivo das dinâmicas de inovação e empreendedorismo, inseridas no contexto "*Regional Helix Turbine*", visando ainda servir de instrumento de comparação entre regiões neste domínio.

Palavras-chave

Inovação, Empreendedorismo, *Networking*, Tripla Hélice, Competitividade, Desenvolvimento regional.

Contents

Part I

Chapter 1

Introduction

1. Statement of the problem

The topics of innovation, entrepreneurship and competitiveness have been the focus of a great deal of research. They have deployed several approaches in this research field to study the behaviour of the dynamics driving innovation, entrepreneurship, economic growth and regional development.

Many studies have posited a direct relationship between entrepreneurship and competitiveness (Acs & Amorós, 2008; Amorós et al., 2011; Audretsch et al., 2012; Cuckovic & Bartlett, 2007; Huggins & Williams, 2011; Szabo & Herman, 2012). In the same sense, current research strongly focuses on the relationship between innovation and competitiveness (Clark et al., 2011; Clark & Guy, 2010; Gibson & Naquin, 2011; Kautonen, 2012; Özçelik & Taymaz, 2004).

There are also several studies linking innovation with entrepreneurship (Chandra & Leenders, 2012; Genç & Zehir, 2012; Oksanen & Technical, 2009; Soriano & Huarng, 2013; Timothy, 2004; Ylinenpää, 2009). Indeed, over recent years, the research orientation has registered the relationships between innovation, entrepreneurship and economic growth (Galindo & Méndez, 2014; Kardos, 2012; Lewrick et al., 2010; Stajano, 2009; Szabo & Herman, 2012).

Several authors have stressed the importance of cooperation within Academia-Industry-Government (A-I-G) networks (Benner & Sandström, 2000; Etzkowitz et al., 2005; Etzkowitz, 2003; Leydesdorff et al., 2006; Leydesdorff & Sun, 2009; Leydesdorff, 2011; Todeva & Etzkowitz, 2014); as well as the role of academia in the context of transferring knowledge and technology (Abramo et al., 2009; Bekkers & Bodas Freitas, 2008; Comacchio et al., 2011; D'Este & Perkmann, 2010; Fagerberg et al., 2012; Giuliani & Arza, 2009; Perkmann et al., 2011; Philbin, 2008; University of Oxford, 2013; van Rijnsoever et al., 2008).

Another area of study long advocated within the context of cooperation networks able to increase competitiveness approaches the formation of regional clusters (Casanueva et al., 2012, 2013; Guo & Guo, 2011; Harvey et al., 2012; Hervás-Oliver & Albors-Garrigós, 2007; Isaksen, 1997; Lin et al., 2012; Porter, 1998; Staber, 2009).

In keeping with this literature review, a central research question emerges: to what extent do the networks of innovation and entrepreneurship prove strong pillars in the development of economies and regions?

Furthermore, a gap persists in the literature lacking studies on the interconnectedness of all these themes within the context of networks of innovation, entrepreneurship and competitiveness. In this perspective, among the multiple paths followed include performance measurement, comprehensive company activities, inter-company analysis, industry-academia collaborative projects and other dynamic territorial relationships (Al-Ashaab et al., 2011; Banker et al., 2004; Bourguignon et al., 2004; Butler et al., 1997; Chytas et al., 2011; Dror, 2008; Herath et al., 2010; Ioppolo et al., 2012; Kaplan & Norton, 1992; Taylor & Baines, 2012); however, there is no focus on the perspective of innovation, entrepreneurship and competitiveness in the context of Triple Helix dynamics (A-I-G), which this thesis aims to address.

According to Stajano (2006), the prosperity of economies is based on their capability to compete in global markets. Global competitiveness depends on the comparative advantages of each economy, never forgetting its respective regional context (Rugman et al., 2011). Competitiveness and regional development derive from different organizational capabilities, reinforced by different strategies and cooperation networks for innovation and entrepreneurship (Carney, 1998; Chorianopoulos et al., 2014).

Economies and organizations aspire to achieve strategic flexibility, most often defined as the ability to identify opportunities for innovation, commit resources to new plans of action or reverse the implementation of unproductive resources (Bock et al., 2012; Bradley et al., 2012). On the demand side, economic opportunities (including GDP growth, innovation and financial development) and the quality of governance (which includes the ease of doing business) serve as stimuli to entrepreneurship (Thai & Turkina, 2014). According to Buesa et al. (2010) and Cantner et al. (2008), innovation has today become a critical factor to global competitiveness and economic growth and resulting in a strong impact on the GDP levels of advanced economies.

The global financial crisis and the developments that followed strengthened the role of emerging economies in the global context, fuelling faster growth, removing millions from poverty. However, although the prospects for the global economy are now more positive than in last year, growth began to slow in many economies, including developed economies in Europe (Schwab, 2014).

Defining competitiveness according to national economic development results in three main stages: (1) factor-driven, (2) efficiency-driven, and (3) innovation-driven; with two transitions between these stages (Acs et al., 2008; Amorós & Bosma, 2014; Porter, 1990; Schwab, 2013).

Given the increasing competitiveness of the global market, regarding innovation and business sophistication, the advantages of cooperation networks lie in their ability to be flexible and to respond quickly to changing market conditions through highly personalized and differentiated products within a "collective entrepreneurship" context (Carney, 1998; Schwab, 2014; Yasuda & Iijima, 2005).

The Global Competitiveness Report (GCR), published since 1979 by the World Economic Forum (WEF), is internationally renowned and brings together around 150 countries in a comparative analysis incorporating a wide range of variables leading to the calculation of the Global Competitiveness Index (GCI), including the pillars of "innovation" and "business sophistication" (Bergsteiner & Avery, 2011; Bronisz et al., 2008; Fendel & Frenkel, 2005; Ketels, 2006; Kravchenko et al., 2013; Schwab, 2013).

Knowledge-based entrepreneurial activity is generally assumed as the driving force behind economic growth, job creation and enhancing competitiveness (Guerrero et al., 2006; Guerrero & Urbano, 2010; Marques et al., 2010). On the other hand, national or regional competitiveness gains global acceptance as the key driver for sustaining prosperity and raising the welfare of citizens (Hoskisson et al., 2011; Schwab, 2013).

On entrepreneurship, the Global Entrepreneurship Monitor (GEM) Project measures individual perceptions, their involvement in entrepreneurial activities and their aspirations in doing so. Initiated in 1997 by academics from the United Kingdom's London Business School and Babson College in the United States, the GEM project reports information from adult population surveys carried out by national survey experts (Bosma et al., 2012; Coduras et al., 2008; Levie & Autio, 2008).

Economic policy drivers at the regional level usually target improving levels of business growth by encouraging new business start-ups, providing appropriate business support, improving access to finance, nurturing specific agglomerations of industries (clusters), important both to regional development and stimulating innovation and investment (Huggins et al., 2014; Huggins & Williams, 2011; Valliere & Peterson, 2009).

Therefore, the following question represents our specific interest in this research field: do the factors of innovation and sophistication prove a strong pillar of socio-economic development to economies? What links entrepreneurship and economic growth?

Answering these questions reveals the impact of the dynamics of innovation and entrepreneurship within the competitiveness of countries and regions. Consequently, this study not only deepens our understanding of the drivers of global competitiveness but also contributes to the literature on innovation, entrepreneurship and socio-economic development.

The field of study analysing innovation systems has expanded in the last decade, which Cooke has actively contributed towards (Cooke, 2005, 2010, 2011). Innovation and entrepreneurship ecosystems in regional development contexts have gained the interest of researchers (Amorós et al., 2011; Asheim et al., 2011; Berger & Bristow, 2009; Kravchenko et al., 2013; Lawton Smith & Bagchi-Sen, 2012; Lawton Smith et al., 2005; Lawton Smith, 1997; Sleuwaegen & Boiardi, 2014).

Technological trajectories vary from region to region. The focus now falls on entrepreneurial regions defined by high levels of innovation and entrepreneurship (EU, 2013). Understanding the concept of "regional triple helix spaces" and "entrepreneurial regions" proves important as a framework for evaluating and comparing the performance of regional spaces.

We here compare the evolution of the high-tech Oxfordshire economy in the UK with a newer and smaller high-tech region, the Centro region of Portugal. Oxfordshire is a core high-tech region in UK while the Centro region of Portugal is an industrialized region, especially along its coastal strip with both displaying a strong academic presence (CCDRC, 2014; Oxfordshire County Council, 2012).

To enable the development of our study, we posed two new research questions: to what extent can both be seen as successful entrepreneurial regions? What factors have led to their growth and to the differences between them?

According to Lawton Smith et al. (2013), the entrepreneurial region concept comprises of three factors: (1) Entrepreneurs and entrepreneurial resources (skills, knowledge, infrastructures, finance and networks); (2) Entrepreneurial vision; and (3) Common vision from the potential regional stakeholders (including universities, companies and local policy makers) and ensuring the putting of ideas into practice within a coordinated perspective. Other authors argue that the regional success stems from the interrelationship between the three Triple Helix regional spaces: (1) Knowledge space; (2) Consensus space (State); and (3) Innovation space (Etzkowitz & Klofsten, 2005; Etzkowitz, 2008; Garnsey & Smith, 1998).

In Europe, this discussion focuses on defining EU policies on competitiveness, led by regional innovation as well as national and local government policy agendas. The Europe 2020 Strategy is a ten-year European Union plan (2010-2020) aimed at growth. Assuming more intelligent,

sustainable and inclusive economies, strategic implementation is based on a set of five key objectives in the areas of employment, education, research and innovation, social inclusion and poverty reduction and climate and energy to be achieved by 2020 (European Commission, 2014b).

Aiming to answer the specific research questions, we carry out a comparative evaluation of the detailed innovation and entrepreneurial profile of the two regions.

The regional level is perceived as an important dimension to understanding entrepreneurship and its impact on the competitiveness of nations. However, the concept of international competitiveness stands out as a complex problem, forcing companies to compete in global market, based on high levels of skills, patterns of specialization, quality and productive dynamics (Audretsch et al., 2012; Castellacci, 2008; Huggins & Williams, 2011).

The increasing globalization of markets and the massification of competition associated with increasing technological complexity make innovation an important factor for firms, increasingly highlighting the importance of establishing cooperation networks (Boschma, 2004; Chesbrough, 2007; Lichtenthaler, 2010). Collaborative networks drive an important contribution to increasing the competitiveness of economies and regions. This networking may involve the development of innovative projects, new technology, cost synergies or access to limited resources. This also results in benefits for regional competitiveness through the geographic proximity between firms and other regional / local actors (Awazu, 2006; Bigliardi & Galati, 2012; Deimel et al., 2010; Semlinger, 2008).

This geographical proximity characterises the emergence of clusters, enhancing the rising levels of competitiveness within a particular specialized industry (Deimel et al., 2010; Isaksen, 1997; Lin & Sun, 2010). The increasing formation of clusters, especially out of agglomerations of SMEs, has attracted the attention of academics, industry analysts and policy makers in recent decades, derived from their good competitive positioning (Isaksen, 1997, 2007; Karlsen et al., 2011; Lin & Sun, 2010).

Geographical proximity, the structures and relationships between the actors involved in the cluster associated with the trust of partners in the network may determine competitive success in the marketplace (Deimel et al., 2010; Lin et al., 2012).

The value chain of the automotive industry represents a major pillar of the modern economy and Europe is a key player. In this competitive environment, this industry takes on a fundamental role in terms of employment, production, outsourcing market, RDI and the level of investment, presenting major challenges and opportunities for the future (ZEW Economic Studies, 2004).

Moulds are indispensable tools and have been widely applied in mass production whether for mechanics, electrics, household appliances, toys, automotive industry, aerospace, medical devices, etcetera (Low & Lee, 2008; Lyu & Chang, 2010; Mota & Castro, 2005; Zhou, 2013). This kind of industry, increasingly sophisticated and competitive, operates in a truly global market, commercializing their products with a high innovative component, supplied in the main by SMEs (Camacho, 2013; Cefamol, 2011; Kalafsky, 2007; Leung et al., 2010).

Through studying the impact of dynamic and innovative entrepreneurs within the context of the Portuguese Engineering and Tooling Cluster, we aim to answer the research question "how do innovative and entrepreneurial activities contribute to the competitiveness of clusters?
One of the main challenges to European economies lies in their limited capacity to convert scientific and technological progress into industrial and commercial applications (Etzkowitz & Klofsten, 2005; Klofsten & Jones-Evans, 2000).

As a result, academic institutions such as entrepreneurial universities have tended to take on more pro-active approaches in close collaboration with industry to contribute to the development of new products and to improve the competitiveness of organizations and countries (Abramo et al., 2009; Comacchio et al., 2011; D'Este & Patel, 2007; Leydesdorff & Sun, 2009; Marques et al., 2006; Philbin, 2008; Rossi, 2013; Tee, 2005).

These new Academia-Industry (A-I) alliances now define an era of policy research, consulting and informal interactions that became ever more frequent as from the 1970s with the Massachusetts Institute of Technology (MIT) and later at Stanford University, both located in the USA, playing pioneering roles (Arza & López, 2011; Ojewale et al., 2001; Perkmann et al., 2013, 2011; Ranga et al., 2003; Van Looy et al., 2004).

Sometimes SMEs prove more effective than large companies with their great research centres at adopting different practices for open innovation, leading to the introduction of new products to the market driven by industrial property protection mechanisms (Bennett et al., 2012; Huizingh, 2011; Spithoven et al., 2013, 2011).

Based on the following research question: how can A-I-G interactions contribute to regional competitiveness through innovation and entrepreneurship?, the aim of this study fills some of the gaps identified in the literature presenting case studies, focused on Academia-Industry knowledge transfer and technology, through open innovation initiatives and innovative entrepreneurship.

The growing interest in the themes of innovation and regional innovation systems among academics, industry practitioners and policymakers has proven a major catalyst for the

competitive advantage of nations and regional territories (Asheim et al., 2011; European Commission, 2014a; Vaz et al., 2014).

Several authors argue that innovation and entrepreneurship interrelate with each other with a consensus around their role as strong determinants of competitiveness and regional development (Kelley et al., 2010; Kuratko et al., 2014; Poly- & Hom, 2000; Porter & Stern, 2001; Porter, 1990, 1998; Wong et al., 2005; Yglesias, 2003).

Business networks and RDI project cooperation potentiate the companies and entities involved in the dynamics of the triple helix or quadruple helix (encompassing the participation of civil society) generating a new competitive positioning in the market with a strong positive impact on regional development (Carayannis & Rakhmatullin, 2014; Colapinto & Porlezza, 2011; Gouvea et al., 2013; Lawton Smith & Bagchi-Sen, 2010, 2012b; Lawton Smith & Romeo, 2012; Leydesdorff, 2011; Marcovich & Shinn, 2011; Prainsack, 2012; Semlinger, 2008; Turok, 2004).

This assumption raises a new research question: how can we measure the impact of triple / quadruple helix collaborative regional networks in context?

Several performance measurement models have been constructed out of the philosophy of the Balanced Scorecard (BSC) introduced by Kaplan and Norton (Felzensztein et al., 2014; Kaplan & Norton, 1992, 1993, 1996, 2000, 2001a, 2001b, 2004; Lundberg & Andresen, 2012). Today deployed as a strategic management tool, the BSC not only applies to intra-company contexts but also their extensive inter-enterprise interactions, industry-academia collaborative projects along with the other dynamics of territorial competitiveness (Al-ashaab et al., 2011; Chytas et al., 2011b; González et al., 2012; Loppolo et al., 2012; Verdecho et al., 2012; Wu & Chang, 2012).

However, there remains a gap in the literature that fails to focus on the dynamics of innovation, entrepreneurship and competitiveness in the regional context of triple/quadruple helix interactions. In response, we propose the development of a measurement model adapted to this performance reality: the Regional Helix Scoreboard and also aiming to facilitate regional comparisons.

2. Unit of analysis and research themes

As indicated by its title, Innovation and Entrepreneurship Networks as Global Competitiveness Drivers represent the key facets to this thesis. We have obtained theoretical knowledge concerning the importance of the factors of "innovation" and "entrepreneurship" on national and regional economies, insights regarding both the functioning of different innovation and

entrepreneurship ecosystems within the context of "regional triple helix spaces" and the empirical results serving to contribute to improving the theory on collaborative networks embedded in the context of interactions within the scope of the triple and/or quadruple helix and their respective contributions to competitiveness. These interactions get placed within the context of regional innovation ecosystems, regional technology clusters and developing collaborative RDI projects between academia-industry. Finally, this thesis derives insights about the methodologies capable of measuring competitive performance within the dynamic interaction of regional spheres.

Given the importance of the issues outlined above, this analytical approach serves to contribute to the development of this field of research. Thus, the core model to this doctoral thesis is correspondingly presented below (see figure 1).
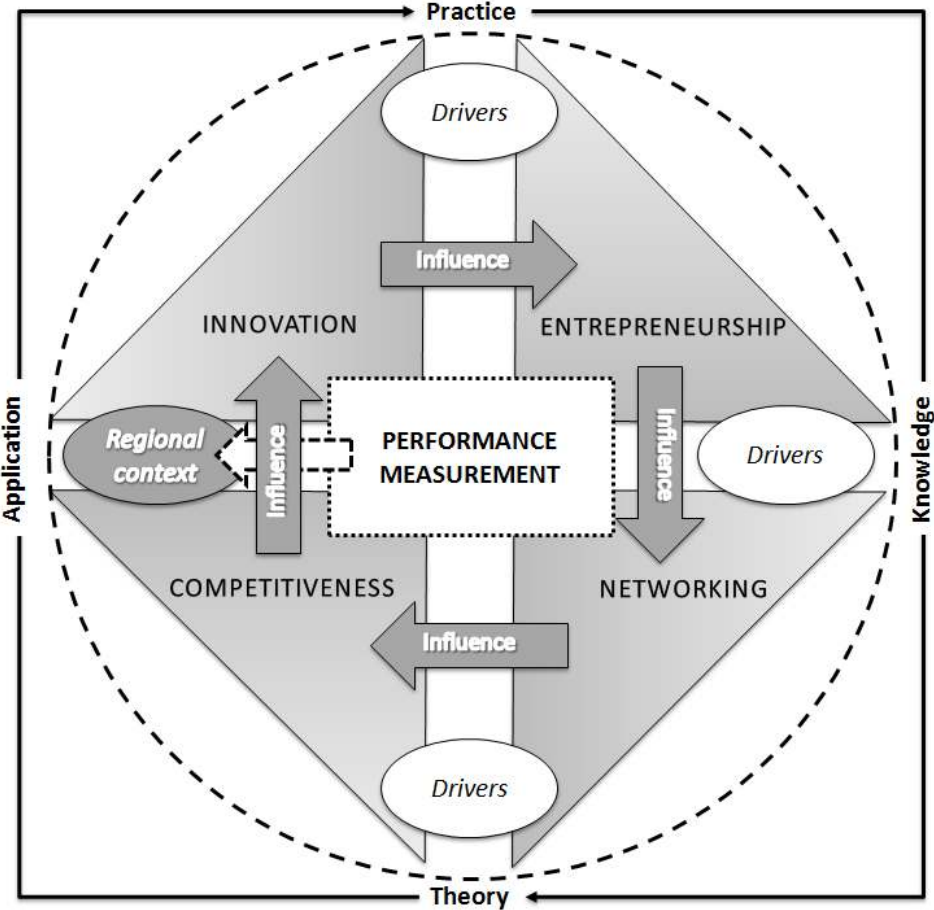
Figure 1 – Core Doctoral Thesis Model

Based on the literature insights applied to our core research model, we aim to achieve the following general objectives:

- Understand the overall contribution of innovation and entrepreneurship to the socio-economic development of regions;
- Understand and compare the trajectories of innovation and entrepreneurship in two European regions positioned at different levels of regional innovation;

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- Study the contribution of the competitive dynamics of networking innovation within a technology cluster in Portugal;
- Analyze knowledge transfer and technology transfer processes and thus the cooperation ongoing between Academia and Industry within the framework of an EU funded R&D project; and
- Find a support model for the performance measurement of the Triple / Quadruple Helix collaborative network context.

Given this greater understanding of the research problem, we may establish a match between the research questions and the proposed objectives (see table 1).

Table 1 – Research objectives

Objectives / Research questions	Obj. 1 Understand the overall contribution of innovation and entrepreneurship to the socio-economic development of regions	Obj. 2 Understand and compare the trajectories of innovation and entrepreneurship in two European regions positioned at different levels of regional innovation	Obj. 3 Study the contribution of the competitive dynamics of networking innovation within a technology cluster in Portugal	Obj. 4 Analyze the processes of knowledge and technology transfer, thus cooperation between academia and industry through an EU funded R&D project	Obj. 5 Find a support model for performance measurement in the Triple / Quadruple Helix collaborative network context
Are networks of innovation and entrepreneurship a key pillar for the socio-economic development of economies and regions?	X				
To what extent can both be seen as successful entrepreneurial regions? What factors have led to their growth and to the differences between them?		X			
How can innovative and entrepreneurial activities contribute to cluster competitiveness?			X		
How can A-I-G interactions contribute to regional competitiveness through innovation and entrepreneurship?		X	X	X	X
How can we measure the impact of triple / quadruple helix collaborative regional networks in context?					X

3. Methodology

We set out the scientific methodology applied in this thesis in section 1.2.1. The framework and specific methodological approaches for each chapter are discussed in section 1.2.2.

3.1. Scientific method

In epistemological terms, discussions of methodology in economics and management are common in the analysis of how economists construct knowledge (Johnson, 1996). Both forms of deductive and inductive reasoning are considered logical processes and applicable in the conducting of research (Goel & Dolan, 2004; Overmars et al., 2007; Sivertsen, 2005).

The 20th century philosophy of science began on a positivistic note, grounded in scientific explanation and the hypothetic-deductive framework (Mahootian & Eastman, 2009). Deductive reasoning is described as the way in which we reason from the general to the particular (Blachowicz, 2009). Four centuries ago, Francis Bacon introduced the inductive method in the practice of empirical science in opposition to the strong current of deductive reason (Mahootian & Eastman, 2009). Induction or "inductive generalization" is reasoning from the specific to the general (Blachowicz, 2009). Nowadays, philosophers of science debate the relative merits of each approach. However, the central issue is the extent to which these types of reasoning contribute to the scientific process (Berhouma, 2013; Blachowicz, 2009; Brown, 2011; Jean & Simard, 2013; Kidd, 2013; Lee & Lo, 2014; Parvin, 2011).

The conduct of this thesis follows the process of deductive reasoning, logic-based construction of a chain of reflection in descending order, from the general theoretical framework to individual research cases (see figure 2).
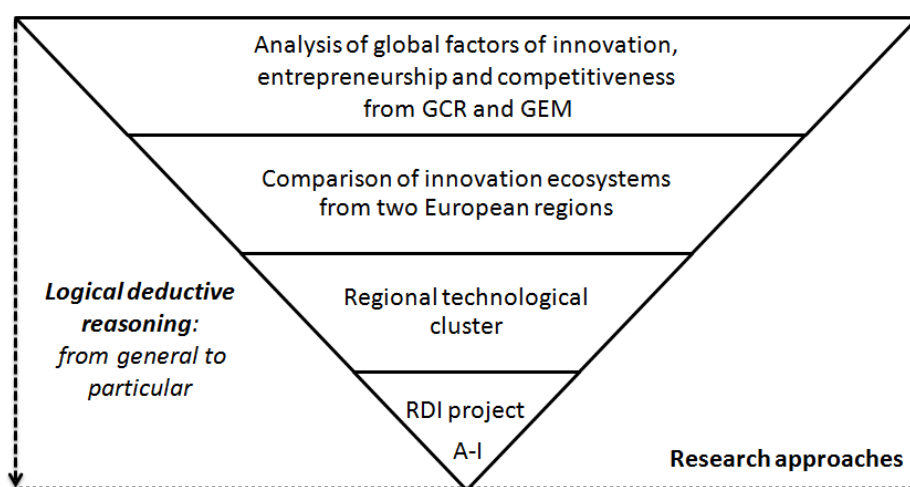
Figure 2 – Research scientific method

3.2. Approaches in individual chapters

This core foundation of the research model of this thesis rests competitiveness being explained by innovation and business sophistication, taking into account the association between the corresponding stages of economic development. Furthermore, entrepreneurship and competitiveness are nevertheless interconnected. In this framework, we consider competitiveness the measure of socio-economic development within the context of different geographies (Acs & Amorós, 2008; Amorós & Bosma, 2014; Bosma & Schutjens, 2011; Reynolds et al., 2005; Schwab, 2014).

The empirical analysis in Chapter 2 then follows a quantitative approach, applying structural equation modelling (SEM) and hierarchical cluster analysis. The data in the descriptive statistics and the SEM were collected from the GCR 2013-2014, relative to a set of 148 countries. We also deploy data from the 2013 GEM Global Report, covering 67 countries in the cluster analysis.

Based on the comparative analysis of two streams of research gathered by two teams, one located in the UK and the other in Portugal, research in the 3rd chapter was guided by the regional triple helix model. We then compare the four-dimensional regions observed: the role of Academia, the role of Industry, the role of the Public sector and their respective networking capacities. Both teams have built their research works on existing sources, enriching them with appropriate updates of data, mainly through primary research.

Case study analysis is a methodology that allows researchers to focus on a specific concrete reality, leading to a better and deeper understanding of the facts (Baxter & Chua, 2003; Corcoran et al., 2004; Singh et al., 2014; Tranfield et al., 2003; Yin, 2014); offering rich descriptions of micro-level mechanisms and processes and thus facilitating the induction of quantitative standards for future research (Singh et al., 2014).

Seeking to fill some of the gaps identified in the literature regarding the focus on innovation management in the technological cluster context and highlighting collaborative RDI projects, chapter 4 adopts a case study based interpretative approach.

Overcoming a gap in the literature regarding direct approaches to collaborative A-I projects, the 5th chapter follows an interpretative case study-based approach. This methodology incorporates the argument that exclusive recourse to quantitative methods prevents the capture of the essence of the phenomenon in certain areas of highly complex knowledge (Beach et al., 2001; Lee & Lo, 2014).

Finally, in the 6th conceptual chapter, our first objective involves analysing the state of the art on BSC to measure the performance of collaborative networks and to this end carrying out

an extensive search of the titles and abstracts of published, peer-reviewed papers held by the Thomson Reuters (ISI) bibliographical database web of knowledge. Hence, we implemented a simplified version of the process outlined by Tranfield et al. (2003) and as also advocated by Perkmann (Pablo D'Este & Perkmann, 2010a, 2010b; Perkmann et al., 2013, 2011). The intended methodological point of arrival comes with the production of a conceptual model for performance measurement adjusted to regional triple and/or quadruple helix collaborative interactions.

4. Thesis outline

The chapters of this thesis consist of five papers that all interrelate with the main research themes, summarised in the core doctoral thesis model. The thesis is thus structured in three parts (see figure 3).

Inserted in the second part, chapters 2 to 6 each discuss one of the papers, which can all also be read individually The first part and second part correspond to the introduction and final considerations, respectively.
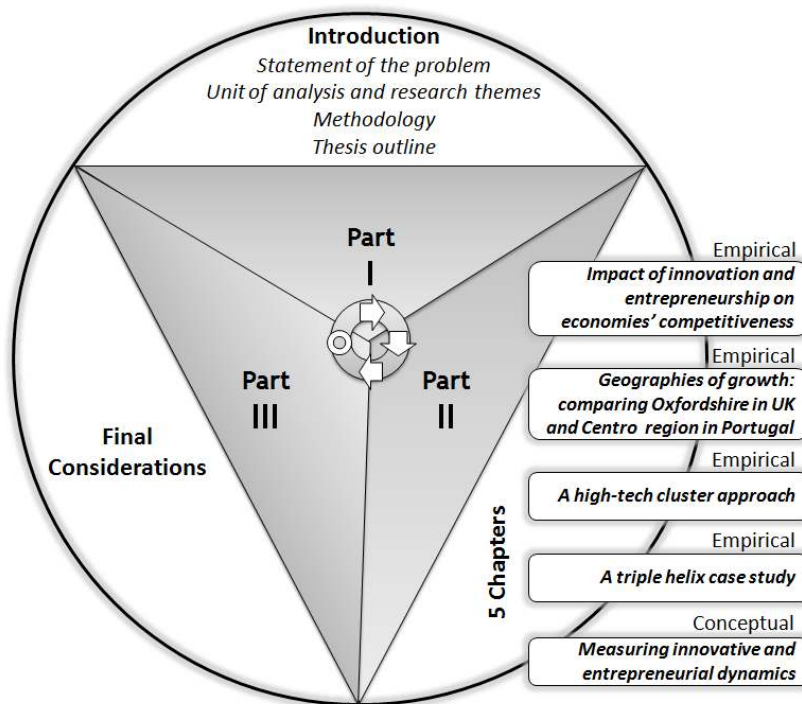
Figure 3 – Thesis design

Finally, chapter 7 sets out the main thesis conclusions and discusses additional observations and insights gained from the research.

Part II

Chapter 2

Impact of innovation and entrepreneurship on national and regional economies

Abstract

The purpose of this paper is to analyse the impact of innovation and entrepreneurship related factors on national and regional economies thus allowing for the emergence of new reflections capable of leading to increased socio-economic prosperity. Following quantitative analysis, we carry out three empirical approaches in order to examine the effects of innovation and entrepreneurship on competitiveness. In accordance with our initial study framework, we test our conceptual model of competitiveness through applying descriptive statistics, structural equation modelling (SEM) and hierarchical cluster analysis. Descriptive statistics and SEM data sources from the Global Competitiveness Report of the World Economic Forum (WEF) were analyzed for 148 countries. The hierarchical cluster analysis furthermore analyzed Global Entrepreneurship Monitor (GEM) data on 67 different countries. The study confirmed that innovation and sophistication factors are crucial to the competitiveness of economies.

In addition, the study also revealed the definition of five clusters relative to the competitive performance of advanced economies following the introduction of new entrepreneurship variables. This research aims to open up avenues for the development of regional competitiveness studies and enable the comparison of best practices between countries and regions.

Keywords

1. Introduction

According to González-Pernía et al. (2011), the last decade has seen much attention devoted to the study of territorial competitiveness and development. The emphasis in the theory of regional development changed from a focus on exogenous factors to an increasing focus on endogenous factors (Ács et al., 2014; Audretsch & Belitski, 2013; Álvarez et al., 2013). Thus,

an economy's' prosperity stems from its capacity to compete in the global marketplace (Stajano, 2006).

The competitiveness rankings of countries presuppose an understanding of the concept of competitiveness. According to Rugman et al. (2011), the double diamond framework (including dimensions for host country diamond and home country diamond) provides a foundation for studying international competitiveness within the framework of which global competitiveness depends on the comparative advantages of each economy whilst never overlooking the regional context. In each of the diamonds, the global comparative advantage includes dimensions such as the supply chain; factor conditions; demand conditions and government conditions.

Innovation has become a crucial factor to global competitiveness and economic growth, generating a strong impact on the Gross Domestic Product (GDP) of advanced nations (Buesa et al., 2010; Cantner et al., 2008). As noted in recent years, a growing number of empirical studies have presented empirical assessments of the competitiveness of national and regional economies (Ketels, 2006). The Global Competitiveness Report (GCR) by the World Economic Forum (WEF) represents an important outcome of internationally recognized prestige (Ketels, 2006; Bronisz et al., 2008; Kravchenko et al., 2013; Bergsteiner & Avery, 2011). The WEF has published the GCR annually since 1979. The number of countries included in the international comparison currently amounts to 148 with these countries accounting for in excess of 97 per cent of world GDP (Fendel & Frenkel, 2005; Schwab, 2013).

The entrepreneurial spirit and entrepreneurship initiatives are generally assumed as key factors to economic development (Marques et al., 2010). An entrepreneurial society applies knowledge-based entrepreneurship as the driving force for economic growth, job creation and enhancing competitiveness (Guerrero & Urbano, 2010). Launched in 1999 as a partnership between the London Business School and Babson College, the Global Entrepreneurship Monitor (GEM) project is an annual assessment of entrepreneurial activity, aspirations and individual attitudes across a broad set of countries (Amorós & Bosma, 2014; Ramos-Rodríguez et al., 2013).

The literature review raised the following research questions inherent to defining our problem: "innovation and sophistication is the stronger pillar for the socio-economic development of economies?", and "what are the links between entrepreneurship and economic growth?"

This study analyses the relationships between innovation and entrepreneurship within the scope of overall economic competitiveness. It also seeks to help open up new means of focusing on the socio-economic development of regional studies.

In order to facilitate interpretation, we structure the chapter into five sections: 1 – Introduction; 2 – Research framework and hypotheses; 3 – Data, variables, and methods; 4 – Empirical results and discussion; and 5 –Conclusions, limitations and further research.

2. Research framework and hypotheses

2.1. Literature review

2.1.1. The global competitive advantage of nations

Porter (1990) defines competitiveness according to national economic development from its positioning across three different stages: (1) factor-driven, (2) efficiency-driven, and (3) innovation-driven; with two transitions between stages (Acs et al., 2008; Porter, 1990). The countries grouped into the first stage compete through cost efficiencies in the production of raw materials or products of low added value (Acs et al., 2008). These economies include numerous non-agricultural self-employment based initiatives (entrepreneurship by necessity) (Acs et al., 2008; Amorós & Bosma, 2014). In the second stage, countries need to increase their productive efficiency levels and enhance the skills of their workforce in order to adapt to the technological developments that endow them with the ability to exploit economies of scale in large markets. There is an increase in foreign direct investment (FDI) accompanied by a decreasing trend of entrepreneurship by necessity underpinned by the assumption of management positions in larger organizations in the belief that they can make more money by working on behalf of others (Acs et al,. 2008; Schwab, 2013). The developing economies, including Brazil, Russia, India and China (BRICs), are at this "efficiency-driven" stage. The "innovation-driven" economies need to develop environmental conditions for entrepreneurship founded upon information and communication technologies. At this stage, there is the emergence of a large number of SMEs, closely linked to services and focused on those innovation factors characterized by a strong growth potential (Schwab, 2013; Amorós & Bosma, 2014; Acs et al., 2008).

According to Schwab (2013), a country's competitiveness is globally accepted as the key driver for sustaining prosperity and raising the welfare of its citizens. The GCR claims to capture the microeconomic and macroeconomic foundations of economic competitiveness based on the set of institutions, policies and factors determining the respective level of national productivity.

