



UNIVERSIDADE DA BEIRA INTERIOR
Engenharia

Essays on Entrepreneurial Transference of Technology and Patenting

Dina Batista Pereira

Tese para obtenção do Grau de Doutor em
Engenharia e Gestão Industrial
(3º ciclo de estudos)

Orientador: Prof. Doutor Tesseleno de Campos Devezas

Covilhã, maio de 2013

Dedication

To João, that made this cruzade possible and helped me during the best and the worst stages with love, support and dedication.

To Rodrigo, who grew up nearby my laptop, never complaining, and always supported me being the best baby a mother can have.

To my parents, Graça and Augusto, who have done everything to help make my dreams come true.

Acknowledgements

I would like to express my deepest appreciation to my mentor, João, who was always a constant source of inspiration and who guided me during all the process and prevented me for quitting. I've learned how to become a critical thinker maintaining the needed humility in order to pursue my journey along the Ph.D programme.

Furthermore, i need to express my gratitude to my supervisor, Prof. Tessaleno Devezas, who is a great professional that marked me for his researcher and personal qualities.

My dissertation is also the result of specific support of some people who made possible the access to valuable data, like José Manuel Mendonça (INESC Porto, UTEN), Paul Seabright (Cambridge Enterprise Limited), Tara Branstad (Carnegie Mellon University) and Gonçalo Silva (Gabinete de Planeamento, Estratégia, Avaliação e Relações Internacionais, Ministério da Ciência, Tecnologia e Ensino Superior).

Last, but not least, this work is also the fruit of support, help and constant stimulus of some very good friends, who deserve a special acknowledgement, Filipe, Andreia, Guida, Carlos, and Sérgio.

Resumo

A presente dissertação consiste em cinco artigos na área da transferência empreendedora de tecnologia e patentes no âmbito da engenharia industrial. O foco da tese baseia-se na intenção de demonstrar como o padrão de comportamento inovador das empresas é determinante nas diversas fases do seu ciclo de vida, iniciando-se com o capítulo 1, o qual consiste num artigo introdutório acerca do papel das universidades como aceleradores da exploração do conhecimento e dos seus fluxos na tradução dos resultados científicos em conhecimento aplicável em meio industrial.

O primeiro artigo efetua, deste modo, uma revisão de literatura dos tópicos da transferência de tecnologia e inovação, tomando como referências as experiências dos Estados Unidos e da Europa. Funciona como uma base teórica para contextualizar um conjunto de artigos inovadores subsequentes no tópico genérico da transferência empreendedora de tecnologia e patentes.

O capítulo 2 analisa o impacto de um conjunto de determinantes para estimar o valor da patente académica, tendo por base duas amostras, nomeadamente 281 patentes de Cambridge University, Reino Unido, e 160 patentes de Carnegie Mellon University, Estados Unidos. Aqui, a dimensão da família de patentes e o tempo de vida da patente até à sua maturidade denotam um impacto positivo sobre o valor da patente académica, bem como o âmbito geográfico da mesma demonstra uma influência negativa. Adicionalmente, para as empresas *spin-off* de Carnegie Mellon University, o efeito do âmbito geográfico de proteção da patente tende a ser negativo e significativo. Para as empresas *spin-off* de Cambridge University, foram detetados 2 efeitos principais, a saber, um impacto negativo e significativo do tempo de vida da patente até à sua maturidade e um impacto positivo e significativo da área técnica da patente no seu valor.

O capítulo 3 efetua o estudo dos determinantes do comportamento inovador das empresas e das suas dinâmicas de cooperação, usando, para tal, uma base de dados de 3682 empresas manufatureiras e 1221 empresas de serviços da *European Community Innovation Survey (CIS)*, 2008. Os resultados revelam que a capacidade das empresas manufatureiras e de serviços para gerarem produtos e serviços inovadores denota uma influência significativa na manutenção de um comportamento inovador. De facto, os acordos de cooperação entre concorrentes e outros *stakeholders* de I&D e a capacidade da empresa para introduzir inovações no mercado revelam-se fatores impulsionadores do desempenho inovador. Em acréscimo, as empresas de serviços denotam que a introdução de inovações de processo dentro da própria empresa, bem como as atividades internas de I&D, são de elevada importância para alavancar e fomentar a capacidade das mesmas para gerarem inovações.

O capítulo 4 analisa os determinantes de crescimento da empresa, aprofundando os estudos efetuados previamente, através da utilização de medidas como as transações de direitos de PI, i.e., atividades de licenciamento interno e atividades de licenciamento externo, recorrendo para tal a uma amostra de 818 empresas (de elevado valor tecnológico e médio valor tecnológico) criadas em 2004 e seguidas pela Kauffman Foundation por um período de seis anos subsequentes. Em termos de conclusões, pode-se avançar que existe um impacto positivo e significativo da intensidade de I&D e do licenciamento externo de patentes no crescimento da empresa. Acresce, ainda, que se denota um efeito negativo e significativo do valor quadrado intensidade da I&D no percurso de crescimento da empresa, o qual revela uma relação em forma de U-invertido, demonstrando que existe um impacto positivo no crescimento da empresa num estágio inicial, seguido por um impacto negativo após alcançar o ponto ótimo. Este impacto, também, é refletido quando se controla o setor de atividade, demonstrando um efeito determinante nas empresas do setor manufatureiro de elevado valor tecnológico, bem como nas empresas de serviços de conhecimento intensivo de elevado valor tecnológico.

Por último, no quinto capítulo, o foco da investigação recai sobre os determinantes do crescimento e sucesso da empresa e a previsão dos fatores que afetam a sua sobrevivência, prevenindo a morte da mesma. A amostra utilizada corresponde a um conjunto de 4928 empresas criadas em 2004 e seguidas pela Kauffman Foundation nos seis anos subsequentes. É, aqui, dedicada especial atenção às empresas "gazela", dado serem estas um agente chave no domínio da economia empreendedora baseada no conhecimento. Por um lado, analisamos as características das empresas, como a idade, a dimensão, a intensidade de PI (designadamente, patentes, copyrights e marcas) e, por outro lado, estudamos um conjunto de atributos relacionados com o fundador, tais como, a idade, a experiência de trabalho em empresas fundadas por si, as habilitações académicas e o género, as quais podem afetar a capacidade de sobrevivência da empresa. Em termos de resultados, o artigo demonstra que uma empresa "gazela" manufatureira, que persegue uma estratégia corporativa orientada para a intensidade inovadora tem menos probabilidades de morrer do que o oposto. Concordantemente, o portfolio de direitos de PI da empresa (maioritariamente, patentes e copyrights) denota um efeito importante no seu rácio de sobrevivência. Para além disto, o artigo demonstra que pequenas empresas com cerca de 4 anos de idade, cujos fundadores, em sua maioria do género masculino, sem grau académico e com mais de 35 anos estão mais predispostas a sobreviver do que as restantes.

Palavras-chave

Empreendedorismo académico; Valor da patente académica; Coopetição; Crescimento; Morte; Gestão de I&D; Spin-off.

Abstract

The present dissertation consists of five studies on entrepreneurial transference of technology and patenting in the framework of industrial engineering. The focus is to show how the pattern of innovative behavior pursued by firms is determinant in several phases of the firm's lifecycle, starting with chapter 1 which consists of an introductory paper around the role of academies as accelerators of knowledge exploitation, their flows on the translation of science results into privately appropriable knowledge.

The first paper makes a review of the theoretical background on the topics of technology transfer and innovation, taking as references the US and the European experiences. It functions as a theoretical basis for framing out a set of innovative papers on the general topic of entrepreneurial transference of technology and patenting.

Chapter 2 studies the impact of a set of determinants for assessing the academic patent's value, based on two samples, 281 patents from Cambridge University, UK, and 160 patents from Carnegie Mellon University, US. Here, size of the patent family impacts positively on the value of the academic patent and the time to maturity and the geographical scope denote a negative influence. In addition, for spin-off firms from Carnegie Mellon University, the impact of geographical scope tends to be negative and significant. For the Cambridge University spin-offs, two main effects are detected, firstly, a negative and significant effect of time to maturity and secondly a positive and significant impact of the technical field on the patent's value.

Chapter 3 analyzes the determinants behind the firms' innovative behavior and their coopetition dynamics, by using a dataset of 3682 manufacturing firms and 1221 service firms from the European Community Innovation Survey (CIS), 2008. Results reveal that the manufacturing and service firms' capacity to generate product and service innovations denote a significant influence for sustaining an innovative behavior. In fact, coopetition arrangements between competitors and other R&D stakeholders and the firm's capacity to introduce innovations into the market are major drivers of innovative performance. Furthermore, service firms denote that the introduction of process innovations inside the firm and the internal R&D activities are of major importance for spurring the firm's capacity to generate innovations.

Chapter 4 analyzes the firm's growth determinants, going a little bit further than previous studies by introducing proxies such as IP rights transactions, e.g., in-licensing activities and out-licensing activities, making use of a sample of 818 firms (high-tech and medium high-tech) created in 2004 and tracked by the Kauffman Foundation in the subsequent six years

period. The main conclusions point out there is a significant and positive impact of R&D intensity and of the in-license of external patents on the firm's growth. Additionally, there is a negative and significant effect of the squared R&D intensity on the growth path of the firm, which reveals a U-inverted relationship to firm's growth, that is, a positive impact on firm growth in an early stage, followed by a negative impact after achieving the optimal level. This impact is also reflected when we control for the activity sector, having a major effect on high-tech manufacturing industries and high-tech knowledge intensive service firms.

Finally in the fifth chapter, the research focus is about the determinants of firm's growth and success and the prediction of the major factors that affect their survival avoiding exit. The sample we use is a sample of 4928 firms created in 2004 and followed by the Kauffman Foundation in the subsequent six years period. A special attention is devoted to the gazelle firms, since they are a key agent in the scope of the knowledge based entrepreneurial economy. From one side, we analyze the firms' characteristics like age, size, IP intensity (namely, patents, copyrights and trademarks) and, from the other side, we study a set of founders' traits, namely, age, work experience, educational background and gender, which are able to affect business survival. Results show that being a manufacturing gazelle which undertakes a corporate strategy oriented at innovation intensity is less probable to exit than the opposite. Conversely, the IPR portfolio of the firm (mainly patents and copyrights) denotes an important effect on its survival ratios. Furthermore, the paper denotes that small firms with more or less 4 years, whose founders, mainly males, with no university degree and with more than 35 years old are significantly more predictive of surviving than other firms.

Keywords

Academic entrepreneurship; Academic patent's value; Coopetition; Growth; Exit; R&D management; Spin-off.

Table of Contents

Introduction	23
Chapter 1	27
The basics on technology transfer and patenting	27
Abstract	27
1. Introduction	28
2. Literature review	30
2.1 Innovation theory: business cycle and technology transfer	30
2.2 National innovation systems and technology transfer	36
2.3 Knowledge filter theory	40
2.4 Technology transfer and innovative performance	43
2.5 University's third mission and knowledge commercialization	45
2.6 IP protection and transfer in academic contexts	49
2.6.1 US experience in Technology Transfer practices	57
2.6.2 European experience in Technology Transfer practices	61
3. Concluding remarks	65
References	67
Chapter 2	77
Does the academic spin-off condition play a role in patent valuation?	77
Abstract	77
1. Introduction	78
2. Literature review	79
2.1 Literature streams	79
2.2 Research hypotheses	85
3 Methodology	89
3.1 The model	89
3.2 The dependent variable	91
3.3 Datasets and variables	92
4 Results and discussion	96
4.1 Empirical findings	96
5. Concluding remarks	100
5.1 Findings	101
5.2 Limitations, future research and implications	102
References	104
Chapter 3	111
Do coopetition arrangements matter for creating innovation? Major differences between manufacturers and service providers.	111

Abstract	111
1. Introduction	113
2. Conceptual framework	115
2.1 Innovation - from concept to sources	115
2.2 Demand pull vs. technology push of innovation	118
2.3 From coopetition to innovation	119
2.4 Coopetition and the strategic use of products/services innovations	127
2.5 Research hypotheses	129
3. Methodology	131
3.1 Dataset, method and variables	131
3.2 Descriptive statistics	132
4. Empirical findings	138
4.1 Probit estimation results	138
4.2 Research hypothesis and discussion	145
5. Concluding remarks	150
5.1 Policy and managerial implications	150
5.2 Limitations and future research	151
References	153
Chapter 4	163
Corporate R&D strategy and growth of high-tech and medium high-tech US start-ups.	163
Abstract	163
1. Introduction	165
2. Literature survey and research hypothesis	165
2.1 Firm growth: theoretical background	166
2.2 The corporate R&D strategy and firm growth	169
3. Methodology	175
3.1 The model	175
3.2. Dataset and model specification	176
3.2.1 Variables and measurement	176
3.2.2. Selection of the model specification	179
4. Results and discussion	178
5. Concluding remarks	192
References	181
Chapter 5	203
Should we stay or should we exit?	203
Unveiling a strategic decision choice for Gazelle and Non-gazelle firms.	203
Abstract	203
1. Introduction	205
2. Literature survey and research hypothesis	207
2.1 Exit as determinant for the entrepreneurial process	207

Essays on Entrepreneurial Transference of Technology and Patenting

2.2 Exit strategies and firm's context	210
2.3 Determinants of exit	213
2.4 What drives gazelles and non-gazelles firms to exit?	216
3. Research method and conceptual model	224
3.1 The model	225
3.2. Dataset and variables	227
4. Results and discussion	228
5. Concluding remarks	234
5.1 Limitations, implications and future research	235
References	237
Conclusions	245

List of Figures

Chapter 1

Fig. 1 - Process of Technology Transfer	50
Fig. 2 - Process of marketing technology push inventions	54
Fig. 3 - Business Model Innovation for Technologies	55
Fig. 4 - Determinants of Technology Transfer	56

Chapter 3

Fig. 1 Composition of manufacturing sample by technological intensity and size	132
Fig. 2 Composition of manufacturing sample by product innovation performance and process innovation authorship	133
Fig. 3 Composition of manufacturing sample by R&D activities	133
Fig. 4 Composition of manufacturing sample by cooperation activities	135
Fig. 5 Composition of service sample by technological intensity and size	135
Fig. 6 Composition of service sample by product innovation performance and process innovation authorship	136
Fig. 7 Composition of service sample by R&D activities	137
Fig. 8 Composition of service sample by cooperation activities	138

Chapter 4

Fig. 1 Growth and Corporate R&D Strategy: Conceptual Model	176
--	-----

Chapter 5

Fig. 1 Determinant factors of firm survival: a conceptual model	225
---	-----

List of Tables

Introduction	
Table 1 - Methodological framework	24
Chapter 1	
Table 1 - Mechanisms of university-industry technology transfer	47
Chapter 2	
Table 1 Determinant factors of patent's value: literature streams	83
Table 2 Patent citations by spin-off condition - Cambridge University (UK)	93
Table 3 Patent citations by spin-off condition - Carnegie Mellon University (US)	94
Table 4 Patent citations by international patent classification - Cambridge University (UK)	94
Table 5 Patent citations by international patent classification - Carnegie Mellon University (US)	94
Table 6 Descriptive statistics - Cambridge University (UK) dataset	95
Table 7 Descriptive statistics - Carnegie Mellon University (US) dataset	95
Table 8 Determinants of patent citation - CAMU (UK)	97
Table 9 Determinants of patent citation - CMU (US)	98
Table 10 Determinants of patent citation for non spin-offs - CAMU (UK)	98
Table 11 Determinants of patent citation for spin-offs - CAMU (UK)	99
Table 12 Determinants of patent citation for non spin-offs - CMU (US)	99
Table 13 Determinants of patent citation for spin-offs - CMU (US)	100
Chapter 3	
Table 1. Theoretical background: Taxonomies of innovation	117
Table 2. Theoretical background: Determinants' dimensions of entrepreneurial innovation capacity	124
Table 3. Results of probit regressions for manufacturing firms	140
Table 4. Results of probit regressions for service firms	144
Table 5. Summary of results of probit estimations for manufacturing and service firms	148
Chapter 4	
Table 1. Measurements of the variables representing the conceptual model	176
Table 2. Descriptive statistics of the variables	178
Table 3. Static panel models (Model I)	182
Table 4. Static panel models (Model II)	183
Table 5. Static panel models (Model III)	184
Table 6. Effects of explanatory variables on firm's growth by NACE classification: Static panel model (Model III)	186
Table 7. Dynamic model GMM for explanatory variables on firm's growth	188
Table 8. Effects of explanatory variables on firm growth by NACE classification	189

Dynamic panel model (Model III)	189
Table 9. Summary of significant results for static and dynamic panel models	191
Table 10. Summary of significant results for static and dynamic by NACE classification	191
Chapter 5	
Table 1. Theoretical approaches on exit	209
Table 2. Description of variables included in the Cox proportional hazard model	228
Table 3. Descriptive statistics of the variables included in the survival model	231
Table 4. Results from the Cox proportional hazard estimations	232
Table 5. Determinant factors of firm survival	233

List of Acronyms

ATP	Advanced Technology Program
AUTM	Association of University Technology Managers
CAMU	Cambridge University
CIS	Community Innovation Survey
CMU	Carnegie Mellon University
ERA	European Research Area
ERC	Engineering Research Centres
ICT	Information and Computing Technologies
IPR	Intellectual Property Rights
IPO	Initial Public Offering
IUCRC	Industry/University Cooperative Research Centres
KIS	Knowledge Intensive Services
KFS	Kauffman Firm Survey
KTT	Knowledge and Technology Transfer
LKIS	Less Knowledge Intensive Services
M&A	Mergers and Acquisitions
NACE	Statistical Classification of Economic Activities in the European Community
NAICS	North American Industry Classification System
OECD	Organisation for Economic Co-operation and Development
R&D	Research and Development
SBIRP	Small Business Innovation Research Program
SME	Small and Medium Enterprises
STTRP	Small Business Technology Transfer Program
TIM	Total Innovation Management
TTO	Technology Transfer Offices
VC	Venture Capital

Introduction

This doctoral thesis consists of five innovative papers on the processes of entrepreneurial transference of technology and patenting. Each chapter looks at one basic pattern of these processes. They are technology transfer, patent valuation, spin-off creation, cooperation and competition, growth and exit. The focus and research question that the present thesis aims to answer is on how the innovative behavior, especially linked with the patenting and IP intensity corporate strategy, affects firms' R&D related decisions, including spin-off creation, strategic cooperation relationships, technology transfer, growth patterns and exit.

Chapter 1 provides a review of the theoretical background on technology transfer and innovation, presenting the US and the European experiences in terms of technology transfer practices. This aims to act as a kick-off step of a set of essays under the general topic of technology transfer and patenting.

Chapter 2 focuses on the problematic of patent valuation linking their main features and attributes to their value by using cross-section data of two samples, namely, 281 patents from Cambridge University, UK, and 160 patents from Carnegie Mellon University, US. In order to assess the impact of a set of attributes on patents being explored by an academic spin-off or by alternative mechanisms like licensing agreements, the empirical approach provides the estimation of a negative binomial regression model for assessing the impact of a set of distinct factors on the academic patents' value.

Chapter 3 approaches cooperation as a mix between cooperation and competition among firms, targeted at producing innovation, creating net value added and economic benefit. This paper reflects on the importance of analyzing the determinants behind the firms' innovative behavior regarding their patent intensity behavior based on cooperation relationships. It uses firms' generation of innovative products and services behavior to unveil their innovative performance and the cooperation dynamics. For accomplishing this, a dataset of 3682 manufacturing firms and 1221 service firms from the European Community Innovation Survey (CIS), 2008, is used to estimate a probit analysis conducted in separate for manufacturing and service firms and per category of firm technology intensiveness.

Chapter 4 analyses the firm's growth, since it's of major importance to firm survival, job creation and economic growth. When focusing on high-tech sectors, where technological change is fast and competition is extremely high, the survival of firms can be strengthened through the exploitation of the 'early-mover' effect and their IPR (intellectual property rights). In this line, for the innovation intensive industries, patents can be of potential benefit

to facilitate the existence of active, creative and transactional goods and services to be traded in technology markets. This paper estimates the determinants of firm’s growth based on a corporate R&D strategy, using as measures, the R&D intensity, the firm’s patent portfolio and the patent transactions, e.g., in-licenses and out-licenses, by using a panel data approach, focusing on the high-tech and medium high-tech firms from a sample of 818 firms created in 2004 and tracked by the Kauffman Foundation in the subsequent six years period.

The last chapter analyzes the drivers of growth and success of firms and predicts the main determinants that are able to affect their performance and survival. The focus of the analysis is concerned with gazelle firms which are characterized by high-growth rates, turbulence, fast change and resilience. In this framework, a set of major determinants is considered, such as firms’ characteristics like age, size, IP intensity (namely patents, copyrights and trademarks) and activity classification from one side, and founders’ traits, namely, age, work experience, educational background and gender from the other side, that impacts on business survival, avoiding exit of start-up firms. In order to accomplish this, we make use of a sample of 4928 firms created in 2004 and tracked by the Kauffman Foundation in the subsequent six years and perform a Cox proportional hazard model to estimate the exit hazard ratios of firms. Major results reveal that a manufacturing gazelle has fewer hypothesis of exiting than a non-gazelle firm, if they tend to pursue a corporate strategy targeted at innovation intensity. Conversely, the IPR portfolio of the firm (mainly patents and copyrights) denotes an important effect on its survival ratios. Furthermore, the paper denotes that small firms with more or less 4 years, whose founders, mainly males, with no university degree and with more than 35 years old are significantly more predictive of survival.

The next table presents the methodological framework with the conceptual model for the thesis.

Table 1 - Methodological framework

Chapter	Goals	Dataset	Econometric method
1	Review the literature on technology transfer and comercialization of patents; compare the american and European TT processes.	--	--
2	Analyse the importance of the determinant factors of the academic patente value.	281 patents of Cambridge University, UK, and 160 patents of Carnegie Mellon	Negative Binomial Regression Model, disaggregated by spin-off condition.

Essays on Entrepreneurial Transference of Technology and Patenting

		University, US	
3	Analyse the determinant factors of the capacity of firms to generate innovations, having as basis the networks of coopetition.	3682 manufacture firms and 1221 service firms (<i>European Community Innovation Survey - CIS, 2008</i>)	Probit Analysis disaggregated by the 2 sectors and by technological intensity.
4	Estimate the determinant effects of firm growth based on the R&D corporate strategy.	818 high tech and medium high tech startups created in 2004 and followed by the Kauffman Foundation until 2010	Panel Data Analysis - static and dynamic estimations - technological intensity controlled by NACE classification.
5	Analyse the factors, at the level of the firms' characteristics and the level of the founder's attributes that determine the survival of fast growing firms - gazelles.	4928 startups (KFS, 2004-2010)	Cox Proportional Hazard Model - estimate the risk and survival ratios and analyse the impact of some risk factors.

Chapter 1

The basics on technology transfer and patenting

Abstract

Following the focus on the role of universities as accelerators of knowledge exploitation and subsequent commercialization, they are considered determinant to provide answers to the needs and agendas of industry and national competitiveness, being pressured to translate the results of their work into privately appropriable knowledge. Academies started dealing with the implementation of regulations to ease the appropriability of universities over their intellectual property (IP) assets, the increasing competition for governmental funding, and the consolidation of commercialization offices. The present work after a review of the theoretical background on technology transfer and innovation, makes a brief presentation of the US and European experiences in technology transfer practices, aiming to make a comparative analysis between the US (acting as a role model) and the European process of technology transfer within the academic context. The present paper intends to act as a literature review on such topics and also as an introductory mechanism for a series of essays under the theme of valuation and commercialization of knowledge.

Keywords

Open innovation; Technology transfer; Commercialization; Knowledge filter; IP valuation.

1. Introduction

Recently there has been an increasing focus on the role played by universities as key agents in determining the needs and agendas of industry and national competitiveness, being pressured to translate the results of their work into privately appropriable knowledge. Factors like the implementation of legislation to ease the appropriability of universities over their intellectual property (IP) assets and the increasing competition for governmental resources, drove universities to search for alternative paths, like the establishment of technology transfer offices and the pursuit of IP protection. Despite the increasing numbers of university patents filled the same pattern in terms of the number of granted patents, licensing statistics or start-ups creation wasn't achieved.

According to several authors (Nelson & Winter, 1982; Pavitt, 1984, Kline & Rosenberg, 1986; Lundvall, 1992) innovation works as an evolutionary process in consequence of the generation of new knowledge, interactions among different actors and its subsequent spread and use as knowledge economically useful.

Etzkowitz (2008) advocates that the interactions among universities, firms and government foster innovation and economic growth in a knowledge-based economy. Universities, as well as governments, are entrepreneurial units that play a key role in the implementation of the triple helix model, by providing technology transfer and incubation of new technology-based ventures. The entrepreneurial activities of universities arise from the premise that research and development (R&D) activities generate new ideas and economic value added.

Kaufmann & Tödtling (2001) state that the innovation process is characterized by the dynamic relationships established within the firm and between itself and the external environment, such as other firms, higher education institutions, consultants, technology transfer offices (TTO), financial institutions, learning institutions and public administration, which act as stakeholders of the firm's activities.

These set of interactions are of extreme importance to the process of production, dissemination and use of knowledge in an economic perspective.

The activities of identifying, creating and commercializing technology are increasingly becoming institutional objectives in almost academic systems (Etzkowitz *et al.*, 2000), being the entrepreneurial activities an answer to the improvement of regional and national economic performance and to the university's financial advantage.

According to Acs & Plummer (2005), another important mechanism is the "knowledge filter" that operates between new knowledge and economic knowledge and fosters the creation of new firms and spin-offs, increasing regional growth.

Pereira *et al.* (2004) argue that universities are paying more attention to the commercialization of the scientific research results, being the intellectual property rights (IPRs) requests on these results object of specific support actions in diverse international contexts, firstly in the United States and afterwards in the European context and developing countries.

According to Thursby *et al.* (2001) a patent is an important precondition to increase subsequent licensing opportunities, being TTO's important pieces at this stage to generate applications, identify potential licensees and to produce sales packages for potential licensors. Matkin (1994) and Sampat & Nelson (2002) agree that there is no one special model of conduit for a technology transfer office, existing however only a few studies on the relations between academic entrepreneurial activity and ways to manage TTO's (for instance, Markman *et al.*, 2004).

In this sense universities are adopting strategies to value the knowledge for promoting the commercialization of IP results. The activities of valuation and licensing allow inventors and universities to obtain additional benefits by establishing commercial deals.

Etzkowitz *et al.* (2000) stress that the Triple Helix (government - university - industry) is promoting a knowledge infrastructure to face the new university mission in terms of overlapping institutional spheres, appearing new hybrid organizations that act as interface engines.

Siegel & Phan (2005), point out that the formal management of the technology portfolio is a task that needs to be improved for increasing efficiency. There is still work to be done regarding the optimal organizational practices such as inventor incentives, technology transfer "pricing," legal issues, strategic objectives, and measurement and monitoring mechanisms.

The present work aims to make a comparative analysis between the US (acting as a role model) and the European process of technology transfer within the academic context, analyzing the filling tendencies in academic patents and the licensing activities in order to provide a conceptual framework to apply in the technology transfer activity.

The present work has a two-fold contribution: (i) Make a review of the theoretical background on technology transfer and IP commercialization; and (ii) Establish a comparative analysis between the US and European process of technology transfer within the university's context, where the university plays an increasingly important role on determining the success of technology and commercialization process.

The paper is structured as follows. Firstly, the innovation theory will be object of study, analysing the business cycle and the technology transfer. Secondly, the national innovation systems will be discussed as well as their relation with the process of technology transfer. Thirdly, the mechanism and concept of the knowledge filter theory will be object of analysis. Fourthly, the process of technology transfer is linked to its innovative performance. Fifthly, the present paper discusses the university's third mission and knowledge commercialization. Sixthly, it will cover the practices of IP protection and technology transfer in academic contexts, concluding with the US and the European experience in technology transfer practices.

2. Literature review

2.1 Innovation theory: business cycle and technology transfer

According to the concept of "Creative Destruction" proposed by Schumpeter (1942), non-innovative firms and products are replaced with innovative ones. The innovative firm is the one that takes advantage from opportunities available in the environment, involving both physical infrastructure and the demand pull for new knowledge intensive business services generated by existing firms. For taking advantage of the opportunities mentioned above, new and existing firms have to make additional investments which generate new spillover sources.

The change of the competitive pattern of firms is achieved by its increasing capacity for innovating. Following Schumpeter (1942) innovation can be seen as a new process, product innovation, use of new raw materials and getting materials in new ways, and organizational innovation. To the same author, the innovative entrepreneur is the economic agent that can attract new products to the market through more efficient combinations of the factors of production or through the practical application of some invention or technological innovation and change to the production process.

Schumpeter's work (1942) initiated the path in terms of the innovation theory research, which focus was changed from the perspective of the economic growth at the macro level to the perspective of enterprises innovation management at the micro level, for stressing the importance of promoting innovation within firms. The author analyses the impact of the radical innovations located in the same period of time generating the creative destruction process that appears from the constant market selections and the replacement of old processes and products. This concept was based on the previous work of Sombart (1928), in which he analyses the destruction process that creates new waves of products and markets, for replacing the traditional ones.

Schumpeter's (1942) contribution refers to the destruction of old sectors and traditional technologies and the appearance of new industrial segments and new technologies capable of generating temporary monopolies and the creative wave, being innovation the agent of the economic transformation. The author approaches the dynamics of economy in four situations: (i) initial equilibrium - the routine is a constant in the agents behaviour along time; (ii) innovation - breaking the routine and destructing the agents that can't follow the innovative dynamic; (iii) equilibrium renewal through creative destruction - process of firms selection and return to a new equilibrium; and (iv) economic evolution. These four situations are cyclical.

Schumpeter's theories caused a rupture among the neoclassic theories since the author presented innovation as an endogenous process of the firms' economic routine as well as the monopolistic situation that drives the firm to the technical and technological advance (Schumpeter, 1942). The innovation is, as expressed before, stimulated by the market structure and the firms' R&D activities. The author defends the origins of innovation among the R&D activities of big firms, opposing to the neoclassic theories that suggested that technology and innovation acted as external factors to the firm and the economy, being the firm a passive user of the inventions generated externally (Nelson, 1993).

Schumpeter (1942) considered innovation as pushed and oriented by the scientific discoveries, having in its base the scientific knowledge - the so called "technology push" or "the science and technology push". In this line of taught the innovation proceeds from inventions and not from the market, the so called "market pull" or "demand pull" where innovation is stimulated by the offer (Nelson, 1959).

Schmookler (1966) defended that technological progress is oriented towards the economical and social factors. In this sense, market opportunities are the most important factor for technological advance.

In the 1970's (Freeman, 1979) the tendency was to break with the traditional perspective, appearing a new combination theory between scientific and technological opportunities and economic needs derived from the market and society.

Innovation is seen as an evolutionary process that results from the production of new knowledge. The interactions between different actors and subsequent knowledge dissemination can act, in a joint basis, as a lever for development and economic growth (Nelson & Winter, 1982; Pavitt, 1984, Kline & Rosenberg, 1986; Lundvall, 1992).

According to Kaufmann & Tödting (2001), the referred interaction is one of the main characteristics of the innovation process that refers to the internal collaboration among the several departments of the firm (namely R&D, production, marketing, logistics, etc.). In turn,

the external cooperation is established with other firms, with other R&D institutions, such as universities, consultants, technology transfer offices, with financial institutions, learning institutions and with public administration. In this sense, the innovation process is increasingly seen as an interactive learning process, made possible through the contribution of several social and economical agents who have diverse access to different types of knowledge and information.

Regarding the entrepreneurial innovation capability in terms of product innovation, it's possible to recognize two different types of innovation namely: 'new to the firm' and 'new to the market'. The first one involves modifications and improvements of the firm's existing products, as well as new products to the firm, extending or substituting existent ones (Kaufmann & Tödting, 2000). This product innovation embraces new variety of the products, small design improvements or technical changes in one or more products and the introduction of new ones. It's called the incremental innovation, which derives from small technical changes resultant from the global, available knowledge.

The second ones involves new products to the firm and the market (Kaufmann & Tödting, 2001), which offers new qualities, services or functions new in the marketplace, without competing products, and conducting to a temporary monopoly. This type of innovations requires more than just incremental development, tending to push innovative advances (CIS II, 1999; Kaufmann & Tödting, 2001).

Dosi (1988) characterizes innovation as a search process, discovery, experimentation, development, imitation and adoption of new products, processes and new organizational techniques. He suggests two new analysis' categories, namely pathways and technological paradigms based on the scientific paradigms of Kuhn.

According to Tigre (1998; 2005) the technical progress plays an important part as a key variable in the changing process of firms, markets and economies, appealing for the capacity of the learner. Here cooperation and knowledge networks are crucial stimulating the learning capacity at the individual and social levels in uncertain environments.

Lastres *et al.* (2005) and Tigre (2005) defend that the changes occurred in firms regarding technical progress, generate new routines and procedures in firms and economy, producing new technological paths and economic growth. The generation of innovations depends on the science development in terms of basic and applied research.

Additionally, entrepreneurship is understood as a driving force towards endogenous growth in modern societies, acting as a pump to foster jobs' creation, firms' creation, economic competitiveness and innovation, being governments pressured to assume its increasing relevance and acting in such a way to develop public policies targeted at promoting

entrepreneurial initiatives (Monitor Group, 2009; Leitão & Baptista, 2009a; Leitão & Baptista, 2011).

In the same vein Stokes (2005) refers that innovation and knowledge are essential for achieving a sustainable economic growth and international competitiveness. Thus, the different nations develop distinct mechanisms for fostering and spurring innovations. Several private and public research institutions play an important role contributing for a common action among university, firms and government, to achieve their goals.

Caraça *et al.* (2009) refer that there are several risks when the expectations are too high regarding the direct impact of science on innovation and, also when other sources of innovation, like experience-based learning within industry, are underestimated. Policy makers are becoming disappointed regarding the expected impact of research outputs on innovation and economic growth. The referred authors state that policy makers are pursuing for adequate mechanisms to explore science commercialization in order to foster economic growth. However this may result in the fact that universities are becoming simple patent producers, neglecting important tasks like the formation of specialized human resources and researchers that will serve industry and society, answering the government pressure to serve industrial needs and overcoming financial constraints.

According to Silva & Leitão (2009) innovation is not something intermittent that happens accidentally, nor something that results from the action of an individual agent. Innovation, instead, is the result of an interactive process between the firm and the environment¹.

Regarding the research streams on innovation management, there can be identified five phases (Qingrui Xu *et al.*, 2007). Chesbrough (2003) presents an additional sixth phase that will be explained hereafter.

The first-phase occurred during the 1940s and 1950s when the focus of research was the innovation of enterprises at the micro level. Research was based on Schumpeter's theory of innovation, where the entrepreneur is seen as the driving force of innovation. The main issues studied were the material innovation process, the success factors which affected innovation, and the driving forces of innovation (Myer & Marquis, 1969; Rothwell & Zegveld, 1981; Freeman, 1995). At this point, the basic questions of innovation were still unsettled and research had its focus on separate components, being the main characteristic of this phase of innovation theory research the research philosophy on individual innovation management.

¹ Kline & Rosenberg (1986) also pointed out that innovation is neither smooth nor linear, nor often well behaved. For these authors innovation promotes the development of science, as well as its demands force the creation of science. Several times, technical development doesn't come from science, but instead it's created from certain market needs.

Along with the advances in the theoretical research on innovation, academic studies became, during the 1960s and the 1970s, more specialized in the different fields of innovation, such as the sources of innovation within organizations, how to attain innovation and how to promote innovation within organizations through the management of the activities of research and development (second phase). In this phase researchers mainly studied R&D departments and their activities. Abernathy & Utterback (1975) presented one of the major contributions of this phase. They developed an “U-A” pattern which divided the evolutionary pattern of product innovation, process innovation and industrial organization into three phases: fluid phase, transitional phase and specific phase, and linked these three to the product life cycle.

During the third phase, in the seventies, research was focused on the role played by users on innovation and the innovation process trying to address the following question: how companies can employ users as a key source of innovation? Von Hippel (1988), one of the main researchers of the field in this third phase, presented the concept of “User as Innovator” and “Lead User”. This concept, by posing the users as innovation sources faced an increasing importance. In the same line, Shapiro (2001) defended that firms should invite users into the R&D process in a co-innovation partnership. Shapiro (2001) developed the method of “lead user,” and the methods of finding innovation sources in “betrayed users” and “potential users.” As seen previously, the sources of innovation are the main fields of study during the second and third phases. The major concerns in the second phase were the internal promotion of innovation, and in the third phase were the interactive promotion of internal R&D through investment and external sources, e.g., users of innovation.

The first three phases of innovation theory had their main focus on individual innovation processes and activities, being those the individual pieces in the five innovation forms cited by Schumpeter (1934). The 1980s and the fourth phase brought a more intensive need for organizations to set more ambitious goals for innovation effectiveness in order to face eminent changing situations, revealing the limitations of the traditional theory. In this framework, Xu *et al.* (1997) and Xu & Chen (2001), based on the system theory, shifted the research focus from the individual pieces of the innovation system to the organizations’ systems, developing the portfolio innovation theory which involves at least five portfolio forms: (i) coordination between product innovation and process innovation; (ii) coordination between radical innovation and incremental innovation; (iii) coordination between implicit innovation benefits and explicit innovation benefits; (iv) coordination between technology innovation and organizational culture innovation; and (v) coordination between independent internal innovation and cooperative external innovation.

During this phase, innovation theory evolved into integrated innovation theory and systemic innovation theory (Iansiti, 1998; Jiang & Chen, 2000; Tidd *et al.*, 2001). The first one embraces the creative integration of existing innovative elements, in a systematic way of thinking. Janszen (2000), for instance, considers enterprise innovation as a complex self-

adaptive system. In this phase, the system-theory-based innovation theories had their focus on the organizations and institutions participating in the generation of technology innovation (Coriat & Weinstein, 2002).

In the fifth phase (21st century) researchers are conducting innovation theory towards the ecosystem theory being the focus on TIM - Total Innovation Management (innovation by anyone at anytime in all processes, among different functions and around the world). Every employee and stakeholder can act as an innovator making effective use of their creativity (Shapiro, 2001; Wheatley, 2001; Tucker, 2002). According to Bean & Radford (2001) innovation must be seen as a business and should take place in every aspect. Following Shapiro (2001), each firm should act one hundred percent in an innovative way for facing the competitors and for addressing the customer's needs. This phase aims to develop the TIM model, for guiding total innovation management in enterprises.

According to Bell & Pavitt (1993), the origin of the innovative process embraces several factors and depends on the characteristics of the product and market. Pavitt (1984) classified the industrial sectors regarding their innovative and technological patterns in four types of firms: dominated by suppliers; intensive scale; specialized suppliers and science based.

An additional sixth phase is introduced by Chesbrough (2003) who defends a shift from a closed innovation paradigm to an open one. In the closed innovation model, knowledge is generated inside the firm, being some projects selected for development and others abandoned, where a part of those are selected to be launched to the market. Since projects can only enter from one way and exit through one way, the process is called a closed system. The author presents the model of AT&T Bell Laboratories (Texas) as an example of this closed system. On the contrary, in the open innovation model, ideas appear from internal and/or external sources as well as technology can enter in the process at different stages and projects can flow to the market in multiple ways (through outlicensing, a spin-off company or through the marketing and sales channels of the firm). The author points the examples of companies like IBM, Intel or Procter & Gamble as open innovation systems.

Spillovers that come from the relations, internal and external, of firms in an open innovation system cannot be seen as a cost to the business, but instead as an opportunity to expand the business and the market. Also, the intellectual property is treated differently in a closed or in an open innovation model. In the closed system, firms store IP in order to assure exclusive rights to explore assets and to avoid costly litigations. Since the great majority of IP assets are not profitable or even usable to explore, in the open innovation model, these ones are seen as critical elements of innovation, as a category of assets that can generate additional profits to the actual business model or to create new models or entry new markets.

The external channels through which technology is introduced in firms, in an open innovation process, like universities, national laboratories, start-up companies, specialized companies, inventors, retired technical staff or graduate students, are of extreme importance to the development of firms and markets. Of great importance in the open innovation system is the role of intermediaries in the innovation markets and in the foster of alliances between technology sources and firms (Nooteboom *et al.*, 1999).

Chesbrough *et al.* (2006), present the concept of open innovation which can be understood as the use of inflows and outflows of knowledge in order to foster internal innovation and to develop the markets for external use of innovation. In this sense, firms can and should make use of external knowledge and internal and external paths to the market while developing their own technology.

This paradigm, in opposition to the closed system innovation, refers to a dynamic process which combines internal and external ideas into systems using business models in order to define requirements for those systems. These business models combine external and internal knowledge to generate value, defining and implementing internal mechanisms to achieve that value.

The mentioned authors view R&D as an open system, since it understands valuable knowledge coming from inside and outside the firm through internal and external channels. The authors state that open innovation understands that useful knowledge can be channelled through a series of multiple sources and can be generated, not only inside firms, but also in a multiple set of agents (from the individual researcher/inventor to an university or a high tech start-up) having the R&D organizations to identify, connect and leverage external knowledge sources as a focus process in innovation.

According to Dahlander & Gann (2010), the interaction between organizations is fundamental since a simple organization cannot innovate in isolation, having to be engaged with several types of partners to acquire ideas and resources from the external context, namely new ways of accessing talents, new IPR results, innovative technologies to be licensed or spinned-out or new forms of collaboration across geographical distances.

2.2 National innovation systems and technology transfer

The terminology of National Innovation System appears for the first time in a Freeman publication (1995) about innovation in Japan, defending that innovation is not a sectorial approach, is not dependent from specific characteristics of each industry and each technology. This approach reveals that each country's institutional set play a strong influence in its innovative outputs.

The systemic perspective of innovation evolved from the perspective of the influence that organizational and environmental factors have towards the innovative performance and the entrepreneurial competitiveness. According to this theory, innovation appears from a collective learning process where institutions play a determinant role.

The innovation capacity results from an interactive process between firms and environment in a synergetic way, stimulating the institutions that support innovation (Lundvall, 1985; Lundvall, 1988; Lundvall, 1992; Nelson, 1993; Cooke *et al.*, 1997; Braczyk *et al.*, 1998; Cooke *et al.*, 2000; Kaufmann & Tödtling, 2001; Lundvall, 2007).

Following this institutional approach Freeman (1995), Lundvall (1992), Nelson (1993) and Edquist (1993; 2001) present different views regarding the national innovation systems.

Freeman (1997) views the role of the network of private and public institutions as fundamental for the technologies development.

Lundvall (1992) advocates the importance of the relations established within the national production, innovation system, especially in the dissemination and use of knowledge.

According to Nelson & Rosenberg (1993) the institutional set and its interactions determine the innovative capacity of the national firms. Edquist & Lundvall (1993) present the importance of the national systems in the direction of the technological change of society.

According to Niosi *et al.* (1993), a national innovation system is grounded on the interaction among firms, universities and governmental agencies, introducing science and technology inside national frontiers. This type of interaction can be of technical, commercial, juridical, social or financial order, generating development, protection, financing or regulation of new science and technology. In this sense, the innovation system consists of the set of institutions and firms, in a specific geographical location, which interact with each other in order to produce new knowledge and to transfer it, generating the innovation that resides beside the economical development.

Callon (1998) proposes the concept of 'Technoeconomical Network', which is understood as the coordinated set of actors (universities, research organizations, firms and end users) that participate in the development and transfer of innovations and organize the networks between research and market.

In this context, the model of the Triple Helix proposed by Etzkowitz & Leydesdorff (2000) also allows the development of national and international policies focused on innovation, under the context of industry-university-government cooperation.

Freeman's initial version of the national innovation system refers to a network of public and private institutions which interact for disseminating new technologies (Freeman, 1995; Freeman & Soete, 1997).

According to Baumol (1968), public policies have a determinant role in increasing the entrepreneurial skills. In this sense, the policy-makers need to understand firstly the determinants of entrepreneurship and the means necessary to expand it. Baumol (1990) proposes a theoretical model suggesting that the regulatory framework is crucial for determining the success of entrepreneurship, being a productive or an unproductive driver of the national productivity growth.

Foreign Direct Investment, which has an important role in fostering public policies for promoting entrepreneurship (Acs & Szerb, 2006) is also associated with technology transfer and knowledge spillovers, materialized in product and process technology, management practices (Findlay, 1978; Dyker, 1999), information on access to foreign countries (Rasiah, 1995) and on intensive competition (Blomström & Kokko, 1997; Markusen & Venables, 1999). Other authors pointed out that the economic activity of a foreign investor can help the acceleration of technological development in the host economy (Hunya, 2000; Lim, 2001; Dyker & Stolberg, 2003; Barbosa & Eiriz, 2007; Leitão & Baptista, 2010).

Edquist (2001) reveals the need for developing Innovation Systems for production, diffusion and use of innovations at an international, national and regional or local level. Organizations - private or public - and other institutions make part of the innovation system (Malerba, 2002).

Link & Link (2009), define an entrepreneurial government as a technological infrastructure, being its involvement both innovative and determined by entrepreneurial risk. In other words it's about providing a technology infrastructure, which aims to leverage the propensity of firms and other agents for participating in a national innovation system, in an efficient way, and contributing to economic growth.

In the opinion of Caraça *et al.* (2009) innovation happens in a complex set of systems, it occurs influenced by a near environment (micro environment) and by a wider complex of institutional structures (the macro environment). This latter one is composed by external sources of learning and transactional relationships, named the sectoral and regional systems of innovation.

Harms *et al.* (2010) present the role of regional academic institutions in strengthening the regional system of innovation. In fact, entrepreneurship education and technology transfer play an important role in the development of innovation at the regional level particularly at the level of small and medium-sized firms, since institutional networks can engage in both entrepreneurship education and technology transfer.

According to Etzkowitz & Leydesdorff (2000) there are different possibilities to reorganize the core relations among government, industry and university and the construction of knowledge society such as the national innovation systems (Nelson, 1993; Etzkowitz & Leytesdorff, 1997; Edquist, 2001; Mowery & Sampat, 2005) the research systems in transition, the Mode 2 - the Double Helix and the Research System Post-Modern (Gibbons *et al.*, 1994; Hicks & Hamilton, 1999; Godin & Gingras, 2000; Mowery *et al.*, 2004).

Another conceptual framework to analyse the changing mission of universities is the Triple Helix (Etzkowitz & Leydesdorff, 1997; Mowery *et al.*, 2004), which as the Mode 2 has its focus on the increased interaction between the referred institutional agents in innovation systems of industrial economies. Baldini (2006) suggests that in Mode 2, appears a new actor with relevant importance which is the society. Nowotny *et al.* (2001) also introduced the concept of the Agora as a metaphor and acting as a mediator between science and its publics. They point to the loss of the monopoly of truth of scientists, being scientific knowledge challenged by all social actors.

Etzkowitz & Zhou (2006) refer to the contrast between disciplinary knowledge (the called Mode 1) and knowledge, generated in the context of application (the called Mode 2). However, this basic typology neglects the practical knowledge generated in the context of theorizing and fundamental investigation, like the one generated in areas such as molecular biology and nanoscale material science. The growth of research fields with simultaneous theoretical, technological and commercial potential is in the basis of the emergence of universities as an arena for innovation and commercialization. This process which forces the recognition that knowledge brings multiple polyvalent attributes strengthened the diverse roles of academics as well as their involvement in technology firms and of industrial researchers in academic pursuits.

According to Dias (2008) the Triple Helix refers to a non stable relation based on the cultural evolution and the biological evolution, being the development of networks and organizations and its configuration not synchronized or pre-determined. The interaction between the three parts creates value added through objectives, strategies and the needed projects towards the development of R&D programs.

This model stimulates the development of norms of conduct allowing the innovation agents to realize innovation activities and knowledge dissemination. It also implies the existence of scientific and knowledge networks which interactions foster and feed the development process. Here the role of government is based on the process of stimulating and fostering cooperation, improving the development of the industrial part and of the scientific infrastructure through governmental incentives and innovation support policies (Dias, 2008).

Etzkowitz *et al.* (2000) argue that the Triple Helix of university-industry-government relations transcends previous models of institutional relationships, where the knowledge sector plays a subsidiary role. This model presents a new configuration of institutional forces emerging within innovation systems (Etzkowitz & Leydesdorff, 1997; Etzkowitz, 1998).

2.3 Knowledge filter theory

According to Acs *et al.* (2004), the principal contribution of the new growth theory was the recognition that investments in knowledge and human capital endogenously generate economic growth and wealth through the knowledge spillover.

The new growth theory doesn't explain under which conditions and why spillovers occur, being the key link the mechanism that converts knowledge into economically relevant knowledge.

In the perspectives of Braunerhjelm *et al.* (2010) the endogenous growth theory brought two crucial contributions which constitute intellectual breakthroughs, namely the formation of knowledge and human capital that works as a response to market opportunities and the assumption that investment in knowledge is tendentially associated with large and persistent spillovers to other agents in the economy.

The referred authors defend that although new knowledge leads to opportunities that can be exploited commercially, economic growth requires that this new knowledge will be converted into economic knowledge that presents itself a commercial opportunity, being this process an unpredictable and complex process. For instance, according to Carlsson & Fridh (2002) only about half of the invention disclosures in US universities are converted in patent applications and from these only half of the applications results in patents. It's also a fact that only one-third of patents are licensed, and only 10-20% of licenses obtain significant revenues, being only 1% or 2% of inventions successful in reaching the market and yielding income.

Although statistics point to an emergence in academic patenting (OECD, 2004), specially in the United States, not all academic patents are licensed and not all generate income. The majority of the academic institutions negotiate a very small number of licenses per year (in general, less than ten). Even in the American case, the average quantity is 24/year/university.

Only some leading institutions in the United States, Germany and Switzerland achieve an interesting amount on licensing revenues, being the gains highly scarce and a few blockbuster inventions represent the greater share of the revenues.

It's also estimated that, even at the more proactive institutions, licensing revenues are considered to be an extra for research and education activities representing, on average, less than 10% of the research budget. Another interesting issue, is that in several countries the high percentage of licenses come from non-patented technologies, namely biological research material and copyrighted works (OECD, 2004).

Rogers *et al.* (2001) and Mowery *et al.* (2004) also stressed that the majority of the revenues from those blockbuster inventions come from the biomedical area, being their appearance rather unpredictable and rarely forcing many US universities to face patenting and licensing activities as unprofitable activities (Trune & Goslin, 1998), being likely that some of these universities will reduce or end their TT activities and some that survive will be devoted to a broader set of goals than royalty income alone (Mowery & Sampat, 2001).

Thursby & Kemp (2000) also point that most university inventions are no more than proof of concepts, needing that the faculty inventor works in further development in order to pursue commercialization pathways (Thursby *et al.*, 2001; Thursby & Thursby, 2004), and being the optimal incentive strategy a mixture of royalties and sponsored research.

According to Audretsch & Lehmann (2005), investment in scientific knowledge and research cannot automatically generate growth and prosperity, having to penetrate the knowledge filter, making innovation possible, competitiveness and economic growth. The knowledge filter can act as a tampon preventing scientific commercialization.

Audretsch *et al.* (2006) point to some of the obstacles that impede or slow down the transference of knowledge, such as difficulties to fund the production of prototypes, changes in the expectations or requisites of possible users that constraint the potential market, difficulties in the industrialization process including initial prototypes, loss of competitiveness because of emergent and alternative technologies, few understand of the commercialization, management and regulatory/legal processes that limit the access of the technology towards the commercial phase. In this sense, the valorization strategies for scientific results are needed in order to obtain profit from research. In other words, it's about increasing the added value of such results with the goal of favoring their transference towards the productive sector and society.

Acs *et al.* (2004) present a model that introduces a filter between knowledge and knowledge that generates value added, identifying entrepreneurship as a mechanism that reduces the knowledge filter. Another facilitator for the knowledge spillovers is the function that public policies possess promoting and fostering entrepreneurship and then acting as a crucial key factor towards the economic growth.

Braunerhjel *et al.* (2010) conclude that entrepreneurship plays an increasing role among the arrival intensity of innovations generating economic growth, and therefore implying a whole new policy configuration. Entrepreneurship is pointed to serve as a conduit for the spillover of new knowledge. Also, even though most of the entrepreneurs are not engaged in R&D activities, they contribute to growth when exploiting knowledge in a way that resembles Schumpeter's approach.

In the vision of Acs & Plummer (2005), new knowledge materialized in the form of products, processes and organizations drive to commercial exploitation of business opportunities. Nevertheless, this process is not an easy task, since the conversion of new ideas into economic growth needs a basic and complex previous routine of transforming new knowledge into economic knowledge that acts and represents a commercial opportunity.

This "knowledge filter" inserted between new knowledge and economic knowledge is capable to identify new ventures and incumbent firms acting as the mechanism capable of reducing the knowledge filter and increasing regional growth.

In this sense, Acs & Plummer (2005) defend the primary role of new venture creation among the absorptive capacity of incumbent firms as a better mechanism for converting new knowledge into economic knowledge. According to Rothaermel & Alexandre (2009) the higher the levels of absorptive capacity from the part of the firm, the better performance this will have to fully capture the benefits resulting from ambidexterity in technology sourcing.

Mueller (2006) defends the strategic role of elements like knowledge and physical capital and labour in the economic growth process, since knowledge can be transferred into products and/or processes and then possibly exploited commercially. The amount of existing knowledge stock and the capacity of the various participating agents involved, like firms' staff or university researchers, are key direct factors that validate the ability to produce, identify and exploit knowledge. Since the existing knowledge stock is not fully explored and commercialized at its best potential, it's important to secure adequate transmission channels in order to make possible the knowledge flow. The referred channels are entrepreneurship and university-industry relations acting as vehicles for knowledge flows and, then, fostering economic growth.

Carlsson *et al.* (2007) also point out that the new growth theory explains that investments in knowledge and human capital generate economic growth through knowledge spillovers. However this theory is not capable, as referred previously (Acs *et al.*, 2004), of explaining how or why spillovers occur, or even why large R&D investments lead to economic growth. The key elements missing here are "the knowledge filter" - the element that distinguishes general knowledge from economically useful knowledge and the mechanism (such as

entrepreneurship) that is capable of converting economically relevant knowledge into economic activity.

According to the previous author, Acs *et al.* (2009) stress the importance of the knowledge filter acting as a mechanism that debugs economically useful knowledge from new knowledge. The authors also defend the prominent capacity of new firms of penetrating the knowledge filter than of incumbent firms being, the first ones more efficient at the task of penetrating the knowledge filter not only in developed economies but also in declining and growing regions as well.

Agarwal *et al.* (2010) stress that when one couples entrepreneurial action of individuals embedded in their context with the underlying mechanism of knowledge spillover strategic entrepreneurship, reinforced by knowledge investments from organizations result in new venture creation, multiplicity of performance and subsequent growth in industries, regions and economies.

2.4 Technology transfer and innovative performance

In the view of Anderson *et al.* (2007) several authors focused on the impact of university research in innovation: Bennet *et al.* (1998) developed their studies on the significant impact of university-industry collaboration for technology transfer in poorer regions of the United Kingdom; Feller *et al.* (2002) and Cohen *et al.* (2002) studied the impact of academic research on industrial innovation; Siegel *et al.* (2003) presented their views regarding the weak impact that science university parks have on research productivity; Shane (2004) focused on the influence of university research in the creation of start-ups.

For Morrissey & Almonacid (2005) technology transfer is a crucial element regarding economic development and innovation across industry, since it works as a process that enables SME's to be more efficient, competitive and flexible in order to adapt themselves to specific needed changes that are essential to their survival.

In the same line of thought, Fritsch & Lukas (1999; 2001) reveal the importance that external relations and technology transfer present to the improvement of the innovative capacity of firms.

In the opinion of Ribeiro (2001) the important step towards the technological change is the incorporation of the invention in the production process, generating impact in the economical development. According to this author one can distinguish invention from innovation.

Invention isolated won't have the economic dimension, referring only to the principle discovery that can be attached to the science field. On the other side, innovation can have practical application, generating the production, transfer and consumption of goods. These two processes are not independent, being the discovery of new principles a generator of a set of applications and the economic resources hereby produced that can be applied to the new knowledge production. This way, innovation refers itself to the introduction of new knowledge or a new set of combinations of existent knowledge. Technological innovation refers to new products and/or production processes and improvements of products and processes.

Etzkowitz *et al.* (2000) argue that as knowledge becomes an increasingly important part of innovation, the role of university as a knowledge producing and disseminating institution becomes more important and plays a crucial role in industrial innovation.

In this sense, the role of knowledge transfer is about providing industry and SME's with the results of teaching and research at universities of applied sciences and research institutes. There is a wide variety of cooperation forms between science and industry, such as cooperation and contractual research, hiving off from scientific areas, personnel transfer and expertise concerning individual questions, further training activities or patent and licensing activities.

In the process of technology transfer the interfaces appear as a key aspect in the channels of interpretation (Caraça *et al.*, 2009). These channels enable firms to identify, select and absorb new potential ideas from other actors and knowledge pools. Being crucial for the process of learning, interfaces open up the channels for interaction and cross-fertilization.

According to Etzkowitz *et al.* (2000) these activities developed in the scope of the concept of the entrepreneurial university emerge as a response to the increasing importance of knowledge in national and regional innovation systems and as the recognition of the university as a cost effective, creative inventor and transfer actor of knowledge and technology. Also, governments play a central role in the process of considering universities as a precious resource in order to achieve innovation and create a regime of science-based economic development.

Cysne (2005) points out that although the innovation process involves a set of distinct phases from the ideas generation towards their application and their transfer, the most complex role is centred in this last phase.

According to Gross (2008) in the United States, previously to the implementation of the Bayh-Dole Act, a technology invented at a university or federally funded lab was of public propriety. Bayh-Dole gave back universities and labs the possibility of achieving property

rights in the transfer process of their discoveries. Other countries in Europe and Asia are replicating the Bayh-Dole Act, since this has improved the American economic competitiveness in nearly every aspect of business and life. For instance, in 2006, government and corporate sources invested approximately \$45 billion in order to support research in the United States, being the result, more than 700 new products introduced in the market through university technology transfer.

However, according to Swamidass (2009), tech transfer offices in universities with limited staff and budget are reduced to tasks like the filling of patent applications and patents are issued at the expense of marketing of inventions. Also, high-tech inventions are difficult to market since there are no ready markets for them or a structured market pain for these inventions, especially if the inventor has no pre-invention contacts with potential licensees. Another set of impediments from the part of tech transfer offices resides in the reduced skills of these units in the process of market space/niche identification for high-tech inventions from university labs, new market creation and the translation of the lab result into an “investor friendly” business plan.

2.5 University’s third mission and knowledge commercialization

Etzkowitz *et al.* (2000) argue that the tasks of identifying, creating and commercializing intellectual property have become institutional objectives in almost academic systems.

According to the Triple Helix concept, referred previously, the university can play an important mission in the innovation process and in the increasing of knowledge-based societies. This model differs from the national systems of innovation thesis (Lundvall, 1988, 1992; Nelson, 1993), which places the firm in a central position having a leading role in innovation, and also from the “Triangle” model of Sábato (1975), that stresses the importance of the state (Sábato *et al.*, 1982). Here the focus is based on the network overlay of communications and expectations that is originated from the institutional arrangements among universities, industries and governmental agencies.

Etzkowitz *et al.* (2000) present four processes related to major changes in the production, exchange and use of knowledge identified by the Triple Helix model. The first corresponds to the internal transformation in each of the helices, like the development of lateral ties between firms through strategic alliances or the assumption that universities have an economic development mission. The second is about the influence of one institutional sphere upon another in the transformation process. It can be pointed as an example, the revision by the American and Swedish governments of the rules of intellectual property ownership to transfer rights from individuals or government to universities. The third refers to the creation

of a new set of trilateral linkages, networks, and organizations among the three helices, providing an institutionalized and reproduced interface, and stimulating organizational creativity and regional cohesiveness. The fourth process is about the effect of these inter-institutional networks representing academia, industry and government on their originating spheres and the wider society.

Mello (2004) states that the Triple Helix poses the dynamics of innovation in a context under permanent evolution, where new and complex relations are established between the three spheres, namely universities, industry and government, being these relations caused by internal transformations in each helix, towards the influences of each helix on the others and by creating new networks made possible through the interaction of the three helices and the effect of that networks in themselves and in society as a whole.

When the central place in the institutional structures of contemporary societies of the military was given to academia, the network of relationships between academia, industry and government suffered great transformations, appearing with an overlay of reflexive communications that increasingly reshapes the infrastructure (Etzkowitz & Leydesdorff, 1997). Thus, these transformations and their effects achieved a central position in the international debate over the role of the university in technology and knowledge transfer.

According to Mawson (2007) universities had left their pedestal, being no longer the isolated ivory towers and becoming engines of the economy of knowledge. Actually, universities while remaining teaching and research institutions are engaged in the activities of the so called "third mission" (Jongbloed *et al.*, 2008), the technology transfer activities engaged in a socio-economic posture.

Orr (2007) argues that the adoption of the "third mission" activities among universities is a consequence of the need of academia to achieve additional funding, affecting university competitiveness for investment, for performance-based funding and, also, for attracting top researchers and students.

Callon (1998) argues that institutional innovations bring closer relations between universities and firms. The basic research, in the sense of being an end in itself, with only long-term practical results expected, is being replaced by another model called 'endless transition' that links basic research to its use through a set of intermediate processes, many times stimulated by government.

The direct results of these transformations in the linear model either expressed in terms of "market pull" or "technology push" demonstrates that it was insufficient to promote knowledge and technology transfer. Publication and patenting became crucial mechanisms to the transformation of knowledge and technology into marketable products. As some authors

defended (OECD, 1980; Rothwell & Zegveld, 1981) rules and regulations had to be reshaped, and the interface strategy had to be created in order to integrate market pull and technology push with new organizational mechanisms.

In the late 20th century the university tended to an entrepreneurial format, arriving to its 'third-mission' of economic development in addition to research and teaching (Readings, 1996).

These changes arise from the internal development of the university and external influences, affecting academic structures, such as the emergence of knowledge-based innovation.

The entrepreneurial activities arise from the improvement of regional or national economic performance and the university's financial advantage. In this sense the entrepreneurial paradigm is not only determined by newly invented technologies or research intensive universities.

The role of knowledge production and dissemination of universities tends to be more important as the knowledge becomes an increasingly important part of innovation, playing these institutions a larger role in industrial innovation.

Wedgewood (2006) and Sorlin (2007) state that the "third mission" tendency in terms of the technology transfer activities has been towards licensing and spin-outs, being these forms of commercial engagement reinforced by governments support regarding funding incentives for the exploitation of scientific results.

The referred activities suffered an expansion deriving in a diverse set of mechanisms and a multiplicity of areas not traditionally open to commercialization, such as arts, humanities and socio-economics (Mould *et al.*, 2008).

Nelles & Vorley (2010) summarize the usual mechanisms of university-industry technology transfer illustrated on Table 1.

Table 1 - Mechanisms of university-industry technology transfer

Specific Mechanisms	Generic Mechanisms
<ul style="list-style-type: none"> • Licensing of university patents to companies • Formation of start-up companies 	<ul style="list-style-type: none"> • Co-funding of research • Collaboration in National Competence Centres • Conferences, seminars and workshops • Continuing education for industry • Co-supervision of PhD and MsC thesis • Employment of graduates • Faculty consultancy • Industry scientists working at universities

	<ul style="list-style-type: none"> • Joint labs • Open university days • Popular lectures • R&D agreements • R&D consortia • Scientific publications • Research contracts • Mobility/exchange of people • University fairs • University sabbaticals
--	---

Etzkowitz *et al.* (2000) argue that in a knowledge-based economy context, the university plays a crucial role in the innovation system, providing human capital and incubators for innovative firms. The institutional spheres - public, private and academic - are increasingly interacting through spiral linkages emerging at different stages of the innovation and industrial policy-making processes.

This author defends that Triple Helix is generating a knowledge infrastructure in order to respond to this new university mission in terms of overlapping institutional spheres, where each one takes the role of the other and where hybrid organizations are emerging as interface engines.

This mission is conducting many countries and regions to attain some form of Triple Helix, being the common objective to achieve an innovative environment providing a central place to university spin-off firms, tri-lateral initiatives for knowledge-based economic development, and strategic alliances among firms (large and small, operating in different areas, and with different technology levels), government laboratories and academic groups. This set of mechanisms is being motivated and encouraged by government, either by a new regulatory framework or through financial assistance.

The model of the Triple Helix denotes not only the relationship between the three spheres, namely university, industry and government, but also internal important changes within each of these spheres and their roles and missions. The university passes from a teaching institution into one which combines teaching with research. This revolution is not yet completed, and is still under development, not only in the USA, but in many other countries too. This development is not always pacific, since there is a tension between the two activities, but nevertheless they coexist because they are more productive and cost effective when combined.

Merton (1942) and Etzkowitz (1998) argue that the capitalization of knowledge is increasingly reaching a strong position since the academics are getting really involved in entrepreneurial activities and this new role is gaining or increasing strength.

Drejer *et al.* (2005) advocate that the Triple Helix model served also to identify the facilitator function of the third one, rather than a player in the tech transfer process and inside this one, in the venture creation process.

2.6 IP protection and transfer in academic contexts

In order to clarify the concept of technology transfer, and since as a discipline is still in an initial phase, several authors show different understands of the term. For instance, the Institute of Knowledge Transfer in the UK defines knowledge transfer as the process by which knowledge and technology are transferred from one party to another generating innovation, profit and socio-economic improvement (Oliveira & Teixeira, 2010).

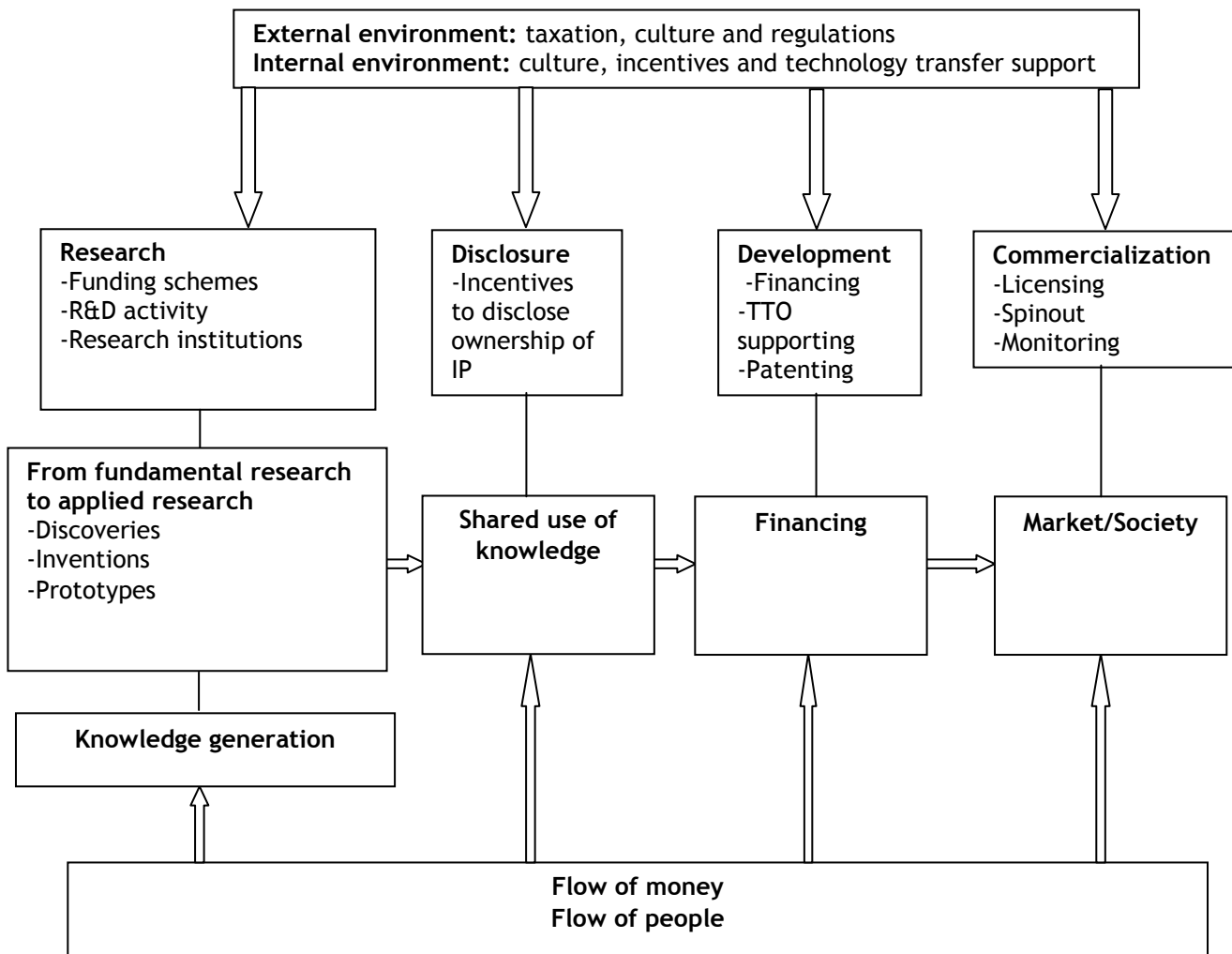
Laranja (2009) states that technology transfer can't be reduced to a linear information transmission, being also a process of reciprocal learning.

Despite these diverse assumptions, the general concept is about transferring knowledge from one entity to other, aiming at development and/or commercialization (Lane, 1999; Lundquist, 2003; Swamidass & Vulasa, 2009).

The process typically starts with the identification of technologies, their protection and the development of commercialization pathways, namely marketing and licensing to industry, or the creation of start-up firms based on that technology (Oliveira & Teixeira, 2010).

A model of technology transfer can be illustrated, as follows:

Fig. 1 - Process of Technology Transfer



According to Chesbrough (2010) a technology only gains value when it is commercialized using a business model. Additionally, a technology which is commercialized in different ways can expect different returns.

The importance of the business model, in order to commercialize the technology and extract value from it, resides in the fact that it presents the value proposition, identifies the market segment, specifying the revenue generation mechanism, points the value chain structure needed to create/distribute the offer and its assets required to secure position in the chain, details the cost structures and profit potential, identifies the stakeholders involved in the process and formulates the competitive strategy through which the owner of the technology will gain and sustain advantage over competitors (Chesbrough & Rosenbloom, 2002).

In this sense, Gross (2008) defends that patent rights can work as a fundamental privilege and a key mechanism towards the achievement of marketplace value from scientific discoveries in a functioning democratic society. This process is possible when it's allowed for the original

inventor to own and transfer the patent rights of his invention to a company. This way, it can be said that useful innovations can be built on the basis of patent rights.

According to Magic (2003), for developed countries and western world the Intellectual Property Rights are seen as an engine to foster innovation, since patents function as an essential mean to promote international economic development because they are able to guarantee a return on investment done in terms of time and capital invested in R&D.

OECD (2004) refers that the growing numbers of business patenting have helped inventors to appropriate the returns of their investments and fostered cooperation through the market transactions of knowledge and technology. There was a great boom in the 1990's in terms of patent applications. In European, Japanese and American IP offices were filed 850.000 patent applications in 2002, comparing to the 600.000 one decade before. These growing figures suggest a new organization of research which tends to be less individualistic and oriented towards knowledge networks and more market-driven.

OECD (2004) also points to a great contribution to these numbers from the areas of new technologies, like ICT (Information and computing technologies) and biotechnology. This ascending situation faced a breakdown since 2002 in response to the economic deterioration at the international level.

Regarding university patents, their relative importance and generality has fallen at the same time as the number of university patents has increased, being this phenomena explained by a fast increase in the number of "low-quality" patents being granted to universities (Henderson *et al.*, 1998). According to the previous authors, despite the increasing numbers in academic patenting, licensing and tech transfer activities, after the implementation of the Bayh-Dole Act in the United States, this situation hadn't impact significantly on the underlying rate of generation of commercially important inventions at universities. Neither universities had shifted their researching agendas towards areas with commercial impact nor the ones that have done it proved to be successful.

Although statistics point to an emergence in academic patenting (OECD, 2003), especially in the US, not all academic patents are licensed and not all generate income. Another interesting issue is that in several countries the high percentage of licenses come from non-patented technologies, namely biological research material and copyrighted works.

Rogers *et al.* (2001) and Mowery *et al.* (2004) also stressed that the majority of the revenues from those blockbuster inventions comes from the biomedical area, being their appearance rather unpredictable and rare forcing many US universities to face patenting and licensing activities as unprofitable activities (Trune & Goslin, 1998), being likely that some of these

universities will reduce or end their transfer activities and some that survive will be devoted to a broader set of goals than royalty income alone (Mowery & Sampat, 2001a).

Henderson *et al.* (1998) refer that it's not clear if this is a socially desirable shift. It is likely that the essence of the economic revenues of academic research come from inventions in the private sector build upon the knowledge base created by university research, rather than from commercial inventions generated directly by universities. This way, being commercial inventions a secondary product of university research, it's important that policy strategies will ensure that inventions that do appear are directly transferred to the private sector, not expecting to directly increase the university research that generates commercial inventions.

In the vision of Webster & Packer (1996), there are important differences of practices towards patent applications and the publication of results, being both the written codification of the research results. In the public sector there exists more obstacles towards the IP protection than in the private sector. Also in terms of different national contexts there exists a substantial difference between national innovation systems, which contributes to the transposition of inventions to innovations. Problems of institutional lack of culture and experience IP/tech transfer oriented with the obvious learning costs act as important obstacles against the commercial success of the filled patents.

Universities, according to Mowery (2007), face other constraints regarding technology transfer, since they can fall in a critical situation of neglecting their mission of involving scholars and students in an interaction with firms, in order to become business enterprises, selling knowledge in the form of patents.

According to Siegel & Phan (2005), the formal management of the intellectual property portfolio is a mechanism that still needs great investment and work in order to function adequately for many universities. This point has led to important doubts among administrators towards the optimal organizational practices related to inventor incentives, technology transfer "pricing," legal issues, strategic objectives and measurement and monitoring mechanisms.

Regarding the patent regimes there has occurred some critical changes in the last two decades (OECD, 2004), in order to reinforce the exclusive rights of patent holders, expanding their coverage and facilitating their enforcement. It's occurring an international harmonization regarding patent regimes. Despite this tendency, there subsists a strong difference between the IP system in the United States and in Europe. For instance, the first one is more flexible, allowing the final grant to be different from the initial applicant, being also less bureaucratic with low patenting requirements.

Another fundamental aspect regarding the technology transfer process and the intellectual property management has to do with the invention disclosures not always done by many faculty members to TTO's (Thursby *et al.*, 2001; Siegel *et al.*, 2003). The usual process when the faculty member decides to file an invention disclosure to the TTO, is that the university administration, in consultation with a faculty committee, has to decide whether to patent the invention. According to the previous authors, the next step for the TTO is the evaluation of the commercial potential of the invention. This study must be done because of the high cost of filing and protecting patents, being some institutions reluctant to file for a patent when there is little interest expressed by industry in the technology.

When a patent is granted, it's common for the university to try to put the invention in the "market", through license contracts or start up firm creation based on the technology.

Here, the importance of personal networks and knowledge about the technology potential users of the licensing officers are of extreme importance. In this sense, Jensen & Thursby (2001) present a theoretical model expressing the importance of the faculty involvement in the success of the technology commercialization process. Licensing agreements can be materialized either in upfront royalties, royalties at a later date, or equity in a start-up launched to commercialize the technology.

In terms of technology transfer mechanisms, Laranja (2009) defends that it's no longer interesting to think of unilateral transfer from the supplier to the recipient. Technology transfer must understand the recipient's capabilities, like technical and organizational capacity to embrace ideas and technologies developed by an external R&D source.

Technology transfer offices play a central role in the process of technology transfer, since they contribute to foster commercialization of research results, improve innovation performance and dissemination of new technologies, develop a better management of IP rights and identify research needs in industry (Siegel *et al.*, 2003; European Commission (b), 2004).

In the opinion of Swamidass & Vulasa (2009) patents issued to companies differ from the ones issued by universities' TTO's. For instance while companies search for patents that can influence positively their business and for internal consumption, universities need to find external licensees for their issued patents, which is an expensive and time-consuming task for the TTO.

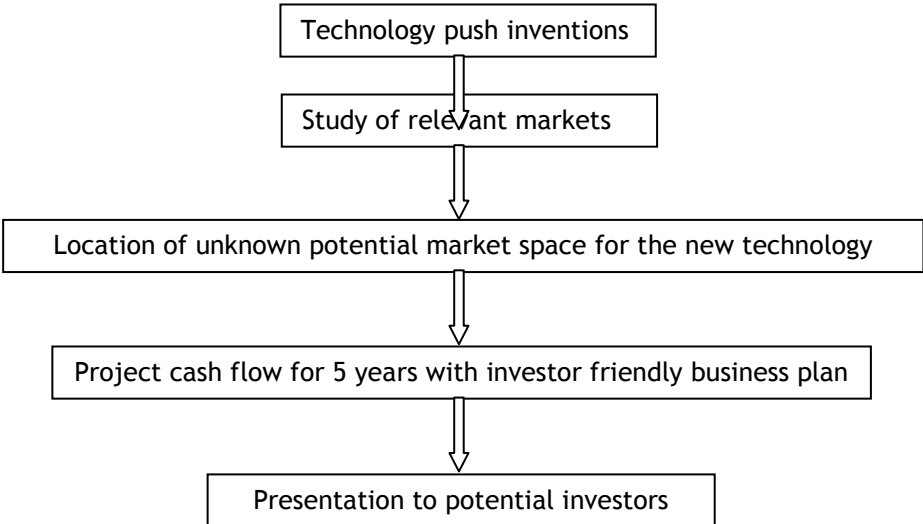
According to Etzkowitz & Goktepe-Hulten (2010) the traditional activities of TTO's start in the identification of research results in the university and continue along the process of transferring them to the market, being fundamental for the successful transference proactive universities and researchers, industrial absorptive capacity and investors. Since TTO's should

act as a bridge between these different factors acting as the glue of the process, it should be secured that TTO's would have capacity to substitute or provide replacements for missing pieces in the technology transfer process. Regarding the above mentioned authors, a passive TTO will fail the expected mission to promote technology transfer. Nevertheless a pro-active one is supposed to help cross the 'valleys of death'.

According to the European Investment Fund (2005) TTO's practices cover IP management (filling of patents and other IP rights, licensing of IP assets), liaison with industry to develop contracts and projects, support to start-ups, business planning and fund raising.

In regard to the tasks of the TTO's and specifically the process of marketing technology push inventions², the following model proposed by Swamidass & Vulasa (2009) can be presented:

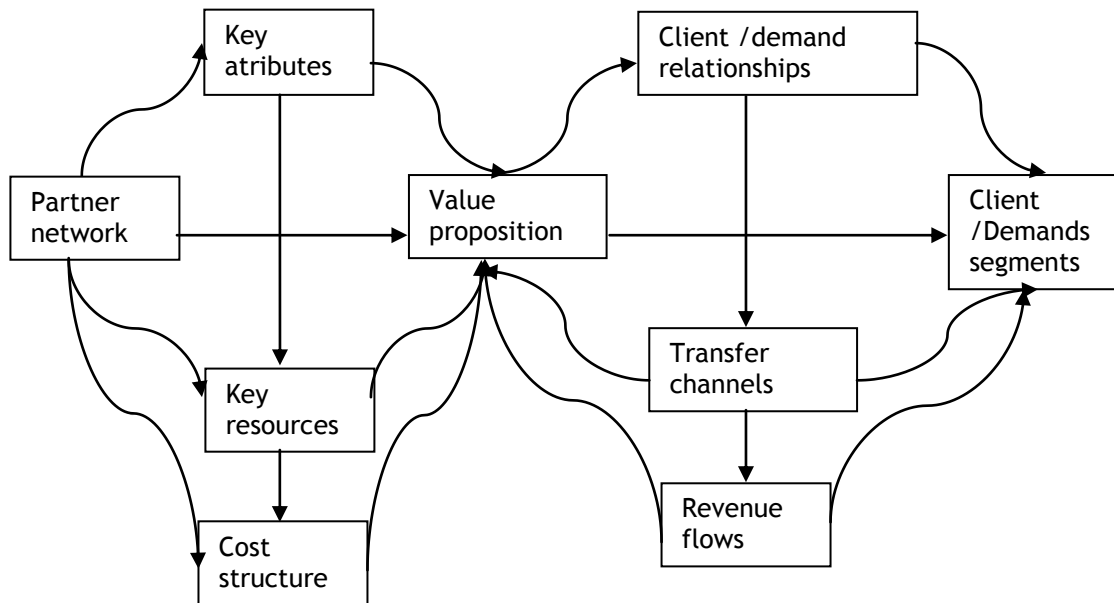
Fig. 2 - Process of marketing technology push inventions



In the opinion of Chesbrough (2010) technology transfers must develop maps of business models for each technology, clarifying the underlying processes that will allow them to act as a source of experiments considering different combinations of the process. The proposed business model innovation where all stakeholders and components interact is an adaptation of the business model innovation suggested by Osterwalder (2004) is presented in Figure 3.

² Swamidass & Vulasa (2009) refer that many university inventions are a “Technology Push” variety which is looking for a market, and don't have the “Market Pull” orientation where the market appeals for the development of a new product.

Fig. 3 - Business Model Innovation for Technologies



Siegel & Phan (2005) stress that for university technology transfer to be fruitful, in terms of launching successful start-ups (and in other aspects of technology transfer), the university must adopt a strategic approach to the commercialization of its intellectual property portfolio. Such an approach begins with establishing clear priorities at the university level, combined with appropriate organization design choices focused on providing a broad supply of inventive disclosures. It also entails changing incentives to stimulate entrepreneurial behaviours and establishing an university level, process-based educational curriculum for all stakeholders engaged in the technology transfer process.

In the opinion of Nelles & Vorley (2008; 2010) in order to implement the third stream activities in the university, along with teaching and research functions, besides establishing support structures like TTO's, it's important to coordinate these ones with the institutional strategies, systems of communication, leadership and culture. TTO's need to be supported and actively integrated into academic and administrative processes and cultures. The third mission success depends largely on the capacity of universities to develop and implement entrepreneurial architectures and on the strategy designed to obtain synergies between missions and maximization of institutional gains.

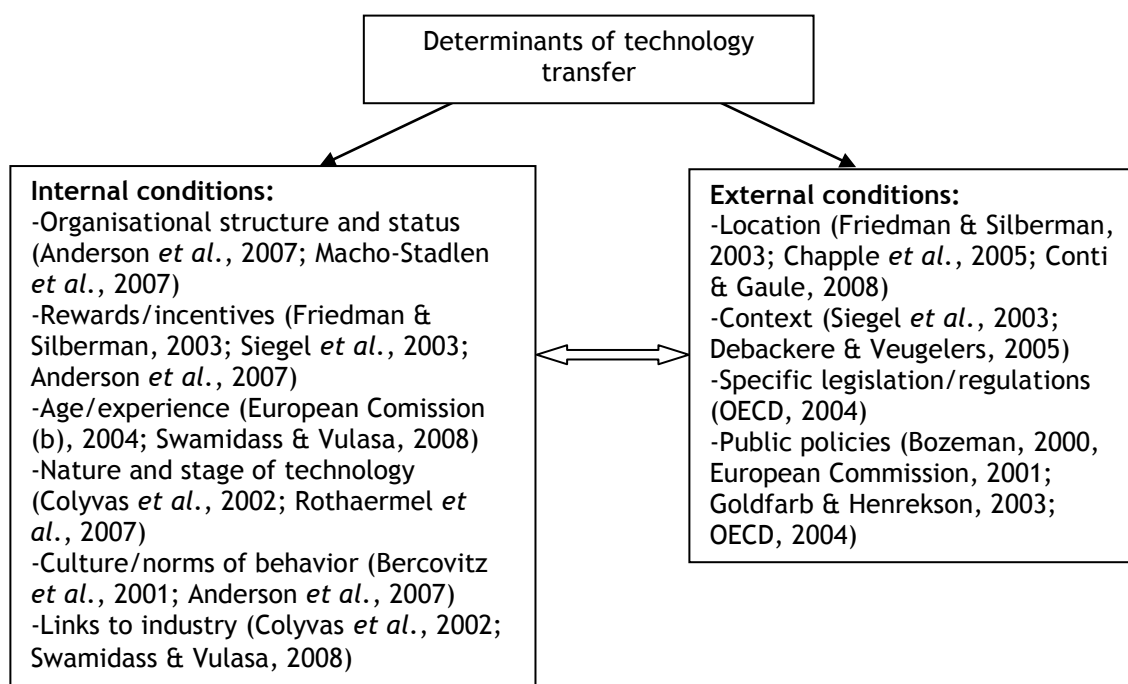
When understanding the work of TTO's, it's important to assess their efficiency and productivity and this can be a hard task, since there are a lot of context variables and many authors presented different approaches of doing so. Sorensen & Chambers (2008) refer the usefulness of the outcomes. Anderson *et al.* (2007) present the universities ranking based on licensing revenues, income from industry research contracts, number of patents granted and

number of spin-offs created. Chapple *et al.* (2005) and Rothaermel *et al.* (2007) prefer the quantitative methods and Thursby & Kemp (2002) defend the analysis of licensing activities in TTO's.

As so, efficiency is the conversion of inputs into outputs by the involvement of several stakeholders, such as researchers, TTO's, entrepreneurs and industrial parties (Anderson *et al.*, 2007).

For the process of technology transfer to occur under optimal conditions, there are a set of determinants that are critical (Oliveira & Teixeira, 2010), namely:

Fig. 4 - Determinants of Technology Transfer



Swamidass & Vulasa (2009) also point out that in a crisis period the budget allocated to TTO's can influence their efficiency in terms of human resources' capacity and train, the information technology infrastructure to develop daily tasks in an automatic way and the overall performance in technology transfer. These authors defend that academics with strong ties with industry are more productive and then more cooperative with TTO's reinforcing their performance.

The effect of the shortage of personnel and budgets allocated to TTO's can produce a negative effect on the latter stages of commercialization, being the TTO's capable to patent the invention but with limited resources left over for marketing them to potential licensees

and investors. Since patents are not an end in themselves, licensed patents are the only ones that can produce income to universities, and that's the stage to which TTO's must devote specific efforts (Swamidass & Vulasa, 2009), in order to avoid the failure of inventions reaching potential licensees and investors.

Regarding cultural and organizational commitment of universities to engage in serious technology transfer, it's important that researchers are conscious of research results valorization, having specific incentives to embrace exploitation activities and to collaborate with industry (European Commission (b), 2004; Siegel *et al.*, 2007; Oliveira & Teixeira, 2010).

Other structural norms and behaviors like the IPR policies in universities can influence directly the efficiency of the TTO (Debackere & Veugelers, 2005; Anderson *et al.*, 2007). Consequently issues like exploitation results distribution, the ownership percentage to the inventor, the trained facilities to help/manage IPR or the investment allocated to the IP lifecycle influence technology transfer activities.

TTO's can act more proactively and efficiently if they are subject to compensation practices, if they aren't understaffed and if the university administration strongly supports their mission (Bercovitz *et al.*, 2001; Siegel *et al.*, 2003; European Investment Fund, 2005; Anderson *et al.*, 2007 and Macho-Stadler *et al.*, 2007).

TTO's are also influenced by the external context, namely the policy related framework conditions which involves public promotion programmes (European Commission, 2001; Debackere & Veugelers, 2005).

Consequently and however the diverse mechanisms used to ease the process of transfer and the openness of firms, Chesbrough (2010) refers that organizational processes must change, the organization must develop and embrace the culture of openness towards innovation, the model to exploit technologies and it must secure internal leaders that will make the process valid and replicable.

2.6.1 US experience in Technology Transfer practices

Chesbrough (2003) states that in the United States, a set of different factors made possible the shift from a "closed innovation system" to an "open innovation system", for example the rise in venture capital, the passage of the Bayh-Dole Act, which started providing incentives for universities and academics to fill patent scientific breakthroughs financed with federal funding, the rise in the pool and subsequent mobility of scientists, and technological breakthroughs in fields like computing (for instance in the area of microprocessor),

biotechnology (in the area of bio and genetic engineering) and, more recently, nanotechnology.

For Mowery *et al.* (2004) and Siegel (2006), since the early 1980s, American universities saw an important increase in their entrepreneurial activities, such as: number of patents filled and licenses (plus revenues), number of spin-offs created, number of incubators, number of science parks created, and investment of equity in start-ups, among other indicators.

According to the OECD (1980) and Rothwell & Zegveld (1981), the linear model either expressed in terms of “market pull” or “technology push” became limited in order to foster the activities of technology transfer. Publication and patenting have different systems and mechanisms with reference to the transformation of knowledge and technology into marketable products. Afterwards, the rules and regulations suffered a transformation, and it was adapted as interface strategy to accomplish the integration of market pull and technology push through new organizational mechanisms.

The American government created several programmes which included the Small Business Innovation Research Program (SBIRP), the Small Business Technology Transfer Program (STTRP), the Advanced Technology Program (ATP), the Industry/University Cooperative Research Centres (IUCRC) and the Engineering Research Centres (ERC) of the National Science Foundation, among others (Etzkowitz *et al.*, 2000).

According to Rogers *et al.* (2001) technology transfer in American research universities is a process that embraces firstly the development of research activities funded by research expenditures, which lead to invention disclosures, and can possibly lead to patent applications of which some can be granted, conducting to active technology licenses that can generate considerable income, in the form of technology royalties and/or start-ups, providing in a final analysis jobs and wealth creation.

The technology transfer activities have shown a great potential in the contribution of science to the economic development, becoming a major source of regional and international competition at the turn of the millennium. The view that location of research was not important, being the location where science was produced not directly linked to its eventual utilization has changed in recent times. The recent emergence of Austin, in Texas, for instance, is explained by the expansion of research at the University of Texas and the direct helps from the State, from industry and from federal funds.