Schwab (2013) argues that there is a need to incorporate countries in accordance with their different respective stages of development and thereby enabling definition of plans for improving their competitiveness (see table 1).

Table 1 – Framework of the Global Competitive Index

Global Competitiveness Index				
Basic requirements		**Efficiency enhancers**		**Innovation and sophistication factors**
1. Institutions 2. Infrastructure 3. Macroeconomic environment 4. Health and primary education		5. Higher education and training 6. Goods market efficiency 7. Labour market efficiency 8. Financial market development 9. Technological readiness 10. Market size		10. Business sophistication 11. Innovation
Stages of development				
1 - Factor-driven economies	*Transition 1-2*	*2 - Efficiency-driven economies*	*Transition 2-3*	*3 - Innovation-driven economies*

Source: Schwab (2013)

To measure these dimensions, the Global Competitiveness Index (GCI) incorporates statistical data such as education enrolment rates, public debt levels, budget deficits and life expectancy and all obtained from internationally recognized agencies. In addition, the GCI applies data from the WEF Annual Executive Opinion Survey to capture concepts either requiring a more qualitative assessment or for which internationally comparable statistics are not available for the entire set of economies (Schwab, 2013).

The best ways to improve the competitiveness of a "factor-driven economy" are not the same as those for an "efficiency-driven economy" or an "innovation-driven economy" (Schwab, 2013). According to this logic, the GCI takes into account the different stages of development, attributing higher relative weights to the most important pillars in each stage (see table 2).

Table 2 – Weightings in the calculation of the WEF Global Competitiveness Index (GCI)

Dimensions	Basic requirements (Stage 1)	Transition (1-2)	Efficiency enhancers (Stage 2)	Transition (2-3)	Innovation and sophistication (Stage 3)
GDP per capita (U.S. $)	<2,000	2,000-2,999	3,000-8,999	9,000-17,000	>17,000
Weight for basic requirements subindex	60%	40%-60%	40%	21%-40%	20%
Weight for efficiency enhancers subindex	35%	35%-50%	50%	50%	50%
Weight for innovation and sophistication factors	5%	5%-10%	10%	10%-30%	30%

Source: Schwab (2013).

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The innovation pillars, particularly important for the most advanced economies, include "business sophistication" and "innovation" factors. Regarding the GCI "Innovation" factors, Schwab (2013) describes the corresponding pillars in the Global Competitiveness Report (see table 3).

Table 3 - Pillars of competitiveness study

Pillars	Economic orientation	Framework
11 - Business sophistication	<u>Innovation</u>	• Business sophistication leads to greater efficiency in the production of goods and services. • This includes the quality of economic networking and the quality of business operations and company strategies. • The quality of an economy's business networks and their supporting industries reflects on the quantity and quality of local suppliers and their interactions. • When firms and suppliers from a particular sector are interconnected in geographically proximate groups (clusters), efficiency is high with greater opportunities for innovation in processes and products and reduced barriers to entry for new firms.
12 - Innovation	<u>Innovation</u>	• The twelfth pillar of competitiveness focuses on technological innovation. • Innovation emerges from new technological and non-technological knowledge (related to the know-how, skills, and working conditions embedded in organizations). • Innovation becomes particularly important for economies as they approach the frontiers of knowledge and the scope for generating added value rather than merely integrating and adapting exogenous technologies.

Source: Elaborated from Schwab (2013)

Audretsch & Belitski, (2013) meanwhile identify the lack of a pillar for the "creativity theory of knowledge spillover entrepreneurship", arguing that creativity generates a source of entrepreneurial opportunities. Audretsch & Peña-Legazkue, (2011) furthermore advocate the importance of the role of entrepreneurship in the transformation of local economies. Entrepreneurship and business growth are fundamental to a nation's economic development as they nurture competitive advantages (Chiang & Yan, 2011).

For this reason, we propose the following hypotheses regarding the effect of innovation and business sophistication on competitiveness:

Hypothesis 1 – The competitiveness of economies is explained by innovation variables.

Hypothesis 2 – This competitiveness is also explained by business sophistication factors.

Hypothesis 3 - There is a strong link between the stage of economic development and competitiveness.

2.1.2. Linking entrepreneurship to economic growth

According to Schumpeter's theory, economic growth is based on innovations (product innovation, new production methods, new raw materials, and new organizational structures in industry) (Witt, 2002; Landström et al., 2012). The contribution of technological innovation to economic growth has also been well established in the economic literature (Wong et al., 2005). Innovation is sought out and implemented by entrepreneurs with specific personalities desiring to attain power, independence with the will to conquer and the joy of creating (Audretsch & Fritsch, 2003; Wong et al., 2005; Landström & Johannisson, 2001). Landström et al. (2012) argue that there is a need for more deeply integrating innovation and entrepreneurship and thus opening the path to developing "entrepreneurship by opportunity" in this field of research.

Entrepreneurial initiatives and exports have a positive impact on national competitiveness increasing both productivity and the numbers of new firms (Hessels & Stel, 2009; Guerrero et al., 2006). Gries and Naudé (2009) emphasize how important entrepreneurship, the process of launching and continuing to expand new businesses, is to economic growth and development. According to a broad range of key players in society, including policymakers, academics, entrepreneurs as well as the general population, entrepreneurship holds an important impact on economic development and social welfare (Amorós & Bosma, 2014).

The GEM research program was designed to comprehensively assess the role of entrepreneurship in national economic growth and at a time characterized by an almost total lack of internationally comparable information regarding entrepreneurship. GEM currently has global coverage, encompassing about 90 countries in 2013 (Wong et al., 2005; Reynolds et al., 2005). Based on principles including how entrepreneurs are ambitious and undertake the mission to encourage innovation thereby accelerating structural changes in the economy, entrepreneurial activity is deemed capable of introducing new competition and thus contributing to the improvement of productivity, job creation and increased national competitiveness (Amorós & Bosma, 2014; Sanyang & Huang, 2009).

The GEM is the only globally harmonized data set dedicated to the study of entrepreneurship (Bosmaet al., 2012; Levie et al., 2013) focusing on the motivations leading to entrepreneurship (opportunity/necessity), innovation, business activities, degree of competition, international orientation, growth expectations as well as factors such as gender, age, education, region and other demographic characteristics (Amorós & Bosma, 2014). The key GEM objectives include measuring differences in entrepreneurial attitudes, activities and aspirations between countries and identifying the determinants of entrepreneurship levels and policy implications (Bosma et al., 2012). The GEM project is a complex initiative involving dozens of national teams and hundreds of individuals, facilitated by a formal focus to guide

the coordination of multiple disparate participants. Between 1999 and 2011, approximately one million people were surveyed with 11,000 experts involved (Álvarez et al., 2013).

Paul Reynolds advanced the GEM model based on a 1997 proposal from Michael Hay about establishing a World Enterprise Index that would represent the equivalent for enterprise and entrepreneurship of the IMD's World Competitiveness Yearbook and the World Economic Forum's Global Competitiveness Index (Levie & Autio, 2008). For data sources, the GEM project is based on representative samples of each country's adult population aged between 18 and 64 (Amorós & Bosma, 2014). Therefore, we expect entrepreneurial activity to contribute positive and significantly to the competitiveness of nations and correspondingly put forward the following hypotheses:

Hypothesis 4 – Entrepreneurship by opportunity represents a key driver for competitiveness in advanced economies.

Hypothesis 5 – Entrepreneurship by necessity represents a key driver for economies positioned in the development "factors-driven" and "efficiency-driven" stages.

Since its founding, the GEM model has pursued and explored the bi-directional relationship between entrepreneurship and economic development (Stel et al., 2005; Wennekers et al., 2005; Ramos-Rodríguez et al., 2013; Acs et al., 2008).

Alongside the GCI, the revised GEM conceptual model groups countries into three stages of economic development, "factors-driven economies", "efficiency-driven economies" and "innovation-driven economies" (Amorós & Bosma, 2014; Bosma et al., 2012). This revised model rests on the concept that the contribution of entrepreneurs to economies varies according to their phase of economic development (Ramos-Rodríguez et al., 2013). The GEM model defines the structural conditions of entrepreneurship and correspondingly reflecting the main socio-economic characteristics of each country expected to generate a significant impact on entrepreneurial activity and therefore on the competitiveness of nations (Amorós & Bosma, 2014; Galindo & Méndez, 2014; Levie et al., 2013). Entrepreneurs in new firms but also in established companies play a key role in local, regional and national economic development by taking risks in getting things done by developing new ideas and/or undertaking innovative tasks (Karlsson & Warda, 2014).

2.2 Research model

The competitiveness of nations / regions is far from constant, starting out with the variation in the global population, the volume of global production (GDP) or respective the global welfare indicator (GDP per capita) (Kwasnicki, 2012). According to Fratesi (2009), the competitiveness of an economy / region is the result of the good working of mechanisms oriented towards local resources, investment and income and thereby fostering innovation,

investment in R&D and income. In the second case, by innovating, the system is able to generate technology continuously and remains market competitive with this competitiveness generating added value that can then be reinvested in learning and R&D enabling continuous improvement and increasing competitiveness. The literature on competitiveness and entrepreneurship takes GDP per capita, job creation, wealth as well as export activities, networking capacities and social values as some of the indicators serving to measure social and economic development (Hessels & Stel, 2009; Kravchenko et al., 2013; Rocha, 2004).

Hypotheses 1 and 2, in which competitiveness is explained by innovation and by business sophistication, set out the starting point of our research model. The model takes into account analysis of the environment based on the framework of hypothesis 3 (the association between the stage of development and competitiveness).

Entrepreneurship and competitiveness are closely linked (Chell & Baines, 2000; Cuckovic & Bartlett, 2007; Huggins & Williams, 2011; Lawton Smith & Bagchi-Sen, 2012; Nordqvist & Melin, 2010). The creativity-entrepreneurship nexus reinforces the approach to entrepreneurship by opportunity (Audretsch & Belitski, 2013). The GEM model reflects differences in the economic effects of entrepreneurship by opportunity and by necessity in both emerging and developed countries (Álvarez et al., 2013). According to this assumption and hypotheses 4 and 5 concerning the role of entrepreneurship in economies, we present our conceptual model of competitiveness (see figure 1).
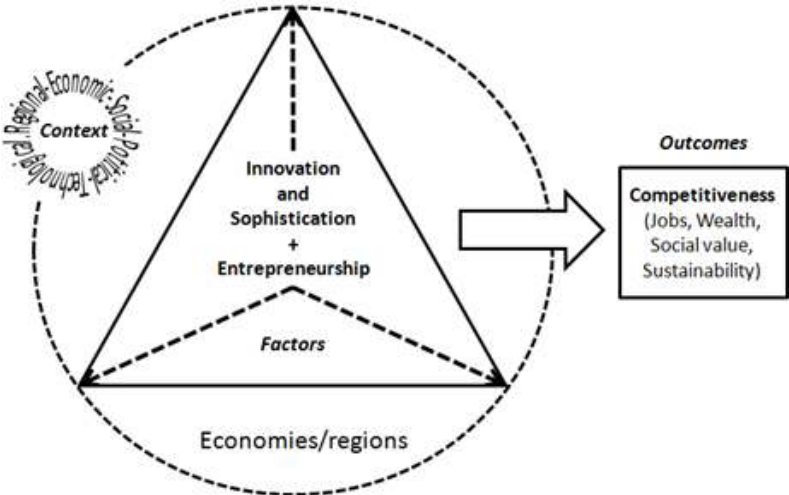
Figure 1 - Conceptual model of competitiveness
Source: Own elaboration

2.3. Data, variables and methods

2.3.1. Dependent variable

We consider competitiveness our measure of socio-economic development in the context of different geographies, responsible for the creation of jobs, wealth, social value and welfare

(Schwab, 2013; Acs & Amorós, 2008; Audretsch & Peña-Legazkue, 2011; Landström et al., 2012; Álvarez et al., 2013; Ramos-Rodríguez et al., 2013; Amorós & Bosma, 2014; Stajano, 2006). Our data on competitiveness derive from the GCI presented in the annual GCR of the World Economic Forum.

2.3.2. Innovation, sophistication and income variables

Based on various studies, we understand innovation as an important variable comprising of a set of items key to the development of economies and regions and that enables the generation of knowledge and the creation of added value whilst leveraging the level of skills and business sophistication (Valliere & Peterson, 2009; Amorós et al., 2011; Amorós & Cristi, 2008; Acs & Amorós, 2008; Rugman et al., 2011; Valliere, 2008; Radosevic, 2009). We apply the business sophistication variable as a key measurement component of competitiveness and intrinsically interconnected with this innovation (Schwab, 2013; Valliere & Peterson, 2009). All the items applied within the study are defined in Table 4.

Table 4 – Independent and control variables

Innovation and sophistication factors (from GCR)	Entrepreneurship factors (from GEM)
Business Sophistication	**Entrepreneurial attitudes and perceptions**
Local supplier quantity	Perceived opportunities
Local supplier quality	Perceived capabilities
State of cluster development	Fear of failure
Nature of competitive advantage	Entrepreneurial intentions
Value chain breadth	Entrepreneurship as a good career choice
Control of international distribution	High status to successful entrepreneurs
Production process sophistication	Media attention to successful entrepreneurs
Extent of marketing	**Entrepreneurial attitudes and perceptions**
Willingness to delegate authority	Nascent entrepreneurship rate
Innovation	New business ownership rate
Capacity for innovation	Early-stage entrepreneurial activity (TEA)
Quality of scientific research institutions	Established business ownership rate
Company spending on R&D	Discontinuation of business
University-industry collaboration in R&D	Necessity-driven (% of TEA)
Gov. procurement of advanced tech products	Improvement driven opportunity (% of TEA)
Availability of scientists and engineers	**Job growth expectations for early-stage entrepreneurship activity**
PCT patents, applications/million pop.	0-5 jobs (% of adult population)
Per capita Income (control variable)	5-19 jobs (% of adult population)
GDP per capita	20 or more jobs (% of adult population)

Given the framework of economies by stage of development, GDP per capita is assumed as a control variable in our study, contributing to the positioning of the nations in the third stage

of development (innovation-driven economies), whenever in excess of U.S.\$ 17,000 (Schwab, 2013; Valliere & Peterson, 2009).

2.3.3. Entrepreneurship variables

According to Valliere and Peterson (2009), entrepreneurship and economic growth are necessarily linked. The GCR data based on the Executive Opinion Survey developed by the WEF does not contain the information necessary to analyse entrepreneurial activities in different economies. Entrepreneurship variables are the key factors for countries to achieve their competitiveness-level goals, responsible for the creation of employment, wealth and social value (Amorós et al., 2011; Valliere, 2008; Ács et al., 2014; Lundström & Stevenson, 2005; Audretsch & Fritsch, 2003).

We considered the critical variables for analysing the items "entrepreneurial attitudes and perceptions", "entrepreneurial activity and perceptions", and "job growth expectations for early-stage entrepreneurship activity" based on the study of GEM as summarized in Table 4 (Bosma & Schutjens, 2010; Amorós et al,. 2011; Amorós & Bosma, 2014).

2.3.4. Method

In order to examine the effects of the innovation and entrepreneurship variables and their impact on competitiveness, we complete three empirical analyses. First, we calculate descriptive statistics for the independent variables of "business sophistication" and "innovation" from the 2013-2014 GCR for the top 50 most competitive economies to better understand the behaviour of these factors.

Second we deploy structural equation modelling (SEM), as a multivariate statistical technique enabling us to simultaneously evaluate multiple relationships between constructs and thereby clarifying the interactions between the independent "business sophistication" and "innovation" variables and the dependent "competitiveness" variable as well as the relationship between "stage of development" and "competitiveness" for the 148 countries comprising the Global Competitiveness Index.

Finally, we perform hierarchical cluster analysis focusing on the 67 interrelated countries resulting from the intersection of the GCI and the GEM project (from the 2013 Global Report) in order to understand the clustering behaviour of countries reported by the independent "business sophistication", "innovation" and "GDP per capita" variables where we introduce new entrepreneurship variables from the GEM. This analysis allows us to confirm the results from

the descriptive statistic and structural equation model outcomes and thus help to understand the impact of entrepreneurship on economies.

3. Empirical results and discussion

3.1. Trends for innovation and business sophistication in the most competitive economies

We find that the most competitive countries (e.g. GCI top 25) display less variation between the 11th and 12th pillars when compared to the GCI trend (see figure 2). The innovation and sophistication factors rank Switzerland in first place followed by Finland, Japan, Germany, Sweden, the United States, the Netherlands, Israel, Taiwan with the United Kingdom in tenth place (Schwab, 2013).
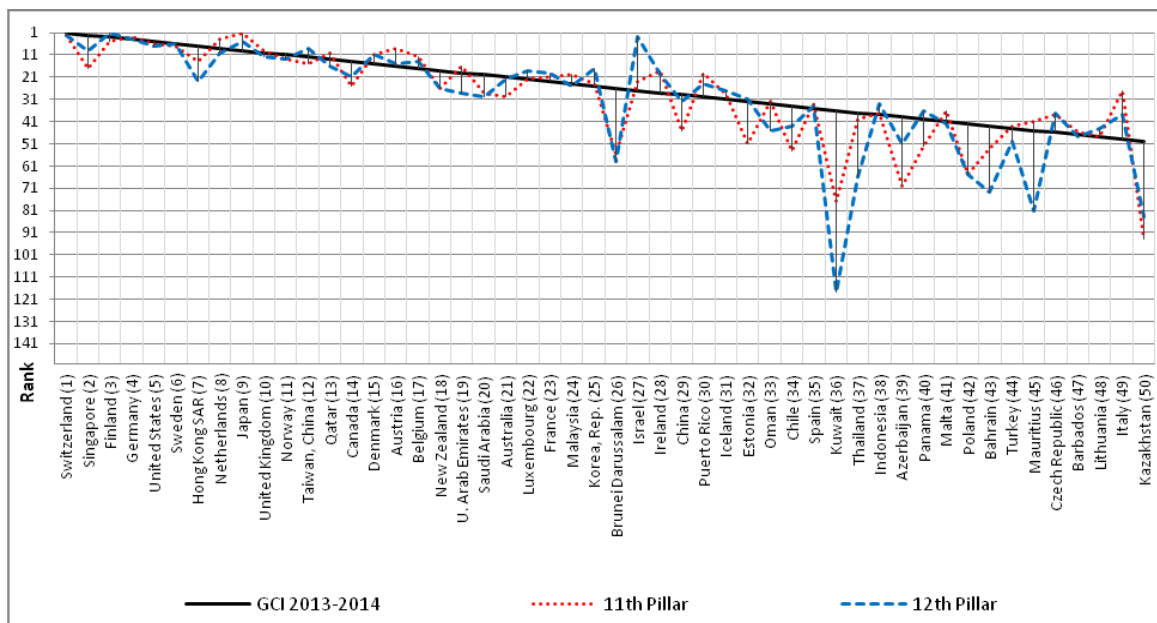
Figure 2 - Countries ordered by GCI (top 50).
Source: Elaborated from Schwab (2013)

Analyzing the GCI top 50 (see figure 2), we report a decrease in the GCI positioning whilst confirming a certain trend towards instability between the two pillars and the competitiveness indicator curve. Comparing the particular cases with greater variance between the pillars and the GCI curve (Azerbaijan, Bahrain, Brunei Darussalam, Kazakhstan, Kuwait, and Mauritius), we identify the factors with the greatest influence on the index (see table 5).

Table 5 – Countries in the top 50 of the GCI, with greater variation on pillars 11th and 12th

Global Competitiveness Index		Azerbaijan	Bahrain	Brunei	Kazakhstan	Kuwait	Mauritius
Economy	GDP per capita (US$)	7,450	23,477	41,703	11,773	45,824	8,850
Position	Rank	39	43	26	50	36	45
	St. of development (Group)	1-2	3	1-2	2-3	1-2	2
Basic requirements	1. Institutions	59	32	25	55	49	39
	2. Infrastructure	69	30	58	62	53	50
	3. Macroeconomic environment	8	21	1	23	3	67
	4. Health and pr. education	109	44	23	97	77	43
Efficiency enhancers	5. Higher educ. and training	87	53	55	54	84	61
	6. Goods market efficiency	71	19	42	56	90	25
	7. Labour market efficiency	30	19	10	15	105	55
	8. Fin. market development	88	25	56	103	70	26
	9. Technological readiness	50	32	71	57	69	63
	10. Market size	72	106	131	54	66	112
Innovation and Sophistication	11. Business Sophistication	70	53	56	94	77	41
	12. Innovation	51	73	59	84	118	81
The most problematic factor for doing business		*Corruption*	*Ineffic. Gover. Bureauc.*	*Access to financing*	*Corruption*	*Ineffic. Gover. Bureauc.*	*Ineffic. Gover. Bureauc.*

With the exception of Mauritius, all the other countries in the top 50 of the GCI with the greatest variance in the 11th and 12th pillars (Azerbaijan, Bahrain, Brunei, Kuwait and Kazakhstan), are very well positioned in Pillar 3 - "Macroeconomic environment" (Brunei is 1st, Kuwait is 3rd, Azerbaijan ranks 8th, Bahrain is 21st with Kazakhstan in 23rd place) (Schwab, 2013).

As set out in Table 7, Brunei Darussalam (ranking 26th in the GCI) takes first position in the "Macroeconomic environment" category (reporting GDP per capita of U.S.$41,703) while also well positioned in terms of "Labour market efficiency", "Health and primary education" and "Institutions". Moreover, the factors of "Market size" and "Technological readiness" reveal the country's greatest weaknesses. Furthermore, the most problematic factor for doing business is "access to financing". Kuwait (ranking 36th in the GCI) takes third position in the competitive advantage category "Macroeconomic Environment" while at a competitive disadvantage in the "Innovation" and "Labour market efficiency" factors.

One positive highlight, GDP of U.S.$45,824, proves higher than the figures attained by countries such as Germany (U.S.$41,513), France (U.S.$41,141) and the UK (U.S.$38,589) with "inefficient government bureaucracy" the greatest weakness to doing business. Azerbaijan (ranking 39th in the GCI) holds competitive advantage in pillar 3 – "Macroeconomic environment", occupying a place below position 50 in "pillar 7 - Labour market efficiency and "pillar 12 - innovation ". As weaknesses the country presents "4th pillar - Health and primary education", "5th pillar - Higher education and training" and "8th pillar - Financial market development". As with Kazakhstan, the most problematic factor to entrepreneurial activities

is corruption. Bahrain is the only country in the lot located in development stage 3 "Innovation-driven economies" and occupies 43rd place in the GCI. It proves relatively well positioned in areas such as "Microeconomic environment", "Labour market efficiency" and "Financial market development". The major constraint to business, alongside Kuwait and Mauritius, is "Inefficient government bureaucracy." Mauritius returns the factors "Goods market efficiency" and "Financial market development" as strengths whilst "Innovation" and "Market size" are its major weaknesses to its 45th place ranking in the GCI. Kazakhstan, last on this list, just above Portugal, ranks well in "Labour market efficiency" and "Macroeconomic Environment" while presenting strong weaknesses in "Financial market development" and "Business sophistication."

3.2. Competitiveness through innovation and business sophistication

Structural equation modelling (SEM) has become a "quasi-standard" in management fields given its capacity to test complete theories and concepts (Hair et al., 2011; Shah & Goldstein, 2006; Smith & Langfield-Smith, 2004). This tool statistical analysis establishes a confirmatory approach for theoretical models, including a set of statistical techniques that enable the assessment of causal relations between latent variables (not directly observable) through a set of observed variables (Hair et al., 2011; Marques et al., 2010).

In order to analyze the validity of our theoretical model, we applied the AMOS 16.0 structural equation models software.

The criteria deployed in constructing the final model presented here were based on the establishment and elimination of relations between variables that led to a better quality of adjustment. This procedure was implemented in accordance with the theoretical framework with the analysis of the goodness-of-fit measures and modification indices playing an important role in this analysis (see figure 3).
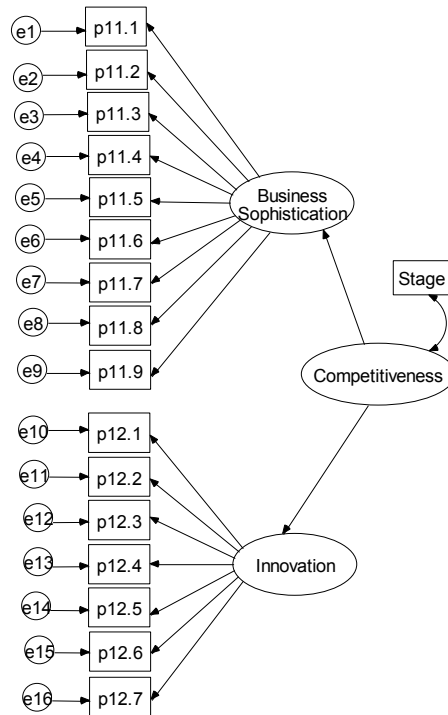
Figure 3 - Conceptual model of competitiveness through innovation and sophistication.

Table 6 presents details on the standardized and estimate factor loadings, standard errors associated with each coefficient and the critical ratio (ratio between the load factor and its standard error deemed significant whenever greater than 1.96 or less than -1,96) for the adjusted model.

Table 6 – Maximum Likelihood Estimates on the structural coefficients for the fitted model

			Estimate	Standard Error	Critical Ratio	p-value	Standard. Estimate
Business_Sophistication	<---	Competitiveness	1.000				1.000
Innovation	<---	Competitiveness	1.867	.173	10.781	***	1.000
p11.1	<---	Business_Sophistication	1.000				.684
p11.5	<---	Business_Sophistication	1.739	.148	11.763	***	.912
p11.9	<---	Business_Sophistication	1.604	.175	9.141	***	.852
p11.2	<---	Business_Sophistication	1.691	.137	12.345	***	.926
p11.3	<---	Business_Sophistication	1.555	.144	10.794	***	.850
p11.4	<---	Business_Sophistication	2.229	.219	10.199	***	.891
p11.6	<---	Business_Sophistication	1.179	.100	11.746	***	.807
p11.7	<---	Business_Sophistication	2.448	.219	11.167	***	.987
p11.8	<---	Business_Sophistication	2.011	.187	10.754	***	.946
p12.4	<---	Innovation	1.115	.049	22.527	***	.923
p12.1	<---	Innovation	1.000				.948
p12.7	<---	Innovation	1.245	.099	12.524	***	.742
p12.2	<---	Innovation	1.276	.060	21.294	***	.909
p12.3	<---	Innovation	1.046	.027	38.088	***	.931
p12.5	<---	Innovation	.491	.058	8.528	***	.565
p12.6	<---	Innovation	.722	.060	12.058	***	.727

*** p<0.001

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The results demonstrate how all the estimated regression coefficients are statistically significant. We would highlight the strong relations between both "Competitiveness" and "Business Sophistication" as well as between "Competitiveness" and "Innovation" (β = 1, p <0.001 for both cases). We also observe that the most crucial variable in "Business Sophistication" is item 11.7 (β = 0.987, p <0.001). This item seeks to respond to the following question: in each economy, how sophisticated are the production processes? The answer may vary from - not at all, labour intensive methods or previous generations of process technology prevail; to highly - the world's best and most efficient process technology prevails (Schwab, 2013).

There are also other very relevant items with correspondingly high coefficients. As examples, we would point to items 11.2 - Local supplier quality, and 11.5 - Value chain breadth. The latter aims to measure whether exporting firms have a narrow or broad presence across the value chain (e.g., if only at the level of natural resource extraction or production or also product design, sales, marketing, logistics and after-sales services). Regarding the innovation variable, the most crucial item returned is 12.1 (β = 0.948, p <0.001) while also highlighting items 12.3 (β = 0.931, p <0.001), 12.4 (β = 0.923, p <0.001) and 12.2 (β = 0.909, p <0.001).

Given the strong relationships between the "Innovation" and "Competitiveness" and "Business Sophistication" and "Competitiveness" items, we may respectively confirm hypotheses 1 and 2. Table 7 outlines the positioning of the countries in terms of their most relevant items in the Business sophistication and Innovation factors.

Table 7 – Most relevant items on Business Sophistication and Innovation factors

Rank	Business Sophistication factors			Innovation factors			
	11.7 - Production process sophistication	11.2 - Local suppliers quality	11.5 - Value chain breadth	12.1 - Capacity for innovation	12.3 - Company spending on R&D	12.4 - University-Industry collaboration in R&D	12.2 - Quality of scientific research institutions
	Country|GCI Rank	*Country|GCI Rank*	*Country|GCI Rank*	*Country|GCI Rank*	*Country|GCI Rank*	*Country|GCI Rank*	*Country|GCI Rank*
1	Japan|9	Switzerland|1	Germany|4	Switzerland|1	Switzerland|1	Switzerland|1	Israel|27
2	Switzerland|1	Japan|9	Japan|9	Finland|3	Japan|9	Finland|3	Switzerland|1
3	Germany|4	Austria|16	Austria|16	Germany|4	Finland|3	Unit. States|5	United King|10
4	Finland|3	Germany|4	Switzerland|1	Israel|27	Germany|4	Singapore|2	Belgium|17
5	Netherlands|8	Belgium|17	France|23	Unit. States|5	Unit. States|5	United King|10	United States|5
6	Austria|16	Netherlands|8	Sweden|6	Japan|9	Israel|27	Belgium|17	Germany|4
7	Unit. States|5	Finland|3	Finland|3	Sweden|6	Sweden|6	Qatar|13	Netherlands|8
8	Norway|11	Sweden|6	Unit. States|5	United King|10	Singapore|2	Israel|27	Austria|16
9	Sweden|6	Taiwan|12	Netherlands|8	Netherlands|8	Qatar|13	Germany|4	Japan|9
10	Ireland|28	Unit. States|5	Qatar|13	Belgium|17	Denmark|15	Sweden|6	Finland|3

Generally, countries well positioned in the GCI return equally good results in the relevant items to the Business sophistication and Innovation factors. Overall, we highlight the top position of Switzerland in almost every item. Table 8 presents the covariance and correlation results for the adjusted model.

Table 8 - Covariance and correlations for the Structural Model

			Estimate	Standard Error	Critical Ratio	p-value	Standard. Estimate
Competitiveness	<-->	Stage	.245	.039	6.301	***	.805
e11	<-->	e13	.092	.015	6.343	***	.598
e10	<-->	e12	.049	.008	6.340	***	.631
e8	<-->	e16	-.123	.020	-6.234	***	-.521
e1	<-->	e6	.060	.011	5.537	***	.398
e1	<-->	e2	.048	.009	5.250	***	.404
e6	<-->	e11	-.032	.008	-3.808	***	-.208
e12	<-->	e14	.071	.014	5.120	***	.429
e14	<-->	e16	-.148	.031	-4.725	***	-.324
e3	<-->	e16	-.121	.023	-5.237	***	-.369
e11	<-->	e15	.065	.015	4.422	***	.288
e1	<-->	e5	.041	.009	4.485	***	.303
e6	<-->	e8	.020	.007	3.075	.002	.208
e4	<-->	e16	.122	.028	4.423	***	.317
e4	<-->	e8	-.049	.010	-4.843	***	-.386
e4	<-->	e5	.055	.011	5.181	***	.384
e3	<-->	Stage	-.051	.012	-4.246	***	-.174
e4	<-->	Stage	.027	.013	2.037	.042	.080
e12	<-->	Stage	-.053	.011	-4.791	***	-.227
e10	<-->	Stage	-.053	.010	-5.386	***	-.279
e9	<-->	Stage	-.054	.014	-3.939	***	-.179
e9	<-->	e14	.040	.014	2.787	.005	.185
e3	<-->	e5	.028	.008	3.459	***	.229
e1	<-->	e3	.035	.010	3.566	***	.209
e1	<-->	e15	.042	.014	3.108	.002	.192
e5	<-->	e15	.025	.010	2.444	.015	.155
e3	<-->	e14	.070	.016	4.314	***	.334
e5	<-->	e6	.027	.007	3.728	***	.249
e14	<-->	Stage	-.074	.019	-3.935	***	-.182
e5	<-->	e9	-.029	.009	-3.438	***	-.234
e3	<-->	e12	.021	.007	2.994	.003	.172
e5	<-->	e12	.017	.005	3.477	***	.172
e2	<-->	e12	-.013	.004	-2.899	.004	-.150
e1	<-->	e9	-.029	.011	-2.750	.006	-.170
e12	<-->	e13	.015	.005	2.984	.003	.142
e4	<-->	e13	-.016	.008	-1.922	.055	-.097
e13	<-->	e14	.016	.010	1.563	.118	.085
e10	<-->	e14	.035	.011	3.257	.001	.261
e9	<-->	e10	.016	.006	2.525	.012	.160

*** p<0.001

We would highlight the associations between "Competitiveness" and "Stage" (r = 0.805, p <0.001), e10 and e12 (r = 0.631, p <0.001). According to Schwab (2013), the stage of national development strongly influences their respective levels of competitiveness with all otherwise being equally valid.

Given the above, we confirm hypothesis 3 - There is an association between the economic stage of development and competitiveness.

Table 9 reports our findings on the quality of the fit indices obtained indicating a satisfactory quality of adjustment given the small sample size subject to analysis.

Table 9 – Indexes of Quality Adjustment

N	148
Chi-square	177.495; df=81
CFI	0.975
RMSEA	0.090
TLI	0.958

CFI - Comparative Fit Index; RMSEA - Root Mean Square Error of Approximation; TLI - Tucker-Lewis Index

3.3. Clustering economies by levels of competitive performance

Competition is the seedbed of the entrepreneurial spirit and the driving force of advanced economies (Nijkamp, 2003). Entrepreneurial activity is generally accepted as an important aspect of the organization of economies most conducive to innovative activity and competition. Thus, entrepreneurial activity influences GDP growth. However, entrepreneurship plays a different role in countries undergoing different stages of economic development (Stel et al., 2005). This application of hierarchical cluster analysis sourced its data from the GCR 2013-2014 and the GEM Global Report 2013 with the study sample consisting of 67 countries, common to both the GCI and the GEM. Table 10 reports the distribution of countries studied by regions and stages of development.