Following Etzkowitz *et al.* (2000) regions characterized by less research-intensive conditions are aware that science, when applied to local economic resources, can be the basic stone for their future potential regarding economic and social development. For these authors, in the USA, it is not acceptable that research funds are channelled to the east and west coasts with

a few places in between in the Midwest, since funding is awarded, not on the bases of the peer review system, but instead, in the premise that all regions need a share of research funding.

According to Pereira *et al.* (2004) there has been given greater attention to the commercialization of the scientific research results, being the intellectual property rights requests on these results object of specific support actions in diverse international contexts. The Bayh-Dole Act in the USA played an important role for developing initiatives to promote and support the process of patenting in research institutions, giving ownership of intellectual property protection deriving from federally funded research to universities. For the inventors in American universities it was guaranteed at least 15% of the returns on their inventions. Also, the law enforced universities for trying to commercialize these rights, namely by creating technology transfer offices.

Soon universities assumed the 'one-third rule', by dividing the financial benefits of research among the researcher, the researcher's department and the university as a whole.

According to Owen-Smith (2001) the 1980's Bayh-Dole Act (Public Law 96-517) represented a milestone that American universities rushed to commercialize their academic research conducted with the aid of federal funding. In addition, the last quarter-century witnessed the dramatic growth in university patenting and licensing activities together with the emergence of a new professional group: TTO managers. Following this trend, other countries launched their own versions of Bayh-Dole Act to accelerate technology transfer from universities to industries for immediate application (Walsh & Saegusa, 2003; Hong 2006).

This way, universities started to supply the industry with improved technology, being this a result of the federal innovation strategy (Etzkowitz *et al.*, 2000).

Nelson (2001) argued that the act had two major implications, since it transferred ownership of invention from State to Academia ensuring that the inventors would obtain a fair share of the benefits of the industrial exploitation of inventions.

According to Mowery *et al.* (2001), this act was specially designed for increasing the number of academic patents, the licensing activities and the establishment of technology transfer offices.

The entrepreneurial university was firstly led in the United States by the Massachusetts Institute of Technology (MIT), Stanford University, Harvard and the University of California which emphasized applied forms of research (Nelles & Vorley, 2010).

In the vision of Shane (2004) the Bayh-Dole Act pursued universities to engage in commercial activities. In this sense, governs around the world influenced universities to foster these activities and took Bayh-Dole policies in order to normalize and institutionalize them (Lawton-Smith, 2006).

Soon countries like Japan and Sweden started restructuration processes of the ownership of academically generated intellectual property allowing for their commercialization. Incentives like TT offices and government granting programs for supporting R&D fostered the participation of researchers in the exploitation of academic results. The mentioned authors present a dual cognitive mode that has emerged in academic science, focusing researchers both on achieving fundamental advances in science and inventions to be patented and commercialized.

Instead of working against the traditional public character of research, the patenting process works as a mechanism to foster the diffusion of knowledge, identifying in a more precise way the scientific results with direct commercial impact.

Mowery *et al.* (2001) recognize that the recent valorisation of IPR applications regarding their potential economic benefit is biased since, for example, in the USA only few organizations really benefit from the exploitation of IPR results.

In terms of the rise and development of the IPR exploitation and as Mowery *et al.* (2001) defend the changes that occurred in the USA, in the 1980's, with the promulgation of the Bayh-Dole Act, acted as a kick-off step in the development of the IP rights' commercialization in universities. By allowing the patent application based on research results developed with public finance, this law contributed for increasing the number of patents filled by research institutions. Data regarding patents filled and conceded to research institutions reveals a serious growth in the recent years. The Bayh-Dole Act has stimulated other countries and their institutions to create similar practices, such as the case of the European Commission or the OECD.

Rafferty (2008) defends that the Act has simplified the task for universities to obtain patents from research funded by the federal government and gave universities an incentive to transform their R&D activities. It has also helped to reduce basic research, considering it doesn't generate licensing income and stimulated applied research (responsible for generating patents and licensing fees). Bayh-Dole might, additionally, foster the willingness from industry to fund university R&D projects once the results are now easier to patent.

According to Audretsch & Aldridge (2010) the Act brought a clear impact on the science commercialization, playing a key role in generating entrepreneurial activity. The authors also suggest that there is a clear link between the commercialization mode (with the help of the

TTO or not) and the commercialization route. Scientists that don't use the services of TTO's, not assigning patents to their university to commercialize research, tend to be more proactive in the creation of new firms. Scientists who use the TTO services/routes by assigning their patents to the university tend to commercialize research results via licensing, being in general assets with lower potential value. However according to data collected by AUTM³, there is a major trend towards the route of licensing patents and a relatively low number of new firms created.

For Owen-Smith (2005) TTO's in the United States, although relatively young, became crucial partners in the prosecution of a hybrid university research mission which mixes commercial and academic regulations in order to produce, disseminate, and make use of scientific findings.

2.6.2 European experience in Technology Transfer practices

In the European case it has been given great attention to foster direct commercialization of technology. In several countries, for instance the case of Denmark, the govern enforced technology transfer as one of the universities' missions⁴ (European Commission, 2001; European Investment Fund, 2005).

According to Freeman (2003) policies to foster technology transfer, close collaboration among industry, government and universities and linkages between science and technology started to be implemented after the Second World War. Firstly these policies were targeted at the military area.

However, early signs were devoted to innovation policies during the subsequent forty years, being these policies for R&D funding and planning object of an irregular evolution (Pavitt, 1998).

Only during the 1970's the European innovation policies started to foster the linkage between science and industry (Grande & Peschke, 1999; Georghiou, 2001). Afterwards, transnational programmes at the European scale, like framework programmes, the Lisbon Strategy or the Eureka reinforced the science-industry permeability⁵.

³ Association of University Technology Managers.

⁴ Denmark published the New University Act that integrates knowledge and technology transfer as parts of the universities' charters.

⁵ Lisbon European Council in March 2000 implemented the European Research Area (ERA), which emphasized the need for programmes and policies as well as a strong European coordination of national and regional research activities (European Commission, 2007).

The European Commission, regarding the increasing importance of the technology transfer activities, launched a series of initiatives in order to respond to the European underperformance in these matters when compared with the US practices. The programme “Putting Knowledge into Practice” intends to foster technology transfer activities, improve regional coverage of innovation support services, help satisfy SME's needs and provide particular services such as patenting support.

In the European context, UK universities took the process leadership assigning ownership of intellectual property derived from publicly funded research⁶. Nevertheless, it was only in 1999/2000 with the Higher Education Funding Council for England (HEFCE) that the third mission was formalized.

In the perspective of Rothaermel *et al.* (2007), European universities, especially some located in Germany, Italy, Sweden, and the United Kingdom, became special sources of technology, although they cannot be compared to American universities, due to different legal systems. However, American universities, that suffered great structural shifts in their orientations, accompanied by the European executive branch which evolved consistently regarding the new mission of universities and academic research, and European universities, all guided their orientations for the inclusion of an economic development premise for universities, parallel to their traditional missions of education and research. Consequently, all these changes and developments attracted the attention of researchers both in the United States and in Europe.

In the opinion of Anderson *et al.* (2007) there are considerable differences between American and European universities in technology transfer efficiency.

Etzkowitz *et al.* (2000) refer that public funding for university research in the UK, for instance, depends on its direct contribution to the economy. One factor that influenced universities to work for industry to attract funding or generate income was the reduction made on the universities' budget. Under these conditions, and responding to government policies both conservative and most recently labour, universities are increasingly engaged in entrepreneurial activities, like patent licensing and the creation of innovation centres.

Economy is suffering great changes too, namely at the level of relationships between knowledge producer and user through outsourcing, the emergence of transorganizationally dependent technologies like bioinformatics and the growth of data sourcing, which resulted in the re-configuration of institutional relationships. Universities are facing major changes, as a result of the previous, starting at the shift from a grant user to an exchange economy perspective, deriving in new institutional orderings, modified regimes that manages and reward entrepreneurial initiative.

⁶ This policy was of the responsibility of the British Technology Group in 1986.

As Etzkowitz *et al.* (2000) state, the commercialization policies that were structured to rule academic entrepreneurial activities appeared as a consequence of the need for exploiting scientific research. From 1985, it was possible for UK universities to exploit their intellectual property by securing property rights in order to ensure the transfer of publicly funded research to industry. This mission was intended to help universities fund themselves and to contribute to national and regional wealth creation.

With all these changes, academic entrepreneurs start to secure the formal rights on their inventions and technologies which can then be commercialized. All this process is facilitated by new institutional units, like the industrial liaison offices and incubator firms, which ease the appropriation of knowledge.

The authors previously mentioned also defend that the traditional academic reward system was changed and in changing process because of this new tech transfer activity. In this sense, the UK Higher Education Funding Council (principal state agency that supports universities) is trying to value patents as evidence of 'quality research' in the National Research Assessment Exercise, in order to become equivalent to other conventional academic outputs, like publications, for instance. In this way, patents can work in two platforms, the market (generating revenues) and the academic (mechanism for assessment of career).

However, until now there is still lots of work to be done by the liaison offices, regarding the level of understand and recognition from academics on IP rights policies for promoting the commercialization of research. Academics usually find these IP rights policies confusing and others just simply don't acknowledge their existence and importance (Etzkowitz *et al.*, 2000).

The integration between entrepreneurial activities and the traditional academic mission is currently under discussion. For instance, in the UK the linkage between university and industry is being reinforced through privately funded contract research, as the university spin-offs face a rapid growth, not only in the UK but also in all Europe. This phenomenon appears as a reaction of the movement regarding science commercialization and R&D contracts with firms.

This situation, in the specific case of UK, following the American changes, was the result of measures taken by the Thatcher government during the 1980's in order to foster commercialization of academic results and intellectual property policies. According to Etzkowitz *et al.* (2000), these measures brought a set of shifts in the academic government models, such as the relative independence of the university sector from the state, that aimed to address in a faster way the technology pull from firms.

As Musselin (1998) points out in the European and Latin American context, universities were usually regarded as state institutions where a great amount of time and resources were spent

in the process of achieving a specific level of independence from the control of bureaucratic institutions such as the Ministry of Education, Culture, Science and Technology. In the case of France, universities only achieved the independent status in 1972, in the scope of the student revolts of 1968.

However, in the last three decades, it was noted a change regarding a greater independence of universities from the state, and a continuous and increased interface with firms. Furthermore, the European Union funding schemes provided a strong basis to the process of changing the university as a traditional learning institution to an entrepreneurial university, since they helped the creation of the called liaison offices that act as an interface with firms.

In the Italian case, the financial crisis of universities resulted in extreme cuts in the public funding, and forced, since the 1980s, universities to adopt new regulations regarding the intellectual property rights and the rights derived from relations with industry in order to obtain private funding. In this specific case, the Italian universities acting as heavy bureaucratic burdens were left behind by the activities of polytechnic institutes to find industrial partnerships. However in this case, the percentage of industrial funded research is still minimal and universities aren't seen as a partner in the innovation process. The role of the European funded programmes brought, although, an increased interface between universities and industry, since they were defined to establish and finance institutionalized networks among the two worlds.

According to Gebhardt (1997), German government developed a strategy directed to strengthen relations between universities and firms, providing the first ones with the capacity to satisfy their own needs, in order to become more independent agents. These measures reassured the importance of launching governmental initiatives oriented to the emergence of entrepreneurial universities. This aims also to surpass unsuccessful experiences that universities had faced with the orientation towards science commercialization and the opposite interests of firms against academic goals.

In Germany there are evidences of a mixed process that aimed to redefine the university system for attracting regional development and thus providing a higher income from commercialization of science results and research activity (Gebhardt, 1997). It's expected that the division between the fundamental research and the more applied research of traditional universities will not prevail in the future, following the recent networks that are emerging to link basic and applied research, and cut across institutional structures.

In Europe, although initial initiatives were targeted to the economic growth and the creation of jobs through start-ups, the tendency after that was to implement initiatives to support technology transfer, namely financial aid to collaborative research, financial and informative support to SME's and researchers mobility to industry (European Commission, 2002).

Examples of this situation are the 'Austrian innovation voucher', directed at SME's to finance R&D contracts/services, the 'Open funds' from Denmark which aim at strengthen research and cooperation between SME's and universities, the Belgian 'Brussels-capital-brains back' that intends to attract researchers, the Portuguese 'Doctoral grants in companies', attracting doctoral students to industry problems or the R&D Voucher to firms and the industry-academy cooperative projects, the Hungarian 'INNOTETT' that fosters services in the technology transfer centres, business incubation, linkages between academia and industry, the Swiss 'KTT - knowledge and technology transfer', to promote good practices in TTO's to the private sector, the 'UK High technology fund' to invest venture capital on early stage high technology, the 'funding scheme for young innovative companies' from Finland to increase the number and development of innovative firms and the creation in several countries of structures to promote the use of IP rights in public science.

In comparison with the American case, at the European level, the linkage between science and industry faces different constraints: from one side, innovation policy isn't only limited by the successful establishment of communication channels for cooperation among the stakeholders involved, on the other side there is a diverse scenario of different national research systems, having the levels of policy making to be integrated (Grande & Peschke, 1999).

3. Concluding remarks

This paper makes a review of the literature on the dynamics of technology transfer related to the topic about valuation and commercialization of academic patents. Technology transfer is hereby analyzed in this framework as an innovation engine which is capable to promote interactions among academic, governmental and industrial agents.

From the current literature review, it can be stated that being innovation the result of an interactive process between the firm and the environment, it can be approached as a successful exploitation of an idea that can be spread and used as knowledge economically useful. It's also worth to stress that the generating process of innovations depends not only on the research production, but also on the diffusion and acquisition of knowledge.

Since public policies play a crucial role in fostering the entrepreneurial skills, it's important that the policy-makers understand the determinants of entrepreneurship and the needed mechanisms to expand it. Thus, the regulatory framework is determinant for the success of entrepreneurship, acting as a productive or an unproductive driver of the national productivity growth.

Not only the investment in research is determinant for the generation of growth, but also the penetration of the knowledge filter making innovation possible and promoting the economic growth.

Aspects like the amount of knowledge stock, the capacity of the multiple agents involved (from firms or universities) are key factors in the production, identification, and exploitation of knowledge. Once the exploitation of knowledge is not fully developed it's important to secure adequate transmission channels, such as entrepreneurship and university-industry relations.

The technology transfer activities emerge, here, as an important response to the increasing importance of knowledge in national and regional innovation systems and as a demonstrator of the possibility of university to be a cost effective engine, of the creative capacity of inventors and as transfer actor of knowledge.

In terms of obstacles towards the intellectual property protection, they are more prevalent and meaningful in the public sector rather than in the private sector. In terms of different national contexts there can occur substantial differences among national innovation systems, contributing more efficiently some rather than others in the transposition of inventions to innovations. Other problems are linked to the institutional lack of culture and experience in the field of intellectual property and tech transfer activities, and also the low level of recognition from academics on IP rights policies in order to promote the commercialization of research.

In the same direction, there is a need for developing a formal management of the intellectual property portfolio, in several aspects, such as the optimal organizational practices related to inventor incentives, technology transfer, pricing, legal issues, strategic objectives, and measurement and monitoring mechanisms of performance.

Regarding the statement, from the current literature review several implications can be derived either to the universities and to firms, namely the need for defining a strategy for IP commercialization by setting priorities, organizing design choices focused on eliciting invention disclosures, adjusting incentives in order to encourage entrepreneurial activities and attitudes and by establishing a career plan involving specialization programmes for the agents involved in the technology transfer process.

In terms of guidelines for future research, we propose to analyze the aspects and previous work in the topic of valuation of academic patents and its commercialization process.

References

- Abernathy, W. and Utterback, J. (1975). A dynamic model of process and product innovation. *Omega*, 3 (6).
- Acs, Z., Audretsch, D., Braunerhjelm, P. and Carlsson, B. (2004). The missing link: the knowledge filter and entrepreneurship in endogenous growth. Centre for Economic Policy Research (CEPR), Discussion Paper N. 4783.
- Acs, Z. and Plummer, L. (2005). Penetrating the 'knowledge filter' in regional economies. *Annals of Regional Science*, 39 (3), 439-456.
- Acs, Z. and Szerb, L. (2006). Entrepreneurship, economic growth and public policy. *Small Business Economics*, 28 (2), 109-122.
- Acs, Z., Plummer, L. and Sutter, R. (2009). Penetrating the knowledge filter in "rust belt" economies. *Annals of Regional Science*, 42 (4), 238-264.
- Agarwal, R., Audretsch, D. and Sarkar, M. (2010). The process of creative construction: knowledge spillovers, entrepreneurship and economic growth. *Strategic Entrepreneurship Journal*, 4(4), 271-283.
- Andersen, S., Dahl, M., Lundvall, B. and Reichstein, T. (2006). Schumpeter's process of creative destruction and the Scandinavian systems: a tale of two effects. DRUID Summer Conference, 2006.
- Anderson, T., Daim, T. and Lavoie, F. (2007). Measuring the efficiency of university technology transfer. *Technovation*, 27 (5), 306-318.
- APAX (2005). Understanding technology transfer, APAX Partners Ltd/the Economist Intelligence Unit.
- Audretsch D and Aldridge T (2010) Does policy influence the commercialization route? Evidence from National Institutes of Health funded scientists in *Research Policy*, Vol. 39, Issue 5.
- Audretsch, D., Keilbach, M. and Lehmann, E. (2006). *Entrepreneurship and economic growth*, Oxford University Press, New York.
- Audretsch, D. and Lehmann, E. (2005). Does the knowledge spillover theory of entrepreneurship hold for regions? *Research Policy*, 34(8), 1191-1202.
- Baldini, N. (2006). University patenting and licensing activity: a review of the literature. *Research Evaluation*, 15 (3), 197-207.
- Barbosa, N. and Eiriz, V. (2007). The role of inward foreign direct investment on entrepreneurship. *International Entrepreneurship and Management Journal*, 5 (3), 319-339.
- Baumol, W. (1968). Entrepreneurship in economic theory. *American Economic Review*, 58 (2), 64-71.
- Baumol, W. (1990). Entrepreneurship: productive, unproductive and destructive. *Journal of Political Economy*, 98 (5), 893-921.
- Bean, R. and Radford, R. (2001). *The business of innovation: Managing the corporate imagination for maximum results*, New York: AMACOM.
- Bell, M. and Pavitt, K. (1993). Technological accumulation and industrial growth: contrasts between developed and developing countries. *Industrial and Corporate Change*, 2 (2), 157-210.
- Bennet, J., Polkinghorne, M., and Pearce, J. (1998). Quantifying the effectiveness of an academia-industry technology transfer initiative in a low prosperity region of the UK, paper presented at the International Conference on Management of Technology.

- Bercovitz, J., Feldman, M., Feller, I. and Burton, R. (2001). Organisational structure as a determinant of academic patent and licensing behaviour: an exploratory study of Duke, Johns Hopkins and Pennsylvania State University. *Journal of Technology Transfer*, 26 (1-2), 21-35.
- Blomström, M. and Kokko, A. (1997). How foreign investment affects host countries, in *Policy Research Working Paper*, 1745, World Bank.
- Bozeman, B. (2000). Technology transfer and public policy: a review of research and theory. *Research Policy*, 29 (4-5), 627-655.
- Braczyk, H., Cooke, P. and Heidenreich, M. (1998). *Regional Innovation Systems: the role of governances in a globalized world*. London: UCL Press.
- Braunerhjelm, P., Acs, Z., Audretsch, D. and Carlsson, B. (2010). The missing link: knowledge diffusion and entrepreneurship in endogenous growth. *Small Business Economy*, 34 (2), 105-125.
- Callon, M. (1998). An essay on framing and overflowing: economic externalities revisited by sociology. Callon M (Ed.), *The Laws of the Market*, Macmillan, London.
- Caraça, J., Lundvall, B. and Mendonça, S. (2009). The changing role of science in the innovation process: from queen to cinderela? *Technological Forecasting & Social Change*, 76 (4), 584-594.
- Carlsson, B., Acs, Z., Audretsch, D. and Braunerhjelm, P. (2007). The knowledge filter, entrepreneurship, and economic growth. *Jena Economic Research Paper*, N. 2007-057.
- Carlsson, B. and Fridh, A. (2002). Technology transfer in United States universities: A survey and statistical analysis. *Journal of Evolutionary Economics*, 12(1-2), 199-232.
- Chapple, W., Lockett, A., Siegel, D. and Wright, M. (2005). Assessing the relative performance of U.K. university technology transfer offices: parametric and nonparametric evidence in *Research Policy*, 34, 369-384.
- Chesbrough, H. (2010). Business model innovation: opportunities and barriers. *Long Range Planning*, 43 (2-3), 354-363.
- Chesbrough, H., Vanhaverbeke, W. and West, J. (2006). *Open innovation: researching a new paradigm*. Oxford University Press, New York.
- Chesbrough, H. (2003). *Open innovation: the new imperative for creating and profiting from technology*. Harvard Business School Press: Boston, MA.
- Chesbrough, H. and Rosenbloom, R. (2002). The role of the business model in capturing value from innovation: evidence from Xerox Corporation's technology spin-offs companies. *Industrial and Corporate Change*, 11 (3), 529-555.
- CIS II (1999) Segundo Inquérito Comunitário às Atividades de Inovação, Observatório das Ciências e Tecnologias, Ministério da Ciência e da Tecnologia, Lisboa.
- Cohen, W., Nelson, R. and Walsh, J. (2002). Links and impacts: the influence of public research on industrial R&D. *Management Science*, 48 (1), 1-23.
- Colyvas, J., Crow, M., Gelijns, A., Mazzoleni, R., Nelson, R., Rosenberg, N. and Sampat, N. (2002) How do university inventions get into practice? *Management Science*, 48 (1), 61-72.
- Conti, A. and Gaule, P. (2008). *The CEMI Survey of University Technology Transfer Offices in Europe*. CEMI Report: École Polytechnique Fédérale de Lausanne: College of Management of Technology.
- Cooke, P., Boekholt, P. and Tödtling, F. (2000). *The governance of innovation in Europe: regional perspectives on global competitiveness*. London: Pinter.
- Cooke, P., Uranga, M. and Etxebarria, G. (1997). Regional innovation systems: institutional and organizational dimensions. *Research Policy*, 26, (4-5), 475-491.
- Coriat, B. and Weinstein, O. (2002). Organizations, firms and institutions in the generation of innovation. *Research Policy*, 31(2), 273-290.

- Cysne, F. (2005). Transferência de tecnologia entre a universidade e a indústria. *Encontros Bibli*, 2º semestre, Nº 020, Universidade Federal de Santa Catarina Florianópolis, Brasil.
- Dahlander, L. and Gann, D. (2010). How open is innovation? *Research Policy*, 39 (6), 699-709.
- Debackere, K. and Veugelers, R. (2005). The role of academic technology transfer organizations in improving industry science links. *Research Policy*, 34 (3), 321-342.
- Dias, L. (2008). Inovação tecnológica e a Tríplice Hélice: interações em rede entre projetos dos Institutos do Milênio (MCT/2001) e análise das patentes brasileiras registradas no escritório norte-americano (USPTO) após 2004. Londrina: PPA UEM/UEL.
- Dosi, G. (1998). The nature of the innovative process. Dosi, G. *et al.* (eds), *Technical Change and Economic Theory*, London: Pinter Publishers.
- Dosi, G. (1982). Technological paradigms and technological trajectories. *Research Policy*, 11 (3), 147-162.
- Drejer, I. and Jørgensen, B. (2005). The dynamic creation of knowledge: Analysing public-private collaborations. *Technovation*, 25 (2), 83-94.
- Drews, D. (2004). Patent license evaluation. Practising Law Institute. IPMetrics LLC.
- Dyker, D. (ed) (1999). *Foreign direct investment and technology transfer in the former Soviet Union*, Cheltenham, Edward Elgar.
- Dyker, D. and Stolberg, C. (2003). Productivity and capability in the transition economies: a historical and comparative perspective, Brighton: University of Sussex, mimeo.
- Edquist, C. (2001). The systems of innovation approach and innovation policy: an account of the state of the art. DRUID Conference, Aalborg.
- Edquist, C. and Lundvall, B. (1993). Comparing the Danish and Swedish systems of innovations. Nelson, R.R. (Ed.), *National Innovation Systems*. Oxford University Press, New York.
- Etzkowitz, H. (2008). *The triple helix: university-industry-government innovation in action*. Routledge, New York.
- Etzkowitz, H. and Goktepe-Hulten, D. (2010). Maybe they can? University technology transfer offices as regional growth engines. *International Journal of Technology Transfer and Commercialisation*, 9, (1-2), 166-181.
- Etzkowitz, H. and Zhou, C. (2006). Triple Helix twins: innovation and sustainability. *Science and Public Policy*. 33 (1), 310-320.
- Etzkowitz, H. (2002). *MIT and the Rise of Entrepreneurial Science*. London: Routledge.
- Etzkowitz, H., Webster, A. and Gebhardt, C. (2000). The future of the university and the university of the future: evolution of ivory tower to entrepreneurial paradigm. *Research Policy*, 29, 313-330.
- Etzkowitz, H. and Leydesdorff, L. (2000). The dynamics of innovation: from national systems and "mode 2" to a triple helix of university-industry-government relations. *Research Policy*, 29 (2), 109-123.
- Etzkowitz, H. (1998). The norms of entrepreneurial science: cognitive effects of the new university-industry linkages. *Research Policy*, 27, 823-833.
- Etzkowitz, H. and Leytesdorff, L. (1997). *Universities in the Global Economy: A Triple Helix of academic-industry-government relation*. London: Croom Helm.
- European Commission (2008). *European Innovation Progress Report 2008*. Inno Policy Trendchart: Enterprise Directorate-General.
- European Commission (2007). *Green paper - The European Research Area: New Perspectives*. Brussels, COM(2007) 161 final.

- European Commission(a) (2004). Technology Transfer Institutions in Europe: an Overview in Improving Institutions for the Transfer of Technology from Science to Enterprise (Best project "ITTE" 1.11/2002): European Commission, Enterprise Directorate-General.
- European Commission(b) (2004). Improving institutions for the transfer of technology from science to enterprises in Expert group report: Conclusions and recommendations (BEST PROJECT ITTE 1.11/2002): European Commission - Enterprise Directorate-General.
- European Commission (2002). Future directions of innovation policy in Europe. Innovation papers, N. 31, Directorate-General for Enterprise, Brussels.
- European Commission (2001). Benchmarking industry-science relations -the role of framework conditions: final report. Enterprise DG and Federal Ministry of Economy and Labour, Vienna/Mannheim, Austria.
- European Investment Fund (2005). Technology transfer accelerator (TTA) final report. September 2005, Contract n° SDCP-CT-2004-516812: European Investment Fund.
- Feller, I., Ailes, C. and Roessner, J. (2002). Impacts of research universities on technological innovation in industry: evidence from engineering research centers. *Research Policy*, 31 (3), 457-474.
- Findlay, R. (1978). Relative backwardness, direct foreign investment, and the transfer of technology: a simple dynamic model. *Quarterly Journal of Economics*, 92 (1), 1-16.
- Foray, D. and Lundvall, B. (1996). The knowledge-based economy: from the economics of knowledge to the learning economy. DRUID Conference, Aalborg.
- Freeman, C. (2003). Policies for Developing New Technologies. SPRU Electronic Working Paper Series: Paper N. 98, Brighton: SPRU - Science and Technology Policy Research.
- Freeman, C. and Soete, L. (1997). The economics of industrial innovation. 3^a ed., Londres: Pinter.
- Freeman, C. (1995). The national system of innovation in historical perspective. *Cambridge Journal of Economics*, 19 (1), 5-24.
- Freeman, C. (1979). The determinants of innovation. *Futures*, June, 206-215.
- Friedman, J., and Silberman, J. (2003). University technology transfer: do incentives, management, and location matter? *Journal of Technology Transfer*, 28 (1), 81-85.
- Fritsch, M. and Lukas, R. (1999). Innovation, cooperation, and the region. Audretsch, D. and Thurik, R. (Eds.). *Innovation, Industry Evolution and Employment*. Cambridge University Press, Cambridge.
- Fritsch, M. and Lukas, R. (2001). Co-operation in regional innovation systems. *Regional Studies*, 35 (4), 297-307.
- Gebhardt, C. (1997). Regionalization of innovation processes in the areas of information technology in the era of globalization. Gabler, Wiesbaden.
- Georghiou, L. (2001). Evolving frameworks for European collaboration in research and technology. *Research Policy*, 30 (6), 891-903.
- Gibbons, M., Limoges, C., Nowotny, H., Swchartzman, S., Scott, P. and Trow, M. (1994). The new production of knowledge: The dynamics of science and research in contemporary societies. London: Sage.
- Godin, B. and Gingras, Y. (2000). The place of universities in the system of knowledge production. *Research Policy*, 29 (2), 273-278.
- Godinho, M. (2003). Inovação: conceitos e perspectivas fundamentais. Rodrigues, M., Neves, A. and Godinho, M. (Orgs.). Para uma política de inovação em Portugal. Dom Quixote, Lisboa: Biblioteca de Economia & Empresa.
- Goldfarb, B. and Henrekson, M. (2003). Bottom-up versus top-down policies towards the commercialization of university intellectual property. *Research Policy*, 32, 639-658.

- Grande, E. and Peschke, A. (1999). Transnational cooperation and policy networks in European science policy-making. *Research Policy*, 28 (1), 43-61.
- Gross, C. (2008). Technology transfer: opportunities and outlook in a challenging economy. *Journal of Technology Transfer*, 34 (1), 118-120.
- Hagelin, T. (2003). A new method to value intellectual property. Syracuse University.
- Harms, R., Wdowiak, M., and Schwarz, E. (2010). The role of entrepreneurship - and technology transfer-oriented initiatives in improving the innovation system in the Western Balkans. *International Journal of Business and Globalisation*, 4 (1), 18-34.
- Henderson, R., Jaffe, A., Trajtenberg, M. (1998). Universities as a source of commercial technology: a detailed analysis of university patenting, 1965-1988. MIT Press, Massachusetts Institute of Technology.
- Hicks, D. and Hamilton, K. (1999). Does university-industry collaboration adversely affect university research? *Issues in Science and Technology Online*, <http://www.nap.edu/issues/15.4/realnumbers.htm>.
- Hong, W. (2006). Technology transfer of chinese universities: is mode 2 sufficient for a developing country? *The Co-Construction of Society and Technology in a Global World*, edited by Leopoldina, F. and Law, P.. The World Scientific Publisher.
- Hunya, G. (ed.) (2000). Integration through foreign direct investment. Cheltenham. Edward Elgar.
- Iansiti, M. (1998). Technology integration: Making critical choices in a dynamic world. Boston, MA: Harvard Business School Press.
- Janszen, F. (2000). The age of innovation: Making business creativity a competence. Not a coincidence. New Jersey: Prentice Hall.
- Jensen, R., Thursby, J. and Thursby, M. (2003). Disclosure and licensing of university inventions: 'The best we can do with the s**t we get to work with'. *International Journal of Industrial Organization*, 21 (9), 1271-1300.
- Jensen, R. and Thursby, M. (2001). Proofs and prototypes for sale: the licensing of university inventions. *American Economic Review*, 91 (1), 240-259.
- Jiang, H. and Chen, J. (2000). Integrated innovation patterns. *Management of Science and Research (Chinese Journal)*, 21 (5), 31-39.
- Jongbloed, B., Enders, J. and Salerno, C. (2008). Higher education and its communities: interconnections, interdependencies and a research agenda. *Higher Education*, 56 (3), 303-324.
- Kamiyama, S., Sheehan, J. and Martinez, C. (2006). Valuation and exploitation of intellectual property. STI Working Paper 2006/5 Statistical Analysis of Science, Technology and Industry.
- Kaufmann, A. and Tödting, F. (2000). Systems of innovation in traditional industrial regions: the case of Styria in a comparative perspective. *Regional Studies*, 34 (1), 29-40.
- Kaufmann, A. and Tödting, F. (2001). Science-industry interaction in the process of innovation: the importance of boundary-crossing between systems. *Research Policy*, 30 (5), 791-804.
- Kline, S. and Rosenberg, N. (1986). An overview of innovation. Laudau, R. and Rosenberg, N. (Eds.). *The Positive sum strategy: harnessing technology for economic growth*. Washington. National Academy Press.
- Lane, J. (1999). Understanding technology transfer. *Assistive technology*, 11 (1), 5-19.
- Laranja, M. (2009). The development of technology infrastructure in Portugal and the need to pull innovation using proactive intermediation policies. *Technovation*, 29 (1), 23-34.

- Lastres, H. and Cassiolato, J. (2005). Innovation systems and local productive arrangements: New strategies to promote the generation, acquisition and diffusion of knowledge. *Innovation: Management, Policy & Practice*, 7 (2-3), Apr./Aug.
- Lawton, H. (2006). *Universities, innovation and the economy*. London: Routledge.
- Leitão, J. and Baptista, R. (2009). Public Policies for Fostering Entrepreneurship: A European Perspective. Series: *International Studies in Entrepreneurship*, 22, Springer, July 2009, USA.
- Leitão, J. and Baptista, R. (2011). Inward FDI and ICT: Are They a Joint Technological Driver of Entrepreneurship? *International Journal of Technology Transfer and Commercialization*, 10 (3), 268-288.
- Leitão, J. (2006). Open innovation clusters: the case of Cova da Beira Region (Portugal). *Conference Proceedings of ISBE 2006*, Cardiff.
- Lemos, C. (1999). *Inovação na era do Conhecimento*. Lastres, H., Albagli, S. (Org.). *Informação e Globalização na era do Conhecimento*, Rio de Janeiro: Campus.
- Lim, E. (2001). Determinants of, and the relation between, foreign direct investment and growth: a summary of the recent literature. *International Monetary Fund - IMF Working Paper*, WP/01/175, Washington DC.
- Link, A. and Link, J. (2009). *Government as entrepreneur*. Oxford University Press, New York.
- Link, N., Scott, T. and Siegel, S. (2003). The economics of intellectual property at universities: an overview of the special issue. *International Journal of Industrial Organization*, 21 (9), 1217-1225.
- Lundvall, B. (2007). National innovation systems - analytical concept and development tool. *Industry and Innovation*, 14 (1), 95-119.
- Lundquist, G. (2003). A Rich vision of technology transfer. *Technology Value Management. Journal of Technology Transfer*, 28 (3-4), 265-284.
- Lundvall, B. (1992). *National systems of innovation: towards a theory of innovation and interactive learning*. London, Pinter Publishers.
- Lundvall, B. (1988). Innovation as an interactive process: from user-producer interaction to the national system of innovation. Dosi, G., Freeman, C., Nelson, R., Silverberg, G. and Soete, L. (eds.). *Technical Change and Economic Theory*. London: Pinter Publishers.
- Lundvall, B. (1985). Product innovation and user-producer interaction. *Industrial Research Series*, N. 31, Aalborg: Aalborg University Press.
- Macho-Stadler, I., Pérez-Castrillo, D. and Veugelers, R. (2007). Licensing of university inventions: The role of a technology transfer office in *International Journal of Industrial Organization*, 25 (4), 675-699.
- Magic, P. (2003). *International technology transfer & intellectual property rights*. University of Texas.
- Malerba, F. (2002). Sectoral systems of innovation and production. *Research Policy*, 31 (2), 247-264.
- Markman, G., Gianiodis, P., Phan, P. and Balkin, D. (2004). Entrepreneurship from the Ivory Tower: do incentive systems matter? *Journal of Technology Transfer*, 29 (3-4), 327-57.
- Markusen, J. and Venables, A. (1999). Foreign Direct Investment as a Catalyst for Industrial Development. *European Economic Review*, 43 (2), 335-356.
- Matkin, G. (1994). Technology transfer and public policy: lessons from a case study. *Policy Studies Journal*, 22 (2), 371-383.
- Mawson, J. (2007). Research councils, universities and local government: building bridges. *Public Money & Management*, 27 (4), 265-272.

- Mello, J. (2004). A abordagem hélice tríplice e o desenvolvimento regional, in II Seminário Internacional Empreendedorismo, Pequenas e Médias Empresas e Desenvolvimento Local. Rio de Janeiro, RJ, Brasil 02 a 04 de Agosto de 2004.
- Merton, R. (1942). The normative structure of science. Reprinted in *The Sociology of Science: Theoretical and Empirical Investigations*, 1973, University of Chicago Press, Chicago.
- Mills, C. (1958). *The power elite*. Oxford Univ. Press, New York.
- Monitor Group (2009). *Paths to Prosperity: Promoting Entrepreneurship in the 21st century*. Monitor Group, http://www.compete.monitor.com/App_Themes/MRCCorpSite_v1/DownloadFiles/NED_report_final.pdf.
- Morrissey, M. and Almonacid, S. (2005). Rethinking technology transfer. *Journal of Food Engineering*, 67 (1-2), 135-145.
- Mould, O., Roodhouse, S. and Vorley, T. (2009). Realising capabilities - academic innovation and creativity. *Creative Industries Journal*, 1 (2), 137-150.
- Mowery, D. (2007). University-industry research collaboration and technology transfer since 1980. Yusuf, S. and Nabeshima, K. (eds.). *How universities promote economic growth*. The World Bank, Washington DC.
- Mowery, D. and Sampat, B. (2005). Universities in national innovation systems. Fagerberg, J., Mowery, D. and Nelson, R. (eds.). *The Oxford Handbook of Innovation*, Oxford University Press, Oxford.
- Mowery, D., Nelson, R., Sampat, B. and Ziedonis, A. (2004). *Ivory tower and industrial innovation, university-industry technology transfer before and after the Bayh-Dole Act*. Stanford University Press, Stanford, California.
- Mowery, D., and Sampat, B. (2001). Patenting and licensing university inventions: lessons from the history of the Research Corporation. *Industrial and Corporate Change*, 10 (2), 317-355.
- Mowery, D., Nelson, R., Sampat, B. and Ziedonis, A. (2001). The growth of patenting and licensing by U.S. universities: an assessment of the effects of the Bayh-Dole act of 1980. *Research Policy*, 30 (1), 99-119.
- Mowery, D. and Rosenberg, N. (1993). *The U.S. national innovation system in national innovation systems: a comparative analysis*, edited by Nelson, R., New York: Oxford University Press.
- Mueller, P. (2006). Exploring the knowledge filter: How entrepreneurship and university-industry relationships drive economic growth. *Research Policy*, 35 (10), 1499-1508.
- Musselin, C. (1998). Do French Universities finally emerge? *Conférence internationale Governance of Universities in a Comparative perspective*. Lausanne, Mars 1998.
- Nelles, J. and Vorley, T. (2010). From policy to practice: engaging and embedding the third mission in contemporary universities. *International Journal of Sociology and Social Policy*, 30 (7-8), 341-356.
- Nelles, J. and Vorley, T. (2008). *Avenging the third mission: the entrepreneurial architecture of a 'new' university*. University of Cambridge Working Paper 0208. Cambridge University, UK.
- Nelson, G. and Soete, L. (eds.) (1988). *Technical change and economic theory*, Chap. 17. London: Printer Publishers.
- Nelson, R. (2001). Observations on the post-Bayh-Dole rise of patenting at american universities. *Journal of Technology Transfer*, 26, 13-19.
- Nelson, R. (1993). *National innovation systems: a comparative analysis*. New York, Oxford University Press.

- Nelson, R. and Rosenberg, N. (1993). Technical innovation and national systems. Nelson, R. (ed), National systems of innovation: a comparative study. Oxford: Oxford University Press.
- Nelson, R. and Winter, S. (1982). An evolutionary theory of economic change. Harvard College, Library of Congress Cataloging in Publication Data.
- Nelson, R. (1959). The simple economics of basic scientific research. *Journal of Political Economy* 67 (3), 297-306.
- Niosi, J., Saviotti, P., Bellon, B. and Crow, M. (1993). National systems of innovation: in search of a workable concept. *Technology in Society*, 15 (2), 207-227.
- Nooteboom, B., Berger, H. and Noorderhaven, N. (1999). Effects of Trust and Governance on Relational Risk. *Academy of Management Journal*, 40 (2), 308-338.
- Nowotny, H., Scott, P. and Gibbons, M. (2001). Re-thinking science: knowledge and the public in an age of uncertainty. Cambridge, UK: Polity Press.
- OECD (2004). Patents and innovation: trends and policy challenges. OECD, Paris.
- OECD (1980). Technical change and economic policy. OECD, Paris.
- Oliveira, M. and Teixeira, A. (2010). The determinants of technology transfer efficiency and the role of innovation policies: a survey. FEP Working Papers, Research Work in Progress, N. 375.
- Orr, D. (2007). More competition in German higher education: expectations, developments, outcomes. Enders, J. and Jongbloed, B. (eds.), *Public-private dynamics in higher education: expectations, developments and outcomes*. Bielefeld.
- Osterwalder, A. (2004). The Business Model Ontology: A Proposition in a Design Science Approach. (Ph.D., l'Ecole des Hautes Etudes Commerciales de l'Université de Lausanne), 1-172.
- Otsuyama, H. (2003). Patent valuation and intellectual assets management. Chapter 5. Samejima, M. (ed.), *Patent Strategy Handbook*. Chuokeizai-sha, Tokyo.
- Owen-Smith, J. and Powell, W. (2001). To patent or not: faculty decisions and institutional success at technology transfer. *Journal of Technology Transfer*, 26 (1), 99-114.
- Pavitt, K. (1998). The inevitable limits of EU R&D funding. *Research Policy*, 27 (6), 559-568.
- Pavitt, K. (1984). Sectoral patterns of technical change: towards a taxonomy and a theory. *Research Policy*, 13, 343-373.
- Pereira, T., Mendonça, S. and Godinho, M. (2004). A comercialização da investigação científica na periferia: Desafios na utilização do patenteamento por instituições de investigação em Portugal. *Actas dos ateliers do Vº Congresso Português de Sociologia - Sociedades Contemporâneas: Reflexividade e Acção Atelier: Ciência e Conhecimento*.
- Qingrui, Xu., Chen, J., Xie, Z., Liu, J., Zheng, G. and Wang, Y. (2007). Total Innovation Management: a novel paradigm of innovation management in the 21st century. *Journal of Technology Transfer*, 32 (1-2), -25.
- Rafferty, M. (2008). The Bayh-Dole Act and university research and development. *Research Policy*, 37 (1), 29-40.
- Rasiah, R. (1995). Foreign capital and industrialisation in Malaysia. New York: St Martin's Press.
- Razgaitis, R. (1999). Early-stage technologies: valuation and pricing. Wiley.
- Readings, W. (1996). The university in ruins. Harvard University Press, Cambridge.
- Ribeiro, P. (2001). Inovação tecnológica e transferência de tecnologia. Brasília: Ministério da Ciência e Tecnologia - Brasil, 2001. Disponível em: <http://site.ebrary.com/lib/buufsc/Doc?id=10058471&page=1>.

- Rogers, E., Takegami, S. and Yin, J. (2001). Lessons learned about technology transfer. *Technovation*, 21 (4), 253-261.
- Rothaermel, F. and Alexandre, M. (2009). Ambidexterity in technology sourcing: the moderating role of absorptive capacity. *Organization Science Archive*, 20 (4), 759-780.
- Rothaermel, F., Agung, S. and Jiang, L. (2007). University entrepreneurship: a taxonomy of the literature. *Industrial and Corporate Change*, 16 (4), 691-71.
- Rothwell, R. and Zegveld, W. (1981). *Industrial innovation and public policy*. Frances Pinter, London.
- Roy, S. (2004). *Introduction to IP valuation - how much is your IP worth?* Canada.
- Sábato, J. (1975). *El pensamiento latinoamericano en la problemática ciencia-tecnología-desarrollo-dependencia*. Paidós, Buenos Aires.
- Sábato, J. and Mackenzi, M. (1982). *La producción de tecnología. autónoma o transnacional*. Nueva Imagen, Mexico.
- Sampat, B. and Nelson, R. (2002). The evolution of university patenting and licensing procedures: an empirical study of institutional management. *New Institutionalism. Strategic Management*, 19, 135-164.
- Schmookler, J. (1966). *Invention and economic growth*. Cambridge, Mass. Harvard University Press.
- Schumpeter, J. (1934). *The theory of economic development*. Transaction Publisher (1993). London.
- Schumpeter, J. (1942). *Capitalism, socialism and democracy*. 5^a ed. George Allen & Unwin. London.
- Shane, S. (2004). *Academic entrepreneurship: university spinoffs and wealth creation*. Edward Elgar: Cheltenham, U.K.
- Shane, S. and Stuart, T. (2002). Organizational endowments and the performance of university start-ups. *Management Science*, 48 (1), 154-170.
- Shapiro, S. (2001). *24/7 Innovation: A blueprint for surviving and thriving in an age of change*. New York: McGraw Hill.
- Siegel, D., Veugelers, R. and Wright, M. (2007). Technology transfer offices and commercialization of university intellectual property: performance and policy implications. *Oxford Review of Economic Policy*, 23 (4), 640-660.
- Siegel, D. (ed.) (2006). *Technology entrepreneurship: institutions and agents involved in university technology transfer*. Vol. 1. Edward Elgar: London.
- Siegel, D. and Phan, P. (2005). Analyzing the effectiveness of university technology transfer: implications for entrepreneurship education. *Advances in the study of Entrepreneurship, Innovation & Economic Growth*, 16 (0426), 1-38.
- Siegel, D., Waldman, D. and Link, A. (2003). Assessing the impact of organizational practices on the productivity of university technology transfer offices: an exploratory study. *Research Policy*, 32(1), 27-48.
- Silva, M. and Leitão, J. (2009). Cooperation in innovation practices among firms in Portugal: do external partners stimulate innovative advances? *International Journal of Entrepreneurship and Small Business*, 7 (4), 391-403.
- Sombart, W. (1928). *O capitalismo moderno*. Munique and Leipzig, Duncker and Humblot.
- Sorensen, J. and Chambers, D. (2008). Evaluating academic technology transfer performance by how well access to knowledge is facilitated - defining an access metric. *Journal of Technology Transfer*, 33, 534-547.
- Sorlin, S. (2007). Funding Diversity: Performance-based Funding Regimes as Drivers of Differentiation. *Higher Education Systems in Higher Education Policy*, 20 (4), 413-440.

- Stokes, D. (2005). *O Quadrante de Pasteur: a ciência básica e a inovação tecnológica*. Campinas: Unicamp.
- Swamidass, P. and Vulasa, V. (2009). Why university inventions rarely produce income? Bottlenecks in university technology transfer. *The Journal of Technology Transfer*, 34 (4), 343-363.
- Thalhammer, R. (2008). *Transfer and Valuation of Biomedical Intellectual Property*. Chapter 22. *Taxation and Valuation of Technology: Theory, Practice and the Law*, Horvath and Chiidikoff Editors.
- Thursby, J., Jensen, R. and Thursby, M. (2001). Objectives, characteristics and outcomes of university licensing: a survey of major U.S. universities. *Journal of Technology Transfer*, 26, 233-245.
- Thursby, J. and Kemp, S. (2000). Growth and productive efficiency of university intellectual property licensing. *Research Policy*, 31 (1), 109-124.
- Thursby, J. and Thursby, M. (2004). "Are Faculty Critical? Their Role in University-Industry Licensing. *Contemporary Economic Policy*, Western Economic Association International, 22 (2), 162-178.
- Tidd, J., Bessant, J. and Pavitt, K. (2001). *Managing innovation: Integrating technological, market, and organizational change*. New York: John Wiley & Sons.
- Tigre, P. (1998). Inovação e teorias da firma em três paradigmas. *Revista de Economia Contemporânea*, 3, Jan-Jul, 67-111.
- Tigre, P. (2005). Paradigmas tecnológicos e teorias econômicas da firma, in *Revista Brasileira de Inovação*, 4, (1), Jan-Jul, 187-224.
- Trune, D. and Goslin, L. (1998). University technology transfer programs: a profit/loss analysis. *Technological Forecasting and Social Change*, 57, (3), 197-204.
- Tucker, R. (2002). *Driving growth through innovation: How leading firms are transforming their futures*. San Francisco: Berrett-Koehler Publishers Inc.
- Von Hippel, E. (1988). *The sources of innovation*. New York: Oxford University Press.
- Walsh, J. and Saegusa, M. (2003). Broadening 'academic' research: adapting to university reforms in Japan. *Journal of Science Policy and Research Management*, 18, 47-58.
- Webster, A. and Packer, K. (1996). *Intellectual property and the wider innovation system*. Webster, A. and Packer, K. (eds). *Innovation and the Intellectual Property System*. Kluwer, London.
- Wedgewood, M. (2006). *Mainstreaming the Third Stream in McNay M, Beyond Mass Higher Education*. Open University Press. McGraw-Hill Education, England.
- Wheatley, M. (2001). We are all innovators. Hesselbein, F., Goldsmith, M. & Somerville, I. (eds.). *Leading for innovation: And organizing for results* (pp. 11-21). San Francisco: Jossey-Bass.
- WIPO (2004). *Successful technology licensing in IP*. Asset Management series.
- WIPO/ITC (2005). *Exchanging value: negotiating technology licensing agreements*. A training manual.
- Xu, Q., Chen, J. and Guo, B. (1997). A theoretic model and an empirical analysis of technology innovation portfolio. *Science and Research Management (Chinese Journal)*, 18 (3), 29-35.
- Xu, Q. and Chen, Z. (2001). *The basic law and pattern of firm's business management*. Hangzhou: Zhejiang University Press.

Chapter 2

Does the academic spin-off condition play a role in patent valuation?

Abstract

We tackle the problematic on patent valuation in an innovative way by assessing the extent through which some patents' attributes are related to its value when considering academic patents, and in addition when disaggregating the formal mechanisms of exploiting these inventions. In this sense, we estimate the important effect of a set of attributes on patents being explored by a spin-off or by alternative mechanisms, for instance licensing agreements. The starting assumption is that academic patent's value increases according to several determinant factors, namely, the patent family, time to maturity, exclusivity, geographical scope, academic spin-off condition and the technical field. We use cross-section data of two samples, namely, 281 patents from Cambridge University, UK, and 160 patents from Carnegie Mellon University, US. We make use of a negative binomial regression model for assessing the impact of a set of factors on academic patents' value. We conclude that size of the patent family influences positively the value of the academic patent. For its turn, we reveal a negative influence played by the time to maturity and geographical scope. Furthermore, when disaggregating the results by spin-off condition we conclude that for spin-off firms from CMU the effect of geographical scope reveals to be negative and significant. For the spin-off firms of the CAMU, on the one hand, a negative and significant effect of time to maturity is verified; on the other hand, the technical field denotes a positive and significant effect on the patent's value.

Keywords

Academic patents; Patent family; Patent value.

1. Introduction

Recently there has been an increasing focus on the role played by universities as key agents in determining the needs and agendas of industry and national competitiveness, being pressured to translate the results of their work into privately appropriable knowledge. Factors like the implementation of legislation to ease the appropriability of universities over their intellectual property (IP) assets, the increasing competition for governmental resources, drove universities to search for alternative paths, like the establishment of technology transfer offices (TTO's) and the pursuit of IP protection. Despite the increasing numbers of university patents filled, the same pattern in terms of the number of patents granted, licensing statistics or start-ups creation wasn't achieved.

Braunerhjelm *et al.* (2010) defend that although new knowledge leads to opportunities that can be exploited commercially, economic growth requires that this new knowledge will be converted into economic knowledge that presents itself a commercial opportunity, being this process an unpredictable and complex process. For instance, according to Carlsson & Fridh (2002) only about half of the invention disclosures in the US universities are converted in patent applications and from these, only half of the applications result in patents. It's also a fact that only one-third of patents are licensed, and only 10-20% of licenses obtain significant revenues, being only 1% or 2% of inventions successful in reaching the market and yielding income.

Siegel *et al.* (2003) point out that the formal management of the technology portfolio is a task that deserves further improvement. The formal management of the technology portfolio needs to be improved for efficiency purposes. There is still work to be done regarding optimal organization practices such as inventor incentives, pricing of IP results, legal issues, strategic objectives and measurement and monitoring mechanisms of performance of technology-based ventures. Patent valuation implies the need for achieving reliable measurements in a scenario based on uncertainty and lack of market data which affects their returns.

As Rivette & Kline (2000), Reitzig (2006) and Kamiyama *et al.* (2006) argue there is a notorious lack of methods that allow the valuation of patents. Pitkethly (2006) also state that most works provide econometric methods of patent valuation which deal with aggregate values rather than individual patents.

Other authors tried to valuate patents in an individual basis, using patent renewal data (Pakes & Shankerman, 1984; Pakes, 1986), citation data (Trajtenberg, 1990) and survey-based measure (Gambardella *et al.*, 2007), nevertheless their results only provided indirect estimations on patent's value.

Patent valuation, in the perspective of Reitzig (2006), is a challenging topic because of the intangible nature of patents and the uncertainty that characterizes the possible returns they are object of.

The perspective of valuing patents as real options has gained increasing attention among academics (Pakes, 1986; Marco, 2005; Pitkethly, 2006; Ziedonis, 2007; Li *et al.*, 2007).

The present paper offers specific contributions into the literature on patent valuation. Firstly, it contributes for expanding the knowledge on the specific role of academic patents for fostering technology transfer from university to industry. Secondly, it analyses the role played by several determinant factors like patent family, time to maturity, exclusivity, geographical scope, spin-off condition and technical field on the valuation of academic patents. It is also innovative in the sense that addresses the caveat found in the literature concerning the need for further understanding of the determinant factors of the value of academic patents, under the context of academic spin-off creation.

The paper is structured as follows. Section 2 develops the theoretical underpinnings, drawing from the literature on patent valuation and commercialization and reviews the major contributions for the theoretical background on patent valuation. Section 3 details the methodological approach used in the present study. Section 4 presents and discusses the results. Lastly, section 5 concludes and provides policy implications, both for practitioners and researchers engaged in valuation and commercialization of academic patents, under a context of academic spin-off creation.

2. Literature review

2.1 Literature streams

According to the OECD (2003) there has been made a restructuration in the IP laws of European countries, in order to foster the ownership of inventions by the institution in which the research is conducted, benchmarking the American Bayh-Dole Act, which allowed institutions to patent federally funded research results (Baldini *et al.*, 2006).

Although the field of academic patenting has not been target of many studies, recently researchers focused on the European context and their differences apart the American one (for instance, Conceição *et al.*, 1998; Jacob *et al.*, 2003; Schmiemann & Durvy, 2003), revealed that cooperation between firms and universities is still an undeveloped area in Europe, nor the European and US patent systems look alike, being the European one less used and pointing to radical differences, such as, the non-patentability of software-related

inventions and the inexistence of the grace period, fostering competition among the European and Japanese systems and the US system (De Juan, 2002; Geuna & Nesta, 2006). Another main difference resides in the bigger facility in the US to finance early-stage technologies and to market new inventions (Henrekson & Rosenberg, 2001).

Universities or research institutions face a common problem when licensing IP assets, of firstly valuating the asset and secondly of having little or no information as to what the “proper” royalty rate should be for a given technology.

Accordingly to Owen-Smith & Powell (2001), there are some constraints when deciding to disclose an invention to the university, namely, the forecasts of the patent benefits, the costs of the process and the help of the structure of licensing professionals and TTO’s.

Otsuyama (2003) refers that the need for a monetary valuation of a patent is especially determinant for using as financing tools by patent holders or as investment assets by financing institutions and venture capitalists. IP is recognized by financial analysts and investors as playing a crucial role on the value of a firm, for example, and as an indicator of its technological capacity.

Hagelin (2003) distinguishes the meaning of value and the nature of valuation, since the value is not equal to the price. The price refers to the value considered in the market transaction of the asset. The referred value corresponds to the utility provided by the asset to the buyer and seller.

Accordingly to Tamboli & Sharma (2011), for better valuing an asset one must use the market, in the form of a transaction among two unrelated entities dealing in a hard way. The problem with intangible assets and IP rights is the fact that they seldom benefit from open market conditions, in one hand because of the novelty issues and in the other due to secrecy factors. Since the amount of investments required to develop and market products is extremely high, there is a strong need for assessing the economic value of the IP, in the early stages of the product development cycle.

Kamiyama *et al.* (2006) argue that the expanding use of IP generates a new set of challenges for patent valuation. Thus, patents need to be valued in order to be used in transactions, to decide whether to file, extend geographically or renew a patent, establish negotiations over licensing fees or use as a collateral mean for a bank loan.

According to Ernst *et al.* (2010) the issue of valuing a patent is a major concern for the management. Several examples are found in the literature that deserve to be underlined in this context, namely, the validation of new indicators for patent valuation (Reitzig, 2004), the measurement process of patent stock, by making use of knowledge indicators (Park &

Park, 2006), the integration of different methods in the nanotechnology field for assessing its economic potential (Malanowski & Zweck, 2007), the analysis of the US patents' value (Bessen, 2008) and the application to the Italian case (Azzone & Manzini, 2008).

In the perspectives of Griliches (1981), Hall & Ziedonis (2001) and Reitzig (2003), researchers since the 1960's have worked in the area of the variety of determinants of patent value.

For instance, some scholars focused on the role of patent families (Grefermann *et al.*, 1974; Schmoch *et al.* 1988; Putnam 1996; Harhoff *et al.*, 1999) and renewals (Schankerman & Pakes, 1986).

Others devoted their efforts to the patent counts as measures of the patent value and its role on the firm value or performance and on new firm creation (Griliches, 1981; Griliches *et al.* 1986; Narin *et al.* 1987; Trajtenberg, 1990; Lerner, 1994; Shane, 2001; Lanjouw & Schankerman, 2004; Hall *et al.*, 2005). In addition, patent features hereby analyzed include citations received from subsequent patent filings (Trajtenberg, 1990), legal disputes in the form of patent oppositions (Graham *et al.*, 2002; Harhoff *et al.*, 2003), litigation (Lanjouw & Schankerman, 1997) and claim counts (Lanjouw & Schankerman, 2004).

Another strand of literature on determinants for patent value makes use of the proposed indicators and correlates for granted and exploiting them in order to deepen the research on different determinants and patterns related to patent value (Guellec & van Pottelsberghe de la Potterie, 2000, 2002; Maurseth, 2005; van Zeebroeck & van Pottelsberghe de la Potterie, 2008).

Authors like, Gilbert & Shapiro (1990), Klemperer (1990), Gallini (1992), Lerner (1994), Green & Scotchmer (1995) and Ernst (1998) have been examining areas such as patent breadth, novelty, disclosure and inventive activity.

Despite the existence of this theoretical background the area of patent valuation deserves further research and deep understanding. On the one hand, previous research only focus on theoretically modelling the patent system (Gallini, 1992), being needed further developments on linking this area to patent valuation in practice (Reitzig, 2003). On the other hand, and regarding Schankerman & Pakes (1986), Trajtenberg (1990), Tong & Frame (1992) and Harhoff *et al.* (2003), previous works have solely focused on the assessment of patents by means of value indicators, such as renewal information, claims, legal arguments, and others.

According to Lev (2004) the need for patent valuation is justified by recent updates on financial reporting standards which determine the requisite of firms to present the balance sheet with the fair value of their intangible assets. For determining the value of a patent for

a firm involved in technological completion the best way is to define it as its asset value (Harhoff *et al.*, 2003).

In the vision of Reitzig (2004), for assessing the patent value, it's important to consider its effect on prices, costs and quantities of patent-protected products by the patent owner and also the non-observable effect on the owner's competitors.

As mentioned before specific issues defined in the licensing contract of the patent are determinant to the value of the underlying technology, namely, the fees paid by the licensee to the licensor, the duration or term of license, e.g., the number of years for the licensee to explore the patent, the scope of the license conceived as well as the overall set of technologies and IP rights exchanged in the transaction (Oriani & Sobrero, 2008).

Other aspects like the contractual clauses agreed between both parties can also determine the value of the asset, the geographical scope regarding the number of countries in which the licensee can exploit the patented technology, the number of citations the patent has been target of since it was conceded until the license date, as well as the exclusivity of the contract which allows the licensee to fully exploit the technology avoiding the possibility of other competitors to endanger his market penetration.

Kulatilaka & Marcus (1992), McGrath (1999), McGrath & Nerkar (2004) and Ziedonis (2007) argue that another determinant of patent value corresponds to the effect of volatility and the sources of uncertainty that increases volatility. MacMillan & McGrath (2002), Anand *et al.* (2007), and Oriani & Sobrero (2008) decomposed uncertainty into market (e.g. uncertainty regarding potential demand) and technological domains (i.e. uncertainty referring to technical and manufacturing performance and feasibility of the underlying technology), by determining the commercial potential of the patent and its potential value.

Hou & Lin (2006) proposed an approach for developing a patent appraisal model, by taking into account four patent appraisal factors, such as the patent transferor, the patent transferee, the patent features and the patent trading specifications, and using a multiple regression model in order to obtain the value of the license fee of the target patent for patent trading.

Linking the previously mentioned organizational practice of patent valuation, and since the goal of the present paper is to go a little bit deeper on the academic spin-off condition as a determinant of the academic patent's value it's important to bring the works of Scherer (1965), Mansfield *et al.* (1981), and Hall & Ziedonis (2001), who reveal that the impact of specific patent characteristics differs according to the specific use of patents. Furthermore, patents from the academic background have different licensing characteristics when compared with firm patents (Jensen & Thursby, 2001).

The table 1 presented below summarizes the literature on determinant factors of patent's value.

Table 1 Determinant factors of patent's value: literature streams

Authors	Research questions	Determinant factors
Otsuyama (2003)	Patent valuation as financing tool or investment asset to be used by financial institutions and venture capital	Technological capability
Reitzig (2004)	New indicators and application of <i>rationales</i>	Effects on prices, costs and quantities of patent-protected products by the patent owner and also non-observable effects on the owner's competitors.
Griliches (1981); Klemperer (1990); Gilbert & Shapiro (1990); Gallini (1992); Lerner (1994); Green & Scotchmer (1995); Ernst (1998); Hall & Ziedonis (2001); Reitzig (2003); Sapsalis & Potterie (2007)	Determination of the patent value	Value indicators, such as renewal information, claims, legal arguments, and others; different licensing characteristics of patents from the academic background compared to firm patents; contractual clauses agreed between parties; geographical scope; patent citations; and exclusivity of the contract.
Scherer (1965); Mansfield <i>et al.</i> (1981); Jensen and Thursby, (2001); Hall & Ziedonis (2001); and Wu & Tseng (2006).	Relationship between patents' value and underlying asset	Underlying asset; time to maturity; risk-free interest rate; volatility; scope and field of the patent; academic background of the patent; and specific use of the patent.
Oriani & Sobrero (2008)	Relationship among patents and underlying asset, scope, exclusivity and licensing contract terms	Fees paid; duration or term of license; scope of the license conceived; overall set of technologies; IP rights exchanged in the transaction; contractual clauses; geographical scope; patent citations; and exclusivity.

According to Etzkowitz (2003) after the US Bayh-Dole Act of 1980, a worldwide expansion of the academic commercialization took place in the university context. Activities like academic patenting (Owen-Smith & Powell, 2001; Mowery & Ziedonis, 2002), technology transfer and licensing (Thursby & Thursby, 2002; Siegel *et al.*, 2003; Lach & Schankerman, 2004; Markman *et al.*, 2005) and spin-off creation (DiGregorio & Shane, 2003; Murray, 2004; Shane, 2004a, 2004b; Wright *et al.*, 2006; O'Shea *et al.*, 2007) have emerged in the university context and got part of the daily practices, becoming institutionalized, in the sense that several

structures were created, such as patent offices, technology liaison offices and business incubation centers.

Langinier (2004) defend that if the academic patent makes an important improvement on the process or product innovation, being highly valuable, it can make the entrant a stronger competitor.

Landry *et al.* (2006) bring the fact that the ownership of valuable patents by academic scientists increases their possibility of creating a firm, mainly in fields like computer sciences and engineering, being this possibility cumulatively determined by the access to financial resources that can be fostered in the presence of high value intangibles. The same authors point out the need that some start-ups denote in having their innovations patented in order to have high venture finance. Other determinant related to the value of the intangibles of the new firm pointed by Landry *et al.* (2006) is linked to the degree of novelty of the invention, which also increases the possibility of generating a spin-off.

In the same line, Stuart & Ding (2006) also focus on the creation of a spin-off in the sequence of having high-value patents, especially in the biotechnology industry.

For Nerkar & Shane (2007) the academic patent's value is defined by the set of attributes of the invention, depending on them the successful commercialization process by avoiding uncertainty regarding the value of the patent and the inexistence of information on the market, namely: the scope of the patent which can allow for greater returns by covering a wider range of technical areas and increasing the creation of new firms, the pioneering nature of the invention by attracting investors to the patent commercialization, and the age of the invention which fosters the possibilities of commercialization.

The value of the academic patent can act as a signaling argument for spin-offs to achieve venture investment and financing by translating an intangible asset into a property right which can also generate returns through licensing, being an effective business model for start-ups whose strategies of technology commercialization are not based on producing and marketing their inventions (Graham & Sichelman, 2008; Hsu & Ziedonis, 2008).

Krabel & Mueller (2009) state that the existence of a patent or a patent portfolio can be determinant for creating a spin-off company, acting as a well-suited mechanism for technology commercialization.

Santoro & Bierly (2006) and Wood (2009) defend that by imbedding the innovation, and in particular the radical innovation, the academic spin-off is the most adequate commercialization route due to its highly tacit nature, since it needs a great deal of nurturing

in order to achieve revenues. In this vein, imbedding the technology into the firm decreases the transaction costs needed for knowledge transfer.

Chang *et al.* (2009) point to a causal relationship between performance, high-value patents, licensing and creation of spin-offs.

Recognizing that the academic patent is characterized by a set of attributes that distinguishes it from other innovations, choosing the adequate governance structure to the development stage and the inherent value, can reduce transaction costs and thus maximizing the value of the asset (Wood, 2009).

Furthermore, Helmers & Rogers (2011) argue that patents, acting as vehicles that allow academic inventors to profit from their inventions, are determinant to confer firms that own this kind of IP asset a competitive advantage conveying a superior performance and subsequent growth when comparing to non-patenting firms. Thus, the patent value may be influenced through the option of creating a spin-off, for exploiting a high-value asset based on a scheme of intellectual property protection of an invention. The authors also advocate that there is a parallel between the patent value distribution and the new firm creation and subsequent performance distribution.

2.2 Research hypotheses

Recent studies (Griliches, 1981; Gilbert & Shapiro, 1990; Klemperer, 1990; Gallini, 1992; Lerner, 1994; Green & Scotchmer, 1995; Ernst, 1998, 2001; Hall & Ziedonis, 2001; Reitzig, 2003; Kamiyama *et al.*, 2006; and Sapsalis & Potterie, 2007) advocate the need for estimating patent value, since the expanding use of IP poses a new set of challenges for patent valuation, such as IP transactions, IP negotiations over licensing fees and decisions on renewal and extension.

Hou & Lin (2006) argue that due to the uniqueness of patents it's very difficult to find a comparable price in the market for a target patent. Additionally, the high uncertainty and information asymmetry in the patent trading market restrains the development of a standard patent appraisal model.

As Bloom & Reenen (2002) point out patents aren't immediately ready to be used and commercialized by firms, being this one a threat regarding the calculation of the value of the underlying technology. The same authors defend that patents represent new products or process innovations, which in order to be exploited need considerable investments in

additional plant and equipment, staff, advertising and marketing, IP protection and extension, being much of these investments sunk or irreversible costs.

The importance of studying the determinants of patent value has been under intensive analysis from the part of several researchers like Griliches (1981), Gilbert & Shapiro (1990), Klemperer (1990), Gallini (1992), Lerner (1994), Green & Scotchmer (1995), Ernst (1998), Hall & Ziedonis (2001), Reitzig (2003), Hou & Lin (2006), Wu & Tseng (2006) and Oriani & Sobrero (2008), among others.

The previous authors analyzed the determinant factors of patent value, namely, the renewal information, claims, legal arguments, geographical scope, patent citations, exclusivity of the contract, patent breadth, novelty, disclosure, inventive activity, underlying asset, time to maturity, risk-free interest rate, volatility, fees paid, duration or term of license, scope of the license conceived, set of technologies and IP rights exchanged in the transaction.

When spin-off firms deal with new technologies that need a monetary valuation to be used by patent holders as investment assets, for obtaining financial support from bank institutions and venture capitalists, IP is recognized by financial analysts and investors as determinant for the value of the firm, acting as an indicator of its technological capacity (Otsuyama, 2003).

Kamiyama *et al.* (2006) argue that patents need to be valued for getting used in transactions, when dealing with decisions on filing or renewing a patent, to establish negotiations over licensing fees or to use as a collateral asset for a bank loan.

For instance, Graham & Sichelman (2008), Hsu & Ziedonis, (2008) and Chang *et al.* (2009) understand the value of the academic patent as a signaling argument for spin-offs to attract venture investment and funding, being a dynamic relation between the value of the technology, the fund raising and the spin-off performance.

Wood (2009) defend that due to the inherent attributes of the academic invention and by reducing transaction costs through the imbedding and further development in a spin-off environment, the value of the technology can increase and thus generate value added.

In the context of the present study, as we intend to assess if there is a relationship between the academic patent's value and the spin-off condition, therefore the following hypothesis is formulated:

H1: Academic patent's value has a positive and significant relationship with the spin-off condition.

The effect of time to maturity when valuing a patent is of importance in order to understand the lifetime and stage of development of the invention and the causality in the valuation process of such technology.

For instance, Jones *et al.* (2002) denoted that the value of the underlying technology is an effect of a set of factors including its residual life cycle and its usefulness, being the result of the technology family lifecycle and the development stage of the asset, and additionally of its time to market.

In the same line, Park & Park (2004) identified two main categories of influential variables to the asset's value, namely the intrinsic and the application factors. The first ones deal with characteristics of the asset and lifetime such as its development level, the life of technology. The second ones are related to the usefulness of the patent and the lifecycle, including its degree of completeness.

Given that the value of the patent, as stated by authors like Oriani & Sobrero (2008) and Cotropia (2009), who analyzed the effect of the number of years for the licensee to explore the patent as determinant for the value of the underlying technology, depends upon its validity and the remaining time for the patent to be in force. In this line of reasoning, the present study aims to assess how time left to maturity determines the academic patent's value.

One question that arises from the indicator time to maturity and its relation with patent citations derives from the fact that these can appear at any point in time, sooner or long after the cited patent was filed, granted, or even reached maturity and end (van Zeebroeck, 2011). Acknowledging the fact that time increases the probability for any patent to have been cited by subsequent patents, the possible via to counterbalance this censoring issue consists of counting citations received by patent applications within a certain period of time (e.g. in this study we will consider patents in force after the first five years from their publication until maturity). In this context, we derive the following hypothesis:

H2: Academic patent's value has a negative and significant relationship with time to maturity.

According to the existing literature (Griliches, 1981; Klemperer, 1990; Gilbert & Shapiro, 1990; Gallini, 1992; Lerner, 1994; Green & Scotchmer, 1995; Ernst, 1998; Hall & Ziedonis, 2001; Reitzig, 2003; Sapsalis & Van Pottelsberghe de la Potterie, 2007; Oriani & Sobrero, 2008), aspects like the contractual clauses agreed between the licensee and the licensor of the patent can be determinant for the value of the asset. Example of this is the exclusivity of

the contract which allows the licensee to fully exploit the technology avoiding the possibility of other competitors to endanger his market penetration. In order to assess if there is a relationship between the exclusivity of the patent and its value, the following hypothesis is considered:

H3: Academic patent's value has a positive and significant relationship with the exclusivity of the patent.

Grefermann *et al.* (1974), Schmoch *et al.* (1988), Putnam (1996), Harhoff *et al.* (1999), Lanjouw & Schankerman (1999) and Reitzig (2004) defend the role played by a set of several determinant factors to increase the patent's value, taking into consideration the patent family size.

In accordance, Harhoff *et al.* (2003) defend that patents with a large family size tend to be more valuable or important, in terms of citations.

Conversely, Wu & Tseng (2006) defend that the quantity of patents issued by a firm doesn't have the same importance as the quality of those ones. In addition they defend that there is a strong positive relationship between the patent's value and patent citations, patent family and technology's importance. The same authors revealed that the underlying asset present a positive and significant relation with the patent's value. These results are also confirmed by Oriani & Sobrero (2008).

In this vein, van Zeebroeck (2011) referred that the investment of firms to file and enforce patents in several countries, is a signal of expectation regarding the patent's value, suggesting the existence of an expected market for the patented technology. Taking this vision into consideration, we raise the following hypothesis:

H4: Academic patent's value has a positive and significant relationship with patent family.

Based upon the literature, one can expect to find that the academic patent's value is influenced by the contractual clauses agreed between both parties when transferring the asset, where the geographical scope of the intangible asset is of major importance (Griliches, 1981; Klemperer, 1990; Gilbert & Shapiro, 1990; Gallini, 1992; Lerner, 1994; Green & Scotchmer, 1995; Ernst, 1998; Lanjouw & Schankerman, 1999; Hall & Ziedonis, 2001; Reitzig, 2003; Sapsalis & Van Pottelsberghe de la Potterie, 2007; Cotropia, 2009).

Authors like Jaffe & Lerner (2004) and Bessen & Meurer (2008) analyzed the inefficiencies of the patent system addressing the negative impact of geographic extensions of patents that can act as an entry barrier and performance for young firms due to the high costs associated with these procedures. This is aligned with Langinier (2004), who analyzed the negative impact of patents on the creation of new firms, acting as entry barriers, in the sequence of the high filling and maintenance costs.

In a more recent study, van Zeebroeck & van Pottelsberghe de la Potterie (2011) showed that developments in patent filling strategies should be also considered by all stakeholders of the patent system that are focused on determinants of patent value, since they relate the series of strategic modelling of fillings to the inherent characteristics of value such as the large number of citations and the larger patent' families, being also these patents the ones that tend to be more frequently opposed, justifying economic value on the market.

Therefore the following hypothesis is considered as follows:

H5: Academic patent's value has a positive and significant relationship with the geographical scope.

3. Methodology

3.1 The model

For assessing the importance of the determinant factors of academic patent's value (apv, in the present study it corresponds to the patent citations), we use Poisson models that are able to provide a form of dealing with high skewness of the dependent variable, due to a low number of cases in the datasets that have more than 10 citations, and simultaneously accounting for its integer nature.

Specifically, a negative binomial model is performed to model the presence of significance over dispersion. Let us assume that a discrete random variable Y (number of patent citations) is Poisson-distributed with intensity or rate parameter μ , $\mu > 0$, and t is the exposure, defined as the length of time during which the events occur. Y is defined by the following density distribution function:

$$\Pr [Y = y] = \frac{e^{-\mu t} (\mu t)^y}{y!} \quad y = 0, 1, 2, \dots, n \quad (1)$$

Where $E[Y]$, being the expected value of Y , is equal to the variance, $V[Y]=\mu t$.

The equality of mean with the variance is known, and also the equidispersion property of the Poisson model. The overdispersion is due to the fact that variance exceeds the mean (Trussell & Rodriguez, 1990; Long, 1997; Allison, 1998; Cameron & Trevedi, 1998).

Particularly in the present study, the dependent variable Y_i is the count of patent citations (apv) for each patent under analysis i , $i = 0,1,2,3,\dots,n$. The count-datum Y_i is dependent from a set of exogenous variables, some observed (the x_i) and some unobserved (ipc, corresponding to the International Patent Classification sectors; pf that corresponds to the patent family; tm which represents the time to maturity; eop being the exclusivity of the ownership of the patent; gsp that represents the geographical scope of the patent; and spo referring to the academic spin-off condition). Representing u_i the unobserved variables and measurement errors on the data, having the following:

$$E \{ Y_i \mid x_i, u_i \} = \lambda (x_i , \beta_i , u_i) = \lambda_i \quad (2)$$

Where: E is the expectation operator, β is the k -dimensional parameter vector to be estimated and u_i corresponds to the unobserved variables and measurement errors in the data. The general form of the log-linear regression model is given by:

$$\log \lambda_i = X_i \beta + u_i = \sum_{j=1}^k X_{ij} \beta_j + u_i \quad (3)$$

The previous equation denotes that all individuals with the same characteristics X_i have a Poisson distribution with the same mean. The link between the expected value of the dependent variable and the linear predictor is a logarithmic function, containing the linear predictor a known part or offset, which allows for estimating the maximum likelihood, standard errors and likelihood ratio goodness-of-fit chi-squares statistics. By making use of the negative binomial model, several equations are estimated in order to show the relationship between the patent's value (number of citations) and the set of exogenous variables mentioned above. The incident rate ratios are obtained by exponentiation of the regression coefficients, that is, $\exp[\beta]$.

3.2 The dependent variable

The number of patent citations is used as a reliable proxy for determining the academic patent's value (apv). Several scholars have used this variable for measuring the value of the asset, and even the value of the firm that owns it, since it can be considered as an intangible asset.

Patent citations and patent value have been associated with market value and the R&D expenditures of firms (Griliches, 1981; Connolly *et al.*, 1988; Lerner, 1994; Hall *et al.*, 2005).

Trajtenberg (1990) defended the role of citations as being a good indicator of the value of innovations.

Lanjouw & Schankerman (1999) also understand the role of backward citations as crucial for assessing the quality and value of the patent.

In the line advocated by Thomas & McMillan (2001), the use of patent citation is justified by the fact that a highly cited patent by previously issued patents is supposed to incorporate important technological advances. Ernst (2001) states that patent citations at foreign patent offices reveal increased patent quality. In this sense, patent count is considered to be a simple proxy for the value of the underlying asset.

Harhoff *et al.* (2003) advocate that patents with many backward and forward citations present a higher value than patents with few citations.

Albert *et al.* (1991), Harhoff *et al.* (1999) and Carpenter *et al.* (2005), have demonstrated that patents highly cited correspond to more important technological developments.

Hall *et al.* (2005) focused on the importance of patent citations as a proxy for measuring the value of a firm's patents, as shown by the stock market valuation that is also determined through the intangibles of the firm.

Martinez-Ruiz (2009) also corroborate the utilization of the number of times that each patent has been cited by another patent, as being the most used indicator to measure the value of patents.

As Sherry & Teece (2004) point out a patent granted has more value than a patent application since patents are only conceded when they have innovative value and newness. Consequently patent counts are related to patents granted at a particular moment for a firm or institution.

Furthermore, by analyzing software patents, Hall & MacGarvie (2010) concluded software patents are more widely valued than other patents and the fact that they have citations increases the value of the firm.

van Zeebroeck (2011) also corroborate the vision for using patent citations as a signal of the social value and market value of patents, revealing that the investment being done on patents is an indicator of the inventions' intrinsic value.

3.3 Datasets and variables

The present study uses cross-section data of two samples, namely, 281 patents from Cambridge University (CAMU, UK) and 160 patents from Carnegie Mellon University (CMU, US). The data available covers the period from 2001 till 2011 and refers solely to patents that are target of exploitation, either through the establishment of licensing agreements or by the creation of a spin-off to commercialize the invention. The datasets were created either by direct access to the databases (in the CAMU's case) and completing them by using the 'Espacenet' data, or by accessing the data available for the patents of the university, completing it with data that is made public at the website of the institution, as it happens in the CMU's case.

The dependent variable, which is operated as patent citations - 'academic patent's value' (apv), refers to the number of documents that have cited the reference patent.

The explanatory variables correspond to the following ones:

- *Patent family*: this variable embraces the group of patents that are all related to each other, by the way of priority(ies) of a particular patent document; and it's equal to 1 if it presents a family of patents and 0 otherwise;
- *Time to maturity*: this variable corresponds to the patent lifetime, counted after priority date, by considering the number of years that corresponds to the remaining time of the patent;
- *Exclusivity*: this variable refers to the ownership of the invention in terms of being licensed to one or more licensees; it takes the value 1, if it is an exclusive license and 0 if it is a non-exclusive license;
- *Geographical scope*: the variable refers to the number of countries where the patent was granted; when patent cooperation treaty (PCT), corresponding to 143 countries it takes the value 1, when non-PCT is equal to 0; and

- *Academic spin-off / Non-academic spin-off condition*: the variable is measured as the patent that belongs to a firm created for exploiting the invention; if it's an academic spin-off is equal to 1, otherwise is 0.

The variable size of the patent family (pf) will use the number of patents related to each other. The variable time to maturity (tm) is measured through patent's lifetime, the number of years that the patent will remain active. The exclusivity of the patent (eop) will be measured through the number of licensees of the patent under analysis.

For its turn, the variable concerning geographical scope (gsp) refers to the number of countries in which the patent is granted, the patent width. This variable will be measured by counting the number of countries previously referred.

The variable academic spin-off condition (spo) will be directly withdrawn from the licensing agreements database. The technical field (ipc) will be identified through the international patent classification obtained from the 'Espacenet' database (a public international database for patents).

We use a control variable, namely the previously mentioned spo (academic spin-off condition). We have also introduced the ipc (international patent classification). The technical field in which the licensed invention is found is used in the estimation because of the rate of the commercialization of the invention which varies according to the technical fields. The fields considered are the following: A - human necessities; B - performing operations; transporting; C - chemistry; metallurgy; D - textiles; paper; E - fixed constructions; F - mechanical engineering; lighting; heating; weapons; blasting; G - physics; and H - electricity.

Table 2 reveals that for the dataset of CAMU (UK), there are more cited patents for spin-off firms than for non-spin-off firms.

Table 2 Patent citations by spin-off condition - Cambridge University (UK)

spo/apv	0	1	2	3	4	5	6	8	9	10	11	15	Total
0	24	18	12	3	7	1	4	1	1	0	0	1	72
1	19	21	20	9	3	5	3	1	0	3	1	0	85
total	43	39	32	12	10	6	7	2	1	3	1	1	157

On its side, for the CMU (US), we find that non-spin-off firms have more cited patents than spin-off firms (table 3).

Table 3 Patent citations by spin-off condition - Carnegie Mellon University (US)

spo/apv	0	1	2	3	4	5	6	7	8	9	10	Total
0	46	88	52	21	6	5	1	2	1	1	1	224
1	11	25	11	6	2	1	0	0	1	0	0	57
Total	57	113	63	27	8	6	1	2	2	1	1	281

Table 4 denotes that for CAMU (UK) the patents on the dataset under analysis have few citation counts, the majority have one or two citations and they are concentrated in sector C - chemistry and/or metallurgy.

Table 4 Patent citations by international patent classification - Cambridge University (UK)

ipc/apv	0	1	2	3	4	5	6	8	9	10	11	15	Total
A	15	5	9	1	2	2	3	0	1	2	1	0	41
B	5	5	5	4	1	0	0	1	0	0	0	0	21
C	11	20	10	2	4	1	1	0	0	1	0	0	50
F	3	0	0	0	0	0	0	0	0	0	0	0	3
G	5	7	4	4	2	2	2	1	0	0	0	1	28
H	4	2	4	1	1	1	1	0	0	0	0	0	14
Total	43	39	32	12	10	6	7	2	1	3	1	1	157

Table 5 shows that for CMU (US) the patents on the dataset under analysis have also few citation counts, the majority have 1 or 2 citations and specially located in sector G - physics and sector C - chemistry and/or metallurgy.

Table 5 Patent citations by international patent classification - Carnegie Mellon University (US)

ipc/apv	0	1	2	3	4	5	6	7	8	9	10	Total
A	5	8	4	3	1	0	0	0	0	1	0	22
B	2	17	6	2	0	0	0	0	0	0	0	27
C	30	20	19	9	5	4	1	1	1	0	1	91
E	0	1	2	0	0	0	0	0	0	0	0	3
G	16	53	28	11	2	2	0	0	1	0	0	113
H	4	14	4	2	0	0	0	1	0	0	0	25
total	57	113	63	27	8	6	1	2	2	1	1	281

The descriptive statistics displayed in table 6 reveal that in the case of CAMU (UK), the average number of patent citations (apv) is 2.55, more than one half of the firms are spin-offs, the average value of time to maturity is 12 years and the average size of patent family is 7 patents.

Table 6 Descriptive statistics - Cambridge University (UK) dataset

apv	Obs	Mean	Std. Dev.	Min	Max	Skewness	Kurtosis
spo	160	0.5375	0.5001572	0	1	0.2501572	0.1504237
ipc	160	3.60625	2.498042	1	8	0.6567942	1.881108
tm	160	11.78125	2.780597	0	15	-2.049696	8.490801
apv	160	2.55625	4.147814	0	30	4.265178	26.15198
gsp	160	0.9625	0.19058	0	1	-4.868843	24.70563
pf	160	7.06875	5.504854	1	35	2.134027	10.50161
eop	160	0.55	0.4990557	0	1	0.2010076	1.040404

In the case of CMU (US) the average number of patent citations (apv) is 1.55, the proportion of spin-off firms is about 20%, the average value of time to maturity is 10 years and the average size of patent family is 9.6 patents (see table 7).

Table 7 Descriptive statistics - Carnegie Mellon University (US) dataset

apv	Obs	Mean	Std. Dev.	Min	Max	Skewness	Kurtosis
spo	281	0.202847	0.4028369	0	1	1.477934	3.184289
ipc	281	4.822064	2.410619	1	8	0.1062121	1.327021
tm	281	10.40569	3.299216	1	15	0.6972133	3.145465
apv	281	1.55516	1.522914	0	10	2.204558	10.22915
gsp	281	0.1316726	0.3387378	0	1	2.178585	5.746234
pf	281	9.686833	16.57951	1	68	2.7466969	9.514274
eop	281	0.1530249	0.3606538	0	1	1.927578	4.715556

4. Results and discussion

4.1 Empirical findings

In tables 8 and 9 are displayed the estimation results of the model previously specified, in which the academic patent's value is estimated, by using the datasets of CAMU (UK) and CMU (US). We follow two steps. First, we estimate the academic patent's value. Second, we disaggregate results by spin-off condition for both cases.

Regarding the set of results of the negative binomial regression model for Cambridge University in table 8, one important determinant corresponds to the international patent classification, i.e., the technological field of the patent, which in the present study impacts the dependent variable in a positive and significant way. This result is aligned with previous findings that pointed out to the existence of a positive and significant relationship between the patents' value and the underlying asset, namely the technological field, the specific uses of the technology and the scope of the patent (Scherer, 1965; Mansfield *et al.*, 1981; Jensen & Thursby, 2001; Hall & Ziedonis, 2001; Wu & Tseng, 2006).

Another important factor effect is the time to maturity, which denotes a negative and significant influence on the patent's value. In simple terms, as the lifetime of the asset increases, the patent's value decreases. This is also in line with previous findings, namely, the studies of Jones *et al.* (2002) and Park & Park (2004), which revealed the effect of the time variable on patent's value and on its development across lifecycle. Furthermore, Wu & Tseng (2006), Oriani & Sobrero (2008) and Cotropia (2009), also denoted the important effect of the remaining time for the patent to be in force on the value and subsequent exploitation of the asset. Regarding the H2 that stresses that the apv has a negative and significant relationship with time to maturity, the results obtained are consistent with the expected results and confirm the results previously obtained, thus we fail to reject the H2.

The effect of the size of the patent family also denotes a positive and significant effect on the dependent variable. This empirical finding is also in line with the theoretical background that advocates a significant relationship between the patent's value and the size of the patent family (Grefermann *et al.*, 1974; Schmoch *et al.*, 1988; Putnam, 1996; Harhoff *et al.*, 1999, 2003; Lanjouw & Schankerman, 1999; Reitzig, 2004; Sherry & Teece, 2004; Wu & Tseng, 2006; and van Zeebroeck, 2011). These authors also defend that the increase in the size of the patent family and the investment made by firms to file and enforce patents abroad, act jointly as a signalling mechanism for the patent value. In this vein, and according to H4 which tests a positive and significant relationship between apv and patent family, the results obtained for the dataset of Cambridge University are consistent with the expected results and the previous findings, thus we fail to reject the H4.

For CAMU (UK) the effects of the spin-off condition, the geographical scope and the exclusivity of the patent do not have significant effect on the patent value. Thus, we reject H1, H3 and H5.

Table 8 Determinants of patent citation - CAMU (UK)

Determinants	Coef.	Std. Err.	Z
spo	0.582859	0.1885368	0.31
ipc	0.1438807***	0.0358068	4.02
tm	-0.189681***	0.365301	-5.19
gsp	-0.0537375	0.4981927	-0.11
pf	0.0529262***	0.205692	2.57
eop	-0.052111	0.1839811	-0.28
Constant	2.118643***	0.4885872	4.34
Lalpha	-0.2950736		
Log Likelihood	-312.21461		
Observations	160		
***significant at 1%			

Table 9 presents the results obtained by using the negative binomial regression model for Carnegie Mellon University, where diverging from the previous results achieved for the case of CAMU (UK), the only significant factor is the time to maturity, which influences in a negative and significant way the patent value. This is also aligned with previous findings (Jones *et al.*, 2002; Park & Park, 2004; Wu & Tseng, 2006; Oriani & Sobrero, 2008; and Cotropia, 2009) and makes us fail to reject H2 that stresses that the apv has a negative and significant relationship with time to maturity.

In the case of CMU (US) the spin-off condition, international patent classification, size of the patent family, geographical scope and exclusivity of the patent do not present a significant effect on the patent's value. Thus, we reject H1, H3, H4 and H5.

Table 9 Determinants of patent citation - CMU (US)

Determinants	Coef.	Std. Err.	
spo	-0.0172082	0.1523371	-0.11
ipc	0.0088074	0.0240499	0.37
tm	-0.0748931***	0.0174553	-4.29
gsp	0.0746174	0.1544827	0.48
pf	0.0050191	0.0034149	1.47
eop	-0.1699959	0.1713801	-0.99
Constant	1.108216***	0.2325217	4.77
Lalpha	-2.002092		
Log Likelihood	-440.01734		
Observations	281		
***significant at 1%			

Tables 10 and 11 present the estimation results of the model for CAMU (UK) and CMU (US) datasets disaggregated by the spin-off condition.

In the case of CAMU (UK), for patents that are being exploited by other forms that do not include the spin-off condition, we verify the existence of a positive and significant relationship between the patent's value and the international patent classification (see table 10). This reveals that the technological field of the asset is important when determining the underlying value of the patent. In addition, the negative and significant effect of time to maturity on the patent's value is also founded, guiding us to fail to reject H2.