Table 10 – Distribution of countries under analysis by regions and stages of development

Region	N	%
Advanced economies	27	40.3
Central and Eastern Europe	8	11.9
Commonwealth of independent States	1	1.5
Developing Asia	7	10.4
Latin America and Caribbean	13	19.4
Middle East, North Africa, Afghanistan, Pakistan	3	4.5
Sub-Saharan Africa	8	11.9
St of Development	**N**	**%**
1	7	10.4
1-2	6	9.0
2	13	19.4
2-3	15	22.4
3	26	38.8

The information in question relates to a set of 16 items (the 11th and 12th pillars from GCI) defined in order to evaluate the competitiveness of countries as regards "Business Sophistication" (9 items) and "Innovation" (7 items). We furthermore included the GDP per capita (US$) of the countries studied. Competitiveness may be defined as the ability of an economy to sell, its ability to earn, its ability to adapt, and its ability to attract (Berger & Bristow, 2009). However, competitiveness based on factors of innovation represents a new path built on the knowledge economy (Kravchenko et al., 2013).

Aiming to detect homogeneous groups of countries in terms of their competitiveness index for pillars 11 and 12 (Business Sophistication and Innovation) and GDP per capita (US$), we proceeded with a Hierarchical Cluster Analysis. We deployed the squared Euclidian distance as a measure of closeness between individuals and as a coupling procedure linking the clusters between groups. The results obtained led to the formation of clusters of five countries as detailed in Figure 4.
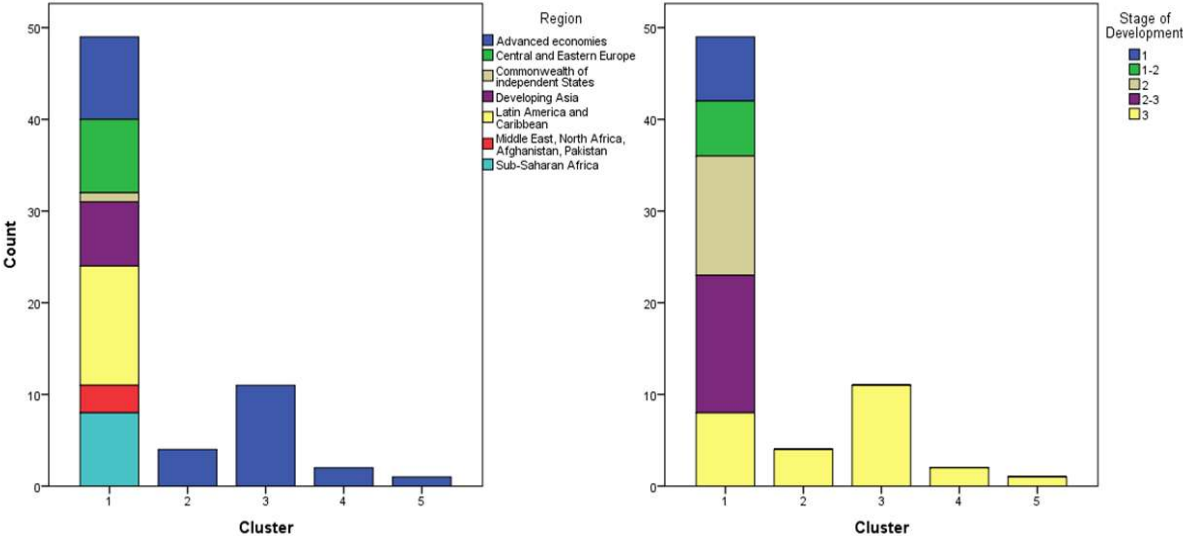
Figure 4 - Distribution of countries by region and stage of development.

Cluster 1, which we called the "Balanced low performance" cluster, is the only one incorporating countries from all regions and all stages of development. Globally, this reports the worst balance of results for all the clusters between the "Business sophistication" and "Innovation" pillars and GDP per capita. Cluster 2, consisting of only four countries in the 3rd stage of development, which we called "moderate competiveness" given the median performance values recorded in pillars 11 and 12 and GDP per capita (average value of U.S.$30,288). Cluster 3, entitled "high competitiveness", comprises eleven countries in the 3rd stage of development and returns a very balanced performance in terms of the 11th and 12th pillars with an average GCI value of 10 and average GDP per capita in excess of U.S.$46,000, with a standard deviation of only U.S.$4,800, revealing a great homogeneity between these countries. Cluster 4, "high GDP per capita", consists of only two small countries (Luxembourg and Norway) classified in the 3rd stage of development and generating

extremely high GDP per capita (exceeding U.S.$100,000 on average). Finally, cluster 5, termed "Performance Excellence", contains only one country, Switzerland, ranked first in the GCI and also first position in the "Innovation and sophistication" factor and generates GDP per capita of U.S.$79,033.

Table 11 contains the set of countries within each cluster.

Table 2 – Distribution of countries by clusters

Cluster 1 - Lower balanced performance	Cluster 1 - Lower balanced performance (N=49)
Algeria	Romania
Angola	Russian Federation
Argentina	Slovak Republic
Bosnia and Herzegovina	Slovenia
Botswana	South Africa
Brazil	Suriname
Canada	Taiwan
Chile	Thailand
China	Trinidad and Tobago
Colombia	Uganda
Croatia	Uruguay
Czech Republic	Vietnam
Ecuador	Zambia
Ghana	**Cluster 2 - Moderate competitiveness (N=4)**
Greece	Israel
Guatemala	Italy
Hungary	Puerto Rico
India	Spain
Indonesia	**Cluster 3 - High competitiveness (N=11)**
Iran, Islamic Rep.	Belgium
Jamaica	Finland
Korea Rep.	France
Latvia	Germany
Lithuania	Ireland
Lybia	Japan
Macedonia, FYR	Netherlands
Malawi	Singapore
Malaysia	Sweden
Mexico	United Kingdom
Nigeria	United States
Panama	**Cluster 4 - High GDP *per capita* (N=2)**
Peru	Luxembourg
Philippines	Norway
Poland	**Cluster 5 - Performance excellence (N=1)**
Portugal	Switzerland

Based on the distribution of countries by cluster, we proceeded to establish the framework conditions for entrepreneurship based on the different GEM variables in terms of "Entrepreneurial attitudes and perceptions", "Entrepreneurial activity and perceptions", and "Job growth expectations for early-stage entrepreneurship activity" (see table 12).

Table 12 - Framework conditions for entrepreneurship

Cluster	Entrepreneurship framework
1 - Lower balanced performance	*Entrepreneurial attitudes and perceptions:*
	Strong propensity for entrepreneurship, placing the highest value on "entrepreneurial intentions", occupying the 2nd best position in terms of "fear of failure". Presents very good levels of "perceived opportunities", "perceived capabilities", "entrepreneurship as a good career choice", "high status to the successful", and "media attention for entrepreneurship ".
	Entrepreneurial activity and perceptions:
	Globally presents a very strong dynamic of entrepreneurial activity. However, this entrepreneurial activity results strongly in "necessity-driven entrepreneurship", which proves greater when compared to other clusters. "Opportunity-driven entrepreneurship" returns the lowest level between clusters.
	Job growth expectations for entrepreneurship:
	It is the cluster reporting higher levels of expectations for job growth from early-stage entrepreneurship activity.
2 - Moderate competitiveness	*Entrepreneurial attitudes and perceptions:*
	Presents moderate values for "entrepreneurial attitudes and perceptions", when compared with cluster 1. The strong increase in "fear of failure" gets highlighted by the lower level of clusters at the level of "perceived opportunities."
	Entrepreneurial activity and perceptions:
	Attains the lowest value between clusters relative to the "opportunity-driven entrepreneurship". However, presents the 2nd best value in terms of "necessity-driven entrepreneurship". Overall, entrepreneurial activity is revealed as moderate in this cluster with the lowest value coming in the "new business ownership rate". However, the rate of business discontinuation is also low.
	Job growth expectations for entrepreneurship:
	The job growth expectation for nascent entrepreneurship is located at a very low level.
3 - High competitiveness	*Entrepreneurial attitudes and perceptions:*
	Attributes a high level to "high status to the successful" and only surpassed in cluster 4. The "perceived opportunities" are higher than cluster 2, however, the "entrepreneurial intentions" are lower, accompanied by "perceived capabilities."
	Entrepreneurial activity and perceptions:
	This denotes a very strong rise in the "opportunity-driven entrepreneurship" curve, accompanied by a smaller reduction in the "necessity-driven entrepreneurship".
	Job growth expectations for entrepreneurship:
	There is a clear improvement in the "job growth expectations" relative to cluster 2.
4 - High GDP *per capita*	*Entrepreneurial attitudes and perceptions:*
	"High status to the successful" is at the highest level among the various clusters as is "perceived opportunities."
	Entrepreneurial activity and perceptions:
	There is a further increase in "opportunity-driven entrepreneurship" as well as a drastic reduction in the "necessity-driven entrepreneurship". Furthermore, there is also a reduction in the "established business ownership rate", contradicted by a small rise in "early-stage entrepreneurial activity" compared to cluster 3.
	Job growth expectations for entrepreneurship:
	There is a slight fall in "job growth expectations."
5 - Performance excellence	*Entrepreneurial attitudes and perceptions:*
	Both the "high status to the successful", the "perceived opportunities" and "fear to fail" are moderately positioned at the level of cluster 1. However, the "entrepreneurial intentions" are located at the level of clusters 3 and 4 (down to clusters 1 and 2).
	Entrepreneurial activity and perceptions:
	Registers a strong rise in the "opportunity-driven entrepreneurship" level and attaining the highest value among all clusters. There is also the highest value in terms of "established business ownership rate." The rate of "discontinuation of business" remains low.
	Job growth expectations for entrepreneurship:
	There is a rise in "job growth expectations" for nascent entrepreneurship, taking 2nd position just behind cluster 1.

In summary, in economies classified as "lower balanced performance", entrepreneurial intentions are high, the "fear of failure" is low, and the dominant entrepreneurial activity is driven by necessity. In "high competitiveness" economies, there is a very high level of "opportunity-driven entrepreneurship", with some reduction in the "necessity-driven entrepreneurship" level. "High GDP per capita" economies strengthen "opportunity-driven entrepreneurship" with a strong reduction in "necessity-driven entrepreneurship". Finally, in economies reporting "performance excellence", we encounter the highest value of "opportunity-driven entrepreneurship" accompanied by a high level of "established business ownership rate".

4. Conclusions, limitations and further research

4.1. Conclusions

The socio-economic prosperity of countries and regions is based on their ability to compete in the global market, their aptitude to attract capital, their capability to generate wealth, job creation and social welfare, in a balanced and sustainable way (Ženka et al., 2012; Stajano, 2006; Buesa et al., 2010; Cantner et al., 2008; Hessels & Stel, 2009). Innovation and business sophistication form the foundations of the advanced economies (Schwab, 2013) with innovation consensually accepted as a crucial factor for competitiveness and economic growth (Kravchenko et al., 2013; Buesa et al,. 2010). Business sophistication includes the ability to network between different stakeholders both at the level of a country or region (Schwab, 2013).

In alignment with the literature, our study reveals that in the top 25 most competitive economies, the variation between the factors "innovation" and "business sophistication" is relatively low compared with the GCI curve trend. At this level of competitiveness, there is accentuated instability between these factors and the GCI trajectory.

Our SEM model results confirm a strong relationship between the "Competitiveness" factor and the independent variables "Business Sophistication" and "Innovation". The study also reveals that in the context of Business Sophistication, an important part of competitiveness is explained by the items "Production process sophistication", "Value chain breadth", and "Local supply quality".

Convergence between the interests of universities and other high-tech organizations, especially in the regional context becomes reinforced by the fact that these university might make recourse to funding programs to stimulate this type of collaborative activities in the field of Research, Development and Innovation (RDI) and entrepreneurship (Huggins et al., 2012; Lawton Smith & Bagchi-Sen, 2012). In our study, the most relevant innovation items are

the "Capacity for innovation", "Company spending on R&D", and "Quality of scientific research institutions", highlighting the importance of the role of national and regional academia-Industry interactions.

Agglomerating economies by levels of competitive performance, we identified five clusters: (1) Lower balanced performance, (2) Moderate competitiveness, (3) High competitiveness, (4) High GDP per capita, and (5) Performance excellence.

Several authors argue that entrepreneurship and company growth are fundamental to economic and social prosperity (Chiang &Yan, 2011; Witt, 2002; Wong et al., 2005) and highlight that economic growth is based on the innovation implemented by entrepreneurs (Audretsch & Fritsch, 2003; Landström & Johannisson, 2001; Landström et al., 2012). In the "Performance excellence" cluster, we encounter the highest level of "opportunity-driven entrepreneurship", and a high level of "established business ownership rate". Also high in this cluster are "Job growth expectations" for nascent entrepreneurship and thus concluding that "opportunity-driven entrepreneurship is a key opportunity for competitiveness" in most advanced economies.

This article contributes to enriching the literature on the fields of national and regional competitiveness, clarifying the impact of innovation and entrepreneurship in improving competitive performance. The study also helps portray new ways of thinking about the Triple Helix actors (Academy-Industry-Policy Decision) whether in national contexts or at the level of regional innovation and entrepreneurship ecosystems.

4.2. Limitations and further research

Not all GCI countries are available in the GEM study, which restricts the scope of analysis found in our comparative model between countries (Amorós & Bosma, 2014; Reynolds et al., 2005). However, the regional level remains an important dimension for understanding entrepreneurship and competitiveness (Huggins & Williams, 2011).

This research opens up avenues for the development of regional competitiveness studies focusing on the dynamics of innovation, entrepreneurship and networking. We suggest the continuity of study for the different regions, such as at the European level, analysing new variables in the data produced by Regional Innovation Systems (Annoni & Dijkstra, 2013; Asheim et al., 2011; European Commission, 2014; Ylinenpää, 2009). Strengthening the networks supporting the Triple Helix model (Industry-Academia-Government) might also play an important role in the regional analysis of best practices in innovation, entrepreneurship and competitiveness (Farinha et al., 2014; Brulin et al., 2012; Leydesdorff & Meyer, 2006; Papagiannidis et al., 2009).

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Chapter 3

Geographies of Growth: comparing Oxfordshire a core high-tech region in the UK with an emerging high-tech region – the Centro of Portugal

Abstract

This article reports on a comparative project comparing the evolution of the Oxfordshire high-tech economy with a newer and much smaller high-tech region, Region Centro of Portugal. Previous research on Oxfordshire has been mainly qualitative. This new study using quantitative data allows insights into what makes regions distinctive, how the performance of regions with some similar and some different attributes compare, and what might be contribute to or inhibit their potential growth trajectories. The conceptual framework for the study is drawn from the 'regional triple helix spaces' (Etzkowitz, 2008) and the regional innovation systems concept (Cooke et al., 1998) concepts. The two regions compared are very different in stages of development. The nature of entrepreneurship and innovation in the two regions is explored as well is responses to the growth of that activity by the local triple helix actors.

Keywords

High-tech economies, regional triple helix spaces, universities

1. Introduction

This paper focuses on two smaller entrepreneurial regions. The first one is Oxfordshire in the UK. The second one is Centro Region of Portugal. The nature of these two regions is very different in terms of innovation and entrepreneurship trajectories and also on economic terms. Oxfordshire is characterised by a long tradition of academic and research excellence. Region Centro is an emerging high-tech centre in Portugal.

The field of systems of innovation analysis at the regional level has grown in recent decades since Cooke's 1992 paper and the subsequent Cooke et al's 1998 book. Various studies have shown that the innovation and entrepreneurship are significant for economic and social development of regions (Amorós et al., 2011; Berger & Bristow, 2009; Buesa et al., 2010; Kravchenko et al. 2013; Sleuwaegen & Boiardi, 2014). Recent variations include entrepreneurship ecosystems and entrepreneurial regions which are characterised by outstanding entrepreneurial visions (EU, 2013; Lawton Smith & Romeo, 2012; Lawton Smith et al., 2013). Such regions develop as a consequence of the intersection of multiple time and place specific factors, including the relative importance of different kinds of organisations in different places working together to facilitate innovation.

Regional innovation systems approaches articulate these interactions geographically. Thus, other significant alternative focus is the importance for economic growth of local-regional innovation networking (Cooke, 2005). However, the emergence of university-industry-government innovation interactions - the triple helix - can be identified as a key factor in regional development (Etzkowitz & Klofsten, 2005). In other words, RIS and Triple Helix are not in opposition, considering both approaches, innovation as a factor of regional competitiveness (Kautonen, 2012; Cooke, 2005; Etzkowitz, 2008; Marques et al., 2006). However, in the latter, universities are placed in a central position in the analysis, a position we adopt here (Etzkowitz et al., 2000). However, it is not claimed by Etzkowitz (2008) that they are always the dominant local actor, although they can take the lead in regional innovation policy where there is no strong regional government.

The regional scale is also an important scale of policy delivery. The EU finds that 'growth is increasingly related to the capacity of regional economies to change and innovate'[1]. The Regional Innovation Scoreboard is designed to help an understand innovation in the regional context and provides some statistical facts on regions' innovation performance by NUTs regions[2]. This allows for comparisons between similar units, but has limitations for comparing sub-units as the political systems and resulting borders will also vary. In the case of these two places, they are both in countries without strong regional authorities and universities are key organisations in the local economies.

The rationale for the comparison of the two places therefore lies in their positions as leading high tech economies in their own countries and in the strength of the universities. Oxfordshire is one of the UK's leading high-tech economies. It has two universities and a number of public and private sector research laboratories. The Region Centro of Portugal is

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[1] http://ec.europa.eu/enterprise/policies/innovation/policy/regional-innovation/ (accessed August 4 2014)
[2] http://epp.eurostat.ec.europa.eu/portal/page/portal/nuts_nomenclature/introduction (accessed August 4 2014)

the second most innovative region of the country. The region has three universities (University of Aveiro, University of Coimbra and University of Beira Interior) and Polytechnic Institutes (in main cities: Viseu, Guarda, Castelo Branco, Coimbra, Leiria and Tomar). The two regions have very similar sectoral compositions including biomedical sciences, energy, ICT&E, creative industries, and an advanced infrastructure of science parks and incubators. However, they differ particularly in the importance of EU policy. Portugal receives much more EU funding as the whole country falls under eligible areas in the EU under the Convergence Objective and the European Competitiveness and Employment Objective. Moreover, Horizon2020 has had a far greater impact on policy formation and practice than in Oxfordshire where national government has been the driving force.

This article is based on joint work between authors in the two countries. It aims to compare the innovation and entrepreneurial trajectories of two very different regions using the regional variant 'regional triple helix spaces' (Etzkowitz, 2008) of the Triple Helix model of university-industry-government interaction (Etzkowitz & Leydesdorff, 1995) as well regional innovation systems as the bases for the conceptual framework. It addresses two research questions: to what extent can both be seen as successful regions? What factors have led to their growth and to the differences between them? The evaluation is conducted through a detailed innovation and entrepreneurial profile of the two regions. The two profiles are then compared using a set of quantitative and qualitative metrics. Finally, some conclusions are drawn about the importance of geo-political contexts in the concept of entrepreneurial regions.

2. Regions in transition

Successful regions start to develop at different times from varying initial conditions and assets (latent or active, Feldman & Francis, 2006). Over time, under certain conditions, such as a rise in entrepreneurial activity supported by the private or by sector government intervention, resources come into play providing possibilities for particular pathways of industrial development. The mix of different initial conditions, the ability of existing and new firms to adapt to the external competitive environment and the role of public support mean that growth trajectories vary from region-to-region.

Hence there are interesting research questions concerning what it is about a region (or a locality) that makes these differences come about. In particular, here the focus is on the role of public policy, using acting in conjunction with the private sector and other non-state bodies in supporting economic development, particularly innovation-led economic development. Here the focus is on what which organisations interact with others, what forms the interconnections take, and to the extent that they can be considered as systems. For policy-makers, the challenge is to achieve the right policy mix, with appropriate actors

involved, based on the diagnosis of the functioning of their local ecosystems, (Berkes & Ross, 2013; Ho & Pollack, 2014; Puissant & Lacour, 2011).

Geographical scale is an important consideration in both the conceptualisation of the basis for policy intervention as well as which actors should be involved. The definition of regional innovation systems illustrates this point of interest in regional innovation systems, effectiveness of different varieties/types, and the relationship between regional innovation systems and regional competitive advantage.

 The central strand of the RIS approach, 'is an emphasis on economic and social interactions between agents, spanning the public and private sectors to engender and diffuse innovation within regions embedded in wider national and global systems' Asheim et al., 2011). Often policy is directed at local clusters of firms, which form part of a bigger regional (national and international) innovation system.   Clusters may be seen as, "a concentration of 'inter-dependent' firms within the same or adjacent [or integrated] industrial sectors in a small geographic area" (Asheim & Coenen, 2005, 1174). However, a RIS consists of "interacting knowledge generation and exploitation subsystems linked to global, national and other regional systems" that may stretch across several sectors in the regional economy (Asheim & Coenen, 2005 p. 1174). Hence, RIS is a more generic concept than clusters and provides a more comprehensive policy framework: clusters are important, but so too are a range of other factors, agents and institutions that combine to promote and diffuse innovation within a region (Asheim et al., 2011) – but presents different challenges in the way or resources and competences to manage.

A similar can be set of issues relates to Etkowitz (2008) three-stage regional triple helix spaces model. In this he proposes stages in a region's development, from nationally/internationally active but regionally inactive assets such as universities, government labs and large companies (anchor firms, Feldman, 2003) (knowledge space); through a cumulative pattern of entrepreneurship with results from recognition of technological-market opportunities by clever people (consensus space); to a fully functioning entrepreneurial environment which includes systems of either formal (state) systems of governance or more self-organised systems involving non-state actors (innovation space, see also Garnsey, 1998).

Anchor firms (large firms and other organisations) which as suppliers of skills and purchasers of goods and services are key assets in successful regions. Under certain conditions, they produce knowledge spillovers and thereby contribute to regional resources that benefit smaller firms and increase overall innovative output in a successful entrepreneurial region. Universities can also be anchor institutions. However, there also needs to be the capacity for local firms to valorise what universities have to offer.

Indeed, two factors relating to the local impact of universities seem to be particularly important: the industrial structure and the labour market. Agrawal & Cockburn (2003) find that regional economies appear to vary markedly in their ability to convert local academic research into local commercial innovation. The presence of a large, local, R&D-intensive firm—an anchor tenant— was found to enhance the regional innovation system such that local university research is more likely to be absorbed by and to stimulate local industrial R&D. Universities and other colleges of education play a key role in supplying skilled people to the local labour market, and hence to city and regional dynamism where there is a demand from entrepreneurial firms and the public sector (Faggian et al., 2009). Thus, the larger the concentration of the highly skilled, the greater is the capacity of high-technology firms to absorb new information from internal and external sources.

Here, following the RIS and Regional triple helix spaces framework, we are interested in the local interplay of entrepreneurship, social relationships and organisational strategies with mechanisms of agency in the form of collective action that shapes the dynamism and identity of regions. In particular, given the innovation agenda in public policy we would expect to see a more active role of the research base (universities and research laboratories) in stimulating and supporting entrepreneurship, including entrepreneurship education, the establishment of such entities as incubators and science parks, and public policy focused on entrepreneurship and innovation. We are also interested in the labour market and the presence of large firms in relation to industrial trajectories. It is these we will examine in reviewing the growth of the two case study regions.

3. Research Methodology

3.1.   Introduction and context

The paper is based on a comparative analysis of two streams of research conducted from the two teams, the one located in the UK and the other one located in Portugal. Both teams have built their research on existing works and sources, enriching them with appropriate updates of data, primarily, through primary research. The comparative approach is guided by the regional triple helix model. The two regions are compared through the analysis of four dimensions: the role of academia, the role of the public sector, the role of the industry, and the networking ability within the three helices.

The context to this discussion is European Union policies towards innovation-led regional development, as well as national and local government policy agenda. The Europe 2020 Strategy is a ten-year plan (2010-2020) of the European Union aimed at growth. It claims to be more intelligent, sustainable and inclusive. The implementation plan is based on a set of

five key objectives in the areas of employment, education, research and innovation, social inclusion and poverty reduction and climate and energy, to be achieved by 2020 (European Commission, 2014).

Regulation (EU) No 1291/2013 of the European Parliament and of the Council establishing Horizon 2020 - the Framework Programme for Research and Innovation (2014-2020), aims to support research and innovation activities, strengthen the scientific and technological base in the EU, promote its benefits to society, improve the operation of economic and industrial potential of policies of innovation, research and technological development. In order to operationalise this goal three priorities were identified: scientific excellence, industry leadership and social challenges. Each Member State, in accordance with a set of recommendations of the EU, adopted their own national and regional objectives in each of these areas of intervention.

3.2. Portugal and the Centro region

The Partnership Agreement "Portugal 2020" proposed to the European Commission adopts the principles of programming for 2020 and establishes the policy of economic, social, environmental and regional development, in order to stimulate growth and job creation. The Partnership 2014-2020 defines interventions, investments and funding priorities, which are conducive to promoting smart, sustainable and inclusive growth (Governo de Portugal, 2014).

3.2.1.   Characterization and governance

The Centro region of Portugal is spread over 28,000 km2 and has about 2.4m inhabitants, which accounts for approximately 31% of total area and 22% of the population in the country. Located in the central part of the Portugal, Centro region has a strategic position since it is located between the two major national urban centres: Lisbon and Oporto. It is characterised by its low population density, resulting in desertification of areas "inland" (except in urban centres located there), contrasting with the "coastal" area, whichever is more populous and urbanised (see figure 1).

	Portugal	Centro	%
Municipalities	308	100	32,5
Area (Km2)	92.212	28.199	30,6
Population, 2011	10.562.178	2.327.755	22,0
GDP 2011 (EUR million)	171.040	31.787	18,6
Exports of goods, 2012 (EUR million)	45.347	8.578	18,9

Figure 1 – Centro region of Portugal
Source: Elaborated from CCDRC (2014c).

Portugal is not a regionalised country, except for the autonomous regions of Azores and Madeira. For the five regions of the continent (Norte, Centro, Lisboa, Alentejo and Algarve) there are members of the central government with responsibility for regional development and there are regional administrations - the Committees for Coordination and Regional Development (CCDR) which are government bodies decentralized centre with administrative and financial autonomy.

The Centro regional economy is highly diversified, including sectors with low levels of industrial technology (e.g., ceramic , glass , cement, forest industries - wood, pulp, paper, and agro-food) , as well as some areas of medium and high technology, such as healthcare , biotechnology, telecommunications , new materials (particularly the mould industry); ICT and renewable energy. There is a strong regional potential from indigenous resources for the production of renewable energy using water, wind, solar, geothermal, biomass and biogas, and bio fuels.

3.2.2.   Regional development policy

The Europe 2020 strategy led to a plan for the Centro region the Regional Plan of Action - CRER 2020. The Regional Plan of Action 2014-2020 identifies six key priorities for the next EU funding cycle: enhancing value creation; organising a polycentric network of medium-sized cities; generating, capturing and retaining talent; strengthening territorial cohesion; ensuring dynamism and sustainability of the existing infrastructure; and strengthening institutional capacity building. These are key elements of a regional innovation system (Cooke, 2002; Cooke et al., 1998).

These dynamics are based on six priority areas: Axis 1) internationalisation of the regional economy; Axis 2) enhancing human potential and institutional capacity building; Axis 3) strengthening the social and territorial cohesion; Axis 4) strengthening the attractiveness and quality of life in regional territories; and Axis 5) ensuring the sustainable use of resources and decarbonisation (CCDRC, 2014d). The regional smart specialisation strategy (RIS3 Centro) was developed based on the following strategic priorities: Agriculture and forestry; Sea-related economic activities; Tourism; ICT - Information and Communication Technologies; Materials; Biotechnology, and Health and Wellness (CCDRC, 2014d).

3.2.3.   Regional Infrastructure for Knowledge and Innovation

The Centro region has an interesting structure for supporting productive activities and innovation together, an infrastructure supporting the transfer of knowledge as well as the presence of an entrepreneurial economy mainly composed of micro and small companies (CCDRC, 2014b). The Potential Research, Development and Innovation (RDI) in the Centro region is reflected in the presence of nine higher education institutions (HEI); three of which are universities (University of Aveiro, University of Coimbra and University of Beira Interior)

and six Polytechnics located in main cities (Viseu, Guarda, Castelo Branco, Coimbra, Tomar and Leiria), a total of 86,000 students.

The region also has important business incubator networks; three technological centres (Centimfe - Technological Centre of Mould Industry, Special Tooling and Plastics; Cenfim - Vocational Training Centre of Metallurgical and Metalworking Industry; and CTCV - Ceramics and Glass Technology Centre); seven science and technology parks; eight clusters and poles of competitiveness (Energy; Engineering & Tooling; Forest-Based Industries; Industries Refining, Petrochemical and Industrial Chemistry; Health, Tourism 2015; Information Technology, Communications and Electronics; Sustainable Habitat and Centro Agribusiness); 73,000 companies, 47 of whom gazelle companies, and eight PROVERE programs (programs of collective efficiency strategies applied to valuing local products and supporting the development of rural environments) (CCDRC, 2014b; Compete, 2009a, 2009b; Tecparques, 2008).

3.2.4.   Centro region compared to other regions NUTS II of Portugal

Hence it has essential elements of a 'knowledge space' and in the form of the last, a consensus and an innovation space (Etzkowitz, 2008; Leydesdorff, 2000).

Rather different to Oxfordshire, the region has developed a set of indicators to evaluate the performance of public policy interventions. The CCDRC developed a barometer which aims to monitor the progress of the Centro region, in alignment with "CRER 2020 'strategy reflected in the Regional Action Plan.

Integrating a set of 25 indicators, the Barometer reflects the position relative to the level in five dimensions: Growth and Competitiveness; Human Potential; Quality of Life; cohesion; and Environmental and Energy Sustainability (CCDRC, 2014a).

Compared to other Portuguese regions, it appears that in the Centro regions there is a need to significantly improve some indicators concerning: Quality of Life, Growth and Competitiveness, and Environmental Sustainability and Energy.

Hence there are weaknesses in the regional innovation system, particularly it can be proposed in the regional triple helix space as growth and competiveness (based on innovation) appear to be relatively low. However, human potential to underpin growth is there (see figure 2).
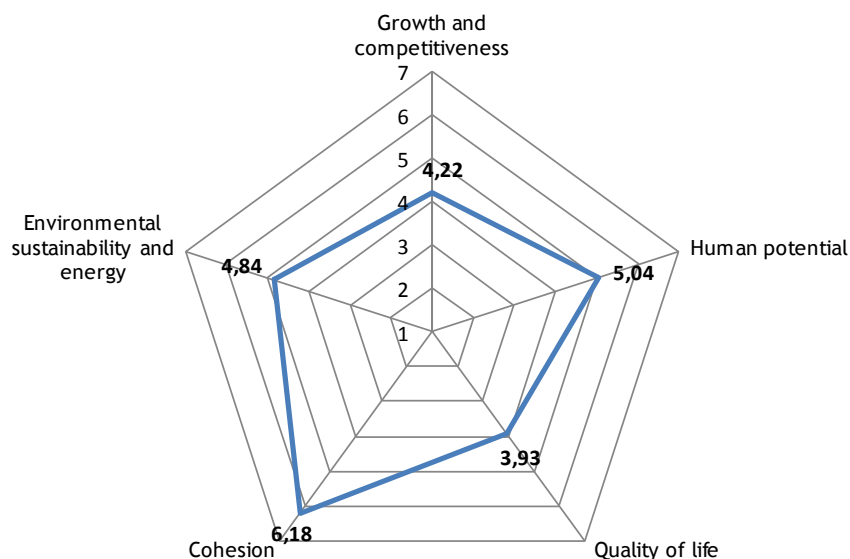
Figure 2 – Barometer of Centro region of Portugal
Source: CCDCR (2014a).

Comparing the Centro region with other six regions of Portugal (Norte, Lisboa, Alentejo, Algarve, Azores, and Madeira), we found the main competitive advantages: unemployment rate, results of national school tests, early school leavers, beneficiaries of social insertion income per capita.

The region also presents as strengths: youth unemployment rate, lifelong learning, good exports in GDP, Regional Innovation Scoreboard, PhDs per capita, net creation companies, renewable in electricity consumption energy. However, the main weaknesses identified in relation to other national regions, and those needs to be overcome are: labour productivity, real GDP growth, GDP per capita, emission of greenhouse gases, and primary energy consumption in GDP (see figure 3).