For this dataset we reject, H1, H3, H4 and H5.

Table 10 Determinants of patent citation for non spin-offs - CAMU (UK)

Determinants	Coef.	Std. Err.	Z
ipc	0.2004958***	0.0722789	2.77
tm	-0.1887732***	0.501878	-3.76
gsp	-0.0649099	0.6418648	-0.10
pf	0.0510499	0.355167	1.44
eop	0.0468908	0.3066327	0.15
Constant	1.892043***	0.6326443	2.99
Lalpha	0.0169647		
Log Likelihood	-143.40861		
Observations	74		
***significant at 1%			

In the same case, for patents that are exploited by a spin-off, we verify the existence of a positive and significant relationship between the patent's value and the technological field. Moreover, we detect a negative and significant effect of the time to maturity on the patent's value, leading us to fail to reject H2 (see table 11).

Table 11 Determinants of patent citation for spin-offs - CAMU (UK)

Determinants	Coef.	Std. Err.	Z
ipc	0.1072506***	0.0411851	2.60
tm	-0.2179787***	0.0605548	-3.60
gsp	0.4440768	1.242618	0.36
pf	0.0372141	0.0246962	1.51
eop	-0.0301038	0.227672	-0.13
Constant	2.286882	1.418735	1.61
Lalpha	-0.7180123		
Log Likelihood	-165.91341		
Observations	86		
***significant at 1%			

In the case of CMU (US), for patents not exploited through spin-offs, the same conclusion of the previous estimations without the disaggregation by spin-off condition are achieved, in a sense that we fail to reject H2, which poses a negative and significant relationship between patent's value and time to maturity.

Table 12 Determinants of patent citation for non spin-offs - CMU (US)

Determinants	Coef.	Std. Err.	z
ipc	0.0040209	0.0268397	0.15
tm	-0.0784012***	0.0185178	-4.23
gsp	0.2478615	0.1699766	1.46
pf	0.0053553	0.0042665	1.26
eop	-0.3061991	0.2264672	-1.35
Constant	1.14597***	0.2483366	4.61
Lalpha	-1.955672		
Log Likelihood	-351.26367		
Observations	224		
***significant at 1%			

In table 13, for the CMU patents exploited in the spin-off form, other important determinant for the patent value is founded, namely the effect of the geographical scope of the patent which denotes a negative and significant effect. This result corroborates previous literature that detected the influence of geographical scope of the intangible asset on transactions and subsequently on the value of the patent (Griliches, 1981; Klemperer, 1990; Gilbert & Shapiro, 1990; Gallini, 1992; Lerner, 1994; Green & Scotchmer, 1995; Ernst, 1998; Lanjouw & Schankerman, 1999; Hall & Ziedonis, 2001; Reitzig, 2003; Sapsalis & Van Pottelsberghe de la Potterie, 2007; Cotropia, 2009; van Zeebroeck & Van Pottelsberghe de la Potterie, 2011).

Therefore we partially fail to reject the fifth research hypothesis that states that the academic patent's value has a positive and significant relationship with the geographical scope, due to the fact that we found a significant effect although in a negative way, thus aligning with previous studies of authors like Jaffe & Lerner (2004) Langinier (2004) and Bessen & Meurer (2008) that discussed the problematic of the high costs associated with geographical extensions and their relation with the creation of young firms and their performance, being needed a strategic cost/benefit exercise to make decisions on renewal and extension processes (as pointed by Bloom & Reenen, 2002).

Table 13 Determinants of patent citation for spin-offs - CMU (US)

Determinants	Coef.	Std. Err.	z
ipc	0.0075501	0.0558969	0.14
tm	-0.077029	0.585208	-1.32
gsp	-0.7365845**	0.4052324	-1.82
pf	0.0035467	0.0072554	0.49
eop	0.022233	0.8677147	1.34
Constant	1.159338	0.8677147	1.34
Lalpha	-3.102019		
Log Likelihood	-85.073309		
Observations	57		
**significant at 5%			

5. Concluding remarks

This paper reviews the literature on dynamics of technology transfer and valuation and commercialization of academic patents. In this framework, the technology transfer is hereby

analyzed as an innovation engine which can foster interrelationships among academic, governmental agencies and academic entrepreneurs.

We tackle the problematic, under an innovative way, by using the spin-off condition's variable as a mechanism to exploit the patent opposing to non-spin-off forms (such as licensing), when assessing the academic patents' value.

5.1 Findings

For the two samples (CAMU and CMU), although we find contradictory signals, we verify that the spin-off condition has not a significant effect on the academic patent's value, thus we reject H1, for both datasets.

When considering the impact of time to maturity on the patent's value, we verify a major importance of this factor as being determinant for assessing the value of the asset, either when we disaggregate the sample by the spin-off condition or not. In this vein, we found a negative and significant impact in the case of CAMU, with and without the disaggregation. Plus this effect is noticed with significance for the cases where the patent is exploited via a spin-off or by other mechanism, such as licensing for instance. Thus we fail to reject H2.

The β_{apv} denotes a non-significant relationship with geographical scope for the CAMU dataset (e.g. we reject H3) with or without disaggregating the spin-off condition. For the case of CMU, we found the importance of the spin-off condition, in what concerns the explanatory variable relative to geographical scope. Going deeper, this means that for a spin-off that is exploiting a patent the geographical scope of the asset can have a significant and negative impact on the value of the patent. This can be mainly due to the high costs for extension and maintenance and their effect on firm's performance, impacting negatively on the success of the exploitation and thus on the asset's value. In this vein, we partially fail to reject H3, signalling the need for assessing, in strategic terms, the filing decisions and their impact on the firm's performance.

Moreover, in the case of CAMU we find a positive and significant relationship between the academic patent's value and the size of patent family, when we make use of the estimation results of the negative binomial regression model without disaggregating by spin-off condition (we fail to reject H4), consistently with the expected results and the previous findings. In this sense, for the CMU dataset we reject H4 with and without the disaggregation.

At last and considering hypothesis 5 that states that there is a positive and significant relationship between the academic patent's value and the exclusivity of the patent, we didn't find evidence of a significant effect, therefore rejecting H5 for both samples.

Summing up, there is an important impact of determinant factors like the size of the patent family, the time to maturity and the geographical scope of the patent on the value of the academic patent. There is to say that the bigger the set of patents related to each other and to the patent under consideration, the higher will be the value of the academic patent. Conversely, the higher the lifetime of the patent, the lower will be the asset's value under analysis. In addition to this, there is a negative and significant relationship between the academic patent's value and the geographical scope of the asset.

Furthermore, the technical field denotes a positive and significant effect on the patent's value, especially in the case of the Cambridge University's sample whose patent citations are higher in chemistry and/or metallurgy sector, both when we disaggregate or not for the spin-off condition.

The last remark lies on the effect of disaggregating the spin-off condition in both cases. For the spin-offs of the Cambridge University's sample, in terms of significant results, it deserves to be stressed the negative effect of time to maturity and the positive impact of the technical field on patent's value. In the Carnegie Mellon University's sample, another important aspect is concerned with the importance of geographical scope of the patent, which denotes a negative and significant effect on the patent's value.

5.2 Limitations, future research and implications

In future research, and for addressing the limitations of the current study we suggest to test two additional determinant factors, namely, existence of pre-incubation structure (dummy variable), use of formal/institutional mechanisms to support and accelerate IP exploitation and disaggregated ipc (dummy variables per technical field), which are not available for the datasets used in the present study.

In terms of implications, and since public policies play a crucial role in fostering entrepreneurial skills and competences, it's important that policy-makers understand the determinants of academic entrepreneurship and the needed incentives and mechanisms to expand it.

Thus, both the national and institutional regulatory framework may determine the success of academic entrepreneurship, acting as a productive or an unproductive driver of the national

productivity growth. Aspects like the amount of knowledge stock, the capacity of the multiple agents involved (from firms to universities or research laboratories and centers) are key factors in the production, identification, and exploitation of business opportunities based on scientific knowledge. Once the exploitation of scientific knowledge is not efficiently accomplished it's important to foster endogenous channels, such as academic entrepreneurship based on university-industry bi-directional relationships. This type of relationships deserves to be explored under a perspective of two-sided platforms founded on a simultaneous operation of demand pull and supply push of science & technology (S&T).

Under the scenario of open innovation systems, a guideline for the policy makers and academic entrepreneurs is derived from the present study, that is, we suggest taking into consideration a strategy of corporate S&T and IP, by designing a patenting methodology that reflects on matters related to an in depth cost-benefit analysis applied to the scope of the IP asset, namely the geographical extensions and the increase of the size and diversity of the patent family, in order to draw the set of corporate decisions on litigations, oppositions, renewal and extension processes.

In the same direction, there is a need for developing formal management of the IP portfolio, in several aspects, such as the optimal organizational practices related to academic inventor incentives, technology transfer, pricing, legal issues, business plan, strategic planning, and measurement and monitoring mechanisms of performance, in order to reinforce the licensing of academic patents.

From the present study several implications can be derived to the university management, namely the need for defining, firstly, a regulatory body for IP, technology management and technology business pre-incubation of academic spin-offs. Afterwards, the attention of the academic leaders should lay on developing a strategy for IP commercialization, by setting priorities, organizing design choices focused on eliciting invention disclosures, adjusting incentives in order to stimulate entrepreneurial intention and orientation, and by establishing a career plan involving specialization programs for the agents involved in technology transfer and commercialization.

References

- Albert, M., Avery, D., Narin, F. and McAllister, P. (1991). Direct validation of citation counts as indicators of industrially important patents. *Research Policy*, 20(3), 251-259.
- Allison, D. (1998). *Logit and Loglinear Analysis Using the SAS System*. University of Pennsylvania.
- Anand, N., Gardner, H. and Morris, T. (2007). Knowledge-Based Innovation: Emergence and Embedding of New Practice Areas in Management Consulting Firms', *The Academy of Management Journal*, 50 (2), 406-428.
- Azzone, G. and Manzini, R. (2008). Quick and dirty technology assessment: The case of an Italian Research Centre. *Technological Forecasting and Social Change*, 75 (8), 1324-1338.
- Baldini, N., Grimaldi, R. and Sobrero, M. (2006). A study of Italian universities' patenting activities between 1965 and 2002. *Research Policy*, 35 (4), 518-532.
- Bessen, J. (2008). The value of U.S. patents by owner and patent characteristics', *Research Policy*, 37 (5), 932-945.
- Bessen, J. and Meurer, M. (2008). *Patent Failure*. Princeton University Press. Princeton.
- Bloom, N. and Reenen, J. (2002). Patents, real options and firm performance. *The Economic Journal*, 112 (March), 97-116.
- Braunerhjelm, P., Acs, Z., Audretsch, D. and Carlsson, B. (2010). The missing link: knowledge diffusion and entrepreneurship in endogenous growth. *Small Business Economics*, 34 (2), 125-135.
- Cameron, A. and Trivedi, P. (1998). *Regression Analysis of Count Data*. Econometric Society Monographs, 30. Cambridge University Press.
- Carlsson, B. and Fridh, A. (2002). Technology transfer in United States universities: A survey and statistical analysis. *Journal of Evolutionary Economics*, 12 (1-2), 19-232.
- Carpenter, M., Narin, F. and Woolf, P. (2005). Citation rates to technologically important patents', *World Patent Information*, 3 (4), 160-163.
- Chang, Y., Yang, P. and Chen, M. (2009). The determinants of academic research -commercial performance: towards an organizational ambidexterity perspective. *Research Policy*, 38, 936-946.
- Conceição, P., Heitor, M. and Oliveira, P. (1998). University-based technology licensing in the knowledge-based economy. *Technovation*, 18 (10), 615-625.
- Connolly, R. and Hirschey, M. (1988). Market value and patents: A Bayesian approach. *Economics Letters*, 27 (1), 83-87.
- Cotropia, C. (2009). Describing patents as real options. *The Journal of Corporate Law*, 34 (4), 1128-1149.
- De Juan, V. (2002). Comparative study of technology transfer practices in Europe and the United States. *Journal of the Association of University Technology Managers*, 14, 31-58.
- DiGregorio, D. and Shane, S. (2003). Why do some universities generate more start-ups than others?, *Research Policy*, 32, 209-227.
- Ernst, H. (1998). Industrial research as a source of important patents. *Research Policy*, 27, 1-15.
- Ernst, H. (2001). Patent applications and subsequent changes of performance: evidence from time-series cross-section analyses on the firm level. *Research Policy*, 30, 143-157.
- Ernst H, Legler, S. and Lichtenthale, U. (2010). Determinants of patent value: Insights from a simulation analysis. *Technological Forecasting & Social Change*, 77, 1-19.

- Etzkowitz, H. (2003). Research groups as 'quasi-firms'? The invention of the entrepreneurial university. *Research Policy*, 32, 109-121.
- Gallini, N. (1992). Patent policy and costly imitation. *The RAND Journal of Economics*, 23, 52-63.
- Gambardella, A., Giuri, P. and Luzzi, A. (2007). The market for patents in Europe. *Research Policy*, 36, 1163-1183.
- Geuna, A. and Nesta, L. (2006). University Patenting and Its Effects on Academic Research. *Research Policy*, 35 (6), 790-807.
- Gilbert, R. and Shapiro, C. (1990). Optimal patent length and breadth. *The RAND Journal of Economics*, 21, 106-113.
- Graham, S., Hall, B., Harhoff, D. and Mowery, D. (2002). Post-issue patent 'quality control': A comparative study of US patent re-examinations and European oppositions. NBER WP 8807, National Bureau of Economic Research (NBER), Cambridge, MA.
- Graham, S. and Sichelman, T.M. (2008). Why do start-ups patent?. *Berkeley Technology Law Journal*, 23 (3), 1064-1097.
- Green, J. and Scotchmer, S. (1995). On the division of profit in sequential innovation', *The RAND Journal of Economics*, 26, 20-33.
- Grefermann, K., Oppenländer, K., Peffgen, E., Röthlingshöfer, K. and Scholz, L. (1974). Patentwesen und technischer Fortschritt. Teil I: Die Wirkung des Patentwesens im Innovationsprozess. Göttingen: Verlag Otto Schwarz & Co.
- Griliches, Z. (1981). Market value, R&D, and patents. *Economics Letters*, 7, 183-187.
- Griliches, Z., Pakes, A. and Hall, B. (1986). The value of patents as indicators of inventive activity. NBER Working Paper No. 2083, National Bureau of Economic Research (NBER), Cambridge, MA.
- Guellec, D., and van Pottelsberghe de la Potterie, B. (2000). Applications, grants and the value of patents. *Economic Letters*, 69 (1), 109-14.
- Guellec, D., and van Pottelsberghe de la Potterie, B. (2002). The value of patents and patenting strategies: Countries and technology areas patterns. *Economics of Innovation and New Technologies*, 11 (2), 133-48.
- Hagelin, T. (2003). Competitive Advantage Valuation of Intellectual Property Assets: A New Tool for IP Managers Idea. *The Journal of Law and Technology*, 44, 79-88.
- Hall, B., Jaffe, A. and Trajtenberg, M. (2005). Market Value and Patent Citations. *RAND Journal of Economics*, 36 (1), 16-38.
- Hall, B. and Ziedonis, R. (2001). The patent paradox revisited: an empirical study of patenting in the U.S. semiconductor industry, 1979-1995. *The RAND Journal of Economics*, 32, 101-128.
- Hall, B. and MacGarvie, M. (2010). The private value of software patents. *Research Policy*, 39 (7), 994-1009.
- Harhoff, D., Narin, F., Scherer, F. and Vopel, K. (1999). Citation frequency and the value of patented inventions. *Review of Economics and Statistics*, 81 (3), 511-515.
- Harhoff, D., Scherer, F. and Vopel, K. (2003). Citations, family size, opposition and the value of patent rights. *Research Policy*, 32, 1343-1363.
- Helmers, C. and Rogers, M. (2011). Does patenting help high-tech start-ups? *Research Policy*, 40, 1016-1027.
- Henrekson, M. and Rosenberg, N. (2001). Designing efficient institutions for science-based entrepreneurship: lesson from U.S. and Sweden. *Journal of Technology Transfer*, 26, 207-231.

- Hou, J. and Lin, H. (2006). A multiple regression model for patent appraisal. *Industrial Management & Data Systems*, 106 (9), 1304-1332.
- Hsu, D. and Ziedonis, R.H. (2008). Patents as quality signals for entrepreneurial ventures. *Academy of Management Best Paper Proceedings*.
- Jacob, M., Lundqvist, M. and Hellsmark, H. (2003). Entrepreneurial transformations in the Swedish university system: the case of Chalmers University of Technology. *Research Policy*, 32, 1555-1568.
- Jaffe, A. and Lerner, J. (2004). *Innovation and its discontents: how our broken patent system is endangering innovation and progress, and what to do about it*. Princeton University Press. Princeton.
- Jensen, R. and Thursby, M. C. (2001). Proofs and prototypes for sale: the tale of university licensing. *American Economic Review*, 91, 240-259.
- Jones, T., Norris, M. and Solomon, I. (2002). Strategies for maximizing value from intellectual capital in a technology-driven business. *The Licensing Journal*, 22 (6), 1-7.
- Kamiyama, S., Sheehan, J. and Martinez, C. (2006). Valuation and Exploitation of Intellectual Property. *Statistical Analysis of Science, Technology and Industry*. Accessed in 2012/02/12, <http://www.oecd.org/sti/working-papers>.
- Klemperer, P. (1990). How Broad Should the Scope of Patent Protection Be?. *The RAND Journal of Economics*, 21 (1), 113-130.
- Krabel, S and Mueller, P. (2009). What drives scientists to start their own company? An empirical investigation of Max Planck Society scientists. *Research Policy*, 38, 947-956.
- Kulatilaka, N. and Marcus, A. (1992). Project valuation under uncertainty: when does DCF fail?', *Journal of Applied Corporate Finance*, 5, 92-100.
- Lach, S. and Schankerman, M. (2004). Royalty sharing and technology licensing in universities. *Journal of the European Economic Association*, 2, 252-264.
- Landry, R., Amara, N. and Rherrad, I. (2006). Why are some university researchers more likely to create spin-offs than others? Evidence from Canadian universities. *Research Policy*, 35, 1599-1615.
- Langinier, C. (2004). Are patents strategic barriers to entry? *Journal of Economics and Business*, 56, 349-361.
- Lanjouw, J. and Schankerman, M. (1997). Stylised facts of patent litigation: Value, scope and ownership. NBER Working Paper No. 6297, National Bureau of Economic Research (NBER), Cambridge, MA.
- Lanjouw, J. and Schankerman, M. (1999) 'The Quality of Ideas: Measuring Innovation with Multiple Indicators' NBER Working Paper 7345.
- Lanjouw, J. and Schankerman, M. (2004). Patent quality and research productivity: Measuring innovation with multiple indicators. *The Economic Journal*, 114, 441-65.
- Lerner, J. (1994). The importance of patent scope: an empirical analysis. *The RAND Journal of Economics*, 25, 319-333.
- Lev, B. (2004). Sharpening the intangibles edge. *Harvard Business Review*, 82, 109-116.
- Li, Y., James, B., Madhavan, R. and Mahoney, J. (2007). Real Options: Taking Stock and Looking Ahead. *Advances in Strategic Management*, 24, 31-66.
- Long, S. (1997). *Regression Models for Categorical and Limited Dependent Variables*. Thousand Oaks, CA: SAGE Publications.
- MacMillan, I. and McGrath, R. (2002). Crafting R&D Project Portfolios. *Research Technology Management*, 45 (5), 1 September 2002, 48-59.
- Malanowski, N. and Zweck, A. (2007). Bridging the gap between foresight and market research: integrating methods to assess the economic potential of nanotechnology. *Technological Forecasting & Social Change*, 74, 1805-1822.

- Mansfield, E., Schwartz, M. and Wagner, S. (1981). Imitation cost and patents: an empirical study. *The Economic Journal*, 91, 907-918.
- Marco, A. (2005). The option value of patent litigation: theory and evidence. *Review of Financial Economics*, 14, 323-351.
- Markman, G., Gianiodis, P., Phan, P. and Balkin, D. (2005). Innovation speed: transferring university technology to market. *Research Policy*, 34, 1058-1075.
- Martinez-Ruiz, A. and Aluja-Banet, T. (2009). Toward the Definition of a Structural Equation Model of Patent Value: PLS Path Modelling with Formative Constructs. *Revstat - Statistical Journal*, 7 (3), 265-290.
- Maurseth, P. (2005). Lovely but dangerous: The impact of patent citations on patent renewal. *Economics of Innovation and New Technology*, 14 (5), 351-74.
- McGrath, R. (1999). Falling forward: Real options reasoning and entrepreneurial failure. *The Academy of Management Review*, 24 (1), 13-30.
- McGrath, R. and Nerkar, A. (2004). Real options reasoning and a new look at the R&D investment strategies of pharmaceutical firms. *Strategic Management Journal*, 25 (1), 1-21.
- Mowery, D. and Ziedonis, A. (2002). Academic patenting quality and quantity before and after the Bayh-Dole Act in the United States. *Research Policy*, 31, 399-418.
- Murray, F. (2004). The role of academic inventors in entrepreneurial firms: sharing the laboratory life. *Research Policy*, 3, 643-659.
- Narin, F., Noma, E. and Perry, R. (1987). Patents as indicators of corporate technological strength. *Research Policy*, 16 (2-4), 143-55.
- Nerkar, A. and Shane, S. (2007). Determinants of invention commercialization: an empirical examination of academically sourced inventions. *Strategic Management Journal*, 28, 1155-1166.
- OECD, Organization for Economic Co-operation and Development (2003). *Turning Science into Business. Patenting and Licensing at Public Research Organizations*. Paris: OECD.
- Otsuyama, H. (2003). Patent valuation and intellectual assets management. Samejima, M., editor. *Patent strategy handbook*, Tokyo: Chuokeizai-sha, 175-183.
- Oriani, R. and Sobrero, M. (2008). Uncertainty and the market valuation of R&D within a real options logic. *Strategic Management Journal*, 29 (4), 343-361.
- O'Shea, R., Allen, T., Morse, K., O'Gorman, C. and Roche, F. (2007). Delineating the anatomy of an entrepreneurial university: the Massachusetts Institute of Technology experience. *R&D Management*, 37, 1-16.
- Owen-Smith, J. and Powell, W. W. (2001). To patent or not: faculty decisions and institutional success at technology transfer. *Journal of Technology Transfer*, 26, 99-114.
- Pakes, A. (1986). Patents as options: some estimates of the value of holding European patent stocks. *Econometrica*, 54, 755-784.
- Pakes, A. and Shankerman, M. (1984). An Exploration into the Determinants of R&D Intensity. Griliches, Z. (ed.), *R&D, Patents, and Productivity*. The University of Chicago Press, Chicago and London, 209-232.
- Park, Y. and Park, G. (2004) 'A new method for technology valuation in monetary value: procedure and application', *Technovation*, Vol. 24: 387-94.
- Park, G. and Park, Y. (2006). On the measurement of patent stock as knowledge indicators. *Technological Forecasting & Social Change*, 73, 793-812.
- Pitkethly, R. (2006). *Analysing the environment*. The Oxford Handbook of Strategy, Faulkner, D. and Campbell, A.. Oxford University Press, 231-267.

- Putnam, J. (1996). *The value of international patent rights*. New Haven, CT: Yale University Press.
- Reitzig, M. (2003). What determines patent value? Insights from the semiconductor industry. *Research Policy*, 32, 13-26.
- Reitzig, M. (2004). Improving patent valuations for management purposes – validating new indicators by analyzing application rationales. *Research Policy*, 33, 939-957.
- Reitzig, M. (2006). Valuing Patents and Patent Portfolios from a Corporate Perspectives: Theoretical Considerations, Applied Needs and Future Challenges. Bosworth D., Webster E. (eds.), *The Management of Intellectual Property*, Cheltenham: Edward Elgar.
- Rivette, K. and Kline, D. (2000). Discovering New Value in Intellectual Property. *Harvard Business Review*, January-February, 55-66.
- Santoro, M. and Bierly, P. (2006). Facilitators of knowledge transfer in university-industry collaborations: A knowledge based perspective. *Transactions of Engineering Management*, 53 (4), 495-507.
- Sapsalis, E. and Van Pottelsberghe de la Potterie, B. (2007). The institutional sources of knowledge and the value of academic patents. *Economic Innovation New Technology*, 16, 139-157.
- Schankerman, M. and Pakes, A. (1986). Estimates and the value of patent rights in European countries during the post-1950 period. *The Economic Journal*, 96, 1052-1076.
- Scherer, F. (1965). Firm size, market structure, opportunity and the output of patented inventions. *American Economic Review*, 55, 1097-1125.
- Schmiemann, M. and Durvy, J-N. (2003). New approaches to technology transfer from publicly funded research. *Journal of Technology Transfer*, 28, 9-15.
- Schmoch, U., Grupp, H., Mannsbart, W. and Schwitalla, B. (1988). *Technikprognosen mit Patentindikatoren*. Köln: Verlag TÜV Rheinland.
- Shane, H. (2001). Technological opportunities and new firm creation. *Management Science*, 47 (2), 205-20.
- Shane, S. (2004a). Encouraging university entrepreneurship? The effect of the Bayh-Dole Act on university patenting in the United States. *Journal of Business Venturing*, 19, 127-151.
- Shane, S. (2004b). *Academic Entrepreneurship: University Spinoffs and Wealth Creation*. Edward Elgar Publishing Inc., MA.
- Sherry, E. and Teece, D. (2004). Royalties, evolving patent rights, and the value of innovation. *Research Policy*, 33, 179-191.
- Siegel, D., Waldmann, D. and Link, A. (2003). Assessing the impact of organizational practices on the productivity of university technology transfer offices: an exploratory study. *Research Policy*, 32, 27-48.
- Stuart, T., Ding, W. (2006). The Social Structural Determinants of Academic Entrepreneurship: An Analysis of University Scientists' Participation in Commercial Ventures. *American Journal of Sociology*, 112 (1), 97-144.
- Tamboli, R. and Sharma, S. (2011). An analytical study of valuation models of intangible assets. *Saaransh RKG Journal of Management*, 3 (1), 5-15.
- Thomas, P. and McMillan, G. (2001). Using science and technology indicators to manage R&D as a business. *Engineering Management Journal*, 13, 9-14.
- Thursby, J. and Thursby, M. (2002). Who is selling the ivory tower? Sources of growth in university licensing. *Management Science*, 48, 90-104.
- Tong, X. and Frame, J. (1992). Measuring national technological performance with patent claims data. *Research Policy*, 23, 133-141.
- Trajtenberg, M. (1990). A penny for your quotes: patent citations and the value of innovations. *The RAND Journal of Economics*, 21, 172-187.

- Trussell, J. and Rodriguez, G. (1990). Heterogeneity in Demographic Research. *Convergent Issues in Genetics and Demography*, (eds.) Adams, J., Lam, A., Hermalin, A. and Smouse, P., New York, Oxford: Oxford University Press.
- van Zeebroeck, N. and Van Pottelsberghe de la Potterie, B. (2008). A brief history of space and time: The scope-year index as a patent value indicator based on families and renewals. *Scientometrics*, 75 (2), 319-38.
- van Zeebroeck, N. and Van Pottelsberghe de la Potterie, B. (2011). Filing strategies and patent value. *Economics of Innovation and New Technology*, 20 (6), 539-561.
- Wood, M. (2009). Does One Size Fit All? The Multiple Organizational Forms Leading to Successful Academic Entrepreneurship. *Entrepreneurship Theory and Practice*, 33, 929-947.
- Wright, M., Lockett, A., Clarysse, B. and Blinks, M. (2006). University spin-out companies and venture capital. *Research Policy*, 35, 481-501.
- Wu, M. and Tseng, C. (2006). Valuation of patent - a real options perspective. *Applied Economics Letters*, 13, 313-318.
- Ziedonis, A. (2007). Real Options in Technology Licensing. *Management Science*, 53 (1), 16-28.

Chapter 3

Do coopetition arrangements matter for creating innovation? Major differences between manufacturers and service providers.

Abstract

Previous studies on coopetition considered the concept as a mix of cooperation and competition among firms, oriented towards producing innovation and generating net value added or economic benefit. The importance of studying the determinants of firms' innovative behavior in order to produce an insightful analysis of their patent intensity behavior based on those coopetition relationships has also warranted increasing attention by several entrepreneurship scholars. This paper tackles the issue in an innovative way, by making use of firms' behavior in generating innovative products and services to reveal their innovative performance and the dynamics of coopetition targeted at open innovation. Thus, we analyze the determinant factors of firms' capacity to generate innovations, which is influenced by the role played by policies oriented to driving innovations among firms, cooperation with scientific stakeholders and development of the capacity to generate and transfer new products. For this purpose, we use a dataset of 3682 manufacturing firms and 1221 service firms that participated in the European Community Innovation Survey (CIS), 2008. A probit analysis is conducted separately for manufacturing and service firms and, within each sector, according to firms' category of technological intensity. The results reveal the significant influence of manufacturing and service firms' capacity to generate product and service innovations, such as coopetition arrangements between competing firms and other R&D stakeholders, and also firms' capacity to introduce innovations to the market. Furthermore, this study also reveals that for service firms the effects of introducing process innovations inside the firm and the existence of internal R&D activities are of major significance for creating a capacity to generate innovations.

Keywords

Product/service/process innovations; Inside R&D; Coopetition relationships.

1. Introduction

Innovation results from an interactive process between firms and the environment, adjusted by the absorptive capacity of the economic system and the stimulating forces of the institutions that foster and promote innovation. In this vein, governments can stimulate innovation in two ways, that is, in a technology-push orientation (in order to decrease the private costs of the innovation process) and in a demand-pull orientation (to increase the private pay-off from successful innovation through adoption of measures targeted at improving Intellectual Property-IP protection) (Nemet, 2009).

As a means of fostering innovation, firms and other institutions make use of so-called cooptation, this being a compound of strategic cooperation and competition among rivals (Rusko, 2011). When dealing with emerging technologies, characterized by uncertainty regarding market opportunities, firms opt for strategic cooptation (Garraffo, 2002). In this sense, both incremental and radical innovations can be developed through cooptation alliances.

The strategic use of IP protection mechanisms (such as patents) has become an important tool for establishing successful innovation cooperation arrangements between private and/or public competitors, due to the risks posed by the flow of knowledge. Another advantage of using IP to develop strategic cooptation is derived from the use of patents as an information source regarding technological position and strength, to detect and predict direction and scope.

This article presents a two-fold contribution: to determine the impact of a set of factors on firms' capacity to generate innovative products/services influenced by policies targeted at driving innovative behavior among firms, scientific stakeholders and competitors; and to measure the impact of the innovative intensity of partners involved in cooptation arrangements regarding the type of strategic cooptation.

It contributes to the empirical literature on cooptation strategy by adopting a different perspective from prior work and complementing earlier studies by deepening understanding of the process of creating innovation in cooptation relationships between firms. Several authors analyzed the strategic use of cooptation by firms dealing with emerging technologies (Brandenburger & Nalebuff, 1996; Gomes-Casseres, 1996; Harbison & Pekar, 1998). Others focused on the benefits of cooptation (Bagshaw & Bagshaw, 2001; Garraffo, 2002; Chien & Peng, 2005; Rusko, 2011).

Previous studies were also devoted to the reasons for cooperating, and proposed four types of cooptation (Garraffo, 2002). Other authors studied cooptation in its different nuances, such as the dyadic features of cooptation (Bengtsson & Kock, 2003), these being defined as

bilateral relationships characterized by the commitment of two firms when they cooperate in upstream activities, such as research and development (R&D), buying and processing of raw materials and on multifaceted coopetition, competing also in downstream activities, namely distribution, services, product development and marketing (Luo, 2004), these being defined as multilateral relationships characterized by the commitment of more than two competing firms to cooperate with each other due to public policy. The author introduces the role of the policy maker as a possible initiator of coopetition relationships between firms.

The risks of opportunistic behavior emerging from coopetition were the object of analysis (Nieto & Santamaria, 2007), as well as the importance of coopetition, especially when it comes to developing incremental innovations in high-tech industries (Abernathy & Clark, 1985; Fjelstad *et al.*, 2004; Ritala & Hurmelinna-Laukkanen, 2009). Some scholars concluded on the need for firms to develop absorptive capacity in order to obtain critical outcomes from coopetition (Escribano *et al.*, 2009; Bergek & Bruzelius, 2010; Cohen & Walsh, 2011). Some authors crossed collaborative partnerships with international cooperation, based on patent data at the inventor level (Bergek & Bruzelius, 2010). The technological patterns of collaborative development were crossed with international trends, also based on patent information (Archambault, 2002). The risks of appropriability regarding IP and knowledge ownership in coopetition alliances were studied by a set of scholars (Seung & Russo, 1996; Rammer, 2002; Blomqvist *et al.*, 2005; Dagnino & Rocco, 2009; Escribano *et al.*, 2009).

The present article intends to analyze the determinant factors of firms' capacity to generate innovative products/services and to produce an insightful analysis of firms' innovative behavior, by making use of the data available in the European CIS Survey, 2008.

The remainder of this article is structured as follows. Section 2 develops the theoretical underpinnings, drawing on the literature on innovation, coopetition and patents. Section 3 presents the empirical approach. Section 4 refers to the analysis, main results and discussion. Finally, the article concludes and presents limitations, implications for policy makers and guidelines for practitioners engaged in strategic and cooperation relationships oriented to creating innovation.

2. Conceptual framework

2.1 Innovation - from concept to sources

Innovation capacity is originated through an interactive process between firms and the external environment. This capacity is influenced by the dynamics of the economic system for learning and also for stimulating the strengths of institutions that support innovation (Lundvall, 1985; 1988; 1992; 2007; Nelson, 1993; Cooke *et al.*, 1997; Braczyk & Cooke, 1998; Cooke *et al.*, 2000; Kaufmann & Tödting, 2001; Silva & Leitão, 2009).

Also pointed out by Luo (2004) is the importance of the initiator role of policy makers in fostering competition relations among firms in order to produce innovation. Accordingly, other authors argue for the need to stimulate public policies in modern societies that are able to promote competence building, based on the rise of the concept of “institutional specialization”, fostering the role of private and public incentives and policies to support science and technology (S&T) and innovation (Conceição & Heitor, 2007).

Laranja (2008) studied the concept of Technology Infrastructure as the set of different kinds of public, semi-public and private centres and research institutes, acting as a basis for the development of technology policies and support structures for technology transfer and innovation. The emergence of a set of public policies aimed at promoting entrepreneurial activities and knowledge-based start-ups, in order to spur knowledge-based activities in general and innovation, was analyzed as being the key to economic growth and employment (Leitão & Baptista, 2009). The set of public policies must be reconsidered and oriented towards an early stage in the entrepreneurial and innovation process, the phase of generating business ideas, before the business is founded.

This dynamic must be a joint effort, supported by an effective mix of public support mechanisms and private incentives in order to promote knowledge networks and flows of skilled people in an uncertain environment (Heitor & Bravo, 2010).

Following this line of thought, Flanagan *et al.*, 2011 point out the emergence, take-up and use of the concept of ‘policy mix’ by innovation policy makers, policy analysts and scholars, referring to the interactions and interdependencies between different policies in the sense that they affect policy outcomes in terms of the future scope and focus of innovation.

Another mechanism enabling innovation is patent protection, which in a static model is able to foster innovation but in a sequential model tends to inhibit complementary innovation (Bessen & Maskin, 2009). In this sense, innovation can be sequential when inventions are

created successively based on previous inventions, or complementary, each innovator following a distinct research path.

In order to classify and label innovative firms, organizational taxonomies help to understand the diversity of innovative patterns in firms and sectors (Pavitt, 1984; Archibugi, 2001).

Schumpeter (1934; 1942) proposed two alternative patterns of innovation, namely the entrepreneurial and the routinized. The first was mainly concerned with the entrepreneurial activity and creativity of small and new firms. The second embraces the generation of innovation in the formal R&D activity of large and established firms.

Utterback and Abernathy (1975) presented some categorization around the generation of new technologies over the stages of the product lifecycle, as they understand that by evolving firms change the basis of their competition from product innovation to process innovation (this is also supported by Klepper, 1997). In the birth stage, firms invest in product differentiation in order to compete with others. As the market matures, firms shift the focus to greater investment in manufacturing and innovative processes. The authors identified and then separated process and product innovations and related the industrial innovation pattern according to three different stages of the innovation process: the uncoordinated (where competition is based on product performance), the segmental (where the rate of product innovation decreases and radical changes are required in the production process) and the systemic (where product and process innovations diminish, being highly interdependent).

According to Nelson & Winter (1977) and Dosi (1982), the taxonomies of innovation are based on the concept of technological regime, the firm's behavior being influenced and determined by the nature of the technologies they use.

Pavitt (1984) proposed a taxonomy of the structural characteristics and organization of innovative firms that can help to differentiate the pattern of firm innovation across sectors. Thus, firms are categorized as: science-based; specialized suppliers; supplier-dominated; and scale-intensive firms. This taxonomy is useful as a predictive mechanism regarding the determinants of firm performance, such as international competitiveness and innovative performance (Jong & Marsili, 2006).

Abernathy & Clark (1985) classified innovation in four categories, namely: incremental; component; architectural; and revolutionary.

Other taxonomies of innovation also based on cognitive mechanisms were studied by Tushman & Anderson (1986) who distinguished between competence-enhancing and competence-destroying innovation.

Dosi (1988) proposed four dimensions regarding technological regime which define boundaries for what firms can achieve in the process of innovation: the level and sources of technological opportunity; the conditions for appropriating economic profits from innovation; the creation of new solutions building on prior ones; and the nature of the knowledge basis relevant for innovation.

Pavitt (1998) focused on the effects of major improvements in technology on the competencies of established firms.

McGahan (2004) also identified four phases regarding change which can make industries' activities obsolete, namely: radical; progressive; creative; and intermediating.

Furthermore, the OECD also classified industry based on the intensity of its technology production, distinguishing between high-tech and low-tech industries, measured through indicators, such as R&D intensity and technology use across sectors (Hatzichronoglou, 1997). Additionally, this classification came to include non-technological dimensions as factors of production, such as intangible investments and human capital (Peneder, 2002).

According to Ritala & Hurmelinna-Laukkanen (2009), incremental and radical innovations can be created through specific forms of cooperation with competitors (i.e. cooptation), especially in high-tech industries.

Table 1 summarizes the previous information about the taxonomies of innovation.

Table 1 Theoretical background: Taxonomies of innovation

Authors	Taxonomies of innovation
Schumpeter (1934, 1942)	Two alternative patterns of innovation: entrepreneurial and routinized.
Utterback & Abernathy (1975)	Classification of industries according to stage of technological evolution regarding the changing nature of product/process innovation: the uncoordinated, the segmental and the systemic.
Pavitt (1984)	Taxonomy of structural characteristics and organization of innovative firms to differentiate the pattern of firms' innovation across sectors: science-based; specialized suppliers; supplier-dominated; and scale-intensive firms.
Abernathy & Clark (1985)	Four categories of innovation: incremental; component; architectural; and revolutionary.

Tushman & Anderson (1986)	Competence-enhancing and competence-destroying innovation.
Dosi (1988)	Four dimensions regarding technological regime: level and sources of technological opportunity; conditions for appropriating economic profits from innovation; creation of new solutions built on prior ones and nature of the knowledge basis relevant for innovation.
Hatzichronoglou (1997)	Classification of industry based on intensity of its technology production: high-tech and low-tech industries.
Pavitt (1998)	Effects of major improvements in technology on the competencies of established firms.
McGahan (2004)	Four phases of change that can make industries' activities obsolete: radical; progressive; creative and intermediating.
Peneder (2002)	Previous classification complemented by inclusion of non-technological dimensions as factors of production: intangible investments and human capital.
Ritala & Hurmelinna-Laukkanen (2009)	Incremental and radical innovations.

2.2 Demand pull vs. technology push of innovation

Nemet (2009) states that governments must address several policies to stimulate innovation. This can be accomplished by using demand pull policies, which can stimulate investment and subsequent technological improvements.

The 1960s and 1970s witnessed a debate on whether the direction and rate of technological change had been strongly influenced by changes in market demand or by developments in S&T (Nemet, 2009). According to the same author, the S&T push orientation defends that advances in science determine the rate and direction of innovation, presupposing the transfer of fundamental science to applied research and product development and thereafter to commercialization. The relation between S&T and the innovation process has a long-term basis that increases complexity and uncertainty. Another constraint lies in the fact that technology-push orientation minimizes the effect of prices and changes in the economy on the outcomes of innovation. Different strands in the literature related to the technology-push paradigm have a less determining orientation.

Although these approaches consider that advances in science determine the rate and direction of innovation, they defend the importance of the interrelatedness of the

technological system in promoting and guiding innovation (Frankel, 1955). Others defend the existence of a clear relationship between the available exploitable technological opportunities and the rate and direction of innovation (Rosenberg, 1974; Nelson & Winter, 1977; Klevorick, 1995). In a complementary way, it can also be stated that firms must invest in R&D to develop their capacity to absorb knowledge and exploit opportunities (Mowery, 1983; Rosenberg & Birdzell, 1990; Cohen & Levinthal, 1990). Alternatively, firms can use the knowledge flows between sectors to overcome limitations detected in the technological system (Rosenberg, 1976; 1994) or even adopt a sequential behavior characterized by science and technology-push (Rothwell, 2002).

Within the demand-pull approach, the rate and direction of innovation are driven by demand. Changes in market conditions, such as production costs, the geographical scope of demand, latent demand, or potential new markets are the main drivers of opportunities to invest in innovation (Hicks, 1932; Griliches, 1957; Vernon, 1966; Schmookler, 1966; 1979; Rosenberg, 1976; Rothwell, 2002). In some situations, the demand-pull approach cannot answer hidden needs in demand (Simon, 1973) helping to explain incremental innovations rather than radical ones which are responsible for the most important innovations (Mowery & Rosenberg, 1979; Cohen *et al.*, 2000); and in some situations it is not able to answer hidden needs in demand (Simon, 1973). Moreover, this approach is too broad to be useful (Mowery & Rosenberg, 1979; Scherer, 1982; Kleinknecht, 1990; Chidamber & Kon, 1994).

The technology-push orientation fails to recognize market conditions and in contrast, the demand-pull paradigm does not take into account technological capabilities. Although they interact simultaneously, both are needed to explain innovation (Arthur, 2007).

Nemet (2009), argues that in a technology-push approach, policy-makers can foster innovation by implementing measures to decrease the private costs of the innovation process. The same author, following a demand-pull orientation, defends that policy-makers can also increase the private payoff of successful innovation. In this connection, and of particular interest in the present study, are measures to increase the protection of IP.

2.3 From coopetition to innovation

Rusko (2011) defines coopetition as a compound of collaboration and competition among firms. According to Luo *et al.* (2007), this concept was introduced in the 1980s by Raymond Noorda and became the subject of several studies during the 1990s, namely the issue of dyadic coopetition (Bengtsson & Kock, 2000; 2003) or multifaceted coopetition (Amburgey & Rao, 1996; Tsai, 2002; Luo & Slotegraaf, 2006).

Brandenburger & Nalebuff (1996) consider coopetition as an alternative way to perform in business, as distinct from competition, strategically used by firms that deal with emerging technologies in innovation networks (e.g. biotechnology, information and communication technologies, electronics and semiconductor industry). Since the area of emerging technologies has a high level of uncertainty regarding market opportunities and technology developments, firms in these industries tend to manage uncertainty by establishing strategic cooperation arrangements with competitors, to share common resources and thus reduce risk (Garraffo, 2002).

In the view of Bagshaw & Bagshaw (2001) coopetition allows better performance for the firms involved than competitive arrangements, as by strategically managing cooperation and competition, the relationship can evolve through controlled behavior by partners and rivals.

Chien & Peng (2005) state that inter-organizational relationships evolve into a social structure of coopetition, becoming a tool for cooperation and also for competition, acting at multiple levels, such as firms, strategic business units, departments and task groups. It can also be used for developing a corporate market strategy, reducing costs, improving firms' competitiveness and acquiring a leading market position.

Rusko (2011) defends that one of the main motivations for competitors to engage in strategic cooperation arrangements is based on the creation of greater value or benefit, in order to improve economic performance. Walley (2007) states that coopetition provides additional benefits not only to competitors but also to customers.

In the view of Garrafo (2002), the decision to cooperate with competitors usually has the following motivations: (a) to access and/or exchange new technologies and complementary knowledge; (b) to enter into new markets; and (c) to influence and/or even control technological standards. Understanding the motivations for coopetition among competitors is crucial for better evaluation of their commitment to technological developments and market creation. Thus, we can state that the option to pursue coopetition projects focused on technological development or on fostering collaborative efforts in market development depends on the partners' purpose in the arrangement.

In this connection, Jong & Marsili (2006) proposed a typology of coopetition arrangements, namely: (i) exchanges of patents and knowledge, characterized by low commitment to cooperative technology developments and low collaborative efforts in market generation; (ii) collaborative R&D activities with high commitment to cooperative technology developments and limited efforts to improve the market on a joint basis; (iii) strategic alliances for setting new standards, determined by high commitment in collaborative efforts focused on market generation and low commitment to cooperative technology development; and (iv) collaborative agreements to integrate established firms, characterized by high commitment

to cooperative technology development and great collaborative efforts to access the market. These types of coopetition arrangements determine the firm's ability to compete in the marketplace and to implement the portfolio of a firm's coopetition activities that evolves over time. When dealing with firms that work on radical innovations, definition of new standards or new converging technologies, coopetition is carried out for sizing market opportunities related to radical innovations, setting new standards, and/or integrating established firms through converging technologies.

Padula & Dagnino (2007) synthesized the two dominant paradigms, on one hand, the competitive paradigm, which underestimates the power of the positive interdependences of cooperation, and on the other hand, the cooperative paradigm which underestimates the benefits of the negative interdependences of cooperation. It embraces the sharing of mutual interests while increasing the positive sum game, in a win-win strategic scenario.

Bengtsson & Kock (2003) define coopetition as a dyadic relationship, since competition is related to output activities such as distribution, services, product development and marketing. In turn, cooperation deals with input activities, like R&D, buying, logistics and processing raw materials. In between the two, there are midstream activities, like production.

Luo (2004) introduced four strategic domains, which are also dyadic, even if they involve other agents, such as the government or the public sector. These domains are: coopetition with global rivals; coopetition with foreign governments; coopetition with strategic partners; and coopetition within a multinational company. Coopetition with the government remains coopetition, since two or more competing firms can strategically collaborate in the context of government procurement or in response to different actions taken by the government to promote this type of strategic relationship.

Different approaches to coopetition using the resource-based view of the firm and the game theory demonstrate that coooperative arrangements can generate more innovative activities than simple collaborations between non-competitors. For Brandenburger & Nalebuff (1996), Dussauge *et al.* (2000) and Tether (2002), competitors engage in a collaborative scheme, through the exchange of resources that generate value for all participants. Several authors point out that the main benefit derived from collaboration between competitors is the creation of completely new products (Tether, 2002; Quintana-Garcia & Benavides-Velasco, 2004).

Additionally, Belderbos *et al.* (2004) defend that R&D cooperation between competitors generates incremental efficiency gains. On the contrary, Nieto & Santa-Maria (2007) argue that coopetition does not favor innovation, since it can promote opportunistic behavior and minimize trust among rivals.

Establishing strategic partnerships between different firms in innovation projects to share risks, costs and expertise has also become an important pattern in innovation management, of interest to both scholars and practitioners (Chesbrough, 2003; Huston & Sakkab, 2006). This pattern results in coopetition, funded on strategic cooperation with competitors in innovation initiatives. Achieving higher absorptive capacity and forming collaboration schemes with competitive partners increases the pace of engaging in coopetition and imitation especially when dealing with incremental innovations, the emphasis on protection being fundamental (Ritala & Hurmelinna-Laukkanen, 2009). Following this line of thought, radical innovations come up against less competitive pressure, since markets are more emergent and differentiation is easier due to the novelty.

Cohen & Walsh (2000) studied this process using the framework based on the concept of the firm's absorptive capacity. This concept refers to identification of valuable knowledge in the environment, the capacity to assimilate it and align it with existing knowledge stocks and finally exploit it in internal R&D activities to achieve successful innovation.

As Cohen & Levinthal (1989) defend, the firm's knowledge base plays the role of both innovation and absorption, since its tendency to assimilate external knowledge creates an incentive to invest in R&D. Gambardella (1992) also states that firms with better in-house R&D programs are more able and prepared to absorb external scientific information. Other authors analyzed the determinant role of the firm's absorptive capacity in exploiting the alliances it establishes (Arora & Gambardella, 1994; Zahra & George, 2002).

Zahra & George (2002) analyzed the concept of absorptive capacity as a dynamic capability, creating a model of the components, antecedents, contingencies and outcomes of absorptive capacity. Their model was innovative because they substituted the component of "recognizing the value" with "acquisition" and relocated the influence of appropriability regimes. Additionally, these scholars enlarged the model with the transformation concept that follows the assimilation component, activation triggers and social integration mechanisms, and divided absorptive capacity into "potential" absorptive capacity and "realized" absorptive capacity. The process of transformation gives firms the capacity to develop changes in existing processes to be able to absorb new knowledge, assimilating it by means of interpretation and comprehension within existing cognitive structures.

Regarding that statement, Todorova & Durisin (2007) proposed that firms cannot transform their knowledge assets when they are not able to assimilate them. Furthermore, Zahra & George (2002) distinguish between potential absorptive capacity and realized absorptive capacity. The first has to do with acquisition and assimilation of new external knowledge by reconfiguring the resource base and deploying capacities, while the second deals with transformation and exploitation of new external knowledge by developing new products and

processes. Potential absorptive capacity without realized capacity does not produce an effect on the firm's competitive advantage.

In addition, the authors identified the activation triggers, social integration mechanisms and appropriability regimes acting as key contingencies. Social integration mechanisms help to lower the barriers between assimilation and transformation, increasing absorptive capacity, which is understood by the proposed model as being a dynamic capacity involving a set of organizational routines (e.g. social interactions) and processes. The ability to learn and absorb depends on the capacity to value external knowledge (Zahra & George, 2002).

Appropriability regimes allow moderation between absorptive capacity and its outcomes, resulting in competitive advantage. Thus, firms with low efficacy of intellectual property rights and easy replication are more prone to fail in the appropriation of innovation returns, giving open space to competitors.

Cockburn & Henderson (1998) state that the firm's ability to recognize the knowledge flow from the scientific community is determined by the close ties established with this community. They also stress the significant role of absorptive capacity in the firm's competitive advantage, since that capacity depends on its knowledge stock and resources.

George & Pradhu (2003) analyzed the importance of a link between firms' absorptive capacity and the country's absorptive capacity, enabling innovation. Moreover, Cassiman & Veugelers (2006) analyzed the positive impact of reliance on more basic R&D, which might proxy a firm's absorptive capacity, on the complementarity between internal and external innovation activities.

According to Rothaermel & Alexandre (2009), the greater the firm's absorptive capacity the greater its ability to fully capture the benefits resulting from flexibility in technology sourcing. Furthermore, the ability to recognize and exploit knowledge flows varies from one firm to another, resulting in unequal benefits acting as a competitive advantage. This absorptive capacity varies according to the firm's existing knowledge stock embedded in its products, processes and people. The authors also suggest that absorptive capacity plays a more determinant role in turbulent knowledge sectors and sectors with tighter and stronger IPR, and therefore governments should develop policies to foster firms' absorptive capacity in high-tech industries in conjunction with initiatives to increase IPR protection.

Silva & Leitão (2009) also explore the benefits and roles of different types of relationships with external partners (including universities and research centers) to stimulate entrepreneurial innovation, resulting in product innovation.

Li (2011) examined sources of external technology, absorptive capacity and innovation capacity in Chinese state-owned high-tech firms, analyzing three types of investment to acquire technological knowledge in determining firms' innovation capacity, namely: in-house R&D; importing foreign technology; and purchasing domestic technology. He concluded that importing foreign technology only promotes innovation if in-house R&D is also conducted. Nevertheless, domestic technology purchases, such as patent licensing, have a favorable direct impact on innovation. The study also finds that absorptive capacity is determined by the source or nature of the external knowledge.

Kostopoulos *et al.* (2011) explore the role of absorptive capacity as a mechanism to identify and translate external knowledge inflows into tangible benefits, and also as a vehicle to achieve greater innovation and time-lagged financial performance. The authors suggest that external knowledge inflows are directly related to absorptive capacity and indirectly related to innovation.

Vasudeva & Anand (2011) studied firms facing technological discontinuities and their use of alliance portfolios to gather knowledge flows. They subdivide absorptive capacity into "latitudinal" and "longitudinal" components. The first corresponds to the use of diverse knowledge and the second is distant knowledge. Their findings suggest that a firm with a moderate latitudinal absorptive capacity, which is equivalent to medium diversity in its portfolio, has a high propensity for optimal use of knowledge.

Table 2 Theoretical background: Determinant dimensions of entrepreneurial innovation capacity

Dimensions	Determinant factors	Authors	Research questions
Product innovation performance	Creation of new products and efficiency gains	Tether (2002); Belderbos <i>et al.</i> (2004); Quintana-Garcia & Benavides-Velasco (2004)	Creation of completely new products. R&D cooperation between competitors generates incremental efficiency gains.
	Generation of additional innovation activities	Ritala & Hurmelinna-Laukkanen (2009)	The development of incremental innovation in current products and services becomes an effective way to generate more innovation activities, especially in high-tech industries.
Policy incentives	Policy measures	Nemet (2009)	Governments can foster innovation by implementing measures to decrease the private costs of the innovation process.

Essays on Entrepreneurial Transference of Technology and Patenting

Market changes	Changes in market conditions	Hicks (1932); Griliches (1957); Schmookler (1966; 1979); Vernon (1966); Rosenberg (1969)	Changes in market conditions, such as production costs, geographical scope of demand, latent demand and potential new markets as the main drivers for investment opportunities in innovation activities.
Absorptive capacity	Incentive to invest in R&D	Cohen & Levinthal (1989)	The firm's knowledge base plays a role both in innovation and absorptive capacity, due to the propensity to assimilate external knowledge which creates, in turn, an incentive to invest in R&D activities.
	Firm's possession of absorptive capacity	Arora & Gambardella (1994)	Determinant role of the firm's absorptive capacity on the exploitation of alliances established with others.
	Firm's absorptive capacity as a dynamic capacity	Zahra & George (2002)	Analyzed the concept of absorptive capacity as a dynamic capacity, creating a model of the components, antecedents, contingencies, and outcomes of absorptive capacity.
	Absorptive capacity of the firm as a path-dependent process.	Todorova & Durisin (2007)	Add the concept of power relationships that interact with cognitive processes, learning and capabilities inside the firm to Zahra and George's model, treating absorptive capacity as a path-dependent process, the increase of knowledge in one area following the development of a related area.
	Innovation-enabling capacity of the country	George & Pradhu (2003)	Importance of a link between firms' absorptive capacity and the country's absorptive capacity enabling innovation.
	Higher levels of absorptive capacity	Rothaermel & Alexandre (2009)	The greater the firm's absorptive capacity, the greater the ability to fully capture the benefits resulting from flexibility in technology sourcing.
Coopetition alliances	Coopetition to generate added value and exchange of resources	Brandenburger & Nalebuff (1996); Dussauge <i>et al.</i> (2000); Tether (2002)	Coopetition arrangements can generate more innovative activities than simple collaborations between non-competitors. Competitors engage in a collaboration scheme, by exchanging resources that generate value for all participants.

	Close ties established between the firm and the scientific community	Cockburn & Henderson (1998)	The firm's ability to recognize the knowledge flow from the scientific community is determined by the close ties established with this community.
	Firm's set of relationships with external partners	Silva & Leitão (2009)	The benefits and roles of different types of relationships with external partners (including universities and research centers) to stimulate entrepreneurial innovation, with particular consideration of the Portuguese case, resulting in the achievement of product innovation.
	External knowledge inflows	Kostopoulos <i>et al.</i> (2011)	External knowledge inflows are directly related to absorptive capacity and indirectly related to innovation.
	Role of alliance portfolios	Vasudeva & Anand (2011)	Use of alliance portfolios to gather knowledge flows.
Firm's R&D intensity	Possession of in-house R&D programs	Gambardella (1992)	Firms with better in-house R&D programs have a higher propensity to absorb external scientific information.
	Basic R&D intensity	Cassiman & Veugelers (2006)	The positive impact of reliance on more basic R&D, which might proxy a firm's absorptive capacity, on the complementarity between internal and external innovation activities.
	Firm's existing knowledge stock	Escribano <i>et al.</i> (2009)	Firms' ability to recognize and exploit knowledge flows varies from one firm to another, resulting in unequal benefits acting as a firm's competitive advantage - varies according to the firm's existing knowledge stock, embedded in its products, processes and people.
	Firm's in-house R&D performance and acquisition of external technology	Li (2011)	Innovation is determined by in-house R&D performed by firms and by technology purchases, such as patent licensing, having a favorable direct impact on innovation.

2.4 Coopetition and the strategic use of product/service innovation

According to Smith (2005), a product or service innovation can be protected via a patent which is a contract established between an inventor and a government that entitles the former to a limited time (twenty years) in which a monopoly for the use and exploitation of a technical invention is ensured. The invention to be patented must be demonstrated to be a non-obvious advance in the state of the art. This confers a limited protection against competitors, to avoid copy or imitation. The patent system is considered to be a tool for promoting the creation of new economically valuable knowledge and also for dissemination of the state of the art in innovation technologies.

Macdonald (2004) argues that the patent is considered to be a means to an end, innovation being the end. In this vein, the public records that gather information on existing patents and applications can be used as an important tool for carrying out technological surveillance and monitoring, including data on granted patents with commercial viability on similar or cited patents. Chen & Chen (2011) state that patents protecting those product/service innovations are one of the firm's important intangible assets, in the sense that they can provide additional revenue to be generated towards product commercialization. Patent databases are of extreme importance for inventors to map new technologies and new products.

Griliches *et al.* (1991) and Chen & Chang (2010a; 2010b) argue that patent information can provide more information than R&D information gathered in financial reports, which usually reveal very limited information (Chen & Chang, 2009; 2010). Also, Macdonald (2004) stated that patent data provides information on patent behavior, by measuring performance in specific technological fields. An increasing number of firms use patent information not only to monitor competitors but also to prevent infringement.

According to Lai *et al.* (2007), patent analysis is able to provide information on technological innovation and its development. This is a critical issue, especially for firms that aim to make major investments and reach a competitive positioning in specific R&D sectors. In this sense, opting for strategic coopetition can be important to pursue sustainable competitive advantage. Additionally, in recent years patent rights have become a crucial tool in the coopetition strategy, since it is possible to obtain specific information regarding the technological position and to strengthen a certain sector, by detecting, forecasting and anticipating changes in terms of competitive positioning and business scope.

Wang (2010) refers to patents as important sources of technical information, since 90% of knowledge is in the form of patent database and 70% is disseminated through literature on patents. Acting as a source of ideas and technology resource, patents are considered to be a lever for technological innovation.

Seymour (2008) and Lee (2009) argue that patent information can allow the identification of trends in technology and commercialization, in terms of patent distribution, competition status and development. In the same line of thought, Ernst (2003) defended that patent information is able to support technology management in five areas, complementing financial data when evaluating a firm's performance, namely: (i) support for R&D investment decisions; (ii) human resources and knowledge management in R&D activities; (iii) IP protection; (iv) screening and evaluation of external technological sources; and (v) maximizing the value of the patent portfolio. The area of patent protection is extremely important in achieving competitive advantage, since it protects patent assignees from imitation and supports the internal use of technologies. Thus, strategic management of the patent portfolio is also important to achieve benefits and obtain competitive advantage (Grindley & Teece, 1997).

According to Ernst (1998; 1999), patent information is valuable since it provides information on R&D even for firms that are not required to disclose R&D data, this information being available in several areas, such as business units, products, technological fields and inventors. This enables firms to carry out more accurate competitor analysis. Moreover, patent data can help firms to develop and guide the technological trajectory and monitor companies' R&D strategies. Patent statistics can be used to measure the outcomes of the codified knowledge from R&D activities and industrial development (Grupp & Schmooch, 1999; Somaya, 2003; Aoki & Schiff, 2008).

Another important aspect of patent information is the data that can be collected to analyze the degree of rivalry, technology tracking and forecasting, identification of important developments, international strategic analysis and infringement monitoring. It is also critical for assessing viability of mergers and acquisitions and technological collaboration (Mogee, 1991; Breitzman & Mogee, 2002; Ma & Lee, 2008).

Bergek & Bruzelius (2010) also point out the interest of patent data as an indicator of collaborative technological activity. The association of several international inventors suggests the existence of international cooperation (Carayol & Roux, 2007; Ma & Lee, 2008). In addition, patents can indicate the emergence of an international trend in a certain technological field, which in turn can contribute to revealing the evolutionary pathway in terms of collaborative development oriented to technological innovation (Archambault, 2002).

In cooperation, controlling knowledge flows during joint R&D activities involves some risk, this being a critical issue in reaching success in strategic alliances oriented towards innovation activities embracing competitors. The risks of appropriability in a strategic alliance can be higher when partners are direct competitors (Park & Russo, 1996). Appropriability methods can be of two types, formal and informal (Rammer, 2002). Formal methods are the legal

forms of protection such as patents, copyrights and trademarks, to prevent others from using the firm's patents and knowledge embedded in them, despite allowing the competing firm to access patent knowledge and learn from it. Informal methods include secrecy, complex design and lead time.

Blomqvist *et al.* (2005) defend the need to use formal tools to regulate collaboration between asymmetric partnerships and to protect intellectual capital. In this vein, IP rights are considered to be critical assets in knowledge-based competition, with discussions regarding ownership emerging during the collaboration process. The strategic management of intangibles is extremely important when regulating collaboration schemes, in order to prevent the incorrect appropriation of knowledge.

As mentioned by Dagnino & Rocco (2009), when coopetition occurs between public and private competitors, for instance between universities and industrial partners, in the challenging task of knowledge production two critical situations can arise: coopetition for publications and coopetition for IPRs. To overcome these problematic issues, the previous authors suggest three strategies to mitigate the competitive pressure between university and industry, namely the sequencing and sanitizing of data and joint patents. The first implies the strategic management and sequential processes of first patenting and then publishing. The second concerns the removal of data that shall not be published, in order to avoid risks when patenting. The third corresponds to the collaborative patenting of knowledge, sharing rights and duties in the patent process. Firms usually regard this type of coopetition strategy as disadvantageous, preferring exclusive rights in order to commercialize technology freely.

2.5 Research hypotheses

Recent studies have taken coopetition as being a compound of collaboration and competition among firms, in order to produce innovation. Furthermore, patents are used, as stated by Carayol & Roux (2007) and Ma & Lee (2008), to establish collaborative technological relationships between firms and their stakeholders. Additionally, one of the main determinants for competing firms to engage in strategic cooperation arrangements and coopetition activities is the generation of value added or benefit, in order to improve their economic performance.

Studying the determinants of firms' capacity to generate innovative products/services and producing an insightful analysis of firms' innovative intensity behavior based on coopetition relationships has been the target of several analyses. Some researchers, for instance Brandenburger & Nalebuff (1996), Dussauge *et al.* (2000) and Tether (2002), devoted their

studies to the association between firms' innovative capacity and the cooperation arrangements they enter to generate value added and increase productivity.

Several scholars (Zahara & George, 2002; Todorova and Durisin, 2007; Rothaermel & Alexandre, 2009; Kostopoulos *et al.*, 2011) devoted their studies to analyzing the impact of introducing process innovations inside the firm, which can be either in the production process or in organizational structure, embracing R&D positioning, such as fostering open innovation channels and absorptive capacity on the firm's capacity to generate innovations. Thus:

H1: The introduction of process innovations inside the firm has a positive and significant impact on the firm's capacity to generate product/service innovations.

The positive and significant impact of firms' investment in R&D activities performed inside the firm was also the subject of multiple studies, such as those by Cohen & Levinthal (1989), Gambardella (1992), Cassiman & Veugelers (2006) and Li (2011). These authors point to the major importance of the firm's possession of in-house R&D programs, of investing in the firm's basic R&D intensity, and of increasing the firm's in-house R&D performance. In this sequence, we present the following hypothesis:

H2: The performance of R&D activities inside the firm has a positive and significant impact on the firm's capacity to generate product/service innovations.

The introduction of innovations to the market was also the subject of several studies (Tether, 2002; Quintana-Garcia & Benavides-Velasco, 2004; Belderbos *et al.*, 2004; Ritala & Hurmelinna-Laukkanen, 2009) which focused on the significant effect of those on the innovation capacity of the firm. In this vein, we formulate Hypothesis 3 as follows:

H3: The introduction of innovations to the market has a positive and significant impact on the firm's capacity to generate product/service innovations.

The determinant factor of establishing cooperation arrangements between competing firms for the firm's capacity to create innovations, either in products or in services, was analyzed by multiple scholars (Bradenburger & Nalebuff, 1996; Bengtsson & Kock, 2000, 2003; Bagshaw & Bagshaw, 2001; Garraffo, 2002; Belderbos *et al.*, 2004; Chien & Peng, 2005; Jong & Marsili, 2006; Ritala & Hurmelinna-Laukkanen, 2009; Rusko, 2011; Vasudeva & Anand, 2011). Thus we hypothesize:

H4: The set of cooperation relationships established between the firm and competing firms has a positive and significant impact on the firm's capacity to generate product/service innovations.

The impact of relationships with the scientific community as being of major importance in generating firms' innovative performance has warranted the attention of several researchers, for example, Cockburn & Henderson (1998), Li (2011), Kostopoulos *et al.* (2011) and Vasudeva & Anand (2011). Thus, we formulate hypothesis 5:

H5: The set of cooperation relationships established between the firm and other R&D stakeholders has a positive and significant impact on the firm's capacity to generate product/service innovations.

3. Methodology

3.1 Dataset, method and variables

The present paper intends to analyze the determinant factors of firms' capacity to generate product and service innovations, by making use of the data available in the European CIS Survey, 2008.

The data available is used to produce two samples related to manufacturing and service firms. The first is divided in two categories, according to the NACE classification, namely high-tech firms and low tech firms⁷. The second is divided into knowledge-intensive service firms and less knowledge-intensive service firms⁸. A probit model is used to assess the probability of the independent variables explaining the determinants of firms' capacity to generate product and service innovations.

The manufacturing firm sample has 3682 respondent firms, considering all firms in the analysis since they are all statistically valid. The service firm sample has 1221 respondent

⁷ Sectors are designated as high-tech or low-tech following the standard OECD sector classification based on NACE Rev.2 at 3-digit level to compile aggregates related to high/medium technology and low-technology (http://epp.eurostat.ec.europa.eu/cache/ITY_SDDS/Annexes/htec_esms_an3.pdf, accessed on: 2012/03/05).

⁸ Sectors are designated as knowledge-intensive service firms (KIS) and less knowledge-intensive service firms (LKIS) following the standard OECD sector classification based on NACE Rev. 1.1 at 3-digit level (http://epp.eurostat.ec.europa.eu/cache/ITY_SDDS/Annexes/htec_esms_an3.pdf, accessed on: 2012/03/05).

firms, also considering all firms in the analysis since they are all statistically valid. The samples of manufacturing and service firms are submitted to a probit regression to estimate the probability associated with the different determinant factors of firms' innovative intensity performed with the independent variables presented in annex 1. For the analysis performed on the manufacturing dataset we consider two more independent variables, namely the low tech firm and the high tech firm. Concerning the service firm sample, two other independent variables are also considered, knowledge-intensive firms and less knowledge-intensive firms.

The dependent variable used is product/service innovation (1 for a firm that has carried out product/service innovation and 0 otherwise), which refers to the firm having generated and introduced to the market a new or improved product or service, with respect to its capacities or potential, ease of use, parts or subsystems. In accordance with previous studies, the creation of new products was also used to analyze firms' innovative capacity, either through formal knowledge protection mechanisms or not (Tether, 2002; Belderbos *et al.*, 2004; Quintana-Garcia and Benavides-Velasco, 2004; Ritala and Hurmelinna-Laukkanen, 2009).

The binary dependent variable suggests use of a probit model for estimation purposes. The dependent variable was used as a proxy to assess the innovative behavior of firms, revealing pro-innovation behavior, according to the data available on the CIS survey.

3.2 Descriptive statistics

In the next figures we present a set of descriptive statistics for the manufacturing firm dataset consisting of 3682 firms. The major conclusions from the statistical analysis are that approximately 88% of firms are low tech and 12 % are high tech as shown below. Additionally, 93% are large firms.

Fig. 1 Composition of manufacturing sample by technological intensity and size

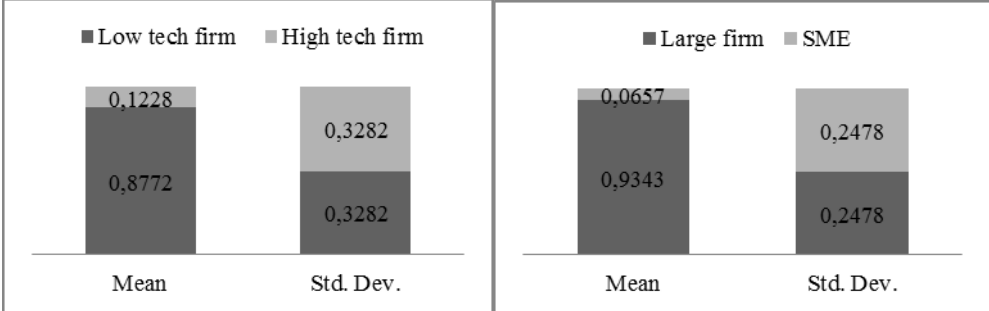
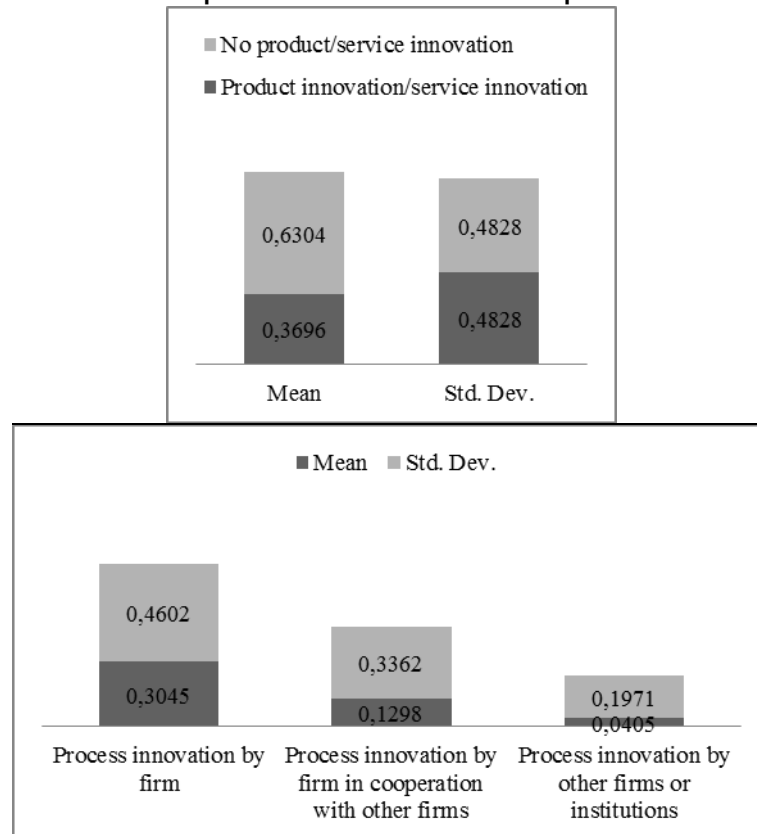


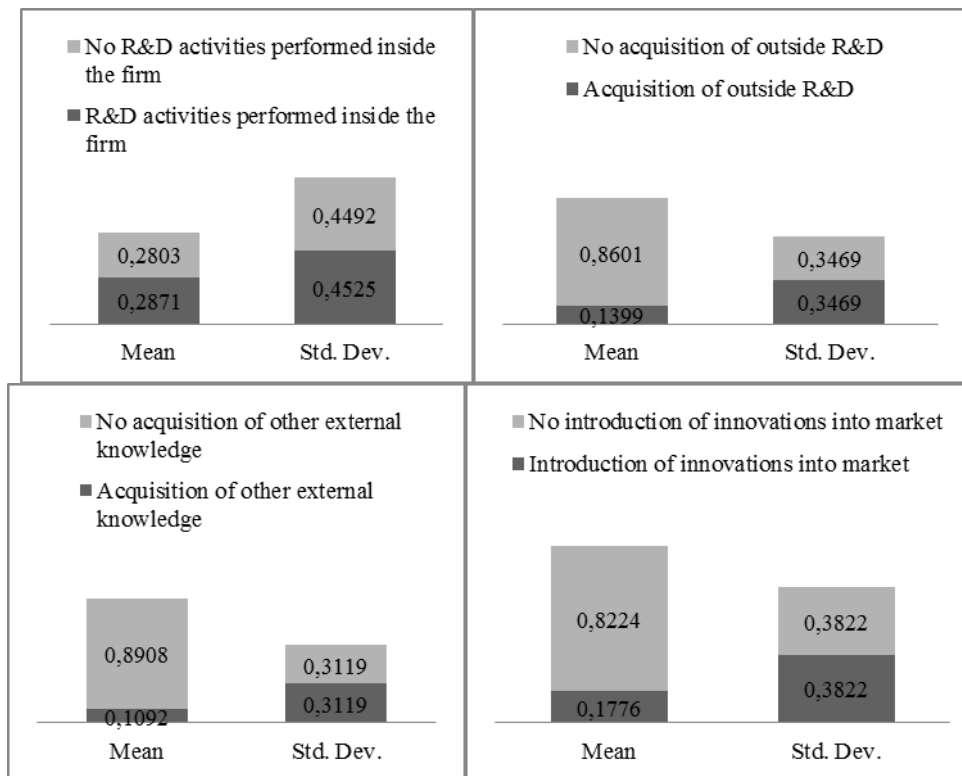
Figure 2 shows that almost 37% have developed product/service innovation, the authorship percentages for process innovations being distributed as follows: 30% by the firm in isolation; 13% by the firm in cooperation and the remaining by other forms.

Fig. 2 Composition of manufacturing sample by product innovation performance and process innovation authorship



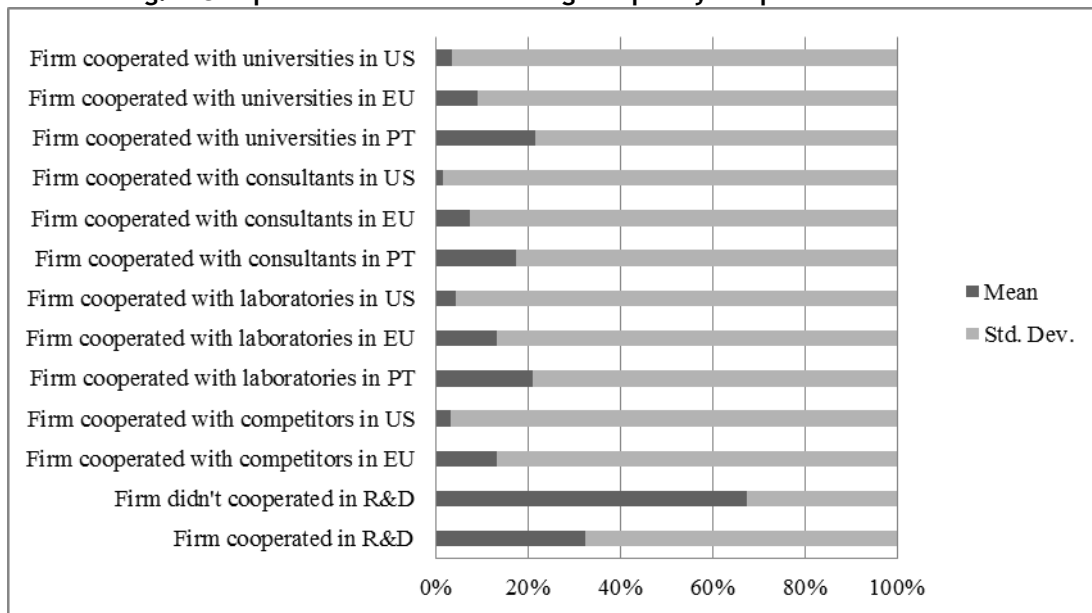
As presented in Figure 3, almost 29% carry out inside R&D activities and approximately 14% acquire outside R&D activities. About 11% acquire other external knowledge (in the form of patents, copyrights and other unprotected knowledge), and 18% show some introduction of new products to the market.

Fig. 3 Composition of manufacturing sample by R&D activities



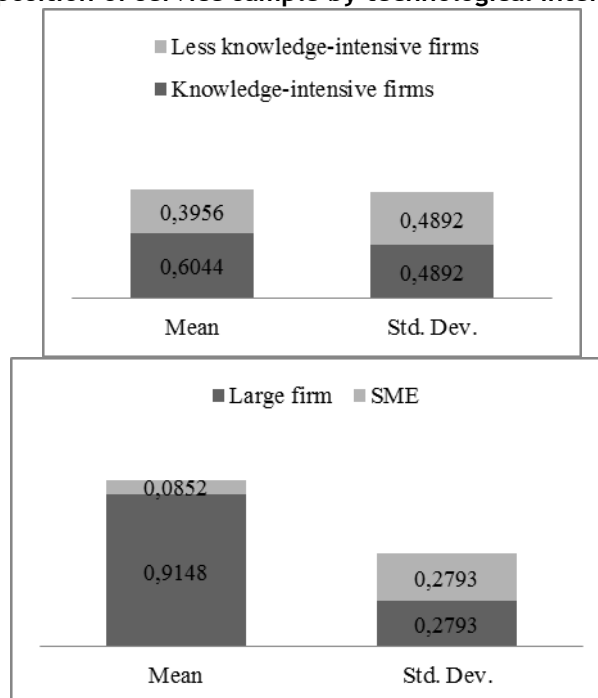
As illustrated in Figure 4, almost 19% state that they cooperate in R&D activities, the preferred type of partner being public partners (83%). In addition, only 4% cooperated with Portuguese competitors, 2% with European, and 1% with American. Almost 7% cooperated with Portuguese laboratories, 2% with European ones, and 0,2% with American ones. Finally, approximately 7% cooperated with Portuguese universities, 10% with European universities and 0,1% with American universities.

Fig. 4 Composition of manufacturing sample by cooperation activities



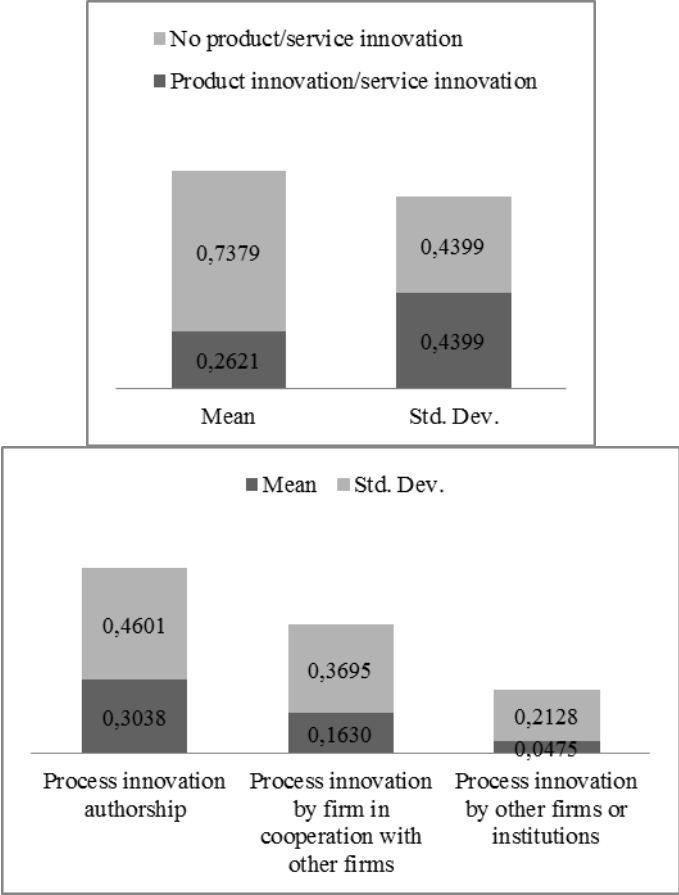
The next figures present the descriptive statistics for the 1221 service firms. Approximately 60% of firms are knowledge-intensive firms, and almost 91% are large, as seen in Figure 5.

Fig. 5 Composition of service sample by technological intensity and size



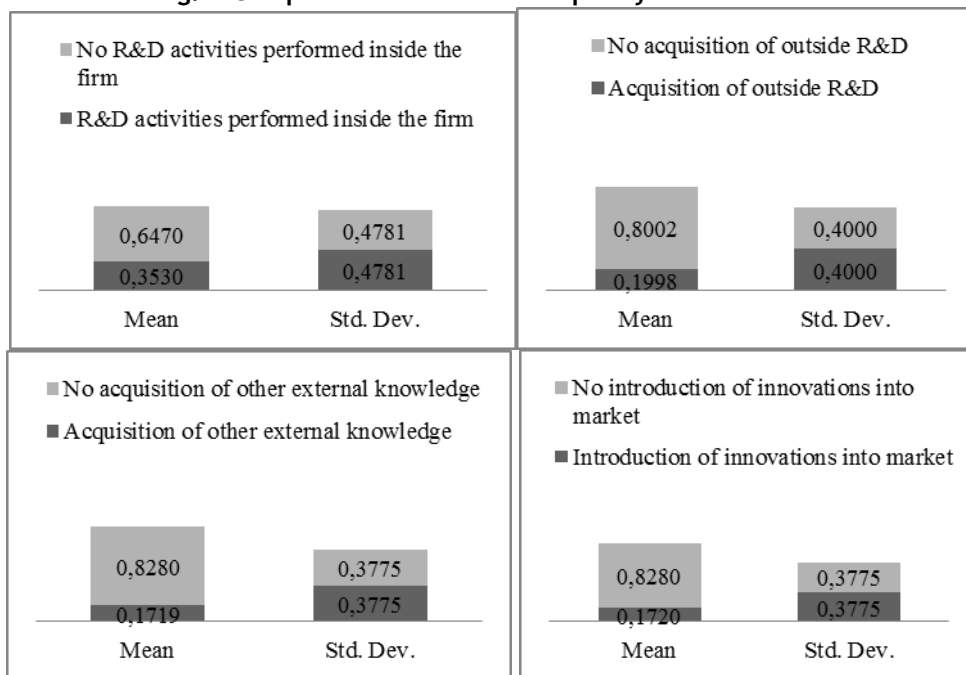
In addition, Figure 6 reveals that 26% have developed product/service innovations, authorship percentages for process innovations being distributed as follows: 30% by the firm itself; 16% by the firm in cooperation with other firms and the remaining by other forms.

Fig. 6 Composition of service sample by product innovation performance and process innovation authorship



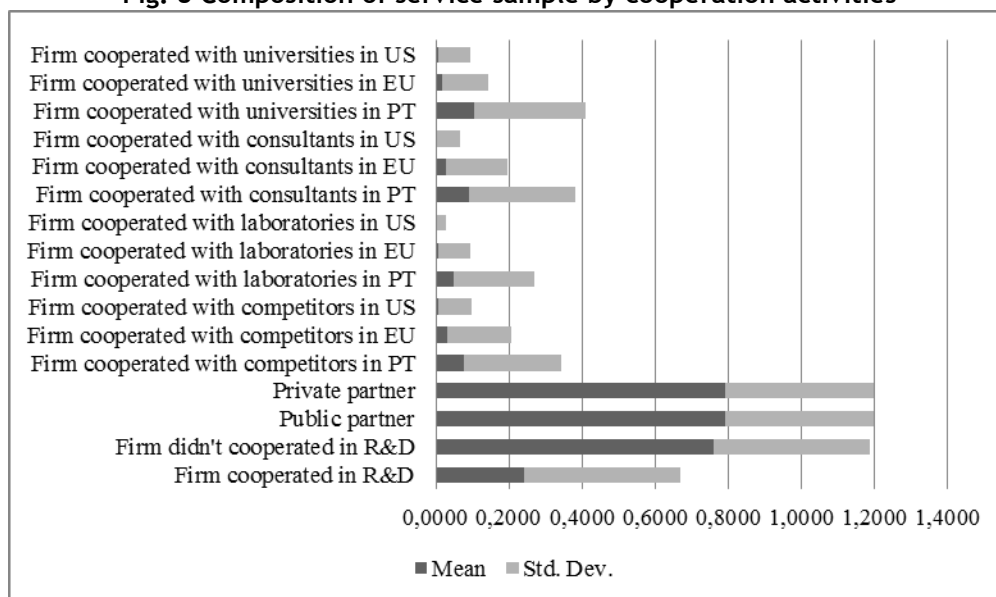
Considering Figure 7, almost 35% perform inside R&D activities and approximately 20% acquire outside R&D activities. About 17% acquire other external knowledge (such as patents, copyrights and other unprotected knowledge), and 17% introduce new products/services to the market.

Fig. 7 Composition of service sample by R&D activities



As presented in Figure 8, almost 24% state that they cooperate in R&D activities, showing no special preference for private or public partners. Moreover, almost 8% cooperated with Portuguese competitors, 3% with European, and almost 1% with American. Approximately 4% cooperated with Portuguese laboratories, 1% with European ones, and 0,08% with American ones. Almost 9% cooperated with Portuguese consultants, 2% with European ones and 0,4% with American. Finally, 10% of firms cooperate with Portuguese universities, 1% with European universities and only about 0,7% deal with American universities in cooperative relationships.

Fig. 8 Composition of service sample by cooperation activities



4. Empirical findings

4.1 Probit estimation results

Probit regressions were run on manufacturing firms and service firms separately. In addition, within each sector two additional separate regressions were run based on the intensity of firms' technology. These groups are based on the NACE classification for low-tech and high-tech manufacturing firms, and knowledge-intensive firms and less knowledge-intensive firms, for the service dataset.

The results of these regressions are presented in Tables 3 and 4.

Regarding the results of the probit regression for the sample of manufacturing firms, from the column of 'all firms', we can conclude that for the 3682 firms under analysis, the likelihood ratio chi-square of 356,21 with a p-value of 0.0000 tells us that our model as a whole is statistically significant, that is, it fits significantly better than a model with no predictors.

According to the values presented in Table 3, two determinant factors with a negative and significant influence on firms' capacity to generate product or service innovations are innovation processes implemented by the firm and non-acquisition of outside R&D services either from firms or from scientific partners.

Furthermore, the firm's cooperation both with Portuguese and European competitors also has a significant effect, although positive. Also having a significant and positive impact is firm cooperation with Portuguese and European laboratories, and Portuguese universities.

The last two columns in Table 3 show regressions for the sub-samples of different technological intensity.

As for the results of the probit regression for the sample of low-tech manufacturing firms, we can conclude that for the 3267 firms under analysis, and considering the likelihood ratio chi-square of 283,49 with a p-value of 0.0000 our model as a whole is also statistically significant, that is, it fits significantly better than a model with no predictors.

Considering the sample of 'high-tech manufacturing firms', the likelihood ratio chi-square being 42.38 with a p-value of 0.0003 our model is also statistically significant for the 415 firms under analysis.

In Table 3, we verify that for 'low-tech manufacturing firms' the fact that firms do not acquire outside R&D activities impacts positively and significantly (at 10% significance) on the product/service innovation performed by the firm. Additionally, cooperation in R&D activities with private partners also has a negative and significant effect on the dependent variable (at 5% significance).

Other determinant factors explaining the innovation capacity of firms to generate new products or services are the firm's attitude towards cooperation with Portuguese competitors, with Portuguese and European laboratories and with Portuguese universities, which impacts positively and significantly (at 1% significance) and with European and American competing firms (at 5% significance).

Considering the sub-group of 'high-tech manufacturing firms', their size is revealed to be important when explaining innovative capacity, i.e., small and medium high-tech firms are more likely to impact positively and significantly (at 10% significance) on product/service innovation. Also, the introduction of innovations to the market reveals a positive and significant impact on the dependent variable (at 1% significance). Firms' cooperation with Portuguese laboratories and universities has a positive and significant effect on their capacity to generate new and innovative products/services (at 10% significance).

Of special interest here are the major differences between the results obtained for high tech and low tech manufacturing firms.

The process innovation carried out by the firm itself or a group of firms is positively and significantly associated with product/service innovation for all firms, but it does not reveal

any importance in the other sub-samples. In addition, non-acquisition of external R&D services in the 'all firms' sample has a negative and significant effect on the firm's product/service innovation, but in the 'low-tech firms' sub-sample it has a positive and significant effect on the dependent variable.

Cooperation activities with Portuguese and European competitors and laboratories, and Portuguese universities, always show a positive association with the firm's innovative capacity for the 'all firms' sample and for the 'low-tech' sub-sample. In addition, for the latter sub-sample, cooperation alliances with US competitors also have a significant, though negative, impact on the firm's innovative capacity.

For 'low-tech firms', the effect of the type of partner is significantly, but negatively associated with innovative capacity.

Finally, for 'high-tech firms', the variables showing a significant association with firms' product/service innovation capacity are slightly different from the other samples, namely the positive significance of firm size, revealing that SMEs are more associated with innovativeness, the capacity to introduce innovations to the market and the set of cooperation activities with Portuguese laboratories and universities.