Barometer of Centro region of Portugal

Figure showing horizontal bar chart with the following variables and rankings:

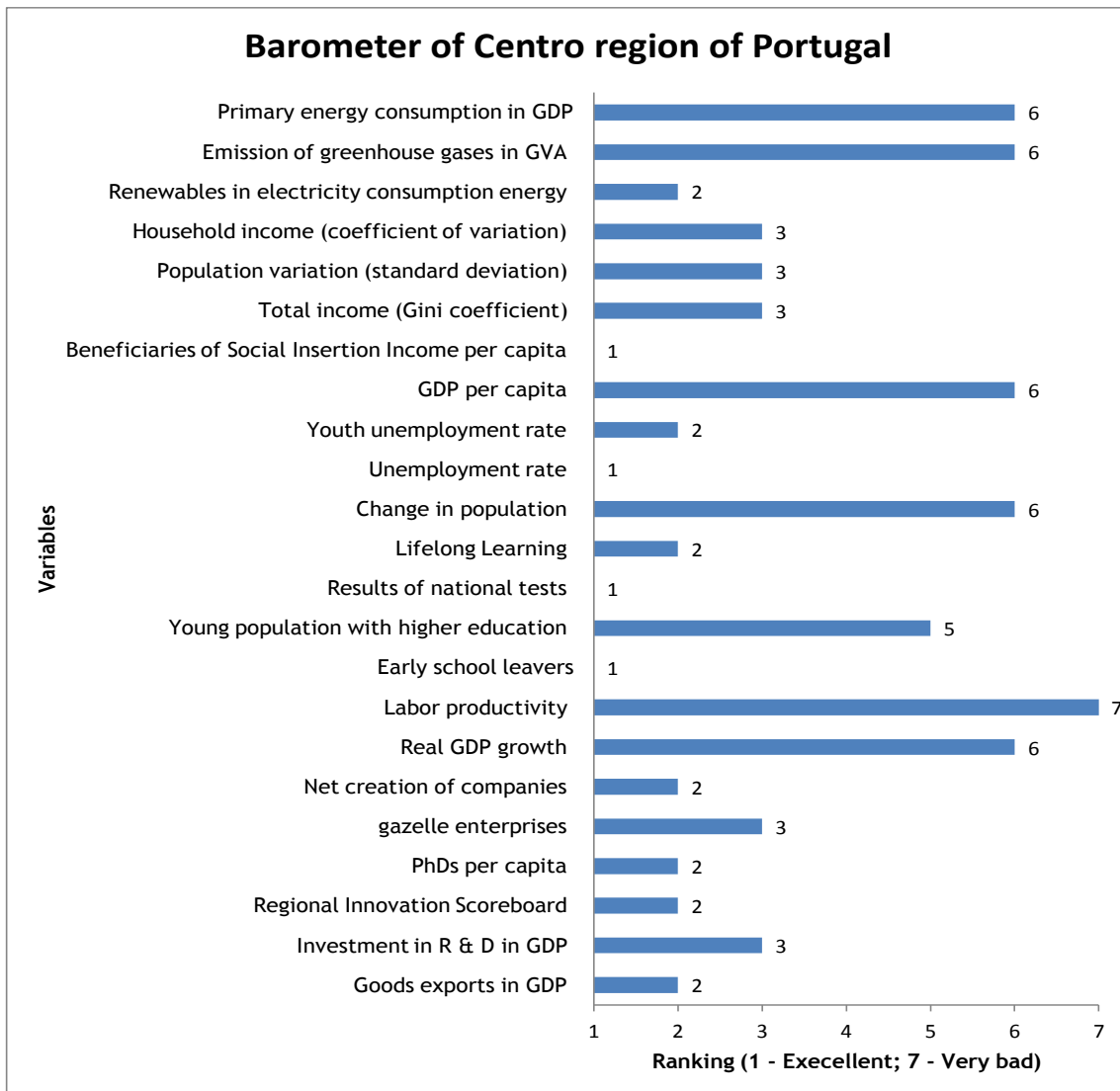| Variable	Ranking
Primary energy consumption in GDP	6
Emission of greenhouse gases in GVA	6
Renewables in electricity consumption energy	2
Household income (coefficient of variation)	3
Population variation (standard deviation)	3
Total income (Gini coefficient)	3
Beneficiaries of Social Insertion Income per capita	1
GDP per capita	6
Youth unemployment rate	2
Unemployment rate	1
Change in population	6
Lifelong Learning	2
Results of national tests	1
Young population with higher education	5
Early school leavers	1
Labor productivity	7
Real GDP growth	6
Net creation of companies	2
gazelle enterprises	3
PhDs per capita	2
Regional Innovation Scoreboard	2
Investment in R & D in GDP	3
Goods exports in GDP	2

Y-axis: Variables; X-axis: Ranking (1 - Excellent; 7 - Very bad)

Figure 3 –Comparison of the Centro region with other regions of Portugal

Source: Elaborated from CCDCR (2014a).

3.2.5. InovC – an innovation ecosystem located in Centro Region of Portugal

The INOVC program is a strategic regional innovation system based programme that aims to develop an innovation ecosystem, in which universities are key organisations. It is located in Centro region of Portugal and includes a strategic team of 10 nuclear innovation stakeholders (universities, polytechnic institutes, incubators and technology parks). It has the involvement of more than 300 regional innovation and entrepreneurship agents (municipalities, companies, regional development agents, living labs, public entities, financial entities, students union, etc). Its structure is based on the triple helix model (Costa et al., 2012; Figueira et. al. 2012a) (see figure 4).
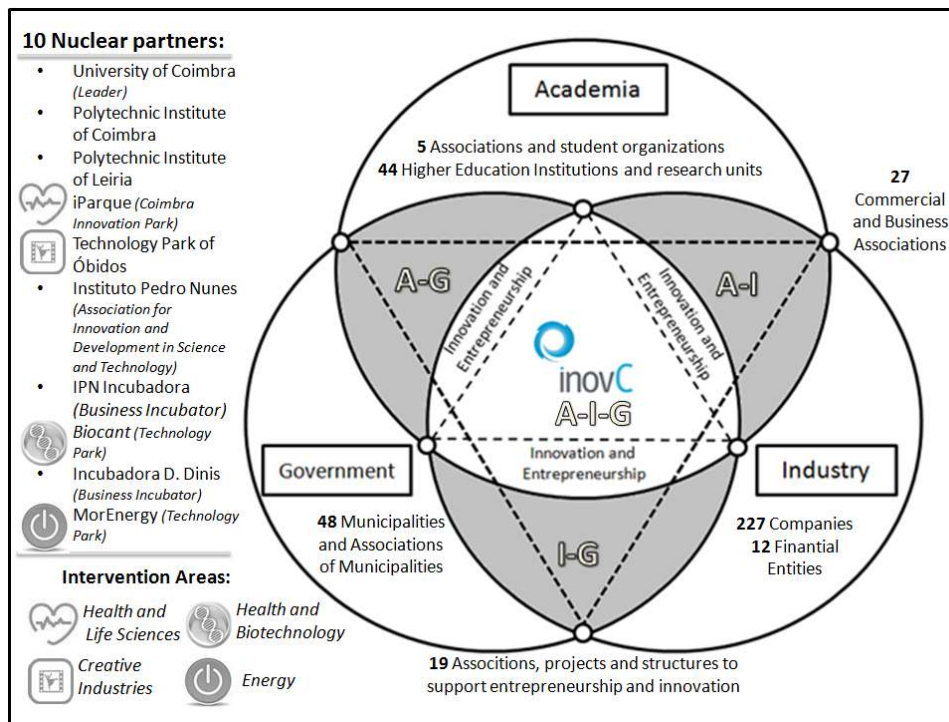
Figure 4 - INOVC Triple Helix model
Source: Elaborated from Figueira et al. (2012a, 2012b); INOVC (2014).

The INOVC can be described as a programme founded on the triple helix model, presenting at regional level, strong relationships between the domains of universities, industry and government (e.g., state or local), in order to develop joint activities. The vision is to transform the Centro region with respect to an international benchmark of knowledge creation, innovation and entrepreneurship, in the areas of life sciences, energy, information technology and communication electronics, and creative industries. The ultimate goal involves consolidating the position of the Centro Region, as the second most innovative region of Portugal, and positioning it among the 100 most innovative regions in Europe in 2017, according to the Regional Innovation Scoreboard (RIS) (Figueira et. al., 2012a; 2012b).

The INOVC involves the participation of more than 380 complementary partners of very diverse nature (research centres, economic and financial companies, municipalities, universities, institutes polytechnics, trade associations). The partners aim primarily to support initiatives related to the Innovation Ecosystem of the Centro Region of Portugal for mutual benefit. The coordinator of the Division of Innovation and Transfer of Knowledge, Mr. Jorge Figueira (JF), University of Coimbra, the unit that drives and manages the program INOVC, he said that, "the investment to be made, corresponding to a volume of ERDF funding of €22,5M, related mostly to the construction of seven infrastructure projects essential to the pursuit of good performance that the region has played, complemented by a set of three innovative projects, contemplating various initiatives to stimulate innovation and entrepreneurship for the different stages of development, of entrepreneurial projects, ensuring its territorial deployment through local and regional".

In order to articulate the required actions, the stakeholders in the innovation process in the region proposed a joint strategy, which aiming at efficient management of the entire pipeline of innovation, involving all actors and territories (Figueira et al., 2012b). According to JF "the innovation pipeline is a series of value-added steps, beginning with getting research results with commercial potential and may generate large companies and rapid growth, generating high quality jobs and high capacity for Research, Development and Innovation (RDI)". During this process of evolution, projects were to follow the pipeline of innovation, which correspond to different phases of the maturation: Business idea; Proposal of value; Business Plan; Start-up / Licensing; Teen firm; Adult firm; and Mature firm.

Throughout the processes of ongoing innovation in the pipeline, it is necessary to have pumping systems create similar to a water pipe, to ensure that a flow rate of innovation is energised and feeds the ecosystem through various processing steps which include: Ignition; Check/testing; Validation; Creation; Acceleration; Consolidation; and Development. The transverse elements throughout the innovation pipeline include: Sensitization and Training in Innovation and Entrepreneurship; Project Management; Integrated Ecosystem Management and the Innovation Pipeline; Monitoring and Control Objectives, Targets and Indicators; Participation in International Projects and Partnerships. Strategic level KPI indicators were selected taking into account the best way to monitor the success of the innovation ecosystem (Table 1).

Table 1 – INOVC Scoreboard

Activities	Target achieved				Objectives	
	2008	2010	2011	2012	2017	2022
# of invention disclosures	43	34	55	89	90	110
# of grants funding ignition	0	12	12	23	15	30
# of patent requests and patents	37	37	55	92	70	90
# of applications for tenders for business ideas	..	294	514	..	70	100
Total number of value propositions developed	80	20	59	..	300	300
Total number of new business plan developed		52	95	..	50	60
# of new companies created	20	30	37	..	75	75
# of technology-based companies created (spin-off)	13	9	22	..	20	20
# of licence industrial property	4	9	3	..	10	10
Occupancy rate for spaces (%)		58%	58%	..	80%	95%
# of technologically based companies > 250 employees	1	1	1	..	5	5
# of internationalized companies	1	19	28	..	5	5
Survival rate of incubated companies	80%	88%	80%	..	70%	75%
# of skilled jobs created		515		..	1000	1300
Turnover (M€)	70	88	77	..	200	300
Volume percentage of exports (M€)	35%	23%	41%	..	50%	60%

Source: Elaborated from Costa et al. (2012); Figueira et al. (2012); INOVC (2014).

The matrix of the respective correlations with projects to develop, as well as their contribution to the battery of indicators were weighted to calculate the ranking of the EU Regional Innovation Scoreboard. In accordance with the goals and objectives outlined, there are a total of 90 invention disclosures in 2012, 23 grants funding ignition and 92 patents. It is anticipated that by 2017 a total of 75 new companies, 20 technology-based companies (spin-offs), 1000 skilled jobs, € 200m of turnover, and 50% of export volume will be created.

3.3. Oxfordshire – A History of Entrepreneurship

The city of Oxford is one of Britain's heritage cities. It is most famous for the University of Oxford. It is located some 50 miles north west of London and has a population of 143,000 people. The city region as a whole, the county Oxfordshire, has a population of 598,000. Although it is the most rural county in the South East of England, it has become one of the most innovative and enterprising economies in the UK. It has an extremely strong 'knowledge space'. It has two universities (Oxford, Oxford Brookes) and some 10 research laboratories, including atomic energy (Culham) and the Rutherford Appleton Laboratory (RAL). RAL has a broad science portfolio and works with the academic and industrial communities in materials science, space and ground-based astronomy technologies, laser science, microelectronics, wafer scale manufacturing, particle and nuclear physics, alternative energy production, radio communications and radar. It is funded by the Science and Technology Facilities Council which is an independent, non-departmental public body of the UK government's Department for Business, Innovation and Skills (BIS).

Oxfordshire has considerable strengths in its labour market, its large high-tech firms, many of which originated in Oxford University, and its resilience in terms of high rates of firm survival. Oxfordshire has one of the most highly skilled workforces in England and Wales, having a higher proportion of graduates than any other English county (University of Oxford/Science Oxford 2013). This is associated with both the growth in the high-tech economy as well as the public sector, particularly higher education, which accounts for 1 in 5 jobs in the city of Oxford. Oxfordshire's workforce also has a very high percentage of people with professional skills.

3.3.1. Early stages

The Segal Quince (1985) report 'The Cambridge Phenomenon' was the first to focus on entrepreneurship in a university town, and provided a useful benchmark of entrepreneurship in Oxfordshire's high-tech economy, although it seriously underestimated the number of high tech firms in Oxfordshire (Lawton Smith, 1990). In fact both counties have followed similar trajectories in both the rate of growth in the number of firms and employment (Garnsey & Lawton Smith, 1998; Lawton Smith & Romeo, 2012; Oxford University/Science Oxford, 2013).

Oxfordshire's high tech roots can be dated to the 1940s and 1950s. The first recorded high-tech firm, Penlon was established 1943, a medical equipment firm, originally the Longworth Scientific Instrument Co. Ltd. It was a spin-off from Oxford University's Department of Anaesthetics. This was followed by two other university spin-offs: 1953 by Littlemore Scientific Engineering Ltd and Oxford Instruments in 1959. It was in the late 1970s that the high-tech economy began to take root and contribute to the changing industrial structure of the economy which had begun to change rapidly a decade earlier. In the 1960s the dominant sector was the automotive industry with some 28,000 employees. By the late 1970s, employment in the automotive sector had fallen to 5000 but was still the largest sector in the county. The number of high-tech firms and employment was estimated at 50 firms employing 7,731 in 1979 (Lawton Smith, 1990).

Growth in the number of start-ups (university and non-university related) was slow until the mid-1980s. Lawton Smith (1990) identified 182 R&D intensive advanced technology firms in existence in 1987. The criterion used was that firms were undertaking research and development (R&D) in one or more of science, computer science and engineering. Collectively these firms employed 10,659 people. The majority had been formed in the late 1970s and early 1980s. Those that were active in 1979 employed nearly 8000 people. Of the 182, the majority were in manufacturing (125), followed by R&D/consultancy (32) and software (25). The rise in the number of high-tech firms and early sectoral specialisation reflects national trends and local conditions. Between 1979 and 1986 UK manufacturing as a whole was in steep decline. However, larger manufacturing firms such as Oxford Instruments (scientific and industrial instruments) and Research Machines (computers used in education) became established. The concentration of R&D consultancy firms reflected the strength of the science base in the universities and government laboratories.

3.3.2.   Increasing maturity

Over time the service sector has come to dwarf that of manufacturing in numbers of both firms and employees. In the mid-1990s the sector with most businesses was computer services, with almost half of all the high-tech companies in the county (635 firms, 45% of companies) which has twice as many companies as technical consultancy & technical testing (22.5%) which is also an important high-tech services sector. Certain sectors, although they are important employers consist of only a small number of companies. For example the motorsport and automotive engineering/design sector accounts for less than 2% of the county's high-tech firms but 7% of its high-tech jobs. The emerging biotech sector had 73 firms but only comprised 5.2% of the county's high-tech firms (OEO, 2014).
More recent data shows that entrepreneurship in the Oxfordshire economy continues to accelerate. In the absence of local data, the Office of National Statistics data show that in 2005 Oxfordshire had some 3,500 high-tech firms employing 45,000 people, around 14 percent

of the county's workforce[3] in 12 percent of the businesses in Oxfordshire (Glasson et al 2006). Using these figures, the county had the third largest high-tech employment amongst UK counties (high-tech as a percentage of total employment). The county is characterised by "diverse specialisation" with high-tech services, including software consultancies and biotechnology being the largest employers. The larger businesses were in high-tech manufacturing, including pharmaceuticals, medical instruments, and computers.

On a majority of indicators, the Oxfordshire high tech economy outperforms that of the whole of England. Definitions of high-tech vary and give different emphases to particular activities and potentially understate or overstate the importance of particular activities. Using the Eurostat definition of high-tech, some 20,000 employees are employed in high-tech sectors in Oxfordshire. This represents 6.2% of all employees in the county, compared with an average for England of 5.1%. Using the wider Eurostat definition, however, the total number of high-tech employees in Oxfordshire is more than doubled to 43,000 in 1500 firms. This represents 13.4% of total employees, compared with the England average of 9.8%. The difference reflects the inclusion of sectors such as publishing, medical instruments and the automobile industry in the wider definition.

Oxfordshire's largest high-tech sectors (wider definition) by employee numbers include computer, electronic and optical products (3,500 employees), motor vehicle manufacture (3,500), publishing activities (5,500), computer related activities (8,200), engineering & technical consultancy (7,100) and scientific research and development (5,700) (Oxford University/Science Oxford 2013, data appendices). By way of comparison, Table 2 shows employment Oxfordshire's high-tech economy and that in Cambridgeshire and the broader Thames Valley.

Table 3 –Employees in High-Tech Sectors (Eurostat Definition), Oxfordshire & Comparators, 2011.

Number of Emplyees	Oxfordshire	Cambridge	Thames Valley	England
High-Tech Manufacturing	4.000	8.100	7.600	213.000
High-Tech SI Services	16.000	22.600	95.300	950.600
Total: Eurostat High-Tech Sectors	*20.000*	*30.700*	*102.900*	*1.163.600*
Total Employees (All Sectors)	320.600	351.300	783.900	22.929.600
As % of Total Employees	Oxfordshire	Cambridge	Thames Valley	England
High-Tech Manufacturing	1,2	2,3	1,0	0,9
High-Tech SI Services	5,0	6,4	12,2	4,1
Total: Eurostat High-Tech Sectors	*6,2*	*8,7*	*13,2*	*5,0*

Source: ONS, Business Register & Employment Survey (NOMIS). High-tech manufacturing: 2007 SIC 21, 26, 30.3. High-tech knowledge intensive services: 2007 SIC 59-63, 72. Figures for total

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[3] ONS uses data from the annual Business Inquiry which uses a more comprehensive dataset with a less restrictive definition of high-tech and includes higher enumerate numbers of businesses in IT and computer-related services)

employees exclude farm-based agriculture (2007 SIC 01000). All figures are rounded to the nearest hundred employees (in Oxford University/Science Oxford, 2013).

Entrepreneurship and Innovation in Oxfordshire during the period 2010-2013

The Oxfordshire high-tech economy suffered slightly under the global economic crisis to start again rising in financial terms, but, more importantly, in innovation terms during the period 2010-2013. Table 3 below shows the most recent data collected through extensive primary research.

Table 3 – Key Performance Indicators in Oxfordshire – 2010-2013

Indicators	Data	Year
Total Number of Companies	33.500	2011
High-Tech Companies Ratio (Total High-Tech/Total Companies)	3,6%	2011
Total Number of High-Tech Companies	1.200	2011
Total Number of High-Tech Companies - Bio-medical	184	2012
Total Number of High-Tech Companies - High-Tech Manufacturing	360	2011
Total Number of High-Tech Companies - Knowledge Intensive Services	840	2011
Total Number Employees	320.600	2011
Total Number Employees in High-Tech Companies	43.000	2011
Total Number Employees in High-Tech Bio-medical	12.499	2011
Total Number Employees in High-Tech Manufacturing	13.000	2011
Total Number Employees in High-Tech Knowledge Intensive Services	30.000	2011
High-Tech Employees Ratio (Total Employee High-Tech/Total Employee)	13,4%	2011
Total Number of Alive Academic Spin-offs in High-Tech Sector	235	2012
High-Tech Academic Spin-off Ratio (Number spin-off/total high-tech company)	19,6%	2011-2012
Total Number of Spin-offs formed in the last three years	11	2011-2013
Total Turnover of High-Tech Companies	14	2011
Number of Science and Technology Parks	10	2012
Number of Accelerator Programmes/Incubators/Technology Transfer Offices	>15	2012
Number of Universities and Furtherer Education Institutes	27	2012
Number of R&D Personnel	15.942	2011
R&D Personnel Ratio (Number of R&D Personnel/Total Employees)	5,0%	2011
R&D Personnel Ratio 2 (Number of R&D Personnel/Total High-tech Employees)	37,1%	2011
Number of Master and PhD Science, Business, Technical and Medical Students (University of Oxford)	3.000	2012
Assessment of Business Networks (Formal)	66	2011
R&D Expenditure in the region	1.364	2011

Source: Own elaboration.

The ratio of high-tech companies to the number of companies is 3.6%. These companies are strongly R&D-centric with almost 40% of employees involved in research and development

activities. The commercial contribution of academia continues to rise: 11 new academic spin-offs during the period June 2011- March 2013. The total number of UK academic spin-offs was 235 at the end of 2012, 19.6% of the total number of UK academic spin-offs. Thus in this respect, 'the knowledge space' is directly contributing to local economic development.

Public and private investment has also contributed to the development of the innovation infrastructure in the form of science parks (e.g. Oxford University's own science park at Begbroke) and joint public-private partnerships at the Harwell Science and Innovation campus[4]. In those cases, university, research organisations and private companies have been central in their provision and are initiatives in which the synergic dynamics of the three helices show strong effects. These initiatives have also contributed to the consolidation of specific technology and science hubs in Oxfordshire such as the biomedical one. Oxfordshire is one of the UK's four leading locations for biotechnology, the others being Cambridgeshire, London and the Edinburgh/Dundee area of Scotland. Studies by OBN have found that the number of bioscience firms is increasing. OBN (2011) estimated that there are around 163 biotech firms in the county, up 14 per cent since the start of 2008. Of the new ones, the majority (86 per cent), were local start-ups or spin-offs and four were either new branches of larger companies or companies which had moved into the county. The trend has been for more start-ups and fewer relocations or new branches. The EU-funded HealthTIES project assessed the size of the biomedical sector in Oxfordshire and found that at the end of 2012, there were 182 companies employing approximately 13,000 people.

4.Comparing regions via the regional innovation systems and regional triple helix models

Over time, both regions have become recognised as nationally important centres of high-tech activity. In Oxfordshire's case it's high-tech economy is also a global brand and many of its firms are technology leaders. However, the Centro region of Portugal has on many indicators pathways to becoming successful entrepreneurial region. Oxfordshire has outstanding assets to support high tech economic growth – its knowledge space - universities and research laboratories.

As a regional innovation system, the Oxfordshire strategic Plan sets out the ambition for Oxfordshire to 2030, aiming to promote accelerated economic growth through its knowledge space - science and knowledge (Oxfordshire LEP, 2014). The Regional Development Strategy proposal for the Centre of Portugal is based on a collective ambition for territorial marketing, concentration of development around core priorities, through a commitment to focus on differentiating areas, and smart specialisation (CCDRC, 2014b).

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[4] http://www.harwelloxford.com/about/joint-venture (accessed August 4 2014)

A key difference between the two regions is that Portugal is a 'lagging region' in EU terms and its economic policy has long been connected to EU agendas and funding. In contrast Oxfordshire's research institutions (Oxford University in particular) have been in mainly in receipt of EU funds for research or applied research such as the 2012 projects for local renewable energy and energy efficiency. Referring to growth and innovation in the region of Oxfordshire, this section is intended to compare good practices between this region and the central region of Portugal, to allow clear paths of maturity and progress for the Portuguese region. It followed the basic interaction model of the Triple Helix model in its regional form (Etzkowitz, 2008) in the comparison of the dynamics between the two regions.

4.1. Academia - the goal of excellence

The University of Oxford is among the best universities in the world, currently ranking second in the Times Higher Education World University Rankings. Oxford Brookes is one of the best performing new UK universities (University of Oxford, 2013).

The Centro region of Portugal has some of the best universities in the country, highlighting the University of Coimbra, founded in 1220, the oldest Portuguese university and one of the oldest in the world. The University of Aveiro is considered among the top 100 of the world's youngest, according to the Times Higher Education (THE). The University of Beira Interior is one of the youngest Portuguese universities, founded in 1986, with about 7,000 students, developing an important effort in attracting foreign students.

According to the Basic Law on Higher Education in Portugal, the Higher Polytechnic education is driven by a constant perspective of applied research and development. Their presence in major cities brings significant economic and social impact for the development of regions (Cunha et al., 2013). In total, Oxfordshire has nearly 44,000 students attending its two universities, and the Centro region of Portugal has about 70,000 students, distributed by its three universities and five polytechnics (see table 4).

Table 4 – Universities and Polytechnic Institutes in Oxfordshire and Centro region

	University (Higher Education Institutions)	World University Rankings*	Total Students
Oxfordshire, UK	The University of Oxford	2 (2013/2014)	25.595
	Oxford Brookes University		18.425
Centro, Portugal	University of Aveiro	351-400 (2012/2013)	13.664
	University of Coimbra	301-350 (2011/2012)	24.087
	University of Beira Interior		6.803
	Polytechnic Institute of Viseu		5.512
	Polytechnic Institute of Guarda		2.645

University (Higher Education Institutions) (continuation)	World University Rankings*	Total Students
Polytechnic Institute of Castelo Branco		4.206
Polytechnic Institute of Coimbra and Nursing School of Coimbra		12.158
Polytechnic Institute of Leiria		10.671
Polytechnic Institute of Tomar		2.734
*Times Higher Education World University Rankings		

Source: DGES (2014); Times Higher Education (2014).

4.2. Governance model for regional competitiveness

In the UK, Oxfordshire was one of 39 competitors recently selected by the government to establish local enterprise partnerships (LEPs) to promote business growth at regional level. The Oxfordshire Local Enterprise Partnership is a voluntary body made up of representatives from business, academia and the wider public sector, that will support and champion nationally recognised areas for growth around: Bicester, Oxford and Science Vale UK (Oxfordshire LEP, 2014).

The model of competitive development set for Oxfordshire is based on the original interactions of Triple Helix (A-I-G), following the evolution of the model from a fourth helix - civil society (Carayannis et al., 2012; Etzkowitz et al., 2000; Etzkowitz, 2003, 2008; Lawton Smith & Bagchi-Sen, 2010; Leydesdorff, 2000, 2011). The Oxford Strategic Economic Plan includes these ambition: invest in a ambitious network of new innovation and incubation centres, invest in growth hubs to help SME to growth through supporting innovation, enable new transport schemes to support developments, deliver over 500 new apprenticeships to young people, and invest heavily in creating new jobs (Oxfordshire LEP, 2014).

However, unlike in the case study region in Portugal, the 'regional innovation system' is much more fragmented, much less coordinated and on a much smaller scale of operation. It is not driven by EU policy. It is much more of an 'entrepreneurial region' based on a continuing upward trend in the number of new technology-based firms (Lawton Smith et al., 2013) with a entrepreneurial vision but rather less in coordinated action.

The Centro Region of Portugal, the second most innovative region of the country, classified as "Innovation Follower", compared to the South East region in the UK, which includes Oxfordshire, classified as "Innovation Leader" (European Commission, 2012). Districts located in the Coast area (Aveiro, Coimbra and Leiria) are the ones with counties ranked at the level of "competitiveness". The districts of the Interior (Viseu, Guarda and Castelo Branco), have their municipalities classified as "transition" and "cohesion. So the future of regional development in Central region of Portugal for 2014-2020, will have as a priority the issue of regional cohesion (CCDRC, 2014b, 2014c) in line with EU Cohesion Policy. The Plan of Action

of the Central Portugal RIS3 defines a roadmap for investment in research and innovation in the next programming period, aided by a model of regional governance based on the interaction of the Triple Helix spheres (CCDRC, 2014d).

The Portuguese model of regional competitiveness (Figure 6) is focused on the model of the quadruple helix (Colapinto & Porlezza, 2011; Leydesdorff, 2011); led by the regional coordinating body (CCDRC), and involving the representation of all regional actors (CCDRC, 2014b, 2014d). It consists of a coordinating Council (responsible for strategic decision), a regional expanded Council (which also was the basis for the development of Regional Innovation system), still having a Strategic Advisory Group, which seeks to support the Management Team and the respective working groups (CCDRC, 2014d) (see figure 5).
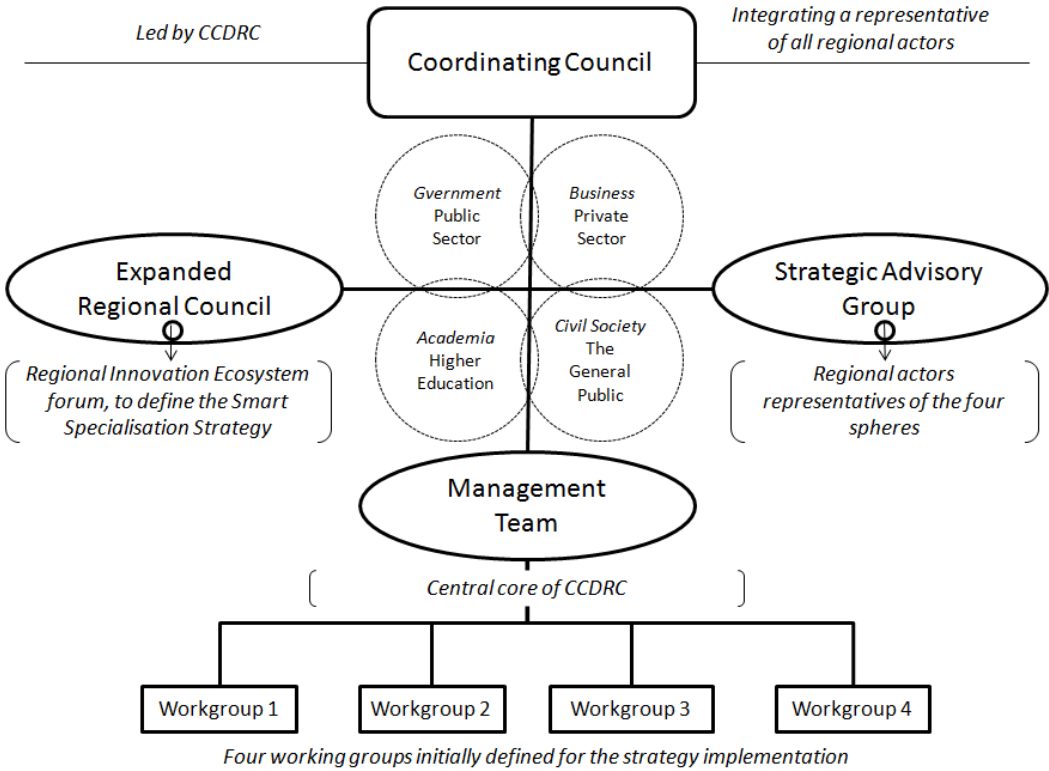

Figure 5 – Model of Competitiveness for Centro region of Portugal
Source: Elaborated from CCDRC (2014b, 2014c).

4.3. Networking Capacity and Innovation Output

The strength of the Oxfordshire economy is its diversity. The region has one of the best universities in the world, investment in high-tech sectors (Bioscience / tech medical / pharmaceuticals, physics-related cryogenics, magnets and instruments; engineering and electronics, and ICT) (Oxfordshire County Council, 2012a, 2012b; Oxfordshire LEP, 2014).

The Centro region is classified by RIS as Innovation Follower, highlighting the presence of two universities included in the Times Higher Education World University Rankings (University of Coimbra and University of Aveiro). The University Hospitals of Coimbra are a national and international reference in the fields of education, research, scientific knowledge and innovation (CCDRC, 2014b) (see figure 6).
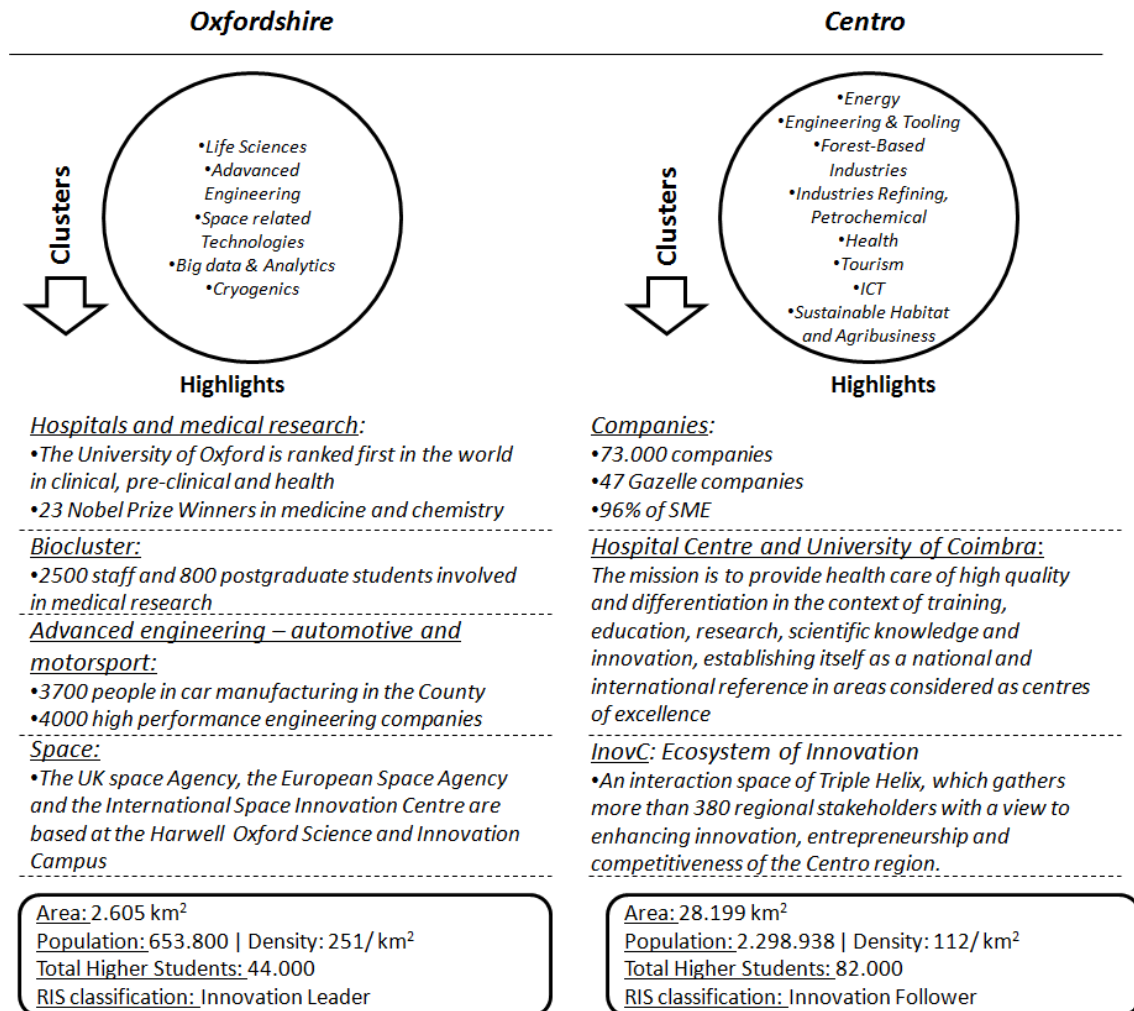

Figure 6 – Benchmarking between Oxfordshire and Centro region

Source: Elaborated from CCDRC (2014b, 2014d); Oxfordshire LEP (2014).

Both regions have strong labour markets. The overlapping high tech core of Oxfordshire is formed from the biotechnology and medical sciences (notwithstanding the University of Oxford occupy the first position in the Top 100 Ranking Universities for Clinical, Pre-clinical and Health of the World University rankings), the related Physics, of Engineering and electronics, and ICT. The Centro region is assumed to be an industrialized region, especially in the coastal zone. However, the technological base encompasses energy, engineering and tooling sectors (the sector of moulds in plastic injection component, put the country as the eighth largest exporter in the world), forest-based industries (sector which exports about 90%

of all production), refining and petrochemical industries, health (supported by dynamic research at the University of Coimbra and also of the University of Aveiro, in the areas of Biotechnology), tourism and sustainable habitat, ICT and Agribusiness (located in the inner zone). Oxfordshire is notable for its high number of formal networks (Lawton Smith & Romeo, 2012).

The unemployment rate is much lower in Oxfordshire (about 6% against 11% in the Centro region). However, the focus on the qualifications of the work force is also strong in the Central region (the proportion of tertiary graduates in science and technology per 1000 inhabitants is 23%). Like Oxfordshire, the birth rate enterprises is high, 11% per annum and survival rates of businesses (2 years) is 53%. Entrepreneurship boosts regional competitiveness, alongside strong connection by firms to the universities (Audretsch & Belitski, 2013; Lawton Smith & Bagchi-Sen, 2012; Ženka et al., 2012).

5. Conclusions and policy implications

The paper set out to examine how two very different regions are evolving as centres of entrepreneurship, and to consider their economic growth trajectories in answering two research questions. The first was, 'to what extent can both be seen as successful entrepreneurial regions? The second was, 'what factors have led to their growth and to the differences between them? The regional triple helix model and the regional innovations systems concept were used as a framework that allows identification the importance of geo-political contexts in shaping regional diversities and specificities. Although the initial methodology was to develop a set of indicators that would allow direct comparisons, it was found to be impossible to do so in a way that allowed the ranking of regions. Therefore it was decided that more qualitative approaches would allow for better understanding of economic growth trajectories.

Although starting from very different periods of time, both regions have become recognised as nationally important centres of entrepreneurship. In Oxfordshire's case its high-tech economy is also a global brand and many of its firms are technology leaders. However, the Centro region of Portugal has on many indicators pathways to becoming a successful entrepreneurial region. Both regions are notable for their strong research bases but both have limitations as well as strengths in the application of those resources into fully functioning regional triple helix spaces (Etzkowitz, 2008). The Centro region has a much stronger claim to have a regional innovation system than Oxfordshire. It has a clear strategy and a management system in place. In Oxfordshire public private partnerships have done more to foster clusters of activity rather than create a coherent system. For all that, it is a successful entrepreneurial region. However, local policy based on regional intelligence which provides

an understanding of strengths and weaknesses, has identified where and how the county could be stronger – and that in creating a better functioning 'innovation space' (Etzkowitz, 2008).

The implication is that each region should bet on its strengths in their local resources, to assert new patterns of regional competitiveness. The Centro does not need to follow the exact trajectory of Oxfordshire, What can be common is the need to find a path of excellence for the Academia and Research, betting on the model of the triple/ quadruple helix to make the transfer of knowledge and technology, always keeping in mind the innovation and sophistication of business and foundations of development regional. Portugal still has to solve a problem of internal cohesion. The Horizon 2020 programme and RIS3 can be a great development opportunity for the Centro region, much more so than for Oxfordshire whose technological trajectory and entrepreneurial base owes much to the presence of so much high quality public sector science and the associated highly skilled labour market.

Acknowledgments

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Chapter 4

Innovation and Competitiveness: a high-tech cluster approach

Abstract

This paper aims to focus on the role of a regional high-tech cluster in innovation and regional competitiveness, through the implementation of a collective efficiency strategy. The study was carried out in the Portuguese Engineering and Tooling (E&T) cluster focusing on the outlooks innovation and international competitiveness. A quantitative and qualitative research is adopted in order to gather information to measure the impact of innovative and entrepreneurial dynamics into the technological cluster. Entities' managers of the E&T cluster located in Centro region of Portugal (Pool-Net – Portuguese Tooling Association and Centimfe - Technological centre of the mould industry, special tooling and plastic) were interviewed in focus groups and semi-structure face-to-face sessions, to deepen the knowledge about the performance, marketing and operation of the cluster, national and international networks. The study also was focused on the analysis of collaborative R&D and Innovation projects. The results show a strong dynamics of cluster in terms of R&D and Innovation projects implementation, aiming at the development of new materials, products and processes. Furthermore, an important commitment in the field of industrial property and national and international networks was evidenced increasing the cluster's notoriety and competitiveness. The findings shed light on the importance of collective efficiency strategies, with a focus on innovation, from a universe of SMEs that operate in an international market for high-tech and highly competitive. There are lessons to be learned at national and international levels about innovation and networking on regional and high-tech clusters to promote new standards of competitiveness. This study is a step towards a new insights to contribute for analyse the innovative and competitiveness dynamics of regional clusters and it will allow developing further research in order to extend this framework to other clusters in European context.

Keywords

Innovation, regional clusters, competitiveness, RDI Projects, Networking, Tooling

1.Introduction

The increasing globalization of markets and the resulting mass of competition associated with greater technological complexity, make innovation as a key aspect for enterprises, revealing increasingly important to establish cooperation networks (Boschma, 2004; Chesbrough, 2007; Lichtenthaler, 2010). The regional level is an important dimension to the understanding of entrepreneurship and competitiveness in the context of the economic performance of nations (Huggins & Williams, 2011). The concept of international competitiveness is indeed a complex problem. However, the ability of an industry to compete with foreign competitors refers to their market performance, patterns of specialization, and productive dynamics, despite its impact in terms of value added and productivity associated (Audretsch, Hülsbeck, & Lehmann, 2012; Castellacci, 2008).

Collaborative networks potentiate an important contribution to increasing the competitiveness of economies and regions, both in terms of collaborative networks for the development of innovative projects, new technologies, or to allow access to resources, skills or cost synergies (Awazu, 2006; Bigliardi & Galati, 2012; Semlinger, 2008). The focus of innovation has changed in recent years from R&D centres of large enterprises to clusters, bringing together companies from different sectors, academic institutions and other organizations (Etzkowitz, de Mello, & Almeida, 2005).

Although collective learning has been considered a key feature of successful clusters, the learning process can involve social prejudices that, in these cases, have the effect of reproducing a collective mentality built on distrust and rivalry (Staber, 2009). It is often hypothesized that geographical proximity in clusters (or industrial districts) has positive effects on firms' access to knowledge and on their own competitiveness (Deimel, Theuvsen, & Ebbeskotte, 2010).

The growth of regional clusters, especially small and medium enterprises (SMEs) in Western Europe and North America has attracted a growing interest by academics, industrial analysts and policy makers over the past decades. In some industries, regional clusters of SMEs are seen as being sometimes more competitive than large companies (Isaksen, 1997; Lin & Sun, 2010). However, new approaches have highlighted the importance of non-local networks to empower enterprises, improving learning and propensity to innovate (Kesidou & Snijders, 2012). In summary, three central constructs can be extracted about influence capacity of collaborative networks, with benefits in terms of regional competitiveness: geographical proximity, structure and relationship of actors, and trust between network partners (Deimel et al., 2010).

In this sense, how can innovative and entrepreneurial activities contribute to regional clusters competitiveness? This paper aims to study the impact of partner's innovative and entrepreneurial dynamics in Portuguese Engineering & Tooling Cluster, and its contribution to the regional economy.

The study is limited to a case study, requiring careful respective on data extrapolation and results. However, it highlights the impact of Engineering and Tooling (E&T) cluster, on Research, Development and Innovation RDI, development and engineering products, services and processes; organization and management of Information Technology and communication; quality, sales and marketing, and capacity of internationalization.

Specific insights on how to analyse a regional cluster dynamics mechanism, implications for scholars and practitioners, as well as futures lines of research, are also discussed.

2. Theoretical Framework

Porter outlined his conceptual framework of competitiveness first in the Competitive Advantage of Nations, focusing on geographic location as a key determinant of company productivity (Porter, 1990, 1998). The competitive challenge for nations is to adapt state economic institutions and economic structures to produce a visible growth in the international scale (Bronisz et al., 2008). According (Stajano, 2006) the European Union's prosperity is based on its capacity to compete in the global market. In this alignment, competitiveness creates the basic conditions for sustainable development and growth, to the creation of new production activities and new jobs, and for a better quality of life (Kravchenko et al., 2013; Stajano, 2006).

Creativity, clustering and networking as a contribution to productive and efficient entrepreneurship, and knowledge is the key for sustainable growth (Vaz & Nijkamp, 2009). Regional Industry clusters, can be understood as an agglomeration of companies within one particular industry in a specific geographical area (Isaksen, 1997; Lechner & Leyronas, 2012). In the regional context, network can be understood as all the relationships between local actors (Lechner & Leyronas, 2012); representing the quadruple helix interactions (Academia, Industry, Political Decision and Society) (Bjerregaard, 2010; Leydesdorff, 2011; Lindberg et al., 2011; MacGregor et al., 2010; Prainsack, 2012).

3. Methodology

3.1 Research position

Aiming to contribute to overcome a gap in the literature regarding the focus of innovation management in the context of technological clusters, based on RDI projects and specific collaborative networks, this paper follows an interpretative approach focused on case study.

Case study analyses are a methodology that enables researchers to conduct their research in a sustained and focused way (Corcoran et al., 2004). The case studies allow into a concrete reality, aiding a better and deeper understanding of the facts, based on the construction of interpretive theory (Baxter & Chua, 2003).

A quantitative and qualitative research is adopted in order to gather information to measure the impact of innovative and entrepreneurial dynamics into the E&T cluster. Interviews with managers of entities from E&T from Portugal (Pool-Net – Portuguese Tooling Association and Centimfe - Technological centre of the mould industry, special tooling and plastic) were conducted, in typologies focus group and semi-structure face-to-face sessions (see Annex I - interview guides). The study also was focused on the collaborative R&D and Innovation projects analysis. A quantitative analysis was performed to characterize the entrepreneurial sector.

How can innovative and entrepreneurial activities contribute to regional clusters competitiveness? How to strengthen the cooperation networks Academia-Industry, in the context of technological clusters?

Developing and maintaining competitiveness, based on the geographical concentration of companies and support agencies, reinforced by the networks Academia-Industry, has been gaining strong political and corporate recognition, explained by the known success of industrial clusters (Arza & López, 2011; McDonald et al., 2006). Through a case study analysis, we seek to demonstrate the importance of cooperation networks and collaborative projects RDI for performance and international competitiveness of the sector E&T (Lucas et al., 2009; Martin et al., 2011; Sharabati-Shahin & Thiruchelvam, 2013).

3.2. Unit of analysis

The sector of moulds, which already has a lifetime of over 50 years in Portugal, is of utmost importance to the national economy (Spi, 2008). Portuguese Tooling Network (Pool-net) is the entity responsible for the management of the Portuguese Engineering and Tooling Cluster, making the connection between institutions that support Portuguese E&T industry (CEFAMOL and CENTIMFE), educational and scientific institutions and mould making companies around a common strategy. The target market of the Industry is energy and environment, electronics, automobile, aeronautics, packaging and medical devices. The collective brand "Engineering &

Tooling from Portugal" intends to represent the industry in domestic and international markets (Pool-net Association, 2014b). In the field of research and cooperation networks, in the international plan, the Portuguese E&T sector is part of the Portuguese Association ISTMA Europe - International Special Tooling & Machining Association; the European Tooling Platform and RITECA - Cross-border Research Network of Extremadura, Centro and Alentejo (Spain/Portugal). Nationally, the sector is integrated into Idt - regional network of innovation, development and technology; RECET - network of technology Centres of Portugal; and APIP - Portuguese Association of the Plastics Industry. This network is also part of the OPEN - Business incubator, support to entrepreneurship initiatives.

4. Case study

The aim of this case study exploring the Portuguese E&T cluster, realizing the nature of its enterprise agglomerated, their national and international cooperation networks, even analyzing the different types of RDI projects developed.

4.1 The Portuguese Engineering and Tooling Industry

The Portuguese Moulds Industry has been growing and consolidating its reputation in the international market, driven either by external demand, either on a competitive quality / price / delivery time, focusing to reduce the current dependence on the automobile industry to values close to 50%, investing in strategic sectors such as energy and environment, electronics, medicine and aeronautics (Cefamol, 2011; Pool-net Association, 2014b). International Engineering and Tooling sector, represented by ISTMA World - International Special Tooling & Machining Association, comprises the areas of Tools, Dies and moulds Industry. In the Portuguese case, the E&T Industry focuses its activities in the subsector of Moulds for Plastic and Rubber, excluding injection or compression types (Camacho, 2013). The code of Portuguese economic activity includes the manufacture of metal moulds.

The export market of the moulds industry in Portugal has been growing over the years, representing in 2013 more than EUR 500 million, well above the apparent domestic market (See Figure 1). Portuguese E&T Industry does not depend on the domestic market, with almost 90% of the production exported. For this reason, Portuguese exports ranks in the eight world place in 2012 (Camacho, 2013; Cefamol, 2012). Main destinations of Portuguese moulds in 2011 are Germany, France, Spain, Brazil, Poland, USA, and Mexico (Cefamol, 2012).
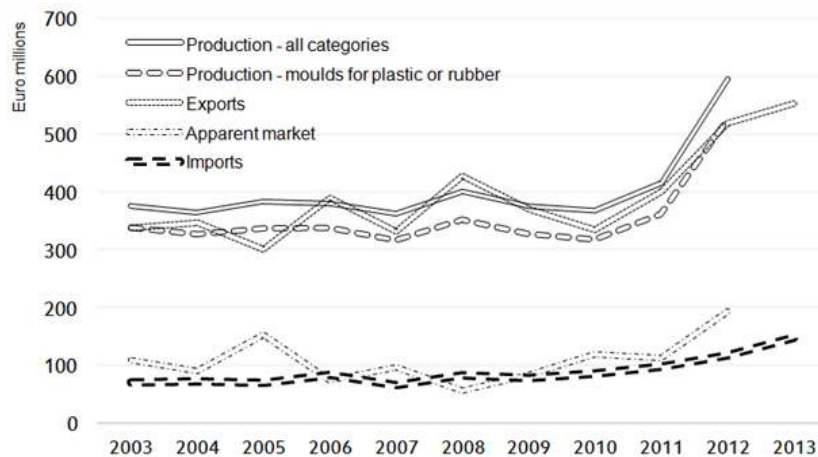
Figure 1 – Portuguese E&T Industry
Source: Elaborated from Camacho (2013).

The mission of E&T from Portugal undergoes integrate an extended mould of high-tech engineering services chain, develop and produce special tools, and precision machined parts with high added value for the customer. It is taken through a strong focus on product innovation and manufacturing process (Pool-net Association, 2014b; Spi, 2008).

In Portugal there are a total of 681 companies with the code of the selected activity. The available data come from a database on 515 of the largest active companies in 2012, representing a turnover of around 500 million euro (Informa D&B, 2013). According to the design criteria of the companies identified by the European Commission (2005), of the total of 515 firms with data on activity, the Portuguese E&T sector has 314 micro firms, 168 small enterprises and 33 medium or large companies (see table 1).

Table 1 – Characterization of the Portuguese E&T Industry

	N° of companies	% of companies	N° of years	Turnover (Euros)	Exports (% of Turnover)	Net Profits (% of Turnover)
Micro	314	61	12	237.869	29	3
Small	168	33	20	1.878.698	48	4
Medium and Large	33	6	29	9.074.677	81	2
Sector average	*515*	*100*	*16*	*1.339.372*	*60*	*3*

Source: Elaborated from Informa D&B (2013).

According to the table 19, the larger companies are the oldest and also the most exporters. The small companies are the most profitable. The figure 2 presents the characterization of companies in the Engineering & Tooling Industry.
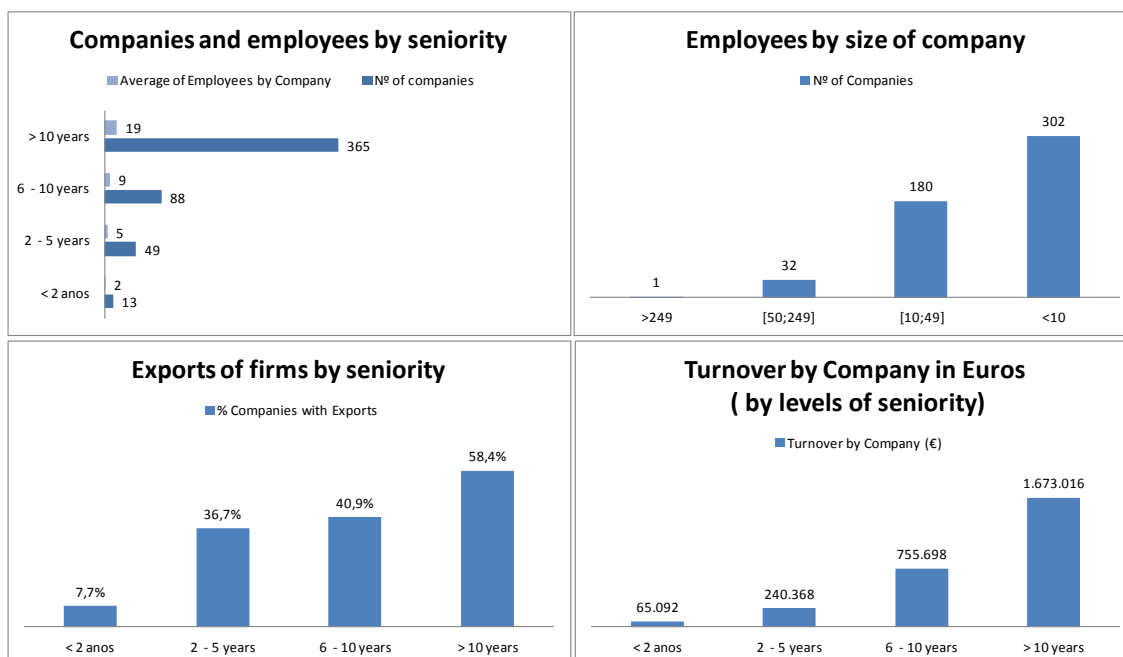
Figure 2 – Characterization of companies in the Engineering & Tooling Industry

Source: Elaborated from Informa D&B (2013).

Looking at Figure 2, we find that firms with five or fewer years of market presence, representing about 12% of jobs in the sector, employing up to five workers on average. We can also observe that 59% of companies employing up to 9 workers on average, thus highlighting its small size. We also acknowledge that companies created over the last decade, representing about 85% of total export sales. Table 2 presents the main indicators from the Portuguese Engineering & Tooling companies.

Table 2 – Main indicators of the Portuguese E&T sector

Indicators	2.013	2012
N.° of companies	515	524
Turnover (Millions of Euros)	690	519
% of Exports	60.4%	90%
Nº of Employees	8.019	7.054
Gross value added (GVA) (Millions of Euros)[5]	270	--
Total EBITDA[6] (Millions of Euros)	87	--
EBITDA % of turnover	12.6%	--
Net Profit% of total turnover	2.9%	--

Source: Elaborated from Informa D&B (2013).

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[5] Gross value added (GVA) is a measure in economics of the value of goods and services produced in an industry or sector of an economy. Provides a Euro value for the amount of goods and services that have been produced, less the cost of all inputs and raw materials that are directly attributable to that production.

[6] EBITDA is essentially net income with interest, taxes, depreciation, and amortization added back to it, and can be used to analyze and compare profitability between companies and industries because it eliminates the effects of financing and accounting decisions.

The sector grew in volume compared to the previous business year, reaching almost 700 million Euros in 2013. This growth occurred mainly in the context of the domestic economy, which has brought down the percentage of exports compared to total industry sales. Currently responsible for employing more than 8,000 people, distributed regionally by the Municipalities of Marinha Grande and Oliveira de Azeméis in Central region of Portugal, the sector has a modest operating profitability, exhibiting the last year an indicator of Earnings Before Interest, Taxes, Depreciation and Amortization - EBITDA in the order of 13% over the turnover.

4.2 Programme of Action and RDI Projects

Smart, sustainable and inclusive growth is the key of EU strategies and programmes. The Quadruple Innovation perspective may be part of the solution to help the economies out of the global crisis announced itself with the demise of Lehman Brothers on September 15, 2008 in New York (Carayannis & Rakhmatullin, 2014). Portuguese E&T cluster has three anchor projects and is a further range of complementary projects that, together with the anchor projects materialize Collective Efficiency Strategy and Action Plan respective. The anchor projects form the basis of cluster development, bringing with it the development of three strategic areas: brand and internationalization (Engineering project & Tooling from Portugal); technology and technical knowledge associated with new challenges (Tooling Edge project - sustainable production of high performance); intervention and intangible factors of competitiveness, specifically with regard to organizational component (ETF project - Tooling Enterprise of the Future)(Pool-net Association, 2008).

The Table 3 presents a set of collaborative projects E&T from Portugal in progress during 2013, highlighting the participation of Pool-Net Association, Centimfe and Cefamol, entities of scientific and technological system, companies, municipalities, among others regional actors (Centimfe, 2014: Pool-net Association, 2014a).

Table 3 – Collaborative projects E&T from Portugal in progress during 2013

Project	Area	Sector	Objective
Tooling Edge	Engineering Product and Process | Mechanical Engineering	Industrial Machinery	Develop scientific and technological knowledge, work methodologies and innovative and adapted to Engineering & Tooling Industry, supported by case studies organization. Seeks to enable increase the overall performance of the industry and added in their processes and products in a targeted strategy for competitive re-positioning the cluster value.
Tooling Surface	Engineering Product and Process | Techn. of materials	Health	Studying the factors that affect the flow behaviour of polymeric material during injection moulding.
BigPROTO	Eng. Product and Process | Mechan.Engineering	Aeronautics and Aerospace	Development of materials, equipment and technologies that enable the manufacture of prototypes or small series of large plastic parts by injection Moulding Reaction of Nylon.

Project (continuation)	Area	Sector	Objective
Hibridmolde XXI	Eng. Product and Process | Techn. of materials	Industrial Machinery	Development of an engineering solution for large plastic parts in small series.
SIMI	Eng.Product and Process | Mec. Engineering	Industrial Machinery	Development of moulding tools for the production of multi-material products.
PRODUTECH_PSI	Eng. Product and Process | Automat. and Robotics	Industrial Machinery	New Products for the transforming activity: Flexible and Efficient Production Systems; Energy and environmental efficiency of production systems.
PRODUTECH_PTI	Engineering Product and Process | Automation and Robotics	Industrial Machinery	New and innovative processes for the forefront of manufacturing technologies. Advanced tools for the development of new products and systems. Allow companies to develop new goods and services quickly and efficiently.
X-NANO	Engineering Product and Process | Technology of materials	Industrial Machinery	Study the application of steel shavings, with a ratio nano / micro grain suitable as raw material in two different ways: framing of various products by injection of powders; and production of hybrid materials from sheet micrometer thickness after dynamic consolidation and rolling followed by micro-injection polymer.
CoolMOULD	Engineering Product and Process | Technology of materials	Industrial Machinery	Studying systems and solutions that improve the thermal and energy performance mould to produce high quality parts at a lower cost, allowing the development of a new product - the mould in a more efficient thermal and energy terms.
METALMORPHOSUS	Eng. Product and Process | Techn. of materials	Industrial Machinery	Study of EMF technology for joining parts in composite materials and metals to obtain hybrid components. The role of Centimfe, is the coordination and sharing of R&D at the level of injecting composites.
MicroHANDLING	Eng. Product and Process | Moulds - Handling of parts	Industrial Machinery	Development of a new value chain directed to the provision of moulds for micro parts, the handling systems and micro-assembly.
BestCRANK	Engineering Product and Process | Technology of materials	Industrial Machinery	Intends to develop a new product with innovative features on the bicycle accessory market. The project will study different materials, geometries and methodologies, thus providing knowledge to develop a design that will maximize crank the resistance that will stand by a high strength / weight / exclusivity.
RITECA II	European project	Research Network	Strengthening the cooperation network between technological and research centres, in Centro and Alentejo Portuguese Regions and Spanish Extremadura.
GAPI Horizon	Innovation and Prospective	Industrial Property	Development activities related to the virtual network, interconnection and communication with IDI RITECA partners.
Platform for Knowledge Transfer	Innovation and Prospective	Sharing and Knowledge Transfer Network	Create a network of sharing and knowledge transfer in a logical approach to the "production of knowledge" and the business community.
Innovation Engineering & Tooling Platform	Innovation and Prospective	Engineering & Tooling Innovation Network	The Network Engineering & Tooling Innovation constitutes a knowledge network that will support and complement the activities undertaken by the Portuguese E&T Cluster under the collective efficiency strategies, in order to increase the representativeness of the Cluster internationally.

Project (continuation)	Area	Sector	Objective
Pense Indústria	Sensitizing Youth for Industry	Industry	Motivate and sensitize young students of the Elementary and Secondary Education, so opt for in your future professional careers related to the business activity of the industrial base.
ETF	Transverse	Industry	The ETF Project - "Tooling Company of the Future" aims to develop methodologies to support companies in the industry Engineering & Tooling, aiming to broaden your competitive basis, repositioning its offering to strategic sectors.
ReMOULD	Transverse	Training	Project training for the retraining of older workers in the field of injection moulding.
LINK2FP7	Innovation and Prospective	European networks	The project aims at integration of stakeholders, including companies in the Engineering & Tooling Cluster, in the context of European RDI networks (in European programs).
GESTOOLING	Innovation and Prospective	Industrial Property	Management and Activities Network. Registration, management and brand promotion "Engineering and Tooling from Portugal." Stimulation of Partnerships and Cooperation Networks. Dissemination and Knowledge Sharing.
Btm - Branding to Market	Innovation and Prospective	Industrial Property	The "BTM - Branding to Market" project aims to promote and consolidate the brand "Engineering and Tooling from Portugal", as a collective, distinguishing and differentiating brand of Industry Engineering & Tooling at national and international level, fostering competitiveness and strengthening the its position in international markets.
GESTOOLING 2014	Innovation and Prospective	Industrial Property	Management and Activities Network. Stimulation of Partnerships and Market Opportunities. Dissemination and Sharing of Information and Knowledge.
Btm 2015 Branding to Market	Innovation and Prospective	Industrial Property	Aims to continue the international campaign promoting the brand and Cluster "Engineering and Tooling from Portugal", fostering competitiveness and strengthening its position in international markets.
Wiintech	Innovation and Prospective	European networks	The project Wiitech develops a common international strategy for cooperation between European clusters, seeking to build interclusters international partnerships, with a focus on clean technologies. This cooperation aims in particular to optimize partnerships and protocols with other Clusters of Japan, USA, Brazil and India.
In-Tooling	Innovation and Prospective	Transverse	This project aims to enhance the intelligence of the cluster through the promotion of a set of strategic studies for the industry, and working for Tooling Technology Roadmap in perspective Horizon 2020.

Source: Own elaboration

Figure 3 presents a summary of the projects described above, grouped into three categories: (1) Product and process engineering, (2) Innovation and prospective, and (3) Sensitizing for Industry and transverse programmes.
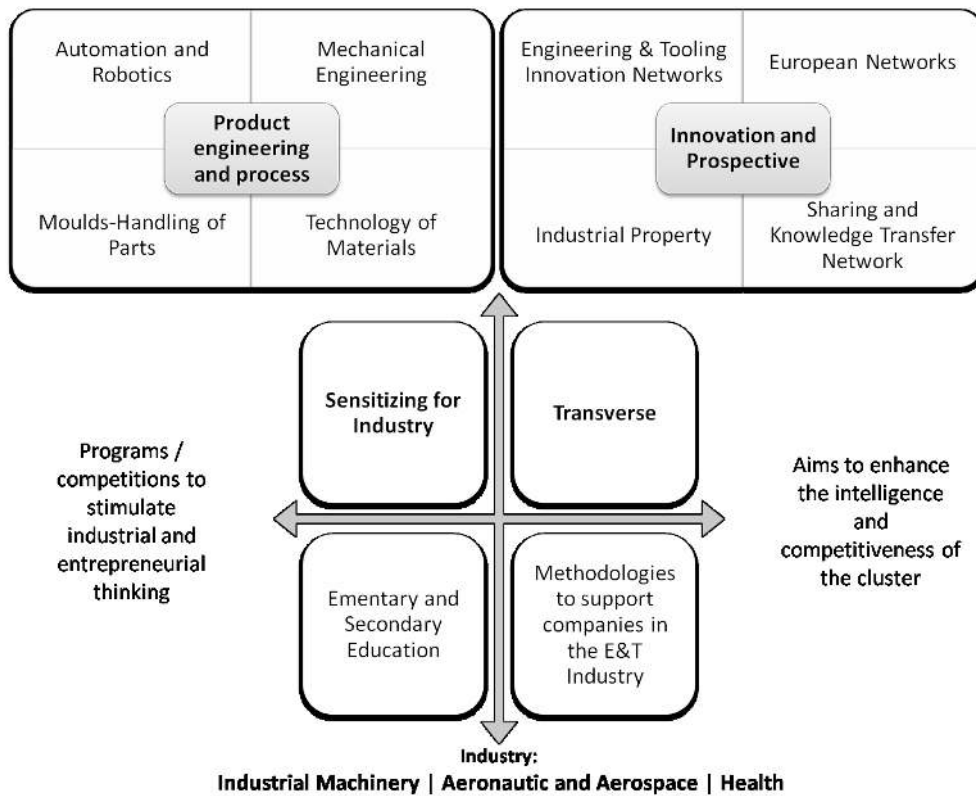
Figure 3 - Nature of Engineering & Tooling projects

Source: Own elaboration.

The projects under review are comprehensive to the sectors of Industrial Machinery, Aeronautic and Aerospace, and Health.

In a comprehensive way, the cluster also develops projects that aims to enhance the intelligence and competitiveness of companies and people, participating in incentive programs of industrial and entrepreneurial thinking (e.g. "Pense Indústria" project, created by RECET - Association of the Technological Centres of Portugal), aimed at raising awareness and training of young people in engineering, technology and innovation, while still aiming their mobilization for Industry.

The cluster has a strong focus in the area of innovation networks and knowledge transfer. In this area, also stands out a strong Industry-Academy cooperation, not only in terms of RDI projects, but including welcoming the Master's and Doctoral Programmes, and other initiatives for entrepreneurship. In late 2013, the cluster E&T began a new cycle of roadshow exhibition, being present in four Higher Education Institutions in Central Portugal (University of Beira Interior, Polytechnic Institute of Coimbra, Polytechnic Institute of Castelo Branco, and University of Aveiro) region. The purpose of the Engineering & Tooling Exhibition (available at http:\\expotooling.centimfe.com), is to make known what is done from the cluster.

Figure 4 represents the size of the main national and international cooperative networks, where the Portuguese Engineering and Tooling is inserted.
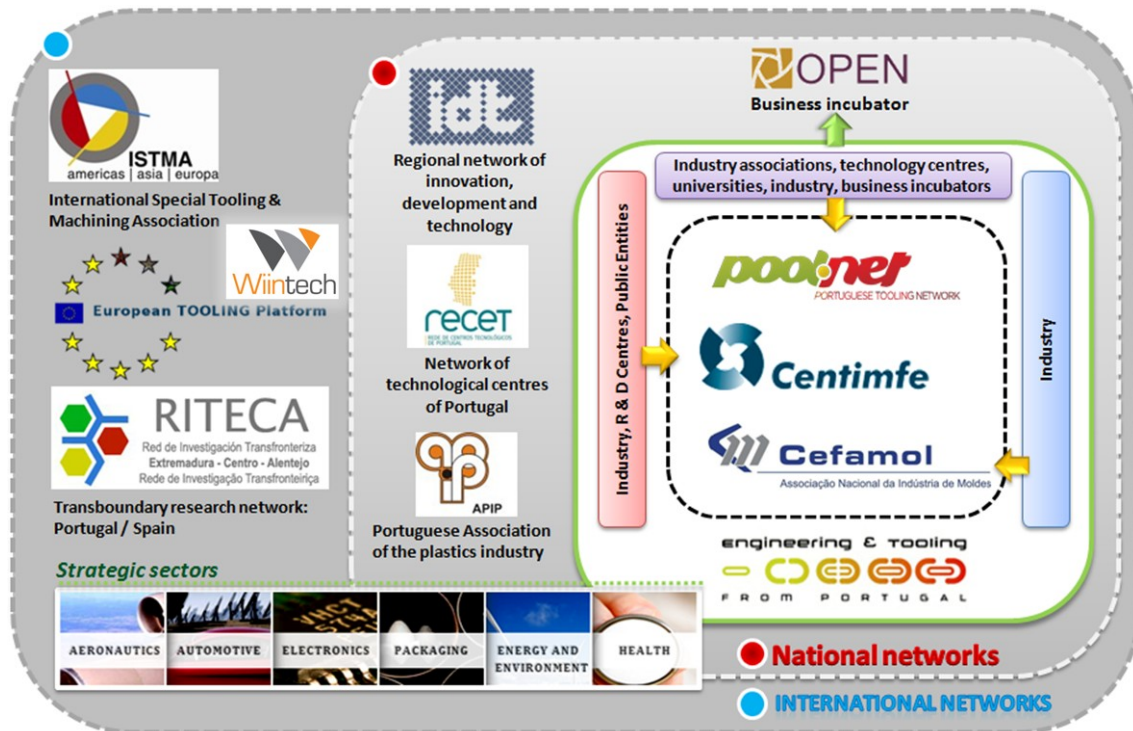

Figure 4 -Portuguese E&T: overview of national and international networks
Source: Own elaboration.

The Portuguese cluster is embedded in important national and international networks, particularly for technological and entrepreneurial cooperation. At the national level, the network starts from the integrating entities (Pool-net - managing entity of the cluster, Centimfe – Technological Centre of Moulds Industry and Plastics; Cefamol - National Association of Moulds Industry, to commercial area and fairs; and Open – Association for Specific Business Opportunities), highlighting its inclusion on the network of technological centres of Portugal - RECET. In the international context the industry is represented by ISTMA - International Special Tooling & Machining Association, also part of other networks such as the European Tooling Platform, or Wiintech - Worldwide initiative for intercluster new materials and processes focused on clean technologies. The cluster has invested heavily in its collective brand-*"Engineering and Tooling from Portugal",* which represents the Portuguese sector, in the context of networks and international markets.