Table 3 Results of probit regressions for manufacturing firms

Product/service innovation	All firms	Low-tech firms	High-tech firms
Low tech firm	-0.0576045	-	-
High tech firm	-	-	-
Large firm	-0.10673	-	-
SME	-	0.0867604	0.6572347*
Product innovation/service innovation	-	0.071071	-
No product/service innovation	-0.046014	-	0.151123
Process innovation by firm	-0.1642524***	-0.1398221	-0.2718769
Process innovation by firm in cooperation with other firms	-0.0801076	-0.0461338	-0.2116772
Process innovation by other firms or institutions	-0.0909556	-0.1386163	0.2278046
R&D activities performed inside the firm	-0.0895601	-0.1275257	0.2301739
No R&D activities performed inside the firm	-0.0106024	-0.0263119	-0.0241219
No acquisition of outside R&D	-0.165559***	0.182017*	0.0541903

Essays on Entrepreneurial Transference of Technology and Patenting

Acquisition of other external knowledge	0.0669793	0.0361933	0.2378885
Introduction of innovations into market	0.016341		0.5726169***
No introduction of innovations into market	-	0.0411851	-
Firm cooperated in R&D	-	-	-0.1123371
Firm did not cooperate in R&D	-0.1790235	-0.2542488	-
Public partner	-	-	-0.095345
Private partner	-0.2591099	-0.3274853**	-
Firm cooperated with competitors in PT	0.5715775***	0.6294335***	0.333516
Firm cooperated with competitors in EU	0.7269029***	0.5445594**	-
Firm cooperated with competitors in US	-1.001.694	-2.222.612**	-
Firm cooperated with laboratories in PT	0.490596***	0.4872625***	0.6268807*
Firm cooperated with laboratories in EU	0.5615345***	0.5449852***	0.8529929
Firm cooperated with laboratories in US	0.4544849	0.7596476	-
Firm cooperated with universities in PT	0.7174335***	0.6918532***	0.7266951*
Firm cooperated with universities in EU	0.510753	0.4389709	-
Firm cooperated with universities in US	-0.6025823	-0.8155625	-
Observations	3682	3267	415
Log Likelihood	-2244.5439	-1954.1143	-264.63102
Pseudo R²	0.0735	0.0676	0.0741
*significant at 10% **significant at 5% ***significant at 1%			

Regarding the set of results of the probit regression for service firms in Table 4, and particularly the 'all firms' column, we can conclude that for the 1221 firms under analysis, the likelihood ratio chi-square of 356.21 with a p-value of 0.0000 confirms that our model as a whole is statistically significant, that is, it fits significantly better than a model with no predictors.

For the sample of 'all service firms', we can conclude that being a large firm impacts positively and significantly on firms' capacity to generate new products or service innovations.

Moreover, the introduction of process innovations, either alone or in cooperation with other firms, by both 'knowledge intensive service firms' and 'less knowledge intensive service firms' has a positive and significant effect on the firm's capacity to generate product or service innovations (at 1% significance). Additionally, for the sample of 'all service firms' there is a positive and significant impact of the introduction of process innovations by other institutions, on the firm's innovative capacity to create new products or services (at 10% significance).

The fact that the firm carries out R&D activities inside the firm and introduces innovations into the market also shows a positive and significant effect on the dependent variable (at 1% significance).

Service firms that neither acquire external R&D activities nor cooperate in R&D activities present a negative and significant (at 1% significance) association with the firm's capacity to generate product/service innovations.

Private partner profile also has a positive and significant impact on the dependent variable (at 1% significance), with European competitors and European universities being the partners with greatest positive and significant impact on product/service innovation (at 10% significance).

Finally, cooperation relationships with American competitors and European laboratories have a significant, but negative, effect on the firm's capacity to generate innovations (at 5% significance).

The last 2 columns show the probit regressions disaggregated into service sub-groups - 'KIS' and 'LKIS'. Considering the sub-sample of 'KIS firms', in a total of 746 firms, the likelihood ratio chi-square presents a value of 267,31 with a p-value of 0.0000, suggesting a statistically significant model.

For this sub-sample, introduction of process innovations to the firm, either by the firm itself or the firm in cooperation with others, presents a positive and significant association with the capacity to generate innovation (at 1% significance). Besides, the set of R&D activities performed inside the firm also has a positive and significant impact on the dependent variable (at 1% significance).

The fact that this type of firm does not introduce innovations to the market has a negative and significant effect on the capacity to generate product/service innovation (at 1% significance), giving an association between the generation of innovation and subsequent market introduction.

Also negative is the impact of the inexistence of cooperative relationships in terms of R&D on the dependent variable (at 1% significance), a public partner being the preferred type of partner in cooperative relationships, this dummy variable having a positive and significant impact (at 1% significance).

Cooperative relationships between the firm and European competitors and universities present a positive and significant association with the firm's capacity to generate innovation (the first at 1% significance and the second at 5% significance).

The set of cooperation agreements with a significant, though negative, impact on the firm's capacity to generate innovations, either product type or service type, are with American competing firms and European laboratories.

When analyzing the sub-sample of 'LKIS service firms', a total of 475 firms, the estimations present a likelihood ratio chi-square value of 89.59 with a p-value of 0.0000, also suggesting a statistically significant model.

For this sub-sample, the dummy variable of SME has a negative and significant impact on the firm's capacity to generate innovations. Furthermore, introduction of process innovations by the firm itself and/or in cooperation with other firms has a positive and significant impact on the firm's capacity to generate product and/or service innovation (at 1% significance).

R&D activities carried out inside the firm also show a positive and significant association with the firm's generation of innovations (at 1% significance). For 'less knowledge intensive service firms', private partners show a positive and significant association with the firm's product/service innovations (at 1% significance), and among all partners, Portuguese laboratories are the ones showing a positive and also significant impact on those innovations (at 10% significance).

The major considerations to be pointed out when comparing results for the sub-samples of 'all firms' and 'KIS' and 'LKIS firms' are the fact that introduction of process innovations in the firm presents a positive and significant association with the firm's capacity to generate innovations in all sub-samples.

Furthermore, size is only important for the sample of 'all firms', showing the positive impact of the large firm variable and for the 'LKIS' sub-sample showing the negative effect of the SME variable.

Carrying out R&D activities inside the firm reveals a positive and significant effect on the firm's capacity to generate innovations for all cases.

Considering the introduction of innovations to market, this has a positive and significant effect on the dependent variable for the 'all firms' sample and in the opposite direction, non-introduction of innovations has a negative and significant impact on the dependent variable, for 'KIS firms'.

For 'KIS firms', the most important type of partner is the public one, this dummy variable having a positive and significant impact on the firm's generation of new products/services. In turn, for 'LKIS firms' and for the 'all firms' sample, it is the private type of partner that shows a positive and significant association with that capacity.

Additionally, EU competitors and EU universities have a positive and significant impact on the firm's capacity to produce innovations for the 'all firms' sample and 'KIS firms'. Conversely, US competitors and EU laboratories show a negative and significant impact on the firm's innovation generation for the 'all firms' and 'KIS firms' samples. On the contrary, for the 'LKIS' sub-sample the only important cooperation is with Portuguese laboratories, where joint actions impact positively and significantly on the dependent variable.

Table 4 Results of probit regressions for service firms

Product/service innovation	All firms	KIS firms	LKIS firms
Less knowledge-intensive firms	-0.0351267	-	-
Large firm	0.2917284*	-	-
SME	-	-0.024813	-0.71954***
Process innovation by firm	0.6788217***	0.6425258***	0.8003994***
Process innovation by firm in cooperation with other firms	0.4931047***	0.579551***	0.5354501***
Process innovation by other firms or institutions	0.4324939***	0.314317	0.4787559
R&D activities performed inside the firm	0.5340988***	0.4726756***	0.6925766***
No R&D activities performed inside the firm	-0.0772205	-0.1096384	-
Acquisition of outside R&D	-	0.2268566	-
No acquisition of outside R&D	-0.2870978***	-	-0.0354656
Acquisition of other external knowledge	-	-	0.3181008
Introduction of innovations into market	0.5200406***	-	-
No introduction of innovations into market	-	-0.8073311***	0.0673119
Firm did not cooperate in R&D	-0.8041166***	-1.037.318***	-0.5045445
Public partner	-3.605.851	0.7028044***	-4.005.418
Private partner	4.071.048***	-	4.335.834***
Firm cooperated with competitors in PT	-0.0816495	-0.326807	0.2739777
Firm cooperated with competitors in EU	0.5535745*	1.375.734***	0.7578617
Firm cooperated with competitors in US	-1.003.039**	-1.929.241***	-1.308.725
Firm cooperated with laboratories in PT	0.3690016	0.318485	0.9656868*
Firm cooperated with laboratories in	-1.708.198**	-2.208.943***	-

EU			
Firm cooperated with consultants in PT	-0.0796663	-0.0186786	0.1562392
Firm cooperated with consultants in EU	-0.2792368	-0.2461181	-0.4516517
Firm cooperated with consultants in US	1.132.891	0.8281421	-
Firm cooperated with universities in PT	-0.1740137	-0.2204494	-0.2928758
Firm cooperated with universities in EU	0.7373061*	1.217.358**	0.2346324
Firm cooperated with universities in US	-0.5046289	-0.12174	-
Observations	1221	746	475
Log Likelihood	-526.22295	-318.34736	-190.09896
Pseudo R²	0,2453	0.2957	0.1907
*significant at 10% **significant at 5% ***significant at 1%			

4.2 Research hypotheses and discussion

Considering the sample of manufacturing firms and the results produced by the probit regressions, we can summarize that regarding the first hypothesis of a positive and significant effect of introducing process innovations in the firm on the firm's capacity to generate innovations, it is possible to confirm a significant, but negative, association, when considering the 'all firms' sample. Thus, we partially fail to reject H1. This is in line with previous studies mentioned (Zahara & George, 2002; Todorova & Durisin, 2007; Rothaermel & Alexandre, 2009; Kostopoulos *et al.*, 2011).

Additionally for this sample, and considering Hypothesis 2, suggesting a significant and positive effect of performing R&D activities inside the firm on its capacity to generate product/service innovations, we conclude that for 'manufacturing firms' this is not of particular importance, and so reject H2. Thus, this is not in line with previous scholars' analyses, such as those of Cohen & Levinthal (1989), Gambardella (1992), Cassiman & Veugelers (2006) and Li (2011).

Also, for Hypothesis 3 proposing a positive and significant impact of the introduction of innovations into the market on the firm's subsequent capacity to generate innovations, we can point out that only for the sub-sample of 'high-tech manufacturing firms' is this effect revealed to be positive and significant, and so we fail to reject H3. Here, we follow previous scholars (Tether, 2002; Belderbos *et al.*, 2004; Quintana-Garcia & Benavides-Velasco, 2004; Ritala & Hurmelinna-Laukkanen, 2009).

Hypothesis 4 proposes a positive and significant association between the set of cooperation relationships with a firm's competitors and its capacity to generate product/service

innovation. For the samples of 'all firms' and 'low-tech firms' this relationship is positive and significant, especially for Portuguese and European competitors, and thus we fail to reject H4. For 'low-tech firms' we also found a significant, but negative, effect when considering American competitors, which means we partially fail to reject H4 in this case, which is in line with previous studies (Bradenburger & Nalebuff, 1996; Bengtsson & Kock, 2000,2003; Bagshaw & Bagshaw, 2001; Garraffo, 2002; Belderbos *et al.*, 2004; Chien & Peng, 2005; Jong & Marsili, 2006; Ritala & Hurmelinna-Laukkanen, 2009; Rusko, 2011; Vasudeva & Anand, 2011).

Regarding Hypothesis 5 suggesting a positive and significant effect of cooperation relationships among firms and other R&D stakeholders on the firm's capacity to generate product/service innovation, we can confirm a positive and significant impact of Portuguese and European laboratories and Portuguese universities in the 'all firms' sample and the 'low-tech firms' sub-sample, leading us to fail to reject H5. Furthermore, when analyzing the 'high-tech' sub-sample, we can corroborate such results, as Portuguese laboratories and Portuguese universities have a positive and significant impact on the dependent variable. Therefore, we also fail to reject H5 for 'high-tech manufacturing firms'. Here, we are in agreement with several studies already mentioned, for instance Cockburn & Henderson (1998), Li (2011), Kostopoulos *et al.* (2011) and Vasudeva & Anand (2011).

Considering the service firm dataset and taking into consideration Hypothesis 1, proposing a positive and significant effect of the introduction of process innovations in the firm on its capacity to generate innovation, we find a significant and positive association for all samples under analysis. Thus, we fail to reject H1. These results are contradictory to those obtained for manufacturing firms which tended towards a negative association.

Taking into account Hypothesis 2 proposing a significant and positive impact of performing R&D activities inside the firm on its capacity to generate product/service innovation, we confirm a positive and significant effect, failing to reject H2. This is also different from the manufacturing dataset, which did not reveal any association between these variables.

For the Hypothesis 3, which defends a positive and significant impact of the introduction of innovations to the market on the firm's capacity to generate innovation, we verified a positive and significant effect, when considering the 'all firms' sample, and so we fail to reject H3. For the 'KIS' and 'LKIS' sub-samples such an effect is not observed. This result is in line with the one obtained for the manufacturing high-tech firms sub-sample.

Considering Hypothesis 4 arguing for a positive and significant association between the set of cooperation relationships with firm's competitors and its capacity to generate product/service innovation, we obtained a positive and significant effect for European competitor relationships, for the 'all firms' sample and the 'KIS firms', leading to failure to reject H4. In addition, we can point out a significant, though negative, impact, of US and Portuguese

coopetition relations on the firm's capacity to generate innovations, and so we partially fail to reject H4. These results are in line with previous results achieved for the manufacturing dataset.

Finally, for Hypothesis 5, proposing a positive and significant effect of coopetition relationships among firms and other R&D stakeholders on the firm's capacity to generate product/service innovation, we confirm a positive and significant impact of European universities for the 'all firms' sample and the 'KIS firms' sub-sample, and so we fail to reject H5. Furthermore, we also detect a significant but negative effect of coopetition relationships, particularly analyzing the impact of European laboratories in the 'all firms' sample and the 'KIS' sub-sample, on the dependent variable. Therefore, we also partially fail to reject H5 for the 'all firms' sample and the 'KIS firms' sub-sample. Table 5 summarizes the conclusions obtained for each hypothesis.

Table 5 Summary of results of probit estimations for manufacturing and service firms

Dependent variable	Product/service innovations							
	All manufacturing firms		Manufacturing H-Tech	Manufacturing L-Tech	All service firms		KIS firms	L-KIS firms
Hypothesis	Expected Results	Results obtained	Results obtained	Results obtained	Expected results	Results obtained	Results obtained	Results obtained
	H1	+	-	ns	ns	+	+	ns
	Zahara & George (2002); Todorova & Durisin (2007); Rothaermel & Alexandre (2009); Kostopoulos <i>et al.</i> (2011)				Zahara & George (2002); Todorova & Durisin (2007); Rothaermel & Alexandre (2009); Kostopoulos <i>et al.</i> (2011)			
H2	+	-	ns	ns	+	+	ns	ns
	Cohen & Levinthal (1989); Gambardella (1992); Cassiman & Veugelers (2006); Li (2011)				Cohen & Levinthal (1989); Gambardella (1992); Cassiman & Veugelers (2006); Li (2011)			
H3	+	ns	+	ns	+	+	ns	ns
	Tether (2002); Belderbos <i>et al.</i> (2004); Quintana-Garcia &				Tether (2002); Belderbos <i>et al.</i> (2004); Quintana-Garcia &			

	Benavides-Velasco (2004); Ritala and Hurmelinna-Laukkanen (2009)				Benavides-Velasco (2004); Ritala and Hurmelinna-Laukkanen (2009)			
H4	+	+	ns	+	+	+	ns	ns
	Bradenburger & Nalebuff (1996); Bengtsson & Kock (2000, 2003); Bagshaw & Bagshaw (2001); Garraffo (2002); Belderbos <i>et al.</i> (2004); Chien & Peng (2005); Jong & Marsili (2006); Ritala & Hurmelinna-Laukkanen (2009); Rusko (2011); Vasudeva & Anand (2011)				Bradenburger & Nalebuff (1996); Bengtsson & Kock (2000, 2003); Bagshaw & Bagshaw (2001); Garraffo (2002); Belderbos <i>et al.</i> (2004); Chien & Peng (2005); Jong & Marsili (2006); Ritala & Hurmelinna-Laukkanen (2009); Rusko (2011); Vasudeva & Anand (2011)			
H5	+	+	ns	+	+	+	+	ns
	Cockburn & Henderson (1998); Li (2011); Kostopoulos <i>et al.</i> (2011); Vasudeva & Anand (2011)				Cockburn & Henderson (1998); Li (2011); Kostopoulos <i>et al.</i> (2011); Vasudeva & Anand (2011)			

5. Concluding remarks

In summing up, it is important to stress some differences detected between regressions with the two samples.

Considering manufacturing firm factors, such as the introduction of process innovations in firms' internal organization and procedures and the practice of internal R&D activities, they do not impact on the firm's capacity to generate innovation.

On the contrary, for the service firm dataset, both these factors are of major importance for the firm's innovative capacity to create new products/services, for the 'all firms' sample and for 'KIS' and 'LKIS firms'.

Regarding the dummy variable of introduction of innovations to the market, this only reveals a significant and positive effect in 'high-tech manufacturing firms' and in the service firm dataset as a whole.

Moreover, the set of cooperation relationships between the firm and competitors is seen to have an impact on the firm's capacity to generate innovation in both datasets, but for manufacturing firms this importance is due to the joint actions of Portuguese plus European competitors and for service firms only European competitors show a positive and significant impact on the dependent variable. However, for 'high-tech manufacturing firms' this effect is not observed, the same being true for 'LKIS' service firms.

Taking into consideration the impact of the set of cooperation relationships between firms and other R&D stakeholders, the major difference detected between the two datasets is the fact that cooperation agreements with European laboratories and manufacturing firms, especially when dealing with the 'all firms' sample and the 'low-tech' sub-sample, have a positive and significant effect on the firm's capacity to generate product/service innovation. On the contrary, the significant effect of cooperation agreements with European laboratories on that capacity is revealed to be negative for service firms, specifically for the 'all firms' sample and the 'KIS firms'. Furthermore, in the manufacturing firm dataset we verified a positive and significant effect of Portuguese universities on the firm's capacity to generate innovation. For service firms, the positive and significant effect is also detected but with European universities.

5.1 Policy and managerial implications

Since public policies play a crucial role in fostering innovative capacities, it is important that policy-makers understand the determinants of firms' capacity to generate innovative products and services, and their effects on innovative performance, the generation of net value added and economic benefits.

In terms of policy implications arising from the present study, it is suggested that public policies should be guided towards the creation and consolidation of open innovation flows, and towards fostering patenting strategies in firms and in consortiums between firms, and between firms and the scientific community, securing formal channels and mechanisms directed at minimizing appropriability risks.

By making use of firms' capacity to generate innovation in order to reveal their innovative performance and the dynamics of coopetition public policies oriented to open innovation, the present study can give insights to those who manage innovation policy orientations, since knowledge of the set of determinant factors of firms' innovative behavior can be helpful in drawing up guidelines to foster and properly manage the open innovation workflows between firms and their stakeholders, and then developing the capacity to generate and transfer new products to market.

Overall, the results of this analysis may provide helpful starting points for practitioners (either in firms or coopetition stakeholders) who wish to estimate the directions of their organization's R&D projects and patents. Hence, the study may increase the effectiveness of innovative behavior among coopetition partners, namely their patenting performance, in fostering synergetic relationships. Furthermore, by facilitating the externalization and codification of technological knowledge, patenting behavior among coopetition partners can be endangered if there are no protection measures regarding appropriability risks. Anticipation of such risks can enhance the efficiency of technology transfer flows, and consequently stimulate the creation, diffusion and regulation of defensive mechanisms to be used as routines by the partners involved.

5.2 Limitations and future research

The main limitation of the present study is the lack of data on firms' innovative capacity when trying to access data on patenting behavior and other IP rights, such as copyrights and trademarks. This is also the main limitation of the database used in this study, the European CIS Survey, 2008, with the quasi-inexistence of data regarding firms' IP performance, considering additional data on patents, copyrights and other IP rights, since the only

reference to innovative products or services generated inside and by the firm that can or cannot be protected via IP formal mechanisms is the variable of product/service innovation.

Other important information about firms' patenting capacity is not included in the survey. Furthermore, this study only relates to Portuguese innovative firms, a sample that should be expanded in future research to consider cross-country differences.

In this connection, future research should be focused on the factors that motivate firms to engage in patenting projects, whether cooptation patenting initiatives, technological surveillance or forecasting projects. Firms' patenting strategies and characteristics, which influence their cooperation arrangements, should also be analyzed.

References

- Abernathy, W., Clark, K. (1985). Innovation: mapping the winds of creative destruction. *Research Policy*, 14, 3-22.
- Agresti, A. (1996). *An Introduction to Categorical Data Analysis*. New York: John Wiley & Sons.
- Amburgey, T., Rao, H. (1996). Organizational ecology: past, present and future directions. *Academy of Management Journal*, 39 (5), 1265-1286.
- Aoki, R., Schiff, A. (2008). Promoting access to intellectual property: patent pools, copyright collectives and clearinghouses. *R&D Management*, 38, 189-204.
- Archambault, E. (2002). Methods for using patents in cross-country comparisons. *Scientometrics*, 54 (1), 15-30.
- Archibugi, D. (2001). Pavitt's taxonomy sixteen years on: a review article. *Economic Innovation and New Technology*, 10, 415-425.
- Arora, A., Gambardella, A. (1994). Evaluating technological information and utilizing it: scientific knowledge, technological capability, and external linkages in biotechnology. *Journal of Economic Behavior and Organization*, 24, 91-114.
- Arthur, W. (2007). The structure of invention. *Research Policy*, 36 (2), 274-287.
- Bagshaw, M., Bagshaw, C. (2001). Co-opetition applied to training - a case study. *Industrial and Commercial Training*, 33 (4/5), 175-177.
- Belderbos, R., Carree, M., Lokshin, B. (2004). Cooperative R&D and firm performance. *Research Policy*, 33, 1477-1492.
- Bengtsson, M., Kock, S. (2000). Coopetition in business networks - to cooperate and compete simultaneously. *Industrial Marketing Management*, 29, 411-426.
- Bengtsson, M., Kock, S. (2003). Tension in co-opetition. *Academy of Marketing Science Annual Conference*, May 28-31, Washington D.C.
- Bergek, A., Bruzelius, M. (2010). Are patents with multiple inventors from different countries a good indicator of international R&D collaboration? The case of ABB. *Research Policy*, 39, 1321-1334.
- Bessen, J., Maskin, E. (2009). Sequential innovation, patents, and imitation. *The RAND Journal of Economics*, 40 (4), Winter, 611-635.
- Blomqvist, K., Hurmelinna, P., Seppanen, R. (2005). Playing the collaboration game right - balancing trust and contracting. *Technovation*, 25, 497-504.
- Braczyk, H., Cooke, P. (1998). *Heidenreich, Regional Innovation Systems*, London: UCL Press.
- Brandenburger, A.M., Nalebuff, B.J. (1996). *Co-opetition*. Currency, Doubleday, New York.
- Breitzman, A., Mogee, M. (2002). The many applications of patent analysis. *Journal of Information Science*, 28 (3), 187-205.
- Carayol, N., Roux, P. (2007). The strategic formation of intra-individual collaboration networks. Evidence from co-invention patterns. *Annales d'Économie et de Statistique*, 87/88, 275-301.
- Cassiman, B., Veugelers, R. (2006). In search of complementarity in the innovation strategy: internal R&D and external knowledge acquisition. *Management Science*, 52, 68-82.
- Chen, Y., Chang, K. (2009). Using neural network to analyse the influence of the patent performance upon the market value of the US pharmaceutical companies. *Scientometrics* 80 (3), 637-655.
- Chen, Y., Chang, K. (2010). The nonlinear nature of the relationships between the patent traits and corporate performance. *Scientometrics* 82 (1), 201-210.

- Chen, Y., Chang, K. (2010a). The relationship between a firm's patent quality and its market value - the case of US pharmaceutical industry. *Technological Forecasting & Social Change*, 77 (1), 20-33.
- Chen, Y., Chang, K. (2010b). Analyzing the nonlinear effects of firm size, profitability and employee productivity on patent citations of the US pharmaceutical companies by using artificial neural network. *Scientometrics*, 82 (1), 75-82.
- Chen, Y., Chen, B. (2011). Utilizing patent analysis to explore the cooperative competition relationship of the two LED companies: Nichia and Osram. *Technological Forecasting & Social Change*, 78, 294-302.
- Chesbrough, H. (2003). *Open Innovation: The New Imperative for Creating and Profiting from Technology*, Boston.
- Chidamber, S., Kon, H. (1994). A Research Retrospective of Innovation Inception and Success: The Technology-Push, Demand-Pull Question. *International Journal of Technology Management*, 9 (1), 94-112.
- Chien, T., Peng, T. (2005). Competition and cooperation intensity in a network - a case study in Taiwan simulator industry. *Journal of American Academy Business*, 7, 150-155.
- Cockburn, I., Henderson, R. (1998). Absorptive capacity, coauthoring behavior, and the organization of research in drug discovery. *The Journal of Industrial Economics*, 46 (2), 157-183.
- Cohen, W., Levinthal, D. (1989). Innovation and learning: the two faces of R&D. *Economic Journal*, 99, 569-596.
- Cohen, W., Levinthal, D. (1990). Absorptive Capacity: A New Perspective on Learning and Innovation Wesley Cohen, M. and Levinthal, D. *Administrative Science Quarterly*, 35 (1), Special Issue: Technology, Organizations, and Innovation, March, 128-152.
- Cohen, W., Nelson, R., Walsh, J. (2000). Protecting their Intellectual Assets: Appropriability Conditions and Why U.S. Manufacturing Firms Patent (or Not). NBER Working Paper, No. 7552.
- Cohen, W., Walsh, J. (2001). R&D Spillovers, Appropriability and R&D Intensity: A Survey Based Approach, The economical evaluation of technological change, June 15-16 1998, Georgetown University Conference Center Washington DC, Editor R. Spivack.
- Conceição, P., Heitor, M. (2007). Diversity and integration of science and technology policies. *Technological Forecasting and Social Change*, 74 (1), January, 1-17.
- Cooke, P., Boekholt, P., Tödtling, F. (2000). *The Governance of Innovation in Europe: Regional Perspectives on Global Competitiveness*, London: Pinter.
- Cooke, P., Uranga, M., Etxebarria, G. (1997). Regional innovation systems: institutional and organizational dimensions. *Research Policy*, 26, (4-5), 475-491.
- Dagnino, G., Rocco, E. (2009). *Coopetition strategy: theory, experiments and cases*, Routledge, New York.
- Dosi, G. (1988). Sources, procedures and microeconomic effects of innovation. *Journal of Economic Literature*, 26(3), 1120-1171.
- Dussauge, P., Garrette, B., Mitchell, W. (2000). Learning from competing partners: outcomes and durations of scale and link alliances in Europe, North America and Asia. *Strategic Management Journal*, 21, 99-126.
- Ernst, H. (1998). Industrial research as a source of important patents. *Research Policy*, 27, 1-15.
- Ernst, H. (1999). Patent portfolios for strategic R&D planning. *Journal of Engineering Technological Management*, 15, 279-308.
- Ernst, H. (2003). Patent information for strategic technology management, *World Patent Information*, 25, 233-242.

- Escribano, A., Fosfuri, A., Tribó, J. (2009). Managing external knowledge flows: The moderating role of absorptive capacity. *Research Policy*, 38, 96-105.
- Ferrão, M. (2003). *Introdução aos modelos de regressão multinível em educação*, Campinas: Komedi.
- Fjelstad, A.D., Becerra, M., Narayanan, S. (2004). Strategic action in network industries: an empirical analysis of the European mobile phone industry. *Scandinavian Journal of Management*, 20, 173-196.
- Flanagan, K., Kieron, E., Laranja, M. (2011). Reconceptualising the 'policy mix' for innovation. *Research Policy*, 40 (5), June, 702-713.
- Frankel, M. (1955). Obsolescence and technological change in a maturing economy. *The American Economic Review*, Vol. 45 (3), June, 296-319.
- Gambardella, A. (1992). Competitive advantages from in-house basic research. *Research Policy*, 21, 391-407.
- Garraffo, F. (2002). Types of coepetition to manage emerging technologies. 2nd Annual Conference, Innovative Research in Management, Stockholm, Sweden.
- George, G., Prabhu, G. (2003). Developmental financial institutions as technology policy instruments: implications for innovation and entrepreneurship in emerging economies. *Research Policy*, 32, 89-108.
- Godinho, M. (2003). *Inovação: Conceitos e Perspectivas Fundamentais*. Rodrigues, M., Neves, A. and Godinho, M. (Orgs.), *Para uma Política de Inovação em Portugal*, Dom Quixote, Lisboa: Biblioteca de Economia & Empresa, 29-51.
- Gomes-Casseres, B. (1996). *The alliance revolution*. Harvard University Press, Cambridge, MA.
- Griliches, Z. (1957). Hybrid corn: an exploration in the economics of technological change. *Econometrica*, 25 (4), 501-522.
- Griliches, Z., Hall, B., Pakes, A. (1991). R&D, patents and market value revisited: is there a second (technological opportunity) factor? *Economic Innovation New Technology*, 1(3), 183-201.
- Grindley, P., Teece, D. (1997). Managing intellectual capital: licensing and cross-licensing in semiconductors and electronics. *California Management Review*, 39, 8-41.
- Grupp, H., Schmooch, U. (1999). Patent statistics in the age of globalization: new legal procedures, new analytical methods, new economic interpretation. *Research Policy*, 28, 377-396.
- Harbison, K., Pekar, P. (1998). *Smart alliances*, Jossey-Bass, San Francisco.
- Hatzichronoglou, T. (1997). Revision of the high-technology sector and product classification. OECD STI Working Paper Series No. 1997/2, Paris.
- Heitor, M., Bravo, M. (2010). Portugal at the crossroads of change, facing the shock of the new: People, knowledge and ideas fostering the social fabric to facilitate the concentration of knowledge integrated communities. *Technological Forecasting and Social Change*, 77 (2), February, 218-247.
- Hicks, J. (1932). *The theory of wages*, London: MacMillan.
- Huston, L., Sakkab, N. (2006). Connect and Develop. *Harvard Business Review*, 84 (3), 58-66.
- Jong, J., Marsili, O. (2006). The fruit flies of innovations: a taxonomy of innovative small firms. *Research Policy*, 35, 213-229.
- Kaufmann, A., Tödtling, F. (2001). Science-industry interaction in the process of innovation: the importance of boundary-crossing between systems. *Research Policy*, 30, 791-804.
- Kleinknecht, A. (1990). Demand and innovation: Schmookler re-examined. *Research Policy*, 19 (4), August, 387-394.
- Klepper, S. (1997). Industry life cycle. *Industrial and Corporate Change*, 6(1), 145-181.

- Klevorick, A.K. (1995). On the sources and significance of inter-industry differences in technological opportunities. *Research Policy*, 24 (2), 185-205.
- Kostopoulos, K., Papalexandris, A., Papachroni, M., Ioannou, G. (2011). Absorptive capacity, innovation, and financial performance. In Press, Corrected Proof.
- Lai, K., Su, F., Weng, C., Chen, C. (2007). Co-Opetition Strategy from The Patent Analysis Perspective: The Case Of The Stent Market. *International Journal of Innovation and Technology Management (IJITM)*, World Scientific Publishing Co. Pte. Ltd., 4(02), 137-153.
- Laranja, M. (2008). The development of technology infrastructure in Portugal and the need to pull innovation using proactive intermediation policies. *Technovation*, 29 (1), January, 23-34.
- Lee, S., Yoon, B., Park, Y. (2009). An approach to discovering new technology opportunities: keyword-based patent map approach. *Technovation*, 29, 481-497.
- Leitão, J., Baptista, R. (2009). *Public Policies for Fostering Entrepreneurship: A European Perspective*. Springer, London, New York.
- Li, X. (2011). Sources of External Technology, Absorptive Capacity, and Innovation Capability in Chinese State-Owned High-Tech Enterprises. *World Development*, 39(7), 1240-1248.
- Lundvall, B-A. (1985). Product innovation and user-producer interaction. *Industrial Research*, No. 31, Aalborg: Aalborg University Press.
- Lundvall, B-A. (1988). Innovation as an interactive process: from user-producer interaction to the national system of innovation. Dosi, G., Freeman, C., Nelson, R., Silverberg, G., Soete, L. (eds.), 1988. *Technical Change and Economic Theory*, Chap. 17, London: Pinter, 349-369.
- Lundvall, B-A. (1992). *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*. London: Pinter.
- Lundvall, B-A. (2007). National innovation systems - analytical concept and development tool. *Industry and Innovation*, 14 (1), 95-119.
- Luo, X., Rindfleisch, A., Tse, D.K. (2007). Working with rivals: the impact of competitor alliances in financial performance. *Journal of Marketing Research*, 44, 73-83.
- Luo, X., Slotegraaf, R. (2006). Cross-functional coopetition: the simultaneous role of cooperation and competition within firms. *Journal of Marketing*, 70(2), 67-80.
- Luo, Y. (2004). *Coopetition in international business*. Copenhagen Business School Press.
- Ma, Z., Lee, Y. (2008). Patent application and technological collaboration in inventive activities: 1980-2005. *Technovation*, 28 (6), 379-390.
- Macdonald, S. (2004). When means become ends: considering the impact of patent strategy on innovation. *Information Economics and Policy*, 16 (1), 135-158.
- McCullagh, P., Nelder, J. (1989). *Generalized Linear Models*, 2nd ed. London: Chapman & Hall.
- McGahan, A. (2004). *How industries evolve: principles for achieving and sustaining superior performance*. Harvard Business School Press.
- Mogee, M. (1991). Using patent data for technology analysis and planning. *Research Technology Management*, 34 (4), 43-49.
- Mowery, D. (1983). The relationship between intrafirm and contractual forms of industrial research in American manufacturing 1900-1940. *Explorations in Economic History*, 20 (4), 351-374.
- Mowery, D., Rosenberg, N. (1979). The influence of market demand upon innovation: A critical review of some empirical studies. *Research Policy*, 8 (2), 102-153.
- Nelson, R. (1993). *National Systems of Innovation: A Comparative Analysis*. Oxford: Oxford University Press.

- Nelson, R., Winter, S. (1977). In search of a useful theory of innovation. *Research Policy*, 6 (1), 36-76.
- Nemet, G. (2009). Demand pull, technology push, and government-led incentives for non-incremental technical change. *Research Policy*, 38 (5), 700-709.
- Nieto, M., Santamaria, L. (2007). The importance of diverse collaborative networks for the novelty of product innovation. *Technovation*, 27 (6-7) 367-377.
- Padula, G., Dagnino, G. (2007). Untangling the rise of coopetition. *International Studies and Management & Organization*, 37 (2), 32-52.
- Park, S., Russo, M. (1996). When Competition Eclipses Cooperation: An Event History Analysis of Joint Venture Failure. *Management Science*, 42 (6), 875-890.
- Pavitt, K. (1984). Sectoral patterns of technological change: towards a taxonomy and theory. *Research Policy*, 13 (6), 343-373.
- Pavitt, K. (1998). Technologies, products and organization in the innovating firm: what Adam Smith tells us and Joseph Schumpeter doesn't. *Industrial and Corporate Change*, 7 (3), 433-452.
- Peneder, M. (2002). Intangible investment and human resources. *Journal of Evolutionary Economics*, 12 (1), 107-134.
- Quintana-Garcia, C., Benavides-Velasco, C.A. (2004). Cooperation, competition, and innovative capability: a panel data of European dedicated biotechnology firms. *Technovation*, 24 (12), 927-938.
- Rammer, C. (2002). Patente Und Marken Als Schutzmechanismen Für Innovationen. *Studien Zum Deutschen Innovationssystem*, 11-2003, Mannheim.
- Ritala, P., Hurmelinna-Laukkanen, P. (2009). What's in it for me? Creating and appropriating value in innovation-related coopetition. *Technovation*, 29 (12), 819-828.
- Rosenberg, N. (1974). Science, invention and economic growth. *The Economic Journal*, 84 (333), 90-108.
- Rosenberg, N. (1976). The direction of technological change: inducement mechanisms and focusing devices. *Economic Development and Cultural Change*, 18, 1-24.
- Rosenberg, N. (1994). *Exploring the black box: technology, economics and history*. Cambridge: Cambridge University Press.
- Rosenberg, N., Birdzell, L.E., Jr. (1990). Science, technology and the Western miracle. *Scientific American*, 263 (5), 42-54.
- Rothaermel, F., Alexandre, M. (2009). Ambidexterity in technology sourcing: the moderating role of absorptive capacity. *Organization Science Archive*, 20 (4), 759-780.
- Rothwell, W. (2002). Putting success into your succession planning. *Journal of Business Strategy*, 23 (3), 32-37.
- Rusko, R. (2011). Exploring the concept of coopetition: a typology for the strategic moves of the Finnish forest industry. *Industrial Marketing Management*, 40 (2), 311-320.
- Scherer, F. (1982). Inter-industry technology flows and productivity growth. *The Review of Economics and Statistics*, 64 (4), 627-634.
- Schmookler, J. (1966). *Invention and economic growth*. Cambridge MA: Harvard University Press.
- Schmookler, J. (1979). Fuentes económicas de la actividad inventiva. Rosenberg, N. (org.), *Economía del cambio tecnológico*. México: Fondo de Cultura Económica, 107-125.
- Schumpeter, J. (1934). *The theory of economic development*. Harvard Economic Studies, Cambridge, Mass.
- Schumpeter, J. (1942). *Capitalism, socialism and democracy*. Harper & Row, New York.

- Seung, P., Russo, M. (1996). When Competition Eclipses Cooperation: An Event History Analysis of Joint Venture Failure. *Management Science*, 42 (6), 875-890.
- Seymour, R. (2008). Platinum group metals patent analysis and mapping. *Platinum Metals Review*, 52 (4), 231-240.
- Silva, M., Leitão, J. (2009). Reinforcing the entrepreneurial innovation capacity of industrial SMEs with networks. Leitão, J., Baptista, R., *Public Policies for Fostering Entrepreneurship: A European Perspective*. Springer, London, New York.
- Silva, M., Leitão, J. (2009). Cooperation in innovation practices among firms in Portugal: do external partners stimulate innovative advances? *International Journal of Entrepreneurship and Small Business*, 7 (4), 391-404.
- Simon, H. (1973). Does scientific discovery have a logic? *Philosophy of Science*, 40, 471-480.
- Skyrms, B. (2004). *The Stag Hunt and Evolution of Social Structure*. Cambridge University Press, Cambridge.
- Smith, K. (2005). Measuring Innovation. Fagerberg, J., Mowery, D., Nelson, R., *The Oxford Handbook of Innovation*. Oxford, Oxford University Press, 148-179.
- Somaya, D. (2003). Strategic determinants of decisions not to settle patent litigation. *Strategic Management Journal*, 24 (1), 17-38.
- Tether, B. S. (2002). Who co-operates for innovation, and why: an empirical analysis. *Research Policy* 31 (6), 947-967.
- Todorova, G., Durisin, B. (2007). Absorptive capacity: valuing a reconceptualization. *Academy of Management Review*, 32 (3), 774-786.
- Tsai, W. (2002). Social structure of coopetition within a multiunit organization, competition and intraorganizational knowledge sharing. *Organization Science*, 13 (2), 179-190.
- Tushman, M., Anderson, P. (1986). Technological discontinuities and organizational environments. *Administrative Science Quarterly*, 31 (3), 439-465.
- Utterback, J., Abernathy, W. (1975). A dynamic model of process and product innovation. *Omega*, 3 (6), 639-656.
- Vasudeva, G., Anand, J. (2011). Unpacking Absorptive Capacity: A Study of Knowledge Utilization from Alliance Portfolio. *The Academy of Management Journal*, 54 (3), 611-623.
- Vernon, R. (1966). International Investment and International Trade in the Product Cycle. *The Quarterly Journal of Economics*, 80 (2), 190-207.
- Walley, K. (2007). Coopetition - an introduction to the subject and an agenda for research. *International Studies of Management & Organization* 37 (2), 11-31.
- Wang, X. (2010). Worldwide patent analysis and mapping of combine harvester innovation. *African Journal of Agricultural Research*, 5 (24), 3493-3499.
- Zahra, S., George, G. (2002). Absorptive capacity: a review, reconceptualization, and extension. *Academy of Management Review*, 27 (2), 185-203.

Annex 1. List of independent variables

Variables	Definition
Manufacturing and service samples	
Large firm	A dummy variable indicating whether the firm is a large firm or not (1 if yes and 0 if no)
Small and medium firm	A dummy variable indicating whether the firm is a small and medium firm or not (1 if yes and 0 if no)
Process innovation authorship by firm	A dummy variable indicating whether the firm's process innovation is of the firm's responsibility or not (1 if yes and 0 if no)
Process innovation authorship by firm in cooperation	A dummy variable indicating whether the firm's process innovation is of the firm's responsibility in cooperation with other firms or not (1 if yes and 0 if no)
Process innovation authorship by others	A dummy variable indicating whether the firm's process innovation is of the firm's responsibility in cooperation with other entities or not (1 if yes and 0 if no)
R&D activities performed inside the firm	A dummy variable indicating whether the firm performed inside R&D activities or not (1 if yes and 0 if no)
No R&D activities performed inside the firm	A dummy variable indicating whether the firm didn't performed inside R&D activities or not (1 if yes and 0 if no)
Acquisition of outside R&D	A dummy variable indicating whether the firm acquired outside R&D or not (1 if yes and 0 if no)
No acquisition of outside R&D	A dummy variable indicating whether the firm didn't acquired outside R&D or not (1 if yes and 0 if no)
Acquisition of other external knowledge	A dummy variable indicating whether the firm acquired other external knowledge or not (1 if yes and 0 if no)
No acquisition of other external knowledge	A dummy variable indicating whether the firm didn't acquired other external knowledge or not (1 if yes and 0 if no)
Introduction of innovations into the market	A dummy variable indicating whether the firm introduced innovations into the market or not (1 if yes and 0 if no)

No introduction of innovations into the market	A dummy variable indicating whether the firm didn't introduced innovations into the market or not (1 if yes and 0 if no)
Firm cooperated in R&D	A dummy variable indicating whether the firm cooperated in R&D or not (1 if yes and 0 if no)
Firm didn't cooperated in R&D	A dummy variable indicating whether the firm didn't cooperated in R&D or not (1 if yes and 0 if no)
Public partner	A dummy variable indicating whether the firm's type of preferred partner is public or not (1 if yes and 0 if no)
Private partner	A dummy variable indicating whether the firm's type of preferred partner is private or not (1 if yes and 0 if no)
Firm cooperated with competitors in PT	A dummy variable indicating whether the firm cooperated with PT competitors or not (1 if yes and 0 if no)
Firm cooperated with competitors in EU	A dummy variable indicating whether the firm cooperated with EU competitors or not (1 if yes and 0 if no)
Firm cooperated with competitors in US	A dummy variable indicating whether the firm cooperated with US competitors or not (1 if yes and 0 if no)
Firm cooperated with laboratories in PT	A dummy variable indicating whether the firm cooperated with PT laboratories or not (1 if yes and 0 if no)
Firm cooperated with laboratories in EU	A dummy variable indicating whether the firm cooperated with EU laboratories or not (1 if yes and 0 if no)
Firm cooperated with laboratories in US	A dummy variable indicating whether the firm cooperated with US laboratories or not (1 if yes and 0 if no)
Firm cooperated with consultants in PT	A dummy variable indicating whether the firm cooperated with PT consultants or not (1 if yes and 0 if no)
Firm cooperated with consultants in EU	A dummy variable indicating whether the firm cooperated with EU consultants or not (1 if yes and 0 if no)
Firm cooperated with	A dummy variable indicating whether the firm

Essays on Entrepreneurial Transference of Technology and Patenting

consultants in US	cooperated with US consultants or not (1 if yes and 0 if no)
Firm cooperated with universities in PT	A dummy variable indicating whether the firm cooperated with PT universities or not (1 if yes and 0 if no)
Firm cooperated with universities in EU	A dummy variable indicating whether the firm cooperated with EU universities or not (1 if yes and 0 if no)
Firm cooperated with universities in US	A dummy variable indicating whether the firm cooperated with US universities or not (1 if yes and 0 if no)
Manufacturing sample	
Low tech firm	A dummy variable indicating whether the firm is low tech or not (1 if yes and 0 if no)
High tech firm	A dummy variable indicating whether the firm is high tech or not (1 if yes and 0 if no)
Service sample	
Knowledge intensive firm	A dummy variable indicating whether the firm is knowledge intensive or not (1 if yes and 0 if no)
Less knowledge intensive firm	A dummy variable indicating whether the firm is less knowledge intensive or not (1 if yes and 0 if no)

Chapter 4

Corporate R&D strategy and growth of high-tech and medium high-tech US start-ups.

Abstract

Firm growth is a topic that has been the target of several analyses in the literature from different approaches, due to its importance and relevance for firm survival, generation of employment, increased economic growth and dynamism as well as the industrial concentration of firms, the process of firm selection and competitiveness in the sequence of diverse efficiency levels, and the introduction of innovation and technological change.