Under the Portuguese E&T cluster, the types of investment recently supported in the field of Collective Efficiency Strategy relate to the development and engineering of products, services and processes; organization and management of information and communication technologies; quality; sales and marketing; and internationalization (Pool-net Association, 2008, 2014b).

4.3 Innovation, Entrepreneurship and Competitiveness Dynamics

Today it is commonly accepted an interactive model for the process innovation and competitiveness, based on the needs of the market and the state of technology and production. The value propositions in the market today offered arise from an innovative idea, following its development, prototyping, manufacturing and finally, marketing effort (Clark & Guy, 2010). Also in the Portuguese E&T sector this process occurs with increasing intensity:

> *For example in the automotive industry, the customer not only wants the moulds, they want the dashboard of the car (...) the market requirement sets the corporate strategy, extending its value chain from design, to prototyping, engineering, production, marketing and solution delivery* (Pool-net Association).

Business networks and cooperation are universally assumed to be the key to success, where firms and other public and private organizations join together in networks, with a view to achieving new standards of competitiveness (Farinha & Ferreira, 2013).

> *The relationships between businesses and the scientific and technological system have existed for many years, and companies have been working collaboratively long. Moreover, business missions, collective participation in fairs has been happening for many years, and therefore the recognition of the pole of competitiveness E&T came to help consolidate and formalize this collaborative relationship* (Pool-net Association).

About cooperation networks maters:

> *Nowadays also have a lot of collaboration outside of research projects. There are many companies before their problems already using laboratories in universities. It also creates some affinity with some aspects at the level of future collaboration... there is also the placement of fellows from universities, companies with more regularity than a few years ago* (Centimfe).

In recent decades, intellectual property has come to play a role as a major commercial asset. Intellectual property rights, i.e. patents, utility models, designs, trademarks, play an important role on insurance for innovation (Rafeiner &Weidinger,1999; Tsolacos, 1997).

> *The flag of the consolidation of the Cluster is the collective brand "Engineering & Tooling from Portugal", which had already been tested in the past, not as a brand, but through slogans. We held, for example, international campaigns of "Moulds Portugal", international campaigns "Tooling and Innovation", at the Hanover Fair. Later, the "Engineering and Tooling", which was already being used as a campaign, because the industry was up in integrating the value chain, but not as a collective*

brand. The question of consolidation of the Cluster, has allowed use this international flag, where companies can realign their strategies. This is probably the added value, which allowed firms to reposition themselves in terms of innovation and competitiveness (Pool-net Association).

In entrepreneurship, sensitization and support for entrepreneurial initiatives, the Portuguese E&T cluster has taken various initiatives to end up either in international field, European Commission and national level, even enhancing interaction with Business Angels networks and wrapping other funders, strengthening the proximity with Institutions of Higher Education and regional Schools.

There has been a very important job to the Horizon 2020 level under the "research and innovation strategies for smart specialization - RIS3", we get the "industrial manufacturing systems" area of tooling, robotics and automation could be considered as a strategic development area. In terms of regional policy decision in this case with the Commission for Coordination and Regional Development of Centro - CCDRC, we have created an open day to reflect on the role of technological infrastructures and technology transfer, with the goal of re-industrialization. We have worked with the local governments of the region, where our incubator OPEN is doing important work to raise the awareness of schools for entrepreneurship, even including some support to the unemployed (Pool-net Association).

Table 4 summarizes the results obtained from the interviews conducted in the fields of international promotion, networking, knowledge and technology transfer, coordinating and supporting the coordination of collaborative projects and innovation support, help find new sources of funding for companies, among other activities, with important socio-economic impact within the cluster and regional space where it belongs.

Table 4 – Table summary of the socio-economic contributions of the cluster

Topic	Cluster's Contribution
International Promotion	International promotion of the industry through collective brand "Engineering and Tooling From Portugal"
	Joint participation in international fairs
	Organizing technical and other international events linked to the sector (eg. Moulds event)
Networking	Encourage cooperation between SMEs in the supply of products brought technological complexity.
	Stimulate cooperation network, with results in terms of access to markets and increase the collective bargaining power
	Access to international networks for cooperation and benchmarking (eg. European Tooling Platform)

Topic (continuation)	Cluster's Contribution
Knowledge and technology	Strengthen the relationship between companies and the National Scientific and Technological System
	Help enterprises in certification processes in Quality and Innovation (eg. Certification according to the AS9100 for aerospace), still helping their qualification before certain suppliers (multinational)
	Encourage training, awareness and attracting young people to the industry, and fostering entrepreneurial spirit, through specific programs
Project Coordination	Coordinate national and European projects, with a view to improving the qualifications, skills and competitiveness in the industry, still enabling the development of new products, process improvements and / or entry into new markets
Support funding	Help to create conditions for better access to new types of business financing
	Participation in the discussion of new lines of action from the European Commission, which calls trying to reflect opportunities for industry E&T at European level
Socio-economic development	Contribute to improving the general standard of living in regional terms, by creating jobs and wealth

Source: Own elaboration

5. Conclusions

Clusters are defined as important catalysts for new competitive economy (Porter, 1998). This study allows us to better understand the competitive positioning of the Portuguese E&T cluster from network initiatives for innovation and entrepreneurship.

To allow a better perception of the cluster framework, we did an analysis of characterization of such companies, and the respective target market. The main collaborative ongoing projects were focused under the initiatives of RDI, with indication of the different areas and goals to achieve.

Following the methodological approach of interpretive research, we have analyzed the international and national networks where the cluster is located, helping us to better understand what types of RDI projects developed and the nature of collaborative relationships undertaken in the Cluster.

The study demonstrates the existence of a strong socio-economic impact of the cluster in its business environment, as well as in the regional context in which it operates. This positive contribution extends to areas of international promotion, with emphasis on the collective brand "Engineering and Tooling from Portugal"; strengthening Academia-Industry relations,

with a special focus the processes of knowledge transfer and technology in which it participates; their role in the areas of project management, and support to attract investment; among other dynamics.

As suggestions for future lines of research, we propose to deepen a debate in the context of areas of RDI and technological entrepreneurship, in order to maximize new international collaborative networks in the field of Triple Helix interactions in high-tech sectors.

Acknowledgments

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Chapter 5

Networks of Innovation and Competitiveness: a Triple Helix case study

Abstract

This paper aims to study the knowledge and technology transfer processes taking place in cooperation between academia and industry through an EU-funded R & D project. We follow a qualitative research methodology through a case study, incorporating interviews with the institutional actors involved (university, industry and government) in the cooperation project. While this study is limited to a case study, it does, however, highlight the importance of Triple Helix networks in order to develop research, development and innovation (RDI) initiatives and their commercialization and correspondingly enabling the identification of both potential opportunities and constraints in the process. Through the practical perspective of a successful Triple Helix cooperation case study, we were able to develop an innovative and continuous olive harvesting machine in order to satisfy a real need in the Mediterranean market. Inserted within the context of the triangulation of the Triple Helix model, this paper demonstrates the importance of RDI cooperation networks and the consequent commercialization of new tradable products with positive consequences to regional competitiveness.

Keywords

1. Introduction

One of the biggest challenges facing European economies resides in the comparatively limited capacity to convert scientific and technological advances into industrial and commercial achievements (Klofsten & Jones-Evans, 2000). As a result, academic institutions have undertaken increasingly proactive approaches reflected in entrepreneurial roles in direct collaboration with industry (Abramo et al., 2009; Crespo & Dridi, 2006; Mueller, 2006).

Entrepreneurial universities have also reinforced their capacities to transfer the knowledge produced, enabling economic and social utility and thus contributing to the development of new products and the improvement of the competitiveness of organizations and countries (Bernasconi, 2005; Dayasindhu, 2002; Etzkowitz, 2003a; Landry eta l., 2006; Tee, 2005).

The growing importance of knowledge and innovation to economic growth and technological competitiveness, and as a key competence in all fields, currently represents a strong concern for policy makers, scientists and managers alike (Aguirre et al., 2006; Ranga et al., 2003).

Academia - Industry (A-I) interactions have become more formal, frequent and planned ever, since the 1970s. The Massachusetts Institute of Technology (MIT) has led the way in this context, driving the emergence of new companies from the outputs produced by the university, before subsequently metamorphosing into the concept of the science park as established at Stanford University and further strengthening the bridge between science (universities, public research laboratories and other financed scientific institutions) and industry (industrial and service), opening up pathways to much needed competitiveness (Ojewale et al., 2001; Ranga et al., 2003). Building new alliances between Academia and Industry has become the cornerstone of research policy and innovation, especially in this context of collaborative research, contract research, consulting and informal relationships A-I (Bjerregaard, 2010; Perkmann et al., 2013). However, the literature review has been advocating how different institutional perspectives on R&D may shape the relationships and cooperation processes between public universities and SMEs, given the existence of differences in goals, interests and time horizons. Nevertheless, some studies contradict this current in observing a facilitated A-I knowledge transfer process (Bjerregaard, 2010). SMEs prove more effective in adopting the different practices of open innovation, especially in terms of introducing new products and achieving higher returns driven by intellectual property protection mechanisms, when compared to large companies that benefit more from their own strategies research processes (Spithoven et al., 2013).

This study aims to contribute to combating any gaps identified in the literature on presenting case studies and thus help reflect on the potential dynamics of A-I interactions and their contribution to regional competitiveness. Therefore, this paper aims to explore, through a case study, the collaborative A-I interactions in Portugal whilst focusing on the literature regarding the transfer of knowledge and technology based on the concepts of open innovation (Chesbrough, 2007) and innovative entrepreneurship, initially advocated by Schumpeter in 1911 and today globally disseminated (Wong et al., 2005). We thus contribute to enriching the theoretical framework in this area. We furthermore seek to reflect on the scope of opportunities and limitations to managing collaborative A-I projects and, through the analysis of a case study, highlighting the main limitations encountered during project implementation from the perspective of each institutional sphere involved Academia – Industry – Government (A-I-G) and thereby provide clues and opportunities for future improvement.

The paper is structured as follows: the second section defines the theoretical framework, followed by the methodology in section 3, and the case study in section 4 before the closing section 5 presents the conclusions of this study.

2. Theoretical Framework

2.1. Regional Competitiveness and Growth

Competitiveness is defined by Schwab (2011) as a set of institutions, policies and factors combining to determine the level of productivity of an economy and its corresponding capacity to generate wealth and returns on investments and determining the potential for economic growth. Regional competitiveness may be defined as the success regions attain in the ongoing mutual competition that occurs in different forms, whether from the point of view of actions and results in national and international markets or whether as regards the capacity to attract financial and human capital resources (Audretsch et al., 2012; Audretsch, 2004).

Furthermore, two of the leading reasons driving this strengthening of competitive pressures are the growing international mobility of capital and the openness of markets in conjunction with phenomena deriving from globalisation. Economies have strengthened their interdependence through raising levels of both exports and imports, boosting foreign direct investment, removing barriers to trade and the transnational organisation of negotiating powers over the transport sector (Turok, 2004). In this growth alignment, less competitive regions strive to enhance their knowledge infrastructures in efforts to attract medium-tech manufacturing and high-tech services (Leydesdorff & Meyer, 2006).

The key to innovation–driven development involves close collaboration between science, technology and financing instruments (Zhou, 2013). Knowledge management is a critical factor influencing global competitiveness even while it remains that the creation, acquisition, interpretation, retention and transfer of knowledge designed to improve performance aims to change intended behaviours based on new knowledge (Dayasindhu, 2002). Academia deploys knowledge to promote the regional development of new resources, taking on the role of cultural and social institutions important in any country and already demonstrated as key players in economic development and all in addition to their traditional functions of teaching and research (Sharabati-Shahin & Thiruchelvam, 2013).

Business activities are becoming increasingly globalized with industrialized countries registering a higher growth of exports and with production and foreign direct investment (FDI) also growing faster than exports over the decades (Carlsson & Mudambi, 2003). Structuring the business model helps companies develop solutions for the effective management of such a

business model, itself requiring complex and sophisticated solutions for coordinating resources and processes across all functions (Storbacka, 2011; Zott & Amit, 2010). The "digitalization" of manufacturing industry, making it possible to remotely monitor the optimization process and ensuring automatic compensation parameters and multifunctional management, has enabled industry to respond quickly to the demands of global markets (Greve, 2013; Zhou, 2013). The new business model is a narrative and calculative device that allows entrepreneurs to exploit a global market and play lead roles by contributing towards the construction of innovative techno-economic networks (Doganova & Eyquem-renault, 2009).

2.2. Innovation and Entrepreneurship

Innovation is now a decisive challenge to global competitiveness; to achieve success companies have to know how to deal with the issues deriving, leveraging the strengths of their location for the creation and commercialization of new products and services (Budd & Hirmisf, 2004; Porter & Stern, 2001; Schwab, 2011). We would note that the slow growth in European economies should support the view that entrepreneurship and innovative SMEs can play an important role in promoting economic growth with academia retaining a strong potential impact on knowledge dissemination, choices over locating new entrepreneurial ventures and the consequent transfers of technology and knowledge (Soete & Stephan, 2004). The intensity and quality of science-industry interactions determine the effective returns on investment in research, commercializing technology, creating jobs and improving the quality of life as well as helping to attract and retain skilled labour and talents, thus instilling and strengthening the entrepreneurial spirit (Ranga et al., 2003; Wong et al., 2007).

A set of factors transversal to the economy support innovation, including: the human and financial resources allocated to scientific and technological advances, the level of technological sophistication, the public policies affecting innovation related activities, intellectual property protection, fiscal incentives for innovation, and enacting and effectively implementing antitrust and abuse of power legislation (Ketels, 2006; Porter & Stern, 2001). Innovation is now generally accepted as a critical parameter of human intelligence and cognitive capacities (Nissan et al., 2011).

Ever since the founding of economic history (Adam Smith, Ricardo), entrepreneurship has been identified as a critical factor to attaining and maintaining successful economic development. In the 20th century, Alfred Marshall, within the context of growth in capitalist economies, directly defined the notion of entrepreneurial competition (Nijkamp, 2003).

Based upon incorporating the already acquired knowledge and as disseminated by the academy, a growing body of research has been considering the dynamics of innovation and

entrepreneurship as organizational processes vital to the survival of businesses and their better performance, especially within an environment of increasingly intense global competition (Marques et al., 2006; Nilsson et al., 2009). In opposition to closed innovation, where a company creates, develops and markets its own ideas, a philosophy that prevailed throughout much of the twentieth century, in the new open innovation model, the ideas themselves are marketed, as well as innovations from other companies, i.e., inputs are purchased outside the boundaries of the organization to incorporate into the business strategy and thereby exploiting the knowledge and experience of human capital extrinsic to the organization in order to effectively meet market needs (Sarkar & Costa, 2008).

The academy has expanded its roles in the innovation process as outlined in the dynamics of the triple helix model (Etzkowitz & Leydesdorf,f 2000) in which the A-I-G alliances attain a new level of prominence (Sharabati-Shahin & Thiruchelvam, 2013).

2.3. Networking and Regional Innovation

Collaborative networks actively contribute to raising the competitiveness of regions, both in terms of new technology network development projects and enabling access to new resources, skills and cost synergies (Aloysius, 2002; Arranz & Fdez de Arroyabe, 2008; Audretsch et al., 2012; Awazu, 2006; Semlinger, 2008).

Entrepreneurial dynamics constitute an important mechanism to regional development, whether deriving from academic spin-offs, rendered support by science and technology parks and incubators, as defended by Salvador (2010), or resulting from the founding and expansion of family based companies, as proposed by Nordqvist & Melin (2010) and, in either case, resulting in locally produced employment and wealth.

The Triple Helix explicitly recognizes the importance of higher education to innovation. However, other authors have suggested the need to model evolution into the context of innovation-driven economies, including new standards of social and environmental responsibility, crucial to sustainable growth (Carayannis et al., 2012; Leydesdorff, 2011). The triple helix development model seeks to nurture robust spheres of A-I-G interaction, allowing for the rethinking of socio-economic development, from resource-based to knowledge based, from exogenous to endogenous and from state-led to university-led (Etzkowitz & Dzisah, 2008). Farinha & Ferreira (2012) present an adjusted "Triangulation of the Triple Helix" (THT) model, aimed at contributing to a better explanation and understanding of the importance of Innovation and Entrepreneurship within the A-I-G dynamic and in the context of regional competitiveness (Figure 1).
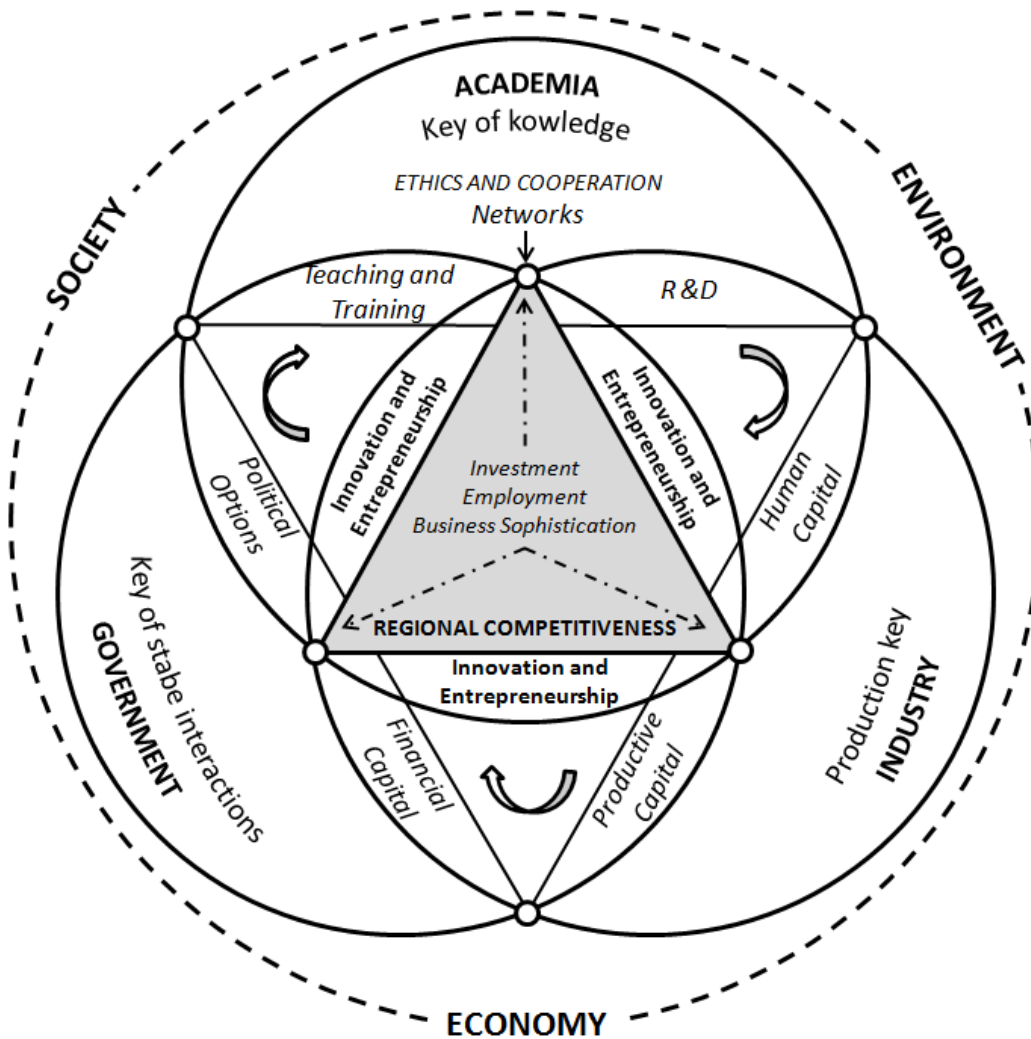
Figure 5 – Triple Helix triangulation model
Source: Farinha & Ferreira (2012)

The THT model is structured around the interactive relationships between three institutional spheres (university – industry – government) referred to by various authors (Etzkowitz & Dzisah, 2008; Etzkowitz & Leydesdorff, 2000; Etzkowitz, 2003b; Lawton Smith & Bagchi-Sen, 2010; Leydesdorff & Meyer, 2006; Leydesdorff, 2011) as institutions crucial to the knowledge that itself represents the key to production that then becomes the key to stable interactions. The THT model assumes innovation and entrepreneurship provide the catalysts of competitiveness and regional development. Key features of this dynamic growth include cooperation between institutional spheres and business sophistication resulting in the creation of wealth and employment from the R&D and innovation launched by the academy and then transferred to industry with support from the government through guaranteeing of structural funds.

3.Methodology

3.1. Research position

Overcoming a gap in the literature in terms of direct approaches to collaborative A-I projects follows an interpretative case study based approach. The singular application of quantitative methods cannot capture the essence of phenomena in certain areas of greater complexity (Beach et al., 2001). However, the role of the case study, and entering into a particular reality, really can contribute to a better understanding of the facts through in depth research into the operations and furthermore registering an increasing trend towards the production of qualitative studies within a context of alternative, interpretative and theory-based research methodologies (Barratt et al., 2011; Baxter & Chua, 2003; Glaser & Strauss, 1965).

How can A-I-G interactions contribute to regional competitiveness through innovation and entrepreneurship? Through the case study, this research strives to demonstrate just how A-I-G interactions are susceptible to leverage and dissemination in order to develop and commercialize new products, providing an effective response to market needs and thus contributing to the creation of wealth and employment as a result of enhancing regional competitiveness (Kelley et al., 2010). Another perspective involves understanding the importance of the role of public funding in backing innovation and entrepreneurship based initiatives (Giuliani & Arza, 2009; Horowitz Gassol, 2007; Lundberg & Andresen, 2012; Meyer&Tang, 2007).

Two in-depth face-to-face field interviews took place during the equipment testing's with the University of Évora Project Coordinator, Professor António Dias, and the entrepreneur and owner of the Torre das Figueiras farm in Monforte, in Portugal's Alentejo region , Mr. Falcão. Another in-depth face-to-face interview was held with the CEO of VICORT, Mr. Miguel Ferreira, on company premises, following the due collection of support documentation. Finally, to capture the government's perspective, the project interviewed Professor Carlos Zorrinho, Professor at the University of Évora, Member of the Portuguese Parliament, and a former Assistant Secretary of State to the Minister of the Interior, Secretary of State of Energy and Innovation (State Secretary with responsibility for supervising Adi – the Portuguese Innovation Agency) as well as formerly the Head of Mission of PROALENTEJO - Integrated Development Program for Alentejo and the National Coordinator of the Lisbon Strategy and the Technological Plan 2005-2009 (see Annex II - interview guides).

3.2. Unit of analysis

The MCCA_II project – Olive harvesting machine in continuous, features on the list of collaborative A-I projects under the co-promotion project typology, officially published by the Portuguese Agency of Innovation (Adi) at http://projectos.adi.pt/, developed between 2009

and 2012. This R&D project typology, conducted in partnerships either between firms or between entities belonging to the National Scientific and Technological System (universities, R&D centres, etc.), is implemented by firms, including the research and intellectual, industrial and/or experimental development activities, leading to the creation of new products, processes or systems or the introduction of significant improvements to products, processes or systems. The Project, identified by the code "ADI / QREN No. 5436 (2009/2012)", resulted from a strategic partnership between the University of Évora (located in the Alentejo region), and the industrial SME VICORT - Vitor Cardoso, Ltd. (located in the Centro region) in Portugal (Figure 2).

Figure 2 - The MCCA_II Project
Source: Own elaboration.

The collaborative project objectives are the following: designing, building, evaluating and developing a prototype for the MCCA_II project. MCCA_II comprises two identical working units symmetrically on the left and right of a row of trees. Each unit is semi-towed by a farm tractor, which also feeds the unit with power. The project offers the following innovative aspects: applying the agricultural tractor already existing in farms as a source of power; harvesting the olive trees by approaching them laterally and therefore imposing no restrictions on its development (that is unlike the continuously propelled harvesting machines on the market, which approach the complete tree and thereby forcing a limitation on the growth size of the tree in accordance with the machine's own internal dimensions). Indeed, its smaller size, when compared to the existing machines on the market, endows the MCCA_II with greater versatility and adaptability to existing constraints on farms in terms of size and topography, as well as meeting road transport requirements with its lighter weight increasing the ease of transit on agricultural land often less than firm at harvest time.

The general project data, including the amount of investment, incentives and total maximum rate of support are defined in Table 1.

Table 1– General Framework of the project

Co-promoters	Investment	Total eligible	Total incentive	Incentive non-refundable	Incentive refundable	Maximum rate Support (%)
Project	395,030	395,030	255,876	255,876	0	64.8
University of Évora	125,721	125,721	94,291	94,291	0	75.0
VICORT	269,309	269,309	161,585	161,585	0	60.0

Currency: euro

Investment totalled 395,030 euro, and the maximum rate of project support, amounted to about 65% of total project investment.

4. Case study

This case study is structured to reflect the research objectives: understanding the knowledge and technology transfer process between Academia and Industry when engaged in cooperation projects and their impact on regional competitiveness while also gaining a better perspective on the importance of open innovation in the project under study, identifying the difficulties and limitations encountered during project implementation and exploring future improvement and funding opportunities in the field of A-I collaborative interactions.

4.1. Entrepreneurial and collaborative networks

We must first bear in mind the different perspectives on the field of entrepreneurial activity. The first comes from the direct entrepreneurial role in A-I collaborations, strengthened by the transfer of knowledge production (Abramo et al., 2009; Crespo & Dridi, 2006; Mueller, 2006), contributing to the development of new products, wealth creation and employability, and thereby also boosting regional competitiveness (Bernasconi, 2005; Dayasindhu, 2002; Etzkowitz, 2003a). In this regard, Professor António Dias (AD) states:

> *If we return to the political paradigm, we have to produce tradable goods. This is one example of a tradable good, which was obtained thanks to the work of research and experimental development, between a company and a university, and as well as an agricultural firm. These cooperation synergies have created a tradable good that can be exported. Just consider that neighbouring Spain is a global colossus in terms of olives, with many thousands of hectares of olive groves.*

In fact, this project resulted in the development and design of a tradable good, with market and export potential, from a collaborative A-I process, spanning the activities of R&D and product design.

Another theory maintains that innovative SMEs with entrepreneurial initiatives play an important role in promoting economic growth (Spithoven et al., 2013). For this type of A-I project, Professor Carlos Zorrinho (CZ) states:

> *(...) often these projects have evolved glued to the large companies that absorbed the bulk of the funds. But the truth is that these big companies, in absorbing the projects, they also kill off part of the innovation. This was due primarily to investing in already good companies and capitalizing on these companies. We have no shortage of business initiatives; we have a lack of scaled business initiatives. This should be a great line, the line to give muscle to companies that are already in international markets and that substitute imports.*

SMEs can play an important role in innovation, even when compared with large firms, which absorb a significant proportion of public funding. According to Spithoven et al. (2012), SMEs are more effective in terms of open innovation and the introduction of new products to the market than large companies. In these cases, the turnover from new products is driven by intellectual property. However, as stated in the interview extract above, there is no shortage of business initiatives but rather these initiatives lack size and scale. Innovation processes and open innovation require the company's ability to absorb external knowledge, facilitated at this level through collaboration with research centres and/or inter-organizational projects (Spithoven et al., 2011). Nevertheless, regional science and technology policies may also play an important role in building regional technological infrastructure by sponsoring collaborative projects meant to create, manage and regulate innovative dynamics (Johnson 2008).

About the prospects for exporting projects, Mr. Miguel Ferreira (MF), CEO of VICORT adds:

> *It is our goal to promote the product at fairs, wherever possible, we will try to do dynamic production demonstrations, because, while recognizing that the domestic market has the capacity and the need for this product, it is true that the Spanish market is much bigger than ours, and therefore we want to strengthen from the export point of view.*

Networks of inter-firm cooperation, institutions and research centres reflect a positive impact on the innovation performance of SMEs (Zeng et al., 2010). There is a high degree of consensus around the idea of competitiveness through the efficient application of the factors of production, the exploitation of endogenous resources or increasing production and

collectively providing the basis for raising the quality of life prevailing (Solleiro & Castañón, 2005; Strand & Leydesdorff, 2013). However, another factor to take into account when seeking to increase competitiveness is the respective export capacity of organizations and regions (Solleiro & Castañón, 2005).

In brief, the A-I networks of cooperation have now become a cornerstone of research and innovation policies (Bjerregaard, 2010; Perkmann et al., 2013). However, CZ also advances the need for greater involvement between the parties:

> *(...) Massachusetts Institute of Technology (MIT) assumes that the teacher spends at least three months at collaborative enterprises. Hence, MIT pays staff for only nine months. For the other three months, they have to find companies to pay them. I have found in Portugal, many cases of highly successful professors, who at one point had to leave the university because their peers did not understand that they could earn more. And the same thing, there is the inability to realize that even a great entrepreneur, for the university to work, should be paid for the value created to universities, because that is what creates robust systems and strong partnerships. That makes the success of partnerships in countries that have these strong partnerships up and running.*

Triple Helix collaborations are considered vital to the success of regional technological development (Johnson, 2008).

4.2. Innovation and open innovation

The MCCA_II is an innovative project, including an open innovation component, receptive to new ideas and the critical participation of olive producers in order to meet their specific needs. Referring to the entrepreneur, olive producer and olive association leader, Mr. Falcão (F), Professor António Dias (AD) describes this project as being:

> *(...) in his potential interest as a farmer, and also as association leader (President of Production Farmers in the Elvas region of the Alentejo region), as well as his links with CAP – the Confederation of Farmers of Portugal, attending Brussels meetings with some frequency, and therefore in contact with a lot of realities, speaking to a lot of people (...) actively collaborating in the development of the project, because he clearly saw and felt that this may be the solution to his problems and those of other farmers.*

The growth of science and technology is necessary to supporting an economic transformation strategy from an industrial-based economy to a post-industrial knowledge-based economy

(Wong & Goh, 2012). Open innovation has been associated with fast-growing technology-intensive industries, however, increasing evidence that this concept and its associated strategies may also prevail in more traditional industries. This is the case with high dependence levels on other entities, such as other firms, public research institutions or end consumers, suppliers, partnerships for development and / or the commercialization of new technologies (Sarkar & Costa, 2008).

Reinforcing this position, the VICORT CEO (MF), in relation to the open innovation component and project effectiveness, refers to F in adding:

> (...) experiencing, seeing, complaining, suggesting, imposing, and it was also important because he brought innovation. In the end, only companies producing equipment for the market and the market have to accept this product. If the product is not capable, the market will not buy it. This environment was critical to the farmer who immediately had feedback from the market, for what was the degree of acceptance of the quality of the equipment itself (...). He brought a very important advantage in terms of contributing to the increased level of reliability and performance of the equipment itself. Anyway, this is what is also allowing us to move onto the next steps. (...) in this type of project, beyond the industrial capacity, the ability of R&D that exists between A-I, it is vital that another factor comes into play, which is the actual acceptance of the product by the end customer, the potential end user.

The complexity of innovation processes led to tremendous growth in SME recourse to external networks (Zeng et al., 2010). The concept of open innovation has been asserted by ideas of 'interactive innovation and innovation networks", creating external paths to innovation. Multiple paths can be followed depending on the rootedness of the "culture of innovation" in businesses and regions: R&D and innovation activities in collaboration with other companies and universities, relationships with spin-off companies and informal knowledge interactions within "local milieux and open innovation campuses" (Tödtling et al., 2011). However, we are convinced that open innovation brings together a joint perspective about the needs of potential consumers, giving rise to new ideas and new market solutions.

4.3. Project difficulties and limitations

The literature emphasizes how different institutional perspectives, resulting from their different goals and interests may drive the emergence of obstacles to collaborative relationships, especially between public universities and SMEs (Bjerregaard, 2010). Looking on the ground for these or other potential difficulties, we obtained the following description from AD:

"At the University, I don't think things have worked badly. I think the level of interconnection between the company and the lender (Adi), in order to streamline processes, help more companies, sometimes not so familiar with the whole set of this kind of bureaucracy that causes or projects need. On the other hand, the funders are also not very familiar with the reality of these companies. These situations might be worth improving".

Looking closer to understand the difficulties, this time we put the question to the company that answered (MF):

I will not say there is much to iron out. In business, as in academia, the persons responsible and involved in the project have a set of tasks beyond the project itself and are not 100% allocated to the project. This led to some delays, delays due to the company's inability and until the University became sufficiently involved in the project and in accordance with what it actually represented.

Asked about the government involvement, MF answers:

At the level of government (Adi), there is very little involvement. The government is a bureaucratic decision maker, a pure administrative. (...)What is needed is for this type of project, when an entity involves industry, there has to be the scope for the company to apply its internal resources to affect the project and the costs associated require due recognition. Otherwise, even while having the internal capacity, the company has to outsource this to an external entity, with the consequent burdening of the project, because the cost of domestic production is much lower than when having to subcontract a third party to produce components (...).The rules of the project itself are extremely rigid, imposed by the European community, pre-determined rules and that in our understanding frequently seek to fund R&D enterprise start-ups without any industrial capacity and this is not our case. Our company is a structured enterprise, easily visible throughout the ERP system, the recognition of costs, determining which are the production costs of parts and as a result, affect them to the project. The important thing is that Adi, in fact, recognizes them.

There are several barriers to A-I collaboration, motivated by different perspectives and orientations, or conflicts of interest whether based on research priorities or in response to obtaining market economic results (Bruneel et al.,2010). In general, a major obstacle for companies is the wish to retain an element of commercial confidentiality to protect their market position and to make a profit. At the university, on the other hand, there is the need

for researchers to publish and publicise their research findings to secure positions in universities and the research community (Lundberg & Andresen, 2012).

Central governments in Europe have seen a reduction in their traditional role as sole intermediary between the sub national and supranational level (Zerbinati, 2012). Furthermore, difficulties were diagnosed in the policy decision component in terms of the resources available (e.g. financial, human). This scarcity of resources leads to a lower intensity of interaction by the sphere of politics/government decision making, which may result in the mere bureaucratic monitoring of projects in some cases, deciding only on the provision or non-provision of public funds, according to the setting of EU regulations in the respective area.

Approaching this facet, the government representative, CZ, advances:

> *I myself supervised the Agency for some time. My idea then was to create a Business Institute that would comprise the multitude of institutes existing in the country, the Institute for Quality, the Institute for the Promotion of SMEs, the Institute for Export, the Institute for Innovation, creating one single entity as there are in many countries, a Business Institute, with many more features, with many more means, and enabling this kind of direct monitoring. The Adi I found, on the one hand, with few people and with few resources and too dependent as a publicly owned company, owned by IAPMEI (Institute of Support to SMEs and Innovation) and the Foundation for Science and Technology, with a great need to raise funds for its own work, and therefore little emphasis as a provider of services in design verification and located in the middle of the process and not at the beginning of the process. Again, I think we need a revolution, we must make choices. We cannot distribute the funds in Portugal, the resources and the means, by dozens of structures, for dozens of projects for dozens of industries we really have to make choices.*

Public R&D and innovation funds are important to increase the absorption capacity of scientific and technological knowledge by enterprises, allowing the use of experimental facilities and research by private companies with low additional costs. However, this direct support for R&D and innovation cannot solve market problems or any lack of overall competitiveness (Nishimura & Okamuro, 2011).

According to our observations, there were no major obstacles to A-I interaction even while however highlighting some limitations in terms of interactions with the government, either because of the inelastic EU rules in terms of recognising internal company costs or due to a lack of capacity to monitor projects in the field.

4.4. Funding opportunities

After the project phase, with the definition of a machine prototype (pre-series version), attentions turn to just what mechanisms might be deployed to enhance product placement in international markets. AD adds:

> *We had contact with someone from the venture capital sector and we will see how far we can take this forward.*

About clues and opportunities for the future of this project type, CZ adds:

> *There is a phase in which the main support that should be given is support certification for the company to attract capital. Today, ever more, the concept of Cloud Funding is developing, which I think will have a great future. We have just made a proposal for setting up an independent certifier for innovative products able to certify the product without promotion, i.e., without taking away the ability of innovation, and assigning a fair rating, so that then you can say, for example, on the Internet, we have a product exception in area X, with the level of risk Y, certificate, and there may be people coming with fifty euro, others with a hundred or a hundred and fifty, and generating global funding. These models are new and innovative.*

In terms of the general framework for financing entrepreneurial activities, we may point to a substantial change in the structure of the US economy as a result of investments in technology. However, venture capital and angel markets have limitations in financing the innovation system, and public programmes can play an important role in the development of potential platform technologies that private investors do not fund because of their high risk (Wessner, 2002). In Europe, the EU Framework Programmes, with regard to R&D and innovation, nevertheless have not been able to deal with competitiveness (Luukkonen, 1998). Given the entrepreneurial aspirations in terms of competitiveness and growth, various routes for obtaining resources and funding sources of the activities are still to be found (Malmström, 2014).

First of all, entrepreneurial ideas with strong potential for success must be identified. According to respondents, the financing opportunities for this project type may be at the level of venture capital, business angels or through innovative systems of financing funds.

5. Conclusions

Research and innovation policies have tended to focus on the A-I collaborative context (Bjerregaard, 2010; Perkmann et al., 2013). In the entrepreneurship and innovative diagram, SMEs with academia potential powers a central role in promoting economic growth (Soete & Stephan, 2004). The A-I networks enable a strong contribution to improving regional competitiveness through the development of new projects and new market technologies (Aloysius, 2002; Arranz & Fdez. de Arroyabe, 2008).

This case study also illuminates how A-I cooperation, with access to public funds, do create, through processes transferring knowledge and technology, new tradable products for the market, sometimes with international potential, thereby contributing to the creation of wealth, employability and the development of regional competitiveness levels. In particular, it proved possible to explore the A-I interaction in Portugal from a project surrounded in a spirit of open innovation and financed by public funds.

However, some obstacles still require overcoming: conflicts of interest between the parties undertaking cooperation, a lack of resources both at the academia and the SME levels, some bureaucratic hurdles associated with the access mechanisms to structural funds, which relate to aspects of policymaking. As the main difficulties and limitations encountered throughout the project highlight the legislative rigidity of EU regulations as applied by Adi, refusing to allow for the recognition of internal costs to component development, related raw materials in stock and not acquired specifically for the project and the corresponding attribution of man/hours and machine/hours, there is thus the need to resort to subcontracting in some of these cases, with direct losses in terms of time consumed and the increase in production costs. As noted opportunities for improvement, the government respondent raised the importance of establishing a recognized certification process for such innovation initiatives and involving the assignment of a rating. Through this certification, promoters might more easily obtain financing from venture capital and / or from an innovative "cloud fund" model. We recognise that this research was confined to just one case study, may differ from the totality of the realities experienced in project co-promotion. As a suggestion for future lines of research, we propose the development of a quantitative study, spanning the population of this project type (431 from 2008 to 2012), thus seeking to obtain answers to these questions under analysis here.

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Chapter 6

Measuring Innovative and Entrepreneurial Dynamics: The Regional Helix Scoreboard

Abstract

Nowadays, innovation represents a challenge crucial to remaining globally competitive. This study seeks to develop a conceptual model aimed at measuring the dynamic interactions of the triple / quadruple helix, balancing innovation and entrepreneurship initiatives as pillars of regional competitiveness – the Regional Helix Scoreboard (RHS). To this aim, different strands of literature are identified according to their focus on specific regional competitiveness governance mechanisms. We also put forward an overview of the state-of-the-art of research and is duly assessed. The literature review demonstrates the existence of multidisciplinary approaches attracting various scientific contributions. However, these approaches have remained fragmented and to our understanding each displays limitations. To go beyond these limitations, we develop and propose a new framework of analysis that enables a more integrated approach. We conclude by presenting the RHS for the study of regional competitiveness dynamics, which integrates and associates different backgrounds and identifies a number of key performance indicators (KPIs) for research challenges.

Keywords

Innovation, Entrepreneurship, Regional Competitiveness, Triple Helix, KPIs.

1. Introduction

Sustainability has to be approached within a perspective combining the environmental, economic and social dimensions (Gopalakrishnan et al., 2012). From the perspective of regional development, the competitive production of companies determines the levels of earnings and employability at the level of the regional business environment while demand is determined according to relative costs (Budd & Hirmisf, 2004).

According to Budd and Hirmisf (2004) competitiveness is productivity, the main determinant in the long run of an economy's standard of living. However, Jiang and Shen (2010) argue that competitiveness needs to be viewed in a balanced way, allowing a focus on the sustainable development orientation. Acs & Amorós (2008) see competitiveness as a result weighted by the behaviour of the different variables making up the Global Competitiveness Index (GCI) published annually by the World Economic Forum (WEF), where the pillars of innovation and business sophistication are included. In a more territorial approach, progressive regions have a competitive advantage in attracting opportunities for development, capturing high-tech companies and talent, ensuring greater wealth creation and employability (Audretsch et al., 2012; Audretsch & Peña-Legazkue, 2011; Singhal et al., 2013).

According to the Regional Innovation Scoreboard (RIS) published by the EU, innovation is a key factor determining productivity and economic growth (European Commission, 2012). In parallel, the interest in regional innovation and regional innovation systems as a source of competitive advantage (Asheim et al., 2011) has grown significantly over the past three decades.

The concepts of creativity and innovation are often used as synonyms in the literature, although some authors emphasize the distinction: creativity results in the creation of new ideas; innovation requires its implementation in practice (Iqbal, 2011). From the perspective of Porter and Stern (2001), there is a set of factors transversal to the economy that support innovation and including: the human and financial resources allocated to scientific and technological advances, the level of technological sophistication, the public policies affecting innovation related activities, intellectual property protection, fiscal incentives for innovation and enacting and effectively implementing antitrust and abuse of power legislation. The regional innovation concept is based on an interactive set of private and public interests, formal institutions and other entities that operate in accordance with organisational and institutional agreements and establish relationships leading to the generation and dissemination of knowledge.

Several experts have been advocating innovation and entrepreneurship as determinants of competitiveness and regional development (Porter & Stern, 2001; Wong, 2005; Nordqvist & Melin, 2010).

The advantages associated with entrepreneurship prove unquestionable from the GEM perspective: the creation of new companies resulting from investment in the heart of the local economy, creating new jobs, enhancing competitiveness and developing the tools serving innovative businesses. Entrepreneurship thus becomes a core driver of employment and economic growth and a key factor in sustaining competitive and globalised market economies (Kelley et al., 2011).

Overall, there is a significant relationship between business activities, networking and productivity, not forgetting the importance of entrepreneurship and innovation capacity in the context of competitive aggressiveness (Maritz, 2010). In recent decades, cooperation and networking have become the guiding paradigms for explaining and encouraging regional development. Today, regional networks increasingly have to cope with the competition posed by other networks at the global level (Semlinger, 2008). We should therefore ascertain the actual capacities of local companies to sell their products in external markets, the value of such sales and their productive levels of efficiency while also taking into account the incorporation of local resources and including both human and capital dimensions (Turok, 2004).

The existence of a strong national diamond cluster is crucial to an economy attaining competitive advantage, capable of putting those investment projects into practice able to boost competition between local rivals whilst not overlooking the need to pre-empt increasingly sophisticated and demanding client needs, and ensuring the capacities of local suppliers and industrial clusters (Porter & Stern, 2001; Budd & Hirmis, 2004). According to the logics underpinning regional development, the predominance of the relationships between (A) Academia – (I) Industry – (G) Government (state or municipal) and specific local activities (for example, local technology transfers, the development of human capital and networking), in conjunction, determine better overall results (Lawton Smith & Bagchi-Sen, 2010).

Lundberg and Andresen (2011) testify to how company behaviour and performance does not only depend on endogenous factors but also on their relational networks. As a tool for measuring performance, Kaplan and Norton (2001) developed the Balanced Scorecard, now used worldwide as a strategic management tool (Chytas et al., 2011; Dror, 2008; Kanji & Sá, 2002; Lazzarotti et al., 2011; Mendes et al., 2012; Philbin, 2008; Sundin et al., 2009; Taylor & Baines, 2012; Theriou et al., 2004; Tseng, 2010; Verdecho et al., 2012; Wu & Chang, 2012). However, some limitations are recognized to the model itself including not being able to respond effectively to all situations under analysis. To meet the changing demands to measuring performance resulting from alliances between institutions and projects management for regional development, new models of performance measurement have now been developed from the original BSC model (Al-Ashaab et al., 2011; Loppolo et al., 2012; Philbin, 2008). Unfortunately, the traditional BSC and its upgrades are neither totally appropriate nor useful to measure the performance of the Triple Helix regional interactions (Academia - Industry - Government), in the regional context of innovation, entrepreneurship and competitiveness. Therefore, this paper proposes a Regional Helix Scoreboard model (RHS) to measure the A-I-G interactions and thereby enriching the literature in this area.

Our purpose here is therefore to address four research questions: Question 1. In regional networking, are knowledge and technology transfer and R&D significant for competitiveness?; Question 2. Do the A-I-G collaborative networks play an important role in innovation and

entrepreneurship?; Question 3. What is the role of the government in A-I-G networks? Question 4. How can we measure the impact of A-I-G collaborative networks in regional competitiveness?

This study aims to develop an integrative conceptual model aimed at measuring the dynamic interactions of the triple helix, balancing innovation and entrepreneurship initiatives as pillars of the competitiveness of regions – the "Regional Helix Scoreboard" (RHS).

The article is structured as follows: firstly, we carry out a literature review on innovation, entrepreneurship, competitiveness and the emergence of the triple helix system and its dynamics. Secondly, we set out a Regional Helix Scoreboard model for regional competitiveness. Finally, we put forward our concluding remarks.

2. Cooperation and collaborative networking: the triple helix approach

In the current regional policy, business and cooperation networking are increasingly seen as the key to success (Semlinger, 2008). Networks of R&D cooperation are assumed to be real organizational and economic contexts where companies join other institutions (companies, research centres, universities or others), creating umbrella networks to various locations in order to develop technological projects that can positively affect competitiveness, also here inserting public institutions aimed at promoting the development of their technology policies, sometimes supported by public framework programs to promote the establishment of networks for the development of R&D projects (Arranz & Fdez, de Arroyabe, 2008). Organizations need to establish networks with external entities in order to acquire or have access to resources not otherwise available, especially the acquisition of technological resources, access to infrastructure and technological know-how or the establishment of agreements to comply with financial, economic and legal issues or at the level of knowledge transfer (Awazu, 2006).

For many people, the terms "cooperation" and "collaboration" are indistinguishable. According to Camarinha-Matos & Afsarmanesh (2008), cooperation involves communication & information exchanges; the complimentary goals and aligning activities; the compatibility of goals, individual identities and working apart. Meanwhile, collaboration adds joint goals, joint identities, creating together and joint responsibility - corresponding to a higher level of integration and maturity.

Backing up this perspective on how regional competitiveness and development determine the productive capacity of companies and regional levels of income and employability (Budd & Hirmisf, 2004), other authors highlight the predominance of relationships between academia – industry – government (state, regional or local) and specific local activities in determining the

best business results and outcomes (Lawton Smith & Bagchi-Sem, 2010). Etzkowitz (2008) argues that the interactions of the triple helix are the key to innovation in societies increasingly based on knowledge, helping students, researchers and policy makers to respond to certain questions: How do we strengthen the role of academia in economic and social development at the regional level?, How can governments encourage citizens to take an active role in promoting innovation?, How can firms collaborate with academia and government? The Triple Helix model centres on interactions between A-I-G as the key to improving the conditions required for the innovations at the heart of knowledge based societies. Industry becomes the dynamic to the triple helix, taking on the role of production while the government is attributed responsibility for overseeing the contractual relationships capable of guaranteeing interactions and stable relationships of exchange with universities allocated the role of producing new knowledge and technology. This represents the principle of production underlying knowledge based economies (Etzkowitz, 2003a). Various evolutionary stages need accounting for in terms of the many interactions between the triple helix spheres (Etzkowitz, 2003a; Etzkowitz, 2008). The evolution of innovation systems and the current dispute over which path is most appropriate for university – industry relationships effects the different institutional agreements in terms of the overall A-I-G relationships (Etzkowitz & Leydesdorff, 2000).

The Triple Helix emerges from regional areas of knowledge, innovation and consensus and thus can play an important role in regional development and competitiveness, through the interaction between the different institutional spheres in a networking logic (Cooke & Leydesdorff, 2006; Etzkowitz & Leydesdorff, 2000; Etzkowitz, 2003; Etzkowitz, 2008; Dzisah & Etzkowitz, 2008). Ozman (2009) further underlines that networks indisputably play an important innovation role. Consistent to this interpretation, a series of academic studies has recognised that cooperation between the three institutional spheres (A-I-G) is fundamental to improving regional and national innovation systems (Etzkowitz, 2003a; Etzkowitz, 2003b; Etzkowitz & Leydesdorff, 2000; Cooke & Leydesdorff, 2006; Leydesdorff & Meyer, 2006; Etzkowitz & Dzisah, 2008; Smith & Bagchi-Sen, 2010; Galindo et al., 2011; Huahai et al., 2011). The productive competitiveness of companies and the stability of relationships in terms of policy decision making relating to areas such as the transfer of knowledge and technology have been included within the Triple Helix framework (Etzkowitz & Leydesdorff, 2000; Etzkowitz, 2003a; Etzkowitz, 2003b; Cooke & Leydesdorff, 2006) and proving fundamental to boosting regional innovation systems (Etzkowitz & Dzisah, 2008; Lawton Smith & Bachi-Sem, 2010; Galindo et al., 2011; Halei et al., 2011).

Contemporary relationships deriving from interactions ongoing between the spheres of university and industry are resulting in a third hybrid current whether out of common interests in basic research, partnership projects between industry and higher education institutions as well as through the joint establishment of research and development programs making recourse to multiple sources of financing (Etzkowitz, 2008). Regional policies aim to

nurture spin-off companies as an important mechanism for deepening A-I relationships and generating employment and wealth. Science parks represent an organisational innovation that spread globally throughout the latter half of the 20th century, fostering the emergence of technology-based initiatives. The presence of company incubators may also enhance the opportunities for networking, providing tenants (companies) with the appropriate technical and other support infrastructures and services (Salvador, 2010).

Aligning the triple helix system to the regional competitiveness factor and the innovative activities of local companies, based upon knowledge and high technology, proves the point of departure for a better theoretical understanding (Galindo et al., 2011).

Given the changes in societies that have shaken off domination by a central instance, some authors have felt the case for presenting possible new alternative model scales with four or more helixes based on new variables (Leydesdorff, 2011; MacGregor et al., 2010) fostering regional competitiveness and development (Audretsch et al., 2011). Appointing innovation as the decisive challenge to overall levels of competitiveness, Porter and Stern (2001) refer to a model framework portraying necessary innovative capacities and reporting on the specific infrastructures and clusters present in innovative environments. Referred to by some researchers within the scope of a fourth helix-pillar are independent organisations, without any profit motive and combining public and private financing. They seek to play a facilitating role between the three traditional pillars (A-I-G), channelling public and private investment while simultaneously planning the division of costs associated with R&D programs, sharing infrastructures and supplying technical products and services. They furthermore aim to establish leadership networks in industry and university, set up R&D focused partnerships, facilitate the pathway to excellence through the attraction, development and retention of the highly qualified individuals (MacGregor et al., 2010) necessary to regional competitiveness and development (Audretsch et al., 2011).

3.Finding a tool for measuring A-I-G network performance levels

As proposed by Kitson et al. (2004), regional competitive advantage furthermore inherently requires articulated involvement and action across a multi-level scenario, within which feature the different variants of capital. The model put forward foresees articulated and dynamic interactions between teaching and research, R&D, human and creative capital; productive capital, financial capital, as well as political options. Supporting the Kelley et al. (2011) perspective, these capital factors combine to establish partnership and cooperation networks enabling the pro-innovation and entrepreneurial environment necessary to attracting investment and providing employment through the creation and maintenance of jobs (enhanced through the valuing of personal competences). Furthermore, increased

business sophistication similarly confers a higher level of regional competitiveness through the provision of non-standardised goods and services of greater added value in the marketplace.

Lawton Smith et al. (2005) focus on entrepreneurship and the geography of talent directly linked to economic performance and also constituting a strong contribution to the sustainable development of the regions.

Other authors argue that entrepreneurial activity is an important mechanism for regional development through job creation and creating local wealth, whether it comes from the transfer of knowledge and technology from academia or simply through the creation of new businesses (Nordqvist & Melin, 2010; Salvador, 2010; Todorovic et al., 2011).

According to Van Looy et al. (2011), the logic of "university ventures" is tightly bound up with the existence of shortcomings in the innovation market. There are two trends shaping the framework of contemporary developments in relationships between university and industry: interests in basic research financed by research entities and councils and industrial projects, which universities are invited to participate in, with a third hybrid current emerging from the formulation of joint research programs making recourse to multiple sources of financing (Etzkowitz, 2008).

According to Gopalakrishnan et al. (2012), sustainability should also be perceived within a three-dimensional approach: environmental, economic-financial and social, thereby boosting the competitive advantage of regions. Harris et al. (2009) point out how ethics and entrepreneurship remain inherently bound up and of particular relevance within the framework of entrepreneurial activities and regional development.

Building on the work of Porter and Stern (2001) and the need for inter-organisational networks, Huahai et al. (2011) stress the need for the interactive engagement of public and private interests based on the dissemination of knowledge and technology within the context of new regional innovation clusters. The triple helix spheres, while set out contextualised within their external environment (the political, economic, social, cultural and technological contexts), as dealt with in the GEM report in Kelley et al., (2011), describe the dynamic and interactive movements of partnerships, supported by and in the format of cooperative networks striving to boost competitiveness, a perspective also defended by Huahai et al. (2011).

From the Global Entrepreneurship Monitor perspective, launching new companies results in investment and job creation enhancing greater competitiveness and development and correspondingly boosting local economic growth (Kelley et al., 2011). The increasing levels of local intellectual capital and institutional support (Etzkowitz & Dzisah, 2008) enable the development of an interactive group of private and public interests, acting through a network

of organisational and institutional agreements and fostering the dissemination of knowledge, technologies and regionally located innovation skills and capacities (Huahai et al., 2011).

Aiming to answer the basic research questions formulated, and based on the literature review conducted, we found the need to measure the performance of the resulting A-I-G network interactions in order to make it possible to measure their impact on regional competitiveness (see figure 1).
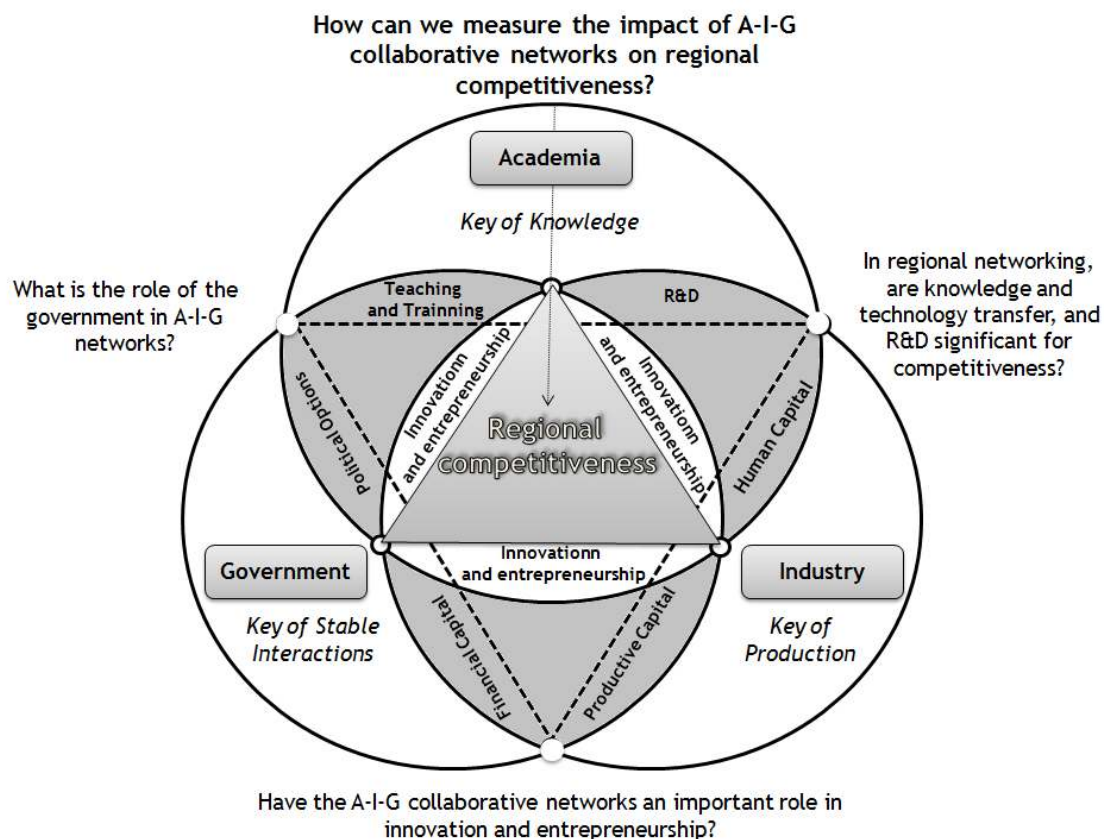
Figure 1 – The triple helix dynamics

The balanced scorecard (BSC) was developed by Kaplan & Norton (1992) to give managers a balanced view of organizations working with other important strategic factors - from continuous improvement and partnerships to teamwork and global scale, besides the classical financial measurements. The BSC seeks to provide answers to four basic questions:

- How do customers see us? (customer perspective)
- What must we excel at? (internal business perspective)
- Can we continue to improve and create value? (innovation and learning perspective)
- How do we look to shareholder? (financial perspective).

Targeting a new impulse to the implementation of the BSC, an article published in the Harvard Business Review set out three case studies applying the scorecard to measure performance and strategy (Kaplan & Norton, 1993). In another work, Kaplan & Norton (1996) presented the BSC as a strategic management system, redefining the four perspectives from vision statements and organizational strategy. The purpose was building a scorecard able to help managers link today's actions with tomorrow's goals. Invoking that the key to executing strategy is to have people in companies understand it, they stress how strategy maps may help traverse this difficult terrain (Kaplan & Norton, 2000).

The BSC developed by Kaplan & Norton (2001) is today used globally as a strategic management tool for measuring performance (Al-ashaab et al., 2011; Chytas et al., 2011; Dror, 2008; Ioppolo et al.,, 2012; Kanji & Sá, 2002; Lazzarotti et al., 2011; Mendes et al., 2012; Philbin, 2008; Sundin et al., 2009; Taylor & Baines, 2012 ; Theriou et al., 2004 ; Tseng, 2010; Verdecho et al., 2012; Wu & Chang, 2012). However, some limitations are recognized as to the model itself and identified as unable to respond effectively to all situations under analysis (Welter et al., 2010; Al-ashaab et al., 2011; Chytas et al., 2011; Ioppolo et al., 2012; Kanji & e Sá, 2002; Philbin, 2008; Verdecho et al., 2012).

4. Data collection and method

Having defined the general framework of innovation, entrepreneurship, competitiveness and the dynamics of the triple helix, we performed a systematic review of the literature about BSC and BSC for networking performance measurement. Such a literature review establishes the state of the art in a specific field (Tranfield, Denyer, & Smart, 2003; Perkmann et al., 2013). For the current article, we followed a simplified version of the process outlined by Tranfield et al. (2003), previously already advocated by Perkmann et al. (2013), that we detail below.

Our objective is to analyse the state of the art on BSC to measure the performance of networks of cooperation and collaboration between different agents. To this end, we applied the following procedure. We first identified all the relevant research published on BSC from 1990 to 2013. We carried out an extensive search through the titles and abstracts of published, peer-reviewed articles held in the bibliographical database Thomson Reuters (ISI) Web of Knowledge, using a predetermined series of keywords (BSC; Cooperation BSC; Collaborative BSC; and Networking performance measuring). We subsequently performed a manual search of the journals with the highest article citations over the past 21 years (1992-2013), filtering the records of the 50 most cited articles in that time period from the around 1,000 articles identified.

Analyzing the trend towards a greater increase in publications about BSC, we encountered a boom between 2010 and 2013. For performing the literature review search, we followed a constructivist methodological approach consisting of the identification of a problem of practical relevance, its theoretical connections and the acquisition of its main postulates (Alfaro et al., 2009; Verdecho, Jua-Jose Alfaro-Saiz, et al., 2012). Thus, we decided to apply a filter adjusted to this time period under analysis - we filtered the records with the most cited articles from 2010 to 2013 achieving a synthesis with the 25 most cited articles in ISI journals. This composed a summary table providing a comparison between the articles within the historical perspective of the 50 most cited and the most recent trend of the 25 most cited (see table 1).

Table 1 – Synthesis of articles most cited by time series

Journal	No. of articles	Citations	Journal	No. of articles	Citations
1992 - 2013: Top 50 - times cited (historical perspective)			**2010-2013: Top 25 - times cited (most recent trend)**		
Accounting Organizations and Society	6	382	Omega - International Journal of Management	3	16
Harvard Business Review	5	2072	Accounting Review	2	6
Accounting Review	4	351	Expert Systems with Applications	2	9
Long Range Planning	3	201	Environmental Monitoring and Assessment	1	21
Expert Systems with Applications	3	157	Technological and Economic Development of Economy	1	20
California Management Review	2	171	Journal of The Royal Society Medicine	1	11
International Journal of Operations & Production Management	2	171	International Journal of Hospitality Management	1	9
Computers & Industrial Engineering	2	148	Evaluation and Program Planning	1	7
European Journal of Operational Research	2	114	Plos Medicine	1	6
Journal of Operational Research	2	114	Clinical Psychology-Science and Practice	1	5
Computers in Industry	2	101	Journal of Operations Management	1	4
Others	17	1301	Others	10	26
Sum	*50*	*5283*	*Sum*	*25*	*140*

Having completed this stage, and better understanding trends in the usage of the BSC performance measurement within networks of cooperation and collaboration, we again applied a filter to our database.

This time, restricted to the keywords "cooperation BSC; collaborative BSC; and networking performance measurement", applied to the period prescribed between 1992 and 2013. After

content analysis, we attained a list with the 10 most cited articles, which establish the basis for the development of our model (see table 2).

Table 2 – BSC for networking performance measurement: top 10 - times cited (1992-2013)

Author(s)	Journal	Title	Methodology/ Method	Year	Citations
Alfaro et al. (2009)	International Journal of Computer Integrated Manufacturing	Business process interoperability and collaborative performance measurement	Conceptual	2009	8
Stanley et al. (2010)	Contemporary clinical trials	Development and implementation of a performance measure tool in an academic pediatric research network	Case study	2010	2
Herath et al. (2010)	Journal of Accounting and Public Policy	Joint selection of balanced scorecard targets and weights in a collaborative setting	Mathematical programming models/Simplex Method	2010	2
Ioppolo et al. (2012)	Land Use Policy	Developing a Territory Balanced Scorecard approach to manage projects for local development: Two case studies	Two case studies	2012	2
Perkmann et al. (2011)	R&D Management	How should firms evaluate success in university-industry alliances? A performance measurement system	Conceptual	2011	2
Verdecho et al. (2012a)	Omega - International Journal of Management	A multi-criteria approach for managing inter-enterprise collaborative relationships	Case study/Analytic Network Process (ANP)	2012	1
Verdecho al. (2012b)	Decision Support Systems	Prioritization and management of inter-enterprise collaborative performance	Quantitative/Analytic Network Process (ANP)	2012	1
Wu and Chang (2012)	Decision Support Systems	Using the balanced scorecard in assessing the performance of e-SCM diffusion: A multi-stage perspective	Quantit./struct. equation modelling (SEM)	2012	1
Chytas et al. (2011)	International Journal of Information Management	A proactive balanced scorecard	Fuzzy logic/Fuzzy Cognitive Maps (FCMs)	2011	1
Al-Ashaab et al.(2011)	Production, Planning & Control	A balanced scorecard for measuring the impact of industry-university collaboration	Two case studies	2011	1

In the range of selected articles, we find works applied to different areas or sectors of activity, from health, management or science of computing, and applying different methodological approaches.

5. Proposed Regional Helix Scoreboard (RHS)

Collaboration amongst enterprises is a common strategy deployed to increase competitiveness. Therefore, this requires the measuring of the performance of these business processes under a strategic approach from an inter-enterprise perspective, defining and using performance measurement/management frameworks composed of performance related factors (objectives, performance indicators, etc.) that facilitate the management of activities as well as monitoring strategy and processes (Alfaro et al., 2009; Verdecho, Alfaro-Saiz, Rodriguez-rodriguez, et al., 2012; Verdecho, Juan-Jose Alfaro-Saiz, et al., 2012).

Promoting high quality research networks inherently requires the establishment of evaluation tools for measuring performance and the corresponding definition of metrics and performance indicators (Stanley et al., 2010). While companies increasingly engage in formal alliances with universities, there is a lack of tools for evaluating the results of these collaborations (Perkmann, Neely, & Walsh, 2011).

The BSC is considered such a strategic measurement tool. Various companies have applied it to measure four key perspectives of their organisation's performance: financial, customer, internal business processes and learning and growth. However, this original model was not developed to measure the impact of collaborative research projects ongoing under an open innovation strategy (Al-ashaab et al., 2011).

In order to meet these new measuring performance requirements resulting from collaborative alliances between institutions, new performance measurement models were developed out of the original balanced scorecard model (Al-Ashaab et al., 2011; Ioppolo et al., 2012; Philbin, 2008). Al –Ashaab et al. (2011) put forward a balanced scorecard for measuring the impact of industry–university collaboration – the collaborative BSC, and Ioppolo et al. (2012) developed the Territory BSC to manage local development projects (see table 3).

Table 3 – Characterization of different performance measurement models

		Metrics													
		Internal view					Networking view								
		Basic perspectives					Intra-company	Inter-enterprises		Academic research network				A-I Collaboration		Internat. Cooperat Projects
	Author(s)	Financial	Customer	Internal Business Processes	Innovation and Learning	Learning and Growth	Collaborative decision-making	Inter-enterprises business process interoperability	Collaborative enterprise network	General contributions	Intellectual development	Project implementation	Timely project completion	Inputs; In-process activities; Outputs; Impact	Competitiveness; Sustainable Development; Innovation; Strategic Knowledge Partnerships; Human Capital; Internal Business Processes	Internal Processes; New Public Governance; Learning & Innovation; Territory Strategic Development
Original model	Kaplan (1992)	X	X	X	X											
	Kaplan (1993)	X	X	X	X											
	Kaplan (1996)	X	X	X		X										
	Kaplan (2000)	X	X	X		X										
Evaluative model	Alfaro et al. (2009)							X								
	Stanley et al. (2010)									X	X	X	X			
	Herath et al. (2010)	X	X	X		X	X									
	Verdecho, Jua-Jose Alfaro-Saiz, et al. (2012)	X	X	X	X				X							
	Verdecho, Jua-Jose Alfaro-Saiz, et al. (2012)	X	X	X	X			X								
	Perkmann et al. (2011)													X		
	Al-ashaab et al. (2011)														X	
	Ioppolo et al. (2012)															X

In terms of regional economic development, Russ & Jones (2008) has defined a set of indicators related to a knowledge-based economy. Additionally, Figueira et al. (2012) presents a set of indicators within the innovation ecosystem in the Centro region of Portugal.

The KTForce is a project supported by the INTERREG IVC Capitalisation Programme, co-financed by the European Regional Development Fund (ERDF), and its aim is to improve the effectiveness of regional development policies in the fields of innovation and the knowledge economy. This involves eleven partners from six regions, covering "modest and moderate innovator" regions (Lithuania, Portugal and Romania) and "innovation follower and leader" regions (France, Germany and Ireland) (European Commission, 2012; KT Force, 2013). For the measuring of innovative performance, the KTForce project comprises a set of indicators, distributed by pillars "Technology licensing", "Spin-offs creation and entrepreneurship" and "University-Industry relations" (KT Force, 2013).

The quality and abilities of the labour force (human capital); the extension, depth and focus of social and institutional networks (social/institutional capital), the range and quality of infrastructure as well as cultural assets (cultural capital), the presence of a creative and innovative class (knowledge/creative capital) and the quality of infrastructural policies and results (infrastructural capital) are all deemed to be critical factors in supporting and determining regional economic outcomes (Kitson et al., 2004).