In high-tech sectors the pace of technological change is commonly high and tends to shorten products' lifecycle. In this connection, and in order to avoid competition, which in this type of sector also tends to be extremely high, firms' success can depend on their IP rights and on the early-mover effect. In innovation intensive industries, patents facilitate active, creative and tradable markets for technology. Also, the protection of knowledge through patents enables innovators to act as licensors and make their assets commercially available to licensees.

This paper intends to estimate the effects of the determinants of firm growth based on a corporate R&D strategy characterized by the firm's innovative intensity, using as proxies, R&D intensity, the firm's patent portfolio and patent transactions, e.g., in-licenses and out-licenses, using a panel data approach. We control for technological intensity through the NACE classification, the purpose being to focus on high-tech and medium high-tech firms.

Using a two-step panel data model, static and dynamic estimations are performed among a sample of 818 firms created in 2004 and tracked by the Kauffman Foundation in the subsequent six years. The major results show a significant and positive impact of R&D intensity and in-license of external patents on firm growth and a negative and significant effect of squared R&D intensity on the firm's growth path, revealing an inverted U-shaped relationship with firm growth, a positive impact on firm growth at an early stage, followed by a negative one after achieving the optimal level. These conclusions are also ratified when controlling the activity sector, having a major impact on sectors like high-tech manufacturing industries and high-tech knowledge-intensive services.

Keywords

Firm growth; Panel data; Patent transactions; R&D intensity.

1. Introduction

According to Kenney & Patton (2011), entrepreneurship and the process of firm creation is considered to act as an enabling lever for economic development, fostering economic growth through the generation, dissemination and exploitation of innovative ideas, in a framework of success.

Helmets & Rogers (2011) argue that patents allow inventors to exploit their inventions successfully, giving firms a competitive advantage in terms of increased performance when compared to non-patenting firms. Additionally, the patent system spurs the creation of new firms based on inventions, relying on their patent assets to capture a share of the market and achieve additional revenue from their innovativeness and thus to grow.

Joshi & Nerkar (2010) state that in innovation intensive industries, patents facilitate active, creative and tradable markets for technology. Also, the protection of knowledge through patents enables innovators to act as licensors and make their assets commercially available to licensees.

Different theories have attempted to explain the causes and effects of firm growth, such as classic economic theory, behaviorist theory, stochastic growth theory, learning models and the evolutionary approach.

The paper analyzes the theoretical background regarding the economic theories used to explain firms' growth process, specifying the various factors used to explain the mechanism of firm growth, and additionally reviews the literature on corporate R&D strategy focusing on patenting as a determinant of firm growth.

This paper differs significantly from previous studies on one count. It employs corporate R&D strategy factors (i.e. innovation proxies, such as R&D intensity, patent portfolio, patent transactions, e.g. in-license and out-license of patents) which are directly connected to firm growth.

The paper is structured as follows. Section 2 develops the theoretical underpinnings, drawing on the literature on firm growth, reviewing the main firm growth theories, major factors for firm growth and determinants based on R&D investment efforts, and analyzes the theoretical background on patents acting as determinants for firm growth. Section 3 presents the empirical approach and discusses the results. Section 4 concludes and provides policy implications and guidelines for entrepreneurs and practitioners in the framework of technological entrepreneurship and firm growth based on corporate R&D strategy factors.

2. Literature survey and research hypothesis

2.1 Firm growth: theoretical background

Firm growth has been the research focus of several analysts due to its impact on employment, industrial concentration, firm survival and economic dynamics (Suárez, 1999).

How to measure firm growth has been a topic under much discussion due to the need for better understanding of growth levers, namely, at the micro and entrepreneurial level.

According to Delmar (1997) and Ardishvili *et al.* (1998), several indicators measure firm growth, such as: financial or stock market value; number of employees; total sales and revenue; productivity; production value; and gross added value.

Kirchhoff & Norton (1992) used three measures, pointing out their interchangeability in the way they produce the same set of results when tested in a period of seven years, namely employment, total assets and sales.

Delmar *et al.* (2003), after analyzing several measures, defend that the use of different indicators has to do with the objectives of the investigation. They also pointed out some limitations of the measures. Sales, for instance, although easy to access, can be an unsatisfactory indicator since it can be biased by the firm's arbitrary decisions and strategies and as a consequence of vertical integration of production processes, and is also sensitive to currency exchange rates and inflation. Added value, although able to explain internal activity, is not publicly available and assets can lose explanatory capacity especially if applied to services.

Authors like Penrose (1959) and Kimberley (1976) state that the number of employees can be a good indicator as this can explain organizational complexity and the managerial implications of growth. Nevertheless, Delmar *et al.* (2003) defend that the number of employees does not reflect firms' strategic decisions, such as labour productivity, technological change, labour processes and others.

Scherer (1970) pointed to a set of factors that influence size and growth, such as economies and diseconomies of scale, mergers and acquisitions, government policies and stochastic determinants of market structure.

Storey (1994) presented a classification based on three main groups of determinant factors for firm growth: those related to the entrepreneur; those concerned with the firm; and those associated with corporate strategy. The first group takes into consideration the individual resources of the entrepreneur, such as motivation, unemployment, education, management

experience, number of founders, prior self-employment, family history, social marginality, functional skills, training, age, prior business failures, prior sector experience, prior firm size experience and gender. The second group deals with age, sector, legal form, location, size and ownership. The third has to do with measures like workforce and training management, external equity, technological sophistication, market positioning and adjustments, planning, new products, recruitment management, state support, customer concentration, competition, information and advice, and exporting.

According to Storey (1994), firms can be divided in three main groups, the "failures", the "trundlers" and the "flyers". The first tend to exit after entering the market. The second survive until the observed period but do not reflect change in size. The last are those responsible for net job creation and increase in size.

Following Gibrat (1931), Mansfield (1962) and Audretsch *et al.* (2004), the so-called Gibrat's Law, which is also known as the Law of Proportionate Effect, states that a firm's growth rate is independent of its size at the beginning of the examined period, the probability of a proportionate change in size during a certain period being the same for all firms in a specified industry, the size of the firm at the starting period under consideration having no influence.

Taking the above into account, we hypothesize that:

H1: A firm's growth has a negative and significant relationship with size.

As defended by Storey (1994), all those elements should be combined so that firms can properly grow. Geroski (1999) added a fourth variable, the randomness that deals with unexpected factors.

Barringer *et al.* (2005) classified these determinant factors in four groups: the founder's characteristics; the firm's attributes; business practices; and human resource management practices.

Besides these factors impacting on firm growth, there are a set of barriers, such as the existence and cost of capital to expand, the overall growth of market demand, increasing competition, marketing, sales and management capacities, skills of the labour force, acquisition of new technology, limitations in its implementation, availability of appropriate premises or sites and access to external markets, for which the firm must acquire the ability to adapt and overcome in order to pursue a growth strategy (Storey, 1994; Geroski, 1995).

In this vein, Sutton (1997) stated that the previous literature was concerned with a set of regularities, namely, size distribution, turbulence, decline and exit, in order to understand the role played by these regularities stimulated by some systematic economic mechanisms. An understanding of the evolution of the market structure, a complex phenomenon, cannot be explained by a single model that encompasses all the statistical regularities observed. Some determinants must be more clearly understood, such as the industry-specific determinants of firm turnover (turbulence), the volatility of market shares and the exit pattern in declining industries.

This set of determinants is covered by several theories, due to the topic's relevance. The main theoretical streams cover four major groups, namely: classical economists; behavioral economists; stochastic theorists; learning and selection models; and evolutionary scholars.

Classical economists focused on the optimal and most efficient size that yields the minimum efficient scale, firm growth being the state between one situation of equilibrium and another. This theoretical approach embraces two different approaches: static, indicating a linear relationship; and dynamic, which denotes a feedback relationship (Viner, 1932; Stigler, 1958; Mazzucato, 2000).

Behaviorists are focused on the managerial approach, due to the central role played by founders/managers in increased firm size. Scholars supporting this theory are Baumol (1959, 1962), Penrose (1959), Chandler (1962), Morris (1964), Richardson (1964) and Williamson (1967).

Stochastic theorists defend that firm growth depends on a stochastic process and present two main objectives, to detect the stochastic factors that affect the firm's performance and to identify inequalities and concentration processes among firms (Gibrat, 1931; Kalecki, 1945; Simon, 1955; Scherer, 1970, 1980; Champernowne, 1973; Ijiri & Simon, 1977; Sutton, 1997).

Scholars like Lucas (1978), Jovanovic (1982), Ericson & Pakes (1995) and Pakes & Ericson (1998) assume that learning and selection models, divided into a passive learning approach and an active learning approach, are linked to the stochastic firm growth theory. In this vein, firm growth and survival depends upon the firm's capacity to absorb, adapt to the environment and act strategically. Thus, it is related to the firm's capacity to innovate following a learning process.

In the vision of Nelson & Winter (1982), the evolutionary approach brings the concept of routine to firms' behavior, concerning firms' regular and predictable behavior patterns. The set of routines includes a range of firms' features, such as technical specifications for production to processes regarding hiring and firing, investment policies, research and development, advertising or business strategies, these routines playing the same role that

genes play in biological evolutionary theory. A firm's routines are a feature of the organism and determine its possible behavior (also determined by the environment), being inherited (today's organisms are the reflection of past organisms) and selectable (in the sense that organisms with specific routines may perform better).

Nelson & Winter (1982) also postulate that not all firms' behaviors follow a regular and predictable tendency, for which the evolutionary approach recognizes the existence and importance of stochastic elements either for the determination of decisions or for decision outcomes.

2.2 Corporate R&D strategy and firm growth

Several studies focused on the relationship between performance and corporate R&D (using R&D expenditure as a proxy) oriented to innovative activities and products.

For instance, Morbey & Reithner (1990) stated that firms' investment in R&D is positively related to firm growth and the generation of knowledge flows needed for product and process innovation. In this sense, R&D activity is assumed to contribute to the success of firms that are dedicated to an innovative strategy.

In the light of the theory of the resource-based view (Barney, 1991; Makadok, 2001), valuable, rare and inimitable resources can act as a competitive advantage for firms in order to grow sustainably.

Kumar & Siddharthan (1994) analyzed the positive relationship between the performance of low and medium technology industries and R&D expenditure.

Geroski & Toker (1996), analyzing a sample of 209 leading UK firms, concluded that innovation has a significant positive relationship with sales growth. Roper (1997) makes use of survey data on 2721 small UK, Irish and German firms in order to verify the positive effect of firms introducing innovative products on sales growth.

Most scholars in studies on growth and innovation used R&D intensity as a proxy for innovation. R&D intensity refers to a firm's expenditure in new technology development and product innovation, taking total sales as a reference (Li, 1999).

Freel (2000), studying 228 small UK manufacturing firms, concluded that innovators are likely to grow more rapidly than non-innovators. Nonetheless, when focusing on the pharmaceutical sector, Bottazzi *et al.* (2001) did not find any significant effect of a firm's innovative behavior

on sales growth. Del Monte & Papagni (2003) also found a positive relationship between sales growth and R&D activity when analyzing a sample of Italian manufacturing firms.

In the studies by Ural & Acaravci (2006), R&D for technological innovation has a central position in defining a firm's business strategy, especially in selection of the competition mode.

For Wiklund *et al.* (2010) and Anderson & Eshima (2011), a firm's resources are of critical importance in developing the capacity to be innovative and proactive, and to assume risk-taking behavior. In this connection, a firm possessing a set of intellectual property assets is an important factor determining the ability to undertake strategies that result in positive outcomes. The authors defend that firms (and especially younger firms under 5 years old) with more intangible resources are more prone to perform strategically in order to pursue opportunities that in the long-term generate higher sales. Thus:

H2: A firm's growth has a positive and significant relationship with R&D intensity.

Despite the theoretical background on the positive relationship between firm growth and R&D intensity, several scholars defend this is not always a linear relationship (Ittner & Larcker, 1998; Canibano *et al.*, 2000; Luft & Shields, 2003). Penrose's growth theory (1959) also stated that firms are not able to pursue unlimited expansion regarding R&D investment since they are constrained by managerial capacity, such investment being responsible for non-positive effects on operating performance. Similarly, Hitt *et al.* (1997) and Bharadwaj *et al.* (1999) found a negative impact of R&D investment on firm performance.

In addition, R&D investment can have a positive impact on firm growth at an early stage, although becoming negative after achieving the optimal level.

In their study of Portuguese SMEs, Serrasqueiro *et al.* (2010) note that R&D intensity is an important determinant for firms' survival, presenting significant non-linearity over growth distribution. They defend that Gibrat's Law cannot be rejected in the case of the small firms analyzed, but it is rejected when firm size increases. R&D intensity is then considered by the authors as a restrictive determinant of firm growth when considering reduced size, acting as a catalyst for growth in the presence of increased size.

Thus:

H3: A firm's R&D intensity has an inverted U-shaped relationship with its growth.

Cuervo (2005) states that if there is a market for almost everything, the firm's competitive advantage for growth can be based on its accumulated intangible assets (knowledge capital) either in the form of brands, reputation and knowledge or in the form of decision and problem-solving systems, such as organizational routines and incentive systems.

According to Baumol (1990) and Wennekers & Turik (1999), entrepreneurship and the process of new firm entry is a key aspect for economic development, contributing to economic growth through the generation, dissemination and exploitation of innovative ideas, enabling efficiency, productivity, increased competition and providing diversification among firms.

Regarding the work by Helmers & Rogers (2011)⁹, by allowing inventors to benefit from their inventions, patents are a determinant giving firms owning this kind of IP asset a competitive advantage, leading to improved performance and subsequent growth when compared to non-patenting firms. Conversely, the patent system motivates the creation of new firms based on inventions, relying on their patent assets to generate a share of the market and achieve additional revenue from their innovativeness. Thus, the patent system works to rectify the appropriability problem, especially when dealing with new, small firms. Start-ups that patent will therefore be more successful than non-patenting ones. In addition, Rosenbusch *et al.* (2011) also conclude there is a relationship between SME growth and an innovation-centric corporate strategy. Thus:

H4: A firm's growth has a positive and significant relationship with its patent portfolio.

Schneider & Veugelers (2010) draw attention to the importance of young, innovative firms fostering innovation and growth.

The main obstacles for the few studies covering this topic are explained by Helmers & Rogers (2011) as being due to difficulties in capturing the effects of a patent on a firm's performance. For instance, there is not so much data available on the patenting of start-up firms, since small firms report very little on their activities. In addition, there is no financial data regarding economic performance, before and after the patent was filed, published or granted, and there is no comparison data with a control group of non-patenting start-ups.

Furthermore, Helmers & Rogers (2010) state that since only a few patents protect really innovative, breakthrough inventions and some of these are associated with small firms, there is a parallel between patent value distribution and new firm performance distribution.

⁹ The authors analyzed a dataset of high tech and medium tech start-ups created in 2000 in the UK (about 7500) in order to assess the effect of a patenting decision on growth in the period 2000-2005.

Subsequently, the authors refer to the concept of one in a hundred, where one patent in a hundred is expected to bring value and success.

In terms of theoretical background, a set of authors have been working on the impact of the patent system on the performance of start-ups and innovation.

The effects of the geographical extension of patents, specific coverage of international patent classification and the subsequent number of patent citations in relation to the creation of new firms and subsequent growth, were analyzed by Shane (2001), revealing the existence of a stimulus effect.

Shane & Khurana (2003) analyzed the firm creation effect based on a patent licensed from MIT (Massachusetts Institute of Technology), concluding there is a sequential effect of past entrepreneurial experience on the creation and growth of a start-up based on an invention.

Jaffe & Lerner (2004) and Bessen & Meurer (2008) analyzed the possible inefficiencies of the patent system, addressing questions like patenting and minimizing competition, causing entry barriers to new firms, increased costs associated with sequential and incremental innovation and patent races.

Other authors analyzed the trade-off between costs and benefits in choosing formal IP mechanisms versus informal mechanisms. For example, Anton & Yao (2004) focused on small and medium value innovations subject to patenting rather than high value innovations. This is explained by the authors considering that if property rights protection is weak, mainly in cases of process inventions, there is the threat of imitation due to disclosure of an invention by patenting.

Strategic use of patents by firms can have several benefits, such as establishing a position in a technological domain, avoiding competitors inventing in the same area, expanding their portfolio gaining a defensive strategy, or even using them in negotiation with other firms.

Langinier (2004) focused on patents as a strategic barrier to entry. He concluded that if market demand is high, the patent can make the competitor stronger if he respects the novelty requirement. However if demand is low and the patent holder renews the patent this will work against the firm.

Nerkar & Shane (2007) reviewed the effect of inventions' attributes on their successful commercialization, some inventions being easier and less risky to transfer than others. For instance, more applied inventions instead of more basic science-based ones.

The authors analyzed the impact of three attributes of technological inventions influencing the strategic performance of the commercialization and transfer process. Firstly, the scope of

the patent, which if broader can allow appropriation of greater returns if commercialization is successful, by covering a wider range of technical areas and also increasing the likelihood of new firms being created to commercialize the invention. Secondly, the pioneering nature of the invention, by increasing the owners' incentive to invest in commercialization of the patent, is able to provide the first mover effect and learning curve advantages, such as the avoidance of imitators and creation of similar products and processes. Thirdly, the age of the invention increases the possibilities of commercialization, since issues such as uncertainty regarding the value of the patent and the lack of information on the market and technology tend to disappear. Nevertheless, age can also be a barrier, as by decreasing the number of years of the patent, the returns from its commercialization decline and more competitors are able to develop substitute products.

Thus:

H5: A firm's growth has a positive and significant relationship with its out-license activity of internal patents.

Kultti *et al.* (2007) also focused on firms' motives for opting for patents instead of other non-formal IP mechanisms, such as secrecy. One such motive can derive from the fact that by opting for a patent the firm can avoid the entry of a possible competitor and be the first innovator in the market, assuring freedom to operate. This is the particular case of high-tech firms.

Hall (2007) studied the subject of the decreasing average quality of patents. Additionally, there are some concerns regarding the role of patents in small firms and start-ups, since the high costs of patenting, the behavior of large firms, the fast growth in overall patenting and the uncertainties over enforceability do not favor that type of firm.

Auti (2007) compares patterns of patenting and generation and performance of start-ups, which tend to be higher in the US than in Europe.

Mann & Sager (2007) analyzed the patenting behavior of venture-backed software start-ups in the US, finding a positive impact of patents on firms' performance, namely on the survival rate, growth and income¹⁰.

Graham & Sichelman (2008) reviewed the possible role of patents in start-up firms in bringing competitive advantages, since these firms will only be able to capitalize on their knowledge

¹⁰ Nevertheless, in the authors' survey, only 25% said they were engaged in patenting their inventions. It is important to add that software inventions are not simple to patent, due to the limitations in the field.

and inventions if the latter are protected by patents, preventing other firms from appropriating the outcomes of the assets. Additionally, these authors say that patents give firms the advantage of more secure protection, especially of inventions where imitation and reverse engineering are relatively easy. They also suggest the possibility of patents working as a signaling mechanism for small, young firms, securing venture investment and financing the transformation process of an intangible asset into a property right. Graham & Sichelman (2008) draw attention to the possibility of start-ups obtaining income via licensing, this being an attractive business model for start-ups that are not interested in producing and marketing their inventions. The motives explaining the investment of start-ups in building a patent portfolio concern the possibility of blocking competitors, having bargaining power for cross-licensing agreements and assuring a defense mechanism when being accused of infringement of third parties' patent rights.

In this line, Hsu & Ziedonis (2008) pointed out that in order to obtain external finance, start-ups can affect investors' valuation positively, by using patents as a signaling mechanism for investors to study the firm's potential. Accordingly, Colombo & Grilli (2010) studied the effects of founders' human capital and their access to venture capital (VC) acting as key drivers of the growth and success of new technology-based firms. They conclude that for non-VC-backed firms, the founder's skills are positively related to firm growth. Furthermore, for VC-backed firms their investors act as scouts analyzing performance levels.

In addition, Cucculelli & Ermini (2012) defend that the introduction of new products is positively correlated with growth in multiproduct firms, stating that new products are also associated with firm growth in R&D-intensive sectors and in sectors that absorb externally originated patents. Thus:

H6: A firm's growth has a positive and significant relationship with the its in-license activity of external patents.

The appropriability regime and its strength can provide a barrier against imitation from competitors, creating sustainable advantages for the new firm's entry and growth, either by limiting competition or by increasing competitors' costs, or even increasing the firm's value, providing additional bargaining power (Tuppura *et al.*, 2010). This study is in line with previous studies on appropriability as a key variable influencing successful entry and growth strategies for radical innovations (Montaguti *et al.*, 2002). Moreover, the authors stress that the higher the appropriability the higher the option for a penetration strategy, since this type of strategy requires protection from rapid competitive imitation.

Kosters (2010) and Parker *et al.* (2010) focused their attention on high growth firms, the so-called “gazelles”, and the role of patents in this type of firm’s growth performance. The concept of “gazelle firms” was first studied by Birch (1979). The author defined it as a small group of high-growth firms responsible for the creation of the majority of net new jobs in the economy. In contrast, “elephant firms” correspond to the few large companies generating a large share of employment, but with a small percentage of these jobs being new. A third typology corresponds to the “mice firms”, which are small, with very slow growth and a low rate of employment growth¹¹.

In this connection, Joshi & Nerkar (2010) state that patents facilitate the markets for technology, since they reduce uncertainty giving the inventor a specific period of time with the exclusive right to use the knowledge asset represented by the patent, earning entrepreneurial income from licensing or exploiting the asset.

Graham *et al.* (2010)¹² focused on the use and usefulness of patents in start-ups. Firstly, they differentiated between start-ups with and without venture capital. They also detected divergences among industries, as for some sectors like biotechnology patents are of extreme importance, while for others, software for example, patents are avoidable. The authors concluded that patents provide limited incentives to invent and few advantages for commercializing innovations, because of the high costs involved in the system and because it is also difficult to avoid competitors inventing something similar. Nevertheless, they recognize the importance of patents to avoid imitation and secure external funding sources, by adding reputation to intangible assets and thus supporting the firm growth.

3. Methodology

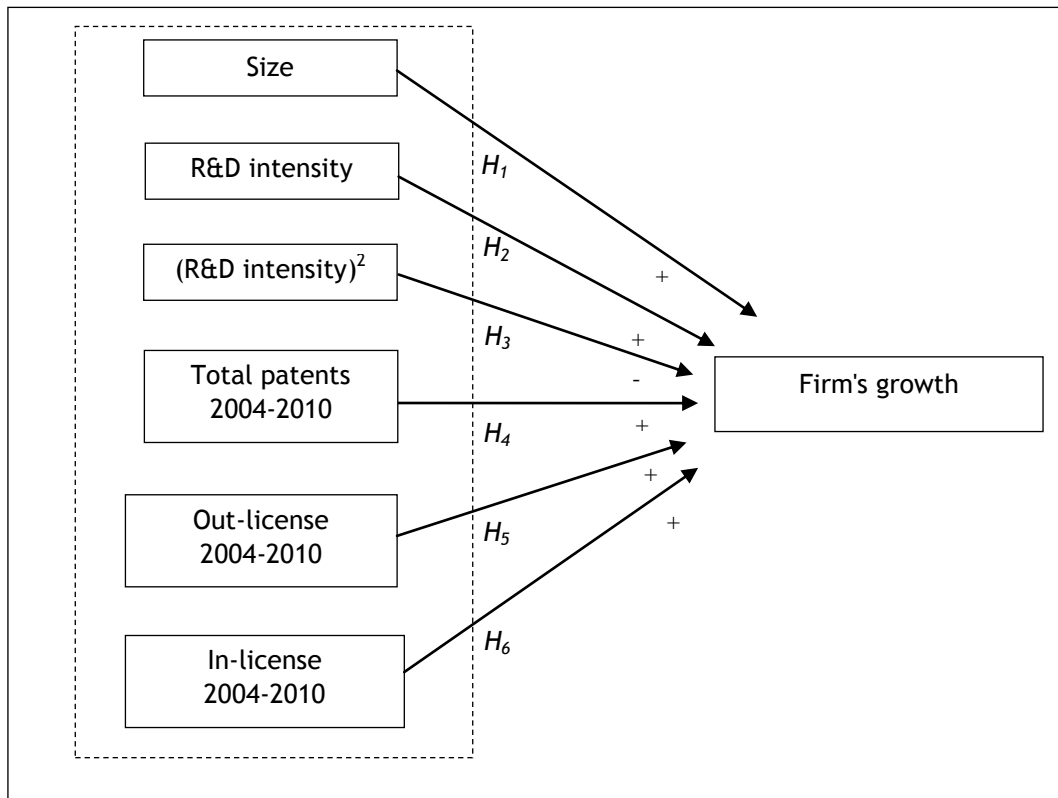
3.1 The model

Based on the literature review, a conceptual model is proposed, to explore the relationships between growth and determinant factors, namely, size and corporate R&D strategy factors (e.g., R&D intensity, patent portfolio and patent transactions) as shown in Figure 1.

¹¹ Another definition, also proposed by Birch *et al.* (1995), has to do with the fact that these firms can obtain at least 20% of sales growth each year over the interval, starting from a base-year revenue of at least \$100,000.

¹² The study was based on a survey applied to 1332 high-tech start-ups founded in the US since 1998.

Fig. 1 Growth and Corporate R&D Strategy: Conceptual Model



3.2. Dataset and model specification

3.2.1 Variables and measurement

This paper uses the Kauffman Firm Survey (KFS)¹³, which is a panel study of 4,928 firms founded in 2004 and tracked over the first six years of operation. This longitudinal panel was created from a random sample of the Dun & Bradstreet (D&B) database list of new businesses started in 2004, including approximately two hundred and fifty-thousand businesses. To achieve the goals of the paper, the KFS dataset was adapted in order to focus on the set of variables under analysis.

¹³ Acknowledgement: Selected data are derived from the Kauffman Firm Survey release 6.0. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the Ewing Marion Kauffman Foundation.

The paper intends to estimate the effects of corporate R&D strategy factors on firm growth, using as proxies R&D intensity, the firm's patent portfolio and patent transactions, which are given by in-licenses and out-licenses. We will control for activity, using the NACE classification for high-tech and medium high-tech firms. For this purpose, we will focus on manufacturing industries and service firms, especially high-tech and medium high-tech firms.

According to Coad & Rao (2008), it is important to avoid noise when selecting the proxies used to quantify 'innovativeness'. To avoid the noise effect, we gather information on both innovative input (R&D efforts) and output (patents), assuring that we obtain useful data on corporate R&D strategy, since we consider both R&D expenditure and patent data.

The variables included in the conceptual model proposed are described in Table 1. The paper's focus is on assessing the importance of a selected set of determinant factors related to corporate R&D strategy for firm growth, using a sample of US start-ups. Some of the variables, for instance, R&D intensity and squared R&D intensity, were computed by using the variables of R&D expenditure and total revenue. Furthermore, firm growth is computed through the average annual change in total assets, and the size variable corresponds to the log of the number of employees. We will use as control variables the firm's technological intensity, based on the NACE classification from the OECD¹⁴.

Table 1 Measurements of the variables representing the conceptual model

Variables	Measurement
Firm growth	Average growth rate in period based on average annual change in firms' total assets
Size	Log value of total number of employees
R&D intensity	Mean R&D intensity per year, calculated by R&D expenditure over total revenue
Squared R&D intensity	Squared R&D intensity
Total patents 2004-2010	Patent count
Out-license 2004-2010	A dummy indicating whether the firm licensed out any patent
In-license 2004-2010	A dummy indicating whether the firm licensed in any patent.
Technological intensity	A control variable indicating the NACE classification of activity - in this case only firms from NACE 32 and 33 and 72 corresponding to high-tech sectors (OECD's definition of high-tech sectors for manufacturing firms in the case of NACE 32 and 33 and knowledge-intensive service firms in the case of sector 72). NACE 31 corresponds to the set of medium high-tech sectors of manufacturing firms.

¹⁴ Sectors are designated as high-tech or low-tech following the standard OECD sector classification based on NACE Rev.2 at 3-digit level to compile aggregates related to high/medium technology and low-technology (http://epp.eurostat.ec.europa.eu/cache/ITY_SDDS/Annexes/htec_esms_an3.pdf, accessed on: 2012/03/05).

In this paper, the relationships between firm growth and corporate R&D strategy factors, namely, patents owned by a firm, its R&D intensity, patent transactions and size, were subject to panel data analysis. Panel data has several advantages such as: (i) we can deal with more observations and there is less multi-collinearity, which will increase the accuracy of estimations; (ii) it gives the possibility of controlling for cross-section effects; and (iii) when extended to a dynamic model, it is possible to address potential endogeneity problems related to the explanatory variables.

The population of the study consists of all firms (818) found on the KFS survey, from the high-tech and medium high-tech sectors, in the period 2004-2010. In this survey we found three high-tech sectors, 32 (Manufacture of radio, television and communication equipment and apparatus) and 33 (Manufacture of medical, precision and optical instruments, watches and clocks) for manufacturing firms and 72 (Computer and related activities) for knowledge-intensive service firms and one medium high-tech sector, namely 31 (Manufacture of electrical machinery and apparatus). The descriptive statistics of the measurements of the dependent and explanatory variables are presented in Table 2.

Table 2 Descriptive statistics of the variables

Variables	Mean	Std. Dev.	Firm's growth	Size	Total patents	R&D intensity	Squared R&D intensity	Out-license	In-license
Firm's growth	3851.56	22591.09	1						
Size	2.25	4.40	-0.061**	1					
Total patents	58.75	1561.25	0.010	0.004	1				
R&D intensity	0.059	1.57	0.008	0.003	0.005	1			
Squared R&D intensity	2.49	167.43	0.004	-0.006	-0.001	0.957**	1		
Out-license	0.010	0.100	-0.013	0.042**	-0.003	0.003	-0.001	1	
In-license	0.04	0.188	-0.010	0.063**	0.043**	0.002	-0.003	0.212**	1

Notes: N=818; **p<0.01

The sample covers 818 start-ups with an average dimension of 2.25 employees. These start-ups possess a mean of 58.75 patents and denote an R&D intensity mean of 0.06 approximately. Table 2, previously presented, reports the descriptive statistics and correlations for the seven variables. It is important to note that regarding the influence of the firm's size, the results denote a consistent negative association with the firm's growth ($\rho = -0.061$). It should also be stressed that concerning the relationship between firm size and the activities of out-license and in-license, the Pearson correlation coefficient indicates that this

variable has a positive and significant relationship with both variables, for the out-license a value of ($\rho = 0.042$) and for the in-license a value of ($\rho = 0.063$).

The variable of the total number of patents owned by the firm only presents a positive and significant relationship with the variable of in-license of IP rights. Curiously, it does not present any association with the activity of out-licensing of IP rights.

The findings show an important correlation between the variables of R&D intensity and squared R&D intensity, revealing a positive and significant association ($\rho = 0.957$).

Another highly ranked variable is out-license of IP rights, which shows a positive and significant relationship with firm size ($\rho = 0.042$) and with in-license activity ($\rho = 0.212$).

Furthermore, the variable concerning activities of in-license of IP rights also indicates strong correlations with the other variables, namely firm size ($\rho = 0.063$), total number of patents ($\rho = 0.043$) and out-license activity ($\rho = 0.212$).

3.2.2. Selection of the model specification

When considering panel data, the same cross-sectional unit is surveyed over a period of time, having as a premise the fact that panel data has a space and time dimension. Since we are dealing with firms' panel data, or other units such as individuals or states, over time, it is possible to observe heterogeneity in these units. Additionally, by combining time-series of cross-section observations, the panel gives more informative data, more variability, less collinearity among variables and increased efficiency. The analysis, presented next, is based on pooled ordinary least squares (OLS), and both random and fixed effect panel estimations.

Greene (2008) presents the basic regression model as follows:

$$Y_{it} = \beta X_{it} + \alpha_i + \varepsilon_{it}, \quad (1)$$

where $i = 1, 2, \dots, N$, referring to a cross-section unit, $t = 1, 2, \dots, T$, relating to time period, Y_{it} corresponds to the dependent variable, X_{it} being the explanatory variables, without the inclusion of a constant term, ε_{it} refers to the disturbance term and β are the unknown coefficients which vary in relation to individuals and time. The individual effect is given by

$z_i\alpha$ where z_i contains a constant term and additionally a set of individual or group specific variables.

In the case where z_i is unobserved and correlated with X_{it} the least squares estimator of B is considered biased and not consistent due to an omitted variable. The model is expressed in the following terms:

$$Y_{it} = \beta X_{it} + \alpha_i + \varepsilon_{it} , \quad (2)$$

considering $\alpha_i = z_i\alpha$ contains all the observable effects and specifies an estimable conditional mean. In this sense, this fixed effect perspective assumes α_i as a group-specific constant term in the regression model.

In the case of unobserved individual heterogeneity, although formulated, it can be assumed to be uncorrelated with the included variables, the model then being formulated as follows:

$$Y_{it} = \beta X_{it} + a + u_i + \varepsilon_{it} , \quad (3)$$

this random effect perspective specifying that u_i is a group specific random element.

Considering static panel data models and the determinants of firm growth for the present study, the estimation can be presented by the following models:

Model I

$$Firm\ Growth_{it} = B_1 (Total\ patents)_{it} + B_2 (R\&D\ intensity)_{it} + \alpha_i + \varepsilon_{it} \quad (4)$$

Model II

$$Firm\ Growth_{it} = B_1 (Total\ patents)_{it} + B_2 (R\&D\ intensity)_{it} + B_3 (Out\text{-}license)_{it} + B_4 (In\text{-}license)_{it} + \alpha_i + \varepsilon_{it} \quad (5)$$

Model III

$$\begin{aligned} \text{Firm Growth}_{it} = & B_1 (\text{Total patents})_{it} + B_2 (\text{Size})_{it} + B_3 (\text{R\&D intensity})_{it} \\ & + B_4 (\text{R\&D intensity})^2 + B_5 (\text{Out-license})_{it} \\ & + B_6 (\text{In-license})_{it} + a_i + \epsilon_{it} \end{aligned} \quad (6)$$

4. Results and discussion

In this paper, choice of the best model was based on the assumption of the Hausman Test. This test implies the presence of a significant correlation between individual specific effects and the set of explanatory variables.

According to Greene (2008), when performing the Hausman Taylor test, in order to decide between fixed or random effects, the null hypothesis being that the preferred model is random versus the alternative of fixed effects as it tests if the unique errors (u_i) are correlated with the regressors, the null hypothesis stating that they are not, we can conclude on choice of the fixed effect model, since the P-value is 0.000 (i.e., statistically significant), which is lower than 0.005.

Table 5 (Model III) shows the results of all explanatory variables on firm growth. The fixed effect model was chosen as the best, since the Hausman Test obtained the value of 18.43 for a P-Value of 0.0007, the econometric specification being specified as follows:

$$\begin{aligned} \text{Firm Growth}_{it} = & B_1 (\text{Total patents})_{it} + B_2 (\text{Size})_{it} + B_3 (\text{R\&D intensity})_{it} \\ & + B_4 (\text{R\&D intensity})^2 + B_5 (\text{Out-license})_{it} + B_6 (\text{In-license})_{it} + a_i + \epsilon_{it} \end{aligned} \quad (7)$$

The results from estimation of the static panel models are presented in Tables 3, 4 and 5 below.

Table 3 Static panel models (Model I)

<i>Dependent variable:</i> Firm growth	Random effects	Fixed effects
<i>Independent variables:</i>		
Total patents	0.1334946 (0.1780455)	-0.0275582 (0.2206556)
R&D intensity	-6.90e-08 (5.33e-06)	-0.0000357 (6.60e-06) ^{***}
Observations	5726	5726
Wald	0.59	
F		14.93
R ²	0.0001	0.0060
Hausman (x ²)	33.38 ^{***}	

Robust standard errors are presented within brackets. The Wald tests are used to test the null hypothesis of non-common significance of the parameters of the explanatory variables against the alternative hypothesis of common significance of the parameters of the explanatory variables. F tests the null hypothesis of non-common significance of the estimated parameters against the alternative hypothesis of common significance of the estimated parameters.

*significant at 10% | **significant at 5% | ***significant at 1%

As illustrated in Table 3, the results of the F and Wald tests show there are some effects of the explanatory variables on the dependent variable. Although the total number of patents has no significant effect on firm growth, R&D intensity has a negative and significant (at 1%) effect on the dependent variable. Thus, we fail to reject hypothesis H2, finding a negative although significant impact on the dependent variable. Analyzing the results obtained for the two methods, we can state that by not considering the existence of individual effects, the impact of some variables on the dependent variable, in this case R&D intensity, is undervalued, in that the coefficient of the variable increases considerably when the fixed effect model is performed.

The result obtained with the Hausman test allows us to reject the null hypothesis at 1% significance. Moreover, it points out that non-observable individual effects are not correlated with the explanatory variables. Thus, we can conclude that the most suitable method of estimation is the fixed effect method.

The next table shows the results of the estimation for Model II, adding patent transactions to Model I, either by in-license or out-license of patents.

Table 4 Static panel models (Model II)

<i>Dependent variable:</i> Firm growth	Random effects	Fixed effects
<i>Independent variables:</i>		
Total patents	0.0356484 (0.1816797)	-0.0966291 (0.2222627)
R&D intensity	-2.30e-06 (5.41e-06)	-0.0000366*** (6.68e-06)
In-license	12.03784*** (2.891837)	9.4966252*** (3.573846)
Out-license	-3.273883 (5.476571)	5.647507 (6.79571)
Observations	5726	5726
Wald	17.93***	
F		9.72***
R ²	0.0022	0.0079
Hausman (x ²)	18.43**	

Robust standard errors are presented within brackets. The Wald test is used to test the null hypothesis of non-common significance of the parameters of the explanatory variables against the alternative hypothesis of common significance of the parameters of the explanatory variables. F tests the null hypothesis of non-common significance of the estimated parameters against the alternative hypothesis of common significance of the estimated parameters.

*significant at 10% | **significant at 5% | ***significant at 1%

The results of the F and Wald tests also reveal some impact of the explanatory variables on firm growth. Despite the fact that the total number of patents and the out-license variables show no significant effect on firm growth, in-license denotes a positive and significant impact (at 1%) when considering the random effect model. Running the fixed effect model we can state that besides the positive and significant impact of in-licensing on firm growth, R&D intensity also has a negative and significant (at 1%) effect on the dependent variable. Thus, we fail to reject hypothesis H2 concerning the existence of a significant but negative effect of R&D intensity on firm growth, and we also fail to reject hypothesis H6, stating there is a positive and significant impact of patents in-license on firm growth.

The Hausman test result shows that by rejecting the null hypothesis at 1% significance, we conclude that the fixed effect method is the most suitable method of estimation.

Table 5 presents the results of the estimation for Model III, where we add firm size and squared R&D intensity to Models I and II.

Table 5 Static panel models (Model III)

<i>Dependent variable:</i> Firm growth	Random effects	Fixed effects
<i>Independent variables:</i>		
Total patents	0.0388338 (0.1817799)	-0.074706 (0.2226921)
R&D intensity	5.88e-06 (0.0000179)	0.0000599*** (0.0000218)
In-license	12.08816*** (2.897496)	9.561642*** (3.576621)
Out-license	-2.943657 (5.509136)	7.771476 (6.810741)
Size	-0.0409015 (0.0794618)	0.1083449 (0.1310199)
(R&D intensity) ²	-9.69e-12 (2.20e-11)	-1.28e-10*** (2.70e-11)
Observations	5726	5726
Wald	90,31***	
F		18.43***
R ²	0.0026	0.0050
Hausman (x ²)	18.43**	

Robust standard errors are presented within brackets. The Wald test is used to test the null hypothesis of non-common significance of the parameters of the explanatory variables against the alternative hypothesis of common significance of the parameters of the explanatory variables. F tests the null hypothesis of non-common significance of the estimated parameters against the alternative hypothesis of common significance of the estimated parameters.

*significant at 10% | **significant at 5% | ***significant at 1%

The results obtained for the F and Wald tests show a significant impact of the set of explanatory variables on the dependent variable. When using the random effect method, the results of the estimations point to a positive and significant impact (at 1%) of in-license on firm growth, although we verify the non-existence of significant effects concerning other explanatory variables. When contrasting the results obtained with the two methods, we can conclude that when not considering individual effects, the impact of some variables on the dependent variable is under-valued. In this sense, the coefficients of some variables increase considerably when we run the fixed effect model. Total patents, out-license and size show no significant impact on firm growth. Nevertheless, in-license of patents and R&D intensity show a positive and significant effect (at 1%) on firm growth. Furthermore, squared R&D intensity has a significant but negative effect (at 1%) on firm growth. We therefore fail to reject hypothesis H2 and H6 concerning the existence of a strong effect of R&D intensity and patent

in-license on firm growth, and also fail to reject hypothesis H3, which argues for a significant impact of squared R&D intensity on firm growth, since we find empirical evidence of an inverted U-shaped curve, concerning the relationship between growth and R&D intensity.

The Hausman test result shows that by rejecting the null hypothesis at 1% significance we conclude that the fixed effect method is the most suitable method of estimation.

In this paper, firms are divided into two groups according to the NACE classification corresponding to firms belonging to the high-tech sector, namely NACE 32 (firms manufacturing radio, television and communication equipment and apparatus), NACE 33 (firms manufacturing medical, precision and optical instruments, watches and clocks) and NACE 72 (knowledge-intensive service firms in the field of computer and related activities) and firms belonging to the medium high-tech sector, namely NACE 31 (Manufacture of electrical machinery and apparatus).

Therefore, the previous model was expanded with group-specific effects for the NACE classification, to provide tests for the sub-groups of firms.

Coefficients of the explanatory variables related to each of the four groups were obtained from Model III, which can be defined as follows.

$$Firm\ Growth_{it} = \sum_{b=1}^4 a_b Group_b + \sum_{b=1}^4 \sum_{c=1}^4 \beta_{bc} (explanatory\ variables_{cit}) + \varepsilon_{it} \quad (8)$$

Table 6 presents the effects of the set of explanatory variables on each of the four groups of medium high-tech firms and high-tech firms.

**Table 6 Effects of explanatory variables on firm growth by NACE classification:
Static panel model (Model III)**

<i>Dependent variable:</i> Firm growth		Fixed effects			
<i>Independent variables:</i>	Medium high-tech firms	High-tech firms			
	NACE 31	NACE 32	NACE 33	NACE 72	
Total patents	0.5398951 (1.271934)	-0.61375 (0.5928311)	0.0648638 (0.2056365)	0-1833405 (3.36721)	
R&D intensity	-6.93e-06 (0.000075)	0.0002051** (0.0000892)	1.05e-06 (0.0000159)	8.94e-06 (0.0016266)	
In-license	1.478734 (3.979211)	39.86206*** (12.85977)	-0.5130497 (2.805205)	2.156899 (17.49601)	
Out-license	0.1690885 (6.324638)	8.769738 (22.52544)	6.598083 (5.677249)	-0.2948615 (52.99631)	
Size	0.094622 (0.105214)	0.9374975 (0.6968148)	0.0426836 (0.1079569)	-0.1628666 (0.2535601)	
(R&D intensity) ²	1.23e-11 (1.32e-10)	-4.35e-10*** (1.05e-10)	-1.02e-11 (1.99e-11)	4.45e-10 (2.69e-08)	
Observations	357	1057	3626	686	
F	0.22	10.06	0.47	0.07	
R ²	0.0043	0.0629	0.0009	0.0007	

Robust standard errors are presented within brackets. F tests the null hypothesis of non-common significance of the estimated parameters against the alternative hypothesis of common significance of the estimated parameters.

significant at 10% | **significant at 5% | *significant at 1%*

Regarding the effects of the set of explanatory variables on firm growth by firm sector, and considering that in our sample of high-tech and medium high-tech sectors we have four sectors, namely 31 (Manufacture of electrical machinery and apparatus) corresponding to the medium high-tech sector of the sample, 32 (Manufacture of radio, television and communication equipment and apparatus), 33 (Manufacture of medical, precision and optical instruments, watches and clocks) and 72 (Computer and related activities) corresponding to the high-tech sector of the sample, we can conclude that for sectors 31, 33 and 72, the explanatory variables show no impact on the explained variable. On the contrary, and confirming the results obtained with the F test, which shows the impact of the set of explanatory variables on the dependent variable, for the sector of Manufacture of radio, television and communication equipment and apparatus, which is a high-tech manufacturing sector, in-license of patents shows a positive and significant effect (at 1%) on firm growth.

Additionally, R&D intensity shows a positive and significant impact on firm growth (at 5%) and squared R&D intensity has a negative and significant impact on firm growth (at 1%).

We therefore support previous considerations by failing to reject hypotheses H2, H3 and H6, finding a positive effect for H2 and H6 and a negative effect for H3.

To check if firm growth is adjusted by the effect of the set of explanatory variables under analysis and in order to contrast the results obtained through static panel estimation, we will present the results of the dynamic panel coefficients.

Considering the previously defined determinants of firm growth, the estimation can be presented as follows:

Model I

$$\begin{aligned} \text{Firm Growth}_{it} = & \gamma \text{Firm Growth}_{it-1} + \beta_0 + \beta_1 (\text{Total patents})_{it} + \\ & \beta_2 (\text{R\&D intensity