Recent developments saw concerted efforts by emerging countries to transform their industrial-based economy into post-industrial knowledge-based economy. The growth of science and technology is necessary to support this economic transformation strategy. The number of published papers and patents as proxies are important indicators of growth performance measurement (Wong & Goh, 2012).

Seeking to fill some of the gaps in the literature on a global model for A-I-G interaction performance measurement, we now proceed with setting out a new conceptual model, based upon the Triple Helix model, as defended by a vast range of authors (Cooke & Leydesdorff, 2006; Etzkowitz, 2003a; Etzkowitz, 2003b; Etzkowitz & Leydesdorff, 2000; Etzkowitz & Dzisah, 2008; Galindo et al., 2011), focused on innovation and entrepreneurship as critical factors to regional competitiveness through their capacities to stimulate new investment and job creation, thus driving economies to attain new standards of competition (Kelley et al., 2011).

In this context, we present the Regional Helix Scoreboard (RHS) (see figure 2).
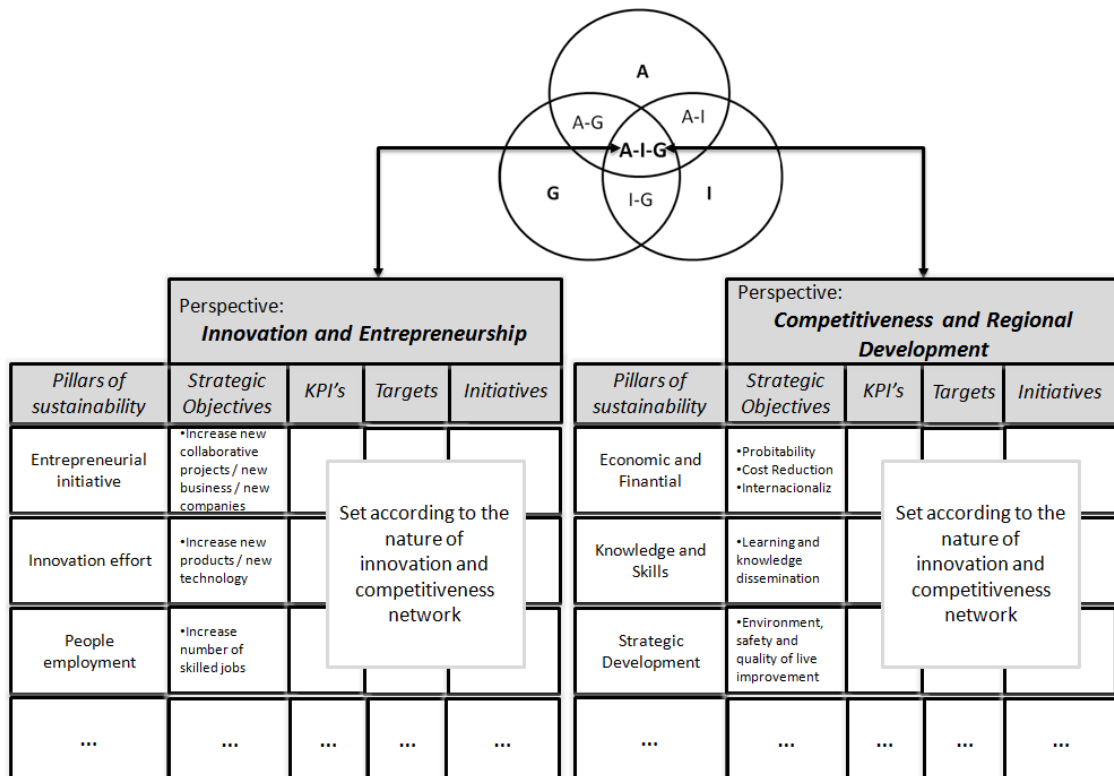
Pillars of sustainability	Strategic Objectives	KPI's	Targets	Initiatives
Entrepreneurial initiative	•Increase new collaborative projects / new business / new companies			
Innovation effort	•Increase new products / new technology	Set according to the nature of innovation and competitiveness network		
People employment	•Increase number of skilled jobs			
...	...	...	...	...

Pillars of sustainability	Strategic Objectives	KPI's	Targets	Initiatives
Economic and Finantial	•Probitability •Cost Reduction •Internacionaliz			
Knowledge and Skills	•Learning and knowledge dissemination	Set according to the nature of innovation and competitiveness network		
Strategic Development	•Environment, safety and quality of live improvement			
...	...	...	...	...

Figure 6 – Regional Helix Scoreboard model

Adjusted to the dynamics of the Triple Helix, and designed from the various inputs identified in the literature review, the THS derives from the initial BSC model (Kaplan & Norton, 1992), focuses on perspectives about "Innovation and entrepreneurship" and "Competitiveness and regional development" in order to measure the performance of the A-I-G interactions. Thus, for each of the perspectives, the model proposes a set of pillars of sustainability, which are the defined strategic objectives, KPIs, targets and initiatives and collectively aiming to answer the central research question: how do innovation and entrepreneurship linked to the dynamics of the triple helix contribute to increasing regional competitiveness and development?

In this perspective, "innovation and entrepreneurship" are identified through three main pillars of sustainability: "entrepreneurial initiative", "innovation effort", and "people employment". Regarding the perspective "regional competitiveness and development", the following pillars of sustainability were selected: "economic and financial", "knowledge and skills", and "strategic development". For each perspective and for each pillar of sustainability, strategic objectives and KPIs are defined and subject to adjustment in accordance with the nature of the respective innovation and competitiveness network.

Some of the most relevant "Innovation and entrepreneurship" strategic objectives and KPIs are:

- *Strategic objectives / KPIs*:
  - Increase in new collaborative projects / new business / new companies
    - Number of new companies created
    - Number of technology based companies created (spin-off)
    - Number of companies created > 250 employees
    - Number of grants funding start ups
    - Total number of value propositions developed
    - Total number of new business plans developed
    - Number of successful proposals developed collaboratively to obtain public funding.
  - Increase in new products / new technology
    - Number of patent requests and patents
    - Number of industrial property licenses
    - Number of intangibles resulting from collaborative projects in the form of patents, licenses, copyright or trademarks.
  - Increase in jobs
    - Number of jobs created
    - Number of skilled jobs created.

For "Competitiveness and regional development":

- *Strategic objectives / KPIs*:
  - Profitability
    - Turnover
    - Sales
  - Cost reduction
    - Percentage of cost savings thanks to alliances
    - Percentage of cost savings thanks to university-based research.
  - Internationalization
    - Export volume percentage
    - Linkages between international cluster networks.
  - Learning and knowledge dissemination
    - R&D spending
    - Number of joint publications in scientific journals or conferences.
  - Environment, safety and quality of life improvement
    - Number of projects developing new models and/or methods to improve sustainability practices: health and safety, recycling methods, sustainable construction, etcetera
    - Percentage of component reutilisation
    - Number of collaborative projects that environmentally or socially improved any region or facility.

Finally, so that evaluative conclusions may be drawn about performance, the definition of *future target values* and *Initiatives with targets to meet* are proposed.

We would note that depending on the nature of the A-I-G interaction (A-I collaborative projects; regional clusters, science parks and technology business incubators, etcetera), attention should be paid to appropriately adjusting the strategic objectives and KPIs.

6. Concluding remarks

This study puts forward an integrative conceptual model displaying a dynamic and interactive triple helix model able to clarify the role of innovation and entrepreneurship as factors of regional competitiveness. Entrepreneurship is defined in the literature as a high risk dynamic and with an especially high binomial level of effort-reward. Companies need to be able to innovate in the global marketplace, designing, producing and commercialising new products and evolving faster than their rivals.

The development of regions may correspondingly be segregated into exogenous development and endogenous development (Etzkowitz & Dzisah, 2008). The triple helix model focuses on interactions ongoing between universities – industry – government as the key to improving the conditions necessary to innovation, based on changing the paradigm from industrial societies to knowledge based societies. Strengthening this perspective on regional competitiveness and development, the productive private sector capacity determines the prevailing levels of regional earnings and employability (Budd & Hirwist, 2004). From the Global Entrepreneurship Monitor perspective, the launch of new companies results in investment inflows, new jobs and driving overall competitiveness and development (Kelley et al., 2011).

The TH relational model reflects the interaction of relationships ongoing between three institutional spheres (university – industry – government) designed to secure regional competitive advantage within the framework of actions interrelated across a multi-level scenario. The TH model thereby serves as the point of departure for designing and implementing empirically based studies, susceptible to providing responses to the questions raised relative to the interactions taking place in the different spheres. This is, in turn, based on the assumption of a positive relationship between the dynamics of innovation and entrepreneurship for regional competitiveness and development that needs empirical validation with recourse to the appropriate research methodologies (quantitative and/or qualitative). Our model, in the context of the dynamics of regional areas of the triple helix, seeks to answer the research questions presented in the introduction to this chapter and thus provides a mechanism for measuring the impact of these networks on regional competitiveness.

Considering the pertinence of developing this theme in future research, and irrespective of the prevailing economic conjuncture – with recessionary pressures at the global level and reflecting in the rescaling and postponement of new investment projects despite the corresponding need for job creation within the framework of a globalised and competitive economy in which innovation stands out as a key factor for competitiveness, all combine to ensure the priority attributed to regional development and its associated competitiveness.

This inherently requires the dissemination of knowledge and technology through a sustainable inter-organisational network. Based on this assumption, as future lines of research, we would suggest the empirical testing of the RHS as a tool for measuring the performance of triple/quadruple helix dynamics created from the Balanced Scorecard model and its developments in the fields of territorial and inter-organization collaborative relationships, now adjusted to the specific interactions of the triple helix.

Finally, we suggest studies which combine quantitative and qualitative research, with the creation and validation of instruments for collecting data through observation and document analysis, field notes, interviews and questionnaires in order to most fully test the Regional Helix Scoreboard here developed.

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Part III

Chapter 7

Final considerations

In the introduction, we formulated the general research objective of this study: "to understand the overall contribution of innovation and entrepreneurship to the socio-economic development of regions". Chapter 2 relates to this aim in explaining the competitive performance of economies through the factors of innovation and entrepreneurship. As our research perceived a need for additional diagnosis support regarding innovation and entrepreneurship ecosystems and collaborative networks, Chapters 3, 4 and 5 focus on this theme. Chapter 6 aims to draft a support conceptual model for measuring performance in the context of these cooperative and interactive triple and/or quadruple helix networks. This final chapter summarizes the main findings derived from the chapters after which some general observations and insights learned from the empirical studies are discussed at the end of this chapter.

This also covers the main constraints identified during the development of the chapters and identifies paths for further research.

1. Main research findings

The socio-economic prosperity of countries and regions depends on their competitive advantages, including their positioning in global markets, their ability to attract investment (including foreign direct investment), their ability to attract and retain skills, which together dictate their overall ability to generate wealth, job creation and social welfare (Buesa et al., 2010; Cantner et al., 2008; Stajano, 2006, 2009 et al., 2012).

Innovation (from new technological and non-technological knowledge) and the sophistication of the business (which includes factor of production efficiency, the quality of management operations and organisation strategies, the quality of cooperation networks between business and stakeholders, the capacity for agglomeration among firms operating in regional clusters, the quantity and quality of local suppliers, among others), represent the foundations for development in advanced economies (Batterink et al., 2010; Gellynck et al., 2007; Karlsson & Warda, 2014; Schwab, 2013). A strong current of authors argue that entrepreneurial activities, especially when focused on factors of innovation, provide the key to economic and social development (Audretsch & Belitski, 2013; Audretsch et al., 2012; D. Audretsch & Fritsch, 2003; Landström et al., 2012; Landström & Johannisson, 2001; P. Witt, 2004; U. Witt, 2002; Ylinenpää, 2009).

For the central issue to our study, encapsulated by the dependent variable "competitiveness" with "GDP per capita" as the control variable, the results obtained in Chapter 2 reported that most advanced economies (the top 25) display strong stability between the pillars of "Innovation" and "Business sophistication" when compared to the GCI trend and contrary to other economies.

According to the literature review, our SEM conceptual model of competitiveness through innovation and sophistication confirmed the hypotheses that the competitiveness of economies is explained by innovation and business sophistication, with a strong association between the stage of development of each economy and its level of competitiveness.

The outcomes from the application of hierarchical cluster analysis enabled us to confirm not only innovation and entrepreneurship as factors of competitiveness but also identified five clusters: (1) Balanced low performance; (2) Moderate competitiveness; (3) High competitiveness, (4) High GDP per capita, and (5) Performance excellence.

Starting from the 2nd goal of this thesis "to understand and compare the trajectories of innovation and entrepreneurship in two European regions positioned at different levels of regional competitiveness and aiming to identify the importance of the geo-political contexts in shaping regional diversities and specificities, in the context of Chapter 3 we applied the regional triple helix model and the regional innovations systems concept. Although starting from a distinct historical context, both regions are recognized nationally as important centres of entrepreneurship. The Centro region runs a clear strategy and a well formalized system of regional management. In Oxfordshire, public private partnerships have done more to foster clusters of activity rather than create a coherent system, making Oxfordshire a region of entrepreneurial success.

Furthermore, the local policy based on regional intelligence allowed a comparative understanding of the strengths and weaknesses of each region, identifying new competitive challenges within the context of implementing "innovation spaces" (Etzkowitz & Dzisah, 2008a, 2008b; Etzkowitz, 2003). The implication is that each region should focus on their own strengths and their endogenous resources to enforce new standards of regional competitiveness. Thus, the Centro region does not need to follow the exact trajectory of Oxfordshire. What may prove common is that need to find the path of excellence for academia and research, focusing on the triple / quadruple helix model for knowledge and technology transfer. Continuous investment in innovation and business sophistication and the foundations of regional development must be deemed a priority.

Nevertheless, Portugal still has a problem of internal cohesion to solve. The Horizon 2020 Programme and RIS3, more than for Oxfordshire (whose technological and entrepreneurial

trends owe much to the high scientific quality of the public sector and highly qualified labour market), constitute a major development opportunity for the Centro region.

The third goal of our research focuses on "contributing to studying the competitive dynamics of innovation within the networking technology cluster in the Centro region of Portugal. According to Porter and other authors, clusters perform a key role in the development of competitive economies and regions, taking on a much broader mission than simply organising thematic events or participating in international fairs in whatever the specialist area (Ketels, 2006; Porter & Stern, 2001; Porter, 1990, 1998). Thesis chapter 4 presents a better understanding of the competitive positioning of the Portuguese Engineering and Tooling Cluster in the global marketplace in accordance with its initiatives and networks of innovation and entrepreneurship.

From analysis of the business agglomerate, we conclude that, of the nearly 600 firms that remain active in the sector, 61% are micro firms and 33% are small firms, employing up to 20 workers on average. Assuming a globally important socio-economic impact on the regional and national economy, the cluster provides jobs for about 8,000 people, contributing to the economy with a turnover in excess of 500 million Euros with more than 70% of this total stemming from the automotive sector with about 80% of output exported, which puts Portugal into the top ten of exporting countries in this industry.

With a strong presence in the development of collaborative RDI projects in the triple helix action sphere, the cluster works in the areas of "product, engineering and process", "innovation, prospecting and networking", projects "to sensitize young people to the industry" and other transversal programmes that aim to enhance cluster intelligence and competitiveness. Integrated into important networks of technological innovation and cooperation (such as the European project Wintech - Worldwide initiative for new intercluster materials and processes focused on clean technologies and ISTMA - International Special Tooling & Machining Association), the Portuguese cluster invested in promoting a collective brand: "Engineering and Tooling from Portugal". In the context of networks, more specifically in academia-industry interactions, the cluster welcomes Master's and Doctoral Programs and having started the "Engineering & Tooling Exhibition" last year, which attended four higher education institutions in the Centro region.

A leading group of authors argues that research and innovation policies tend to concentrate within AI interactional contexts through the development of new projects and new technologies for the market and thereby making an important contribution to regional competitiveness (Bennett et al., 2012; Bjerregaard, 2010; Pablo D'Este & Perkmann, 2010a; Perkmann et al., 2013, 2011; Petruzzelli, 2011; Plewa et al., 2013; Soete & Stephan, 2004; Vaz et al., 2014).

In accordance with goal number 4 of our research project, "to analyze processes of knowledge and technology transfer, thus cooperation between Academia and Industry through an EU funded R&D project," Chapter 5 illuminates the emergence of new tradable products in the market with international value, which corresponds to a socio-economic contribution to the territories reflecting in both maintaining and creating jobs and wealth. Following on the ground the process of designing and developing an innovative olive harvest machine that operates on a continuous regime, it proved possible to confirm the importance of innovation and entrepreneurship networks, in this case represented by a scientific and technological system, ICAAM - the Institute for Mediterranean Agricultural and Environmental Sciences, the University of Évora, one SME operating in the mechanical engineering industry, with experience in international markets and an agricultural entrepreneur, a member of Portugal's olive oil producers association, building project value through contributions from open innovation. However, we also report on some difficulties relating to bureaucracy and accessing public funding experienced throughout project development.

In order to facilitate reader understanding of the entire literature review and the outcomes of empirical research undertaken in this thesis, we developed the following model synthesis referred to as the "Regional Helix Turbine" (see figure 1).
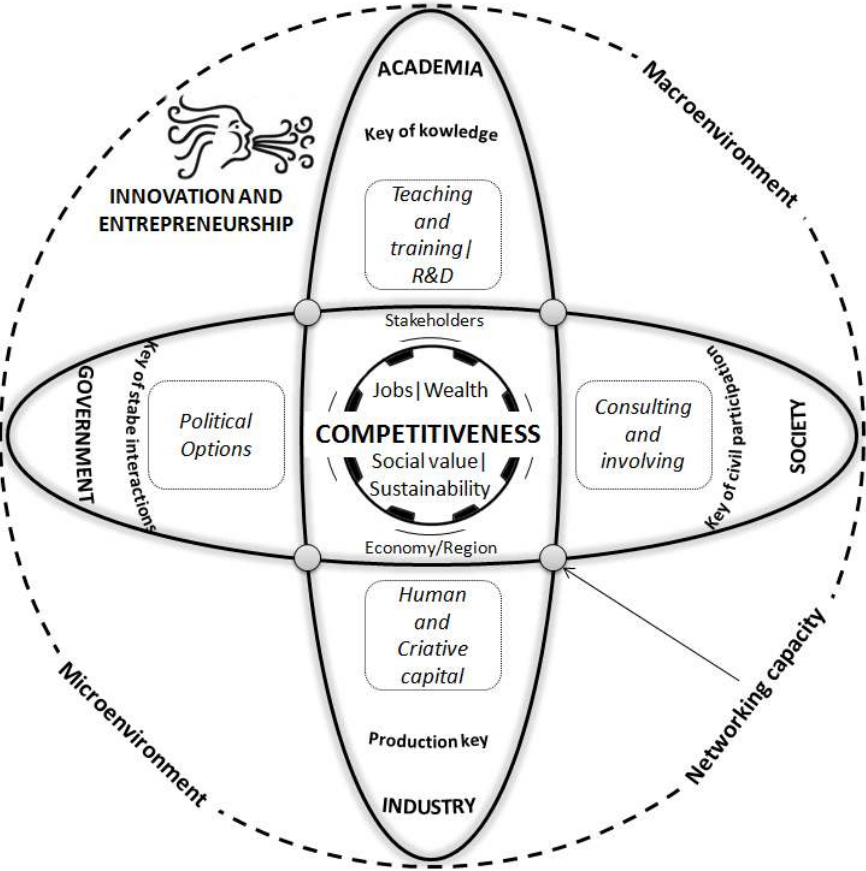

Figure 1 – Regional Helix Turbine Model

In keeping with goal number 5 of the thesis, "to find a support model for performance measurement in the context of collaborative triple/quadruple helix networks", whose relevance is advocated not only throughout chapter 6 and the literature review but also in the empirical research findings set out in chapters 2 to 5, we also propose a new conceptual performance measurement model named the "Regional Helix Scoreboard".

The model aims to measure the impact of competitive performance on the dynamics of innovation and entrepreneurship, embedded in the "Regional Helix Turbine" context, further facilitating comparisons between regions in these terms.

2. Limitations and future lines of research

Unfortunately, in the context of Chapter 2, not all GCI countries are available in the GEM study, forcing a restriction and analysing only the variables available in both studies in the comparative analysis. In our case, this approach opens up new avenues for the development of empirical research in the context of comparisons between regional spaces through recourse to the variables intrinsic to the pillars of innovation, entrepreneurship and business sophistication.

Concerning the comparisons between triple helix regional spaces carried out in Chapter 3, we initially experienced some difficulties in obtaining equivalent quantitative data for both regions that were subsequently overcome through the triple helix model adopting a more qualitative approach. We believe that the new model proposed (the Helix Regional Scoreboard) represents an important aid in systematizing and defining comparative information whilst also assisting in the search for new key performance indicators for regions.

The context of innovation and entrepreneurship networks within the cluster managing the moulds industry in Portugal (Engineering & Tooling), discussed in Chapter 4, displays high complexity and a broad scope involving a very wide range of partner organizations, projects and ongoing partnerships. Clearly a challenge rather than a limitation, this complexity actually appears as a huge opportunity for the development of future empirical research in both the fields of management and engineering. As suggestions for future lines of research on Triple Helix interactions in high-tech sectors, we propose deepening the debate on the context of areas of RDI and technological entrepreneurship in order to maximize new international collaborative networks (comparing Portuguese Engineering & Tooling with its other counterparts in Europe and on other continents or comparing with other mechatronics area clusters, e.g. Bucharest - Mechatronics Ilfov regional cluster – Mechatrec).

We acknowledge certain limitations in the empirical research carried out in Chapter 5 despite dealing with a case study on a collaborative A-I project extracted from the population of

projects supported by the Portuguese Innovation Agency (Adi). In this area and as a suggestion for future lines of research, we propose the development of a quantitative study, encompassing the universe of such projects, thus seeking to obtain answers to the questions under analysis here.

Finally, in summary of the whole thesis work, we plan to implement the "Regional Helix Scoreboard" for a comparison between the Oxfordshire and Centro regions involving the time validation of the model before its application to other regions.

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List of Annexes

Annex I – (Chapter 4)

Interview guide with leaders of Pool-net and Centimfe under the Portuguese Engineering & Tooling Cluster

Annex II – (Chapter 5)

Interview guide to the interveners in the project MCCA_II

Annex I

Interview guide with leaders of Pool-net and Centimfe under the Portuguese Engineering & Tooling Cluster

Part I – Focus group

<u>Methodology and objective</u>: focus group / collective semi – structured interview, based on a generic guide, previously given to respondents.

The purpose of the session aimed to explore and understand the competitive dynamics into the Portuguese Engineering & Tooling cluster, the prospects for innovation, entrepreneurship and regional competitiveness.

The session was led by Luís Farinha.

<u>Date</u>: October, 2013.

<u>Time</u>: 1.5 hours (10:30AM-12:00AM).

<u>Location</u>: Centimfe, Marinha Grande.

<u>Participants:</u>
- [CV]- Dr. Cecilia Vicente –Department of Innovation, Centimfe
- [RT] - Dr. Rui Tocha - CEO of Net-Pool and Centimfe
- [RS] - Rui Soares - Technology Watch, Centimfe
- [AB] - Antonio Batista - Technology Watch, Centimfe
- [DS] - Dulcinia Santos - RDI projects, Centimfe

<u>General information</u>: The goal of the session was introduced. The guide of the interview was delivered to respondents, before the start of the debate. The interview was recorded, with the permission of all participants. The context was very informal.

<u>General guide available for interview:</u>
- What is the role of the Pool-Net Association and its importance for the competitiveness and dynamism of the Cluster "Engineering and Tooling"?
- How to Pool-Net Association, Centimfe and Cefamol hang together, and what their respective roles?
- What is the role of the Pole of competitiveness in boosting factor "Innovation" in the moulds and special tools Industry on Portugal?
- What are the dynamics of entrepreneurship developed within the cluster?
- How can measure the contribution of the cluster in terms of regional development? What indicators can be highlighted?
- What is the intervention of the pole of competitiveness to the level of R & D?
  - Support R & D
  - Strengthening inter-technological cooperation
  - Licensing / Intellectual Property
  - Other
- What is the intervention of the pole of competitiveness to the level of funding support?
  - Access to debt financing

- Access to Business Angels
- Access to Venture Capital
- Access to other sources of funding
- Support to the implementation of investment projects / access to structural funds
- Other
- What is the intervention of the pole of competitiveness to the level of support for the strengthening of entrepreneurial capacity?
  - Training and experience of entrepreneurs
  - Entrepreneurship and and management skills
  - Infrastructure to support entrepreneurship
  - Other
- What is the intervention to the strengthening of the competitiveness of the dynamic cluster level?
  - Supporting the development of new products / processes
  - Support the improvement of product / process
  - Inter Synergies (central purchasing consortia, R & D, training, ...)
  - Development of a collective mark
  - Support for internationalization
  - Strengthening relationships of cooperation Academy - Industry (collaborative projects, R & D, scientific publications, books, supporting the realization of masters / doctoral theses, ...)
  - Other
- What is the intervention of the pole of competitiveness with the regional community by strengthening the entrepreneurial culture level:
  - Attitude towards risk?
  - Entrepreneurial Attitude?
  - Desire to have your own business?
  - Education for entrepreneurship?
- Innovation: Type of support? Types of innovation?

Types of innovation?

- (New products, new processes and procedures in production, introduction of new processes and procedures in the administrative process, new image / brand redesign, marketing innovation, social innovation, open innovation, ...).

Other topics / question followed throughout the interview:
- Pool-net framework, as manager of the Networking in the cluster. What's to know?
- What is the entity that manages this network in the commercial side?
- How does the approach happen to companies? Multinational companies contact individual firms or already know this dynamic cluster, and directly contact the Pool-net or Cefamol?
- A collective brand does not refer to "Moulds" why? It is strategic?
- It appeared that other sectors such as the aviation industry, the health sector, among others, have observed these good practices of E & T reflected in the automobile industry and decided to consult the cluster to supply product?
- As the automotive sector is in crisis, how do you justify increasing the turnover for this industry?
- The automotive industry when delivering a budget request to the cluster of moulds, plastics speaking, what order? 500 automobile bumpers, plastic automotive, optics, whatever it is, or demand integrated solutions?

- Another question I would like to put relates to the credit risk of companies where some companies in the sector are in light orange or red, and I would like to understand better why?
- I realized that cooperation is made of a strong form in the commercial side, but I also would like to know if within the cluster there are other types of cooperation, particularly in terms of R & D, central purchasing, or other.
- Who encourages and streamlines the research within the cluster?
- The universities also address the cluster to develop research? We are talking about which universities?
- Is usually through projects in co-promoting and mobilizing projects that establish these partnerships?
- In short, what is the primary role of Pool-net for innovation into the cluster?
- How can it be measured the contribution of the cluster in terms of regional development and which indicators can be highlighted?
- In terms of performance measurement, I can say that only lacks a scoreboard with all these indicators?
- In summary, the moulds also sell, but the ultimate goal is to sell integrated solutions that it can also include moulds ...
- What is the role of the cluster in terms of funding support?
- Do you would like to add anything else?

Close of the session, thanking the collaboration of all involved.

Part II – Semi-structured interview with the CEO of Pool-net and Centimfe

Participant: Dr. Rui Tocha, CEO of Pool-net and Centimfe.

Date: October, 2013.

Time: 30 minutes.

Location: Centimfe, Marinha Grande.

<u>Objective:</u> To explore the dynamics of entrepreneurship within the cluster.

<u>Topics / questions:</u>
- What are the dynamics of entrepreneurship within the cluster?
- Universities will be awakened to the importance and potential for collaboration in this industry?
- Which the dynamics in terms of developing collaborative projects? What are the typologies?
- And other projects within the "Pense Indústria", or similar?

Thanks for attention and availability.

Annex II

Interview guide to the interveners in the project MCCA_II

<u>Methodology and objective</u>: semi – structured interview, based on a generic guide. The goal is to understand the whole process of design and development of the project MCCA_II.

The session was led by Luís Farinha.

Date: November, 2012.

Time: 2.5 hours, during the follow-up tests to the olive harvest machine, in olive grove.

Location: Herdade Torre das Figueiras, Monforte.

<u>General information</u>: The interview was conducted in the groves of Farm Torre das Figueiras, during final testing machine. The interview has suffered several interruptions derived from the monitoring of the testing machine process. The interview began around 10:30 am, having been a break for lunch in the field, being taken up of late, with the beginning of the new phase of the testing machine.

Part I – Interview with Professor António Dias, University of Évora

Professor António Dias, member of the mechanization of the department of Rural Engineering, University of Évora, stated that began in 1995, the work of experimentation related to the mechanization of the olive harvest, in collaboration with Eng. Falcão, manager of the farm Torre das Figueiras, Monforte, family property.

<u>Topics / questions:</u>

- Prof. António Dias, I ask you to explain to me the whole process of development of this collaborative project. How it all began?
- What is the state of the art until now, and why this project?
- This is a project that almost fits the spirit of open innovation, because in addition to the project partners, there is also the feedback given by the farmers themselves …
- What type of co-funded project that was the basis of this entrepreneurial initiative?
- Today we are at Herdade Torre das Figueiras, owned by a farmer, entrepreneur, man seeking innovation for your business ... even praised by the media ...
- When did you start collaboration for the development of the project?
- In terms of agents in collaborative project, we have U.Évora, Vicort and the farmer. What is the framework of the olive grower, will be the acquirer of the machine?
- Other farmers may also feel the same needs; need to purchase machines like this?
- These machines may be subcontracted to other people who do not have profitable farms alone, or do not have the possibility to purchase?

- The enthusiasm of Eng. Falcão leads him to also invest in the project, in order to develop faster?
- The Eng. Falcão feels the difficulties in the skin, because he wants the machines to work for him?
- Prof. António Dias, your availability in the project, on behalf of the University must be high?
- Imagining now that the machine is completely ready, what is missing to be able to sell?
- Given the presence of the different partners of the project, how we would operationalize the sale of these machines on the market? Who sold them?
- Commercialize based on a business model from a consortium with shared patents?
- In terms of competitiveness and development of the regions, we ended up being to support the University that develops RDI, finding new solutions to the farmer, the industry also develops and operationalizes innovation research, creating jobs and wealth ...
- But there are other markets in the Mediterranean?
- What's to improve for the future, not the machine but the level of functioning of the collaboration? What could be improved? For a new project, what is changing? Of the University, on the part of the Company, on the part of lenders ...
- Argues that collaboration between the Academy, through the transfer of knowledge and technology, and the industry through innovation and the implementation of projects, can contribute to the competitiveness and development of the regions?

Part II – Interview with Eng. Falcão, owner of the grove where the machine was tested

- Eng. Falcão, tell me the story of your family, entrepreneurship, innovation, the way these ideas are born ...
- In terms of these entrepreneurial initiatives, the impetus was given only by the industry, there was no community support funds or even the collaboration of the Academy?
- But from what you said, in Spain Universities longer went knocking on the door of the industry in order to develop new projects in collaboration?
- And here, when the University of Évora appears to support?
- In your opinion, what we can improve in the future on similar projects?
- Easily be able to sell 100 copies of these in the country?
- The machine itself can operate in a subcontracting?

Part III – Interview with Dr. Miguel Ferreira, CEO of Vicort

Date and place: November 2012, on the premises of Vicort in Castelo Branco.

Objective: To understand the position of the industry in the context of this collaborative project.

Time: 30 minutes.

Topics / questions:
- What are the biggest difficulties encountered during the development of the project?
- From the point of view of the interaction / cooperation between Academia - Industry - Government, what to improve for the future (on future projects)?
- And the government / policy making level, particularly as regards EU funds, which could suggest that future projects be more agile?
- In short, if treating a project with knowledge and technology transfer between Academia-Industry, with the support of EU funds NSRF / incumbent by Adi, in an industrial company that develops an innovation project position, which suggests recommendations in order to expedite this type of projects?
- In terms of business model, what are your prospects, your vision in terms of tradability of the machine?
- The Eng. Falcão, as an entrepreneur, and olive grower association leader, may also contribute to this whole dynamic ...

Thanks

Part IV – Interview with Professor and deputy in parliament, Prof. Carlos Zorrinho

Professor Carlos Zorrinho, representative of the policy decision in Portugal, was interviewed by Luís Farinha, in February 2013.

Professor, Department of Business Administration, University of Évora, was Pro-Rector of the same University and President of the Directing Council and the Scientific Council of the Department of Economics and Business. Deputy in parliament (Legislature XI). He was a deputy in VII, VIII and IX Legislatures, serving as Assistant Secretary of State for the Home Secretary, Secretary of State for Energy and Innovation (Secretary of State with responsibility for supervising National Innovation Agency - Adi), Responsible for the Mission PROALENTEJO and National Coordinator of the Lisbon Strategy and the Technological Plan 2005-2009.

Objective: To understand the position and involvement of political decision before this kind of projects, still giving him know the major difficulties in implementing the project, namely the bureaucratic level and access to public funds.

Time: 45 minutes.
Location: Portuguese Parliament, at Lisbon.

Topics / questions:

- Being aware of the existence of a significant competitive constraint on the type of collaborative projects A-I, despite the companies having the capability to internally develop the entire project, with its own resources, provided with information systems that allow you to demonstrate the costs incurred and the corresponding allocation the project, the truth is that some of these expenditures are not recognized by Adi, for lack of proof of purchase and the respective payment. What can be done to change this situation, given the framework of the EU Regulation, direct transposition into national law?

- Another feeling that was revealed in the context of previous interviews, including from the VICORT, was that the only involvement of Adi with this project was the invitation and insistence, because otherwise it was merely a bureaucratic body that received documentation checking compliance and bottom, releasing the funds, without ever having even seen the final project ...

- What financing mechanisms exist for it to be taken the next step of placing the product in the international market, which in fact is the main objective of this type of projects?

- One final note, as we could in fact strengthen collaboration Academia-Industry, which is much needed in our country, and given the number of collaborative projects, whether in co-promotion or mobilizers, who from 2008 to today are about 400, and of these maybe a small part entered the market, getting the project, what incentives or what can be done to trigger this collaborative interest so necessary for competitiveness in our country?

Thanks and visit to the Parliament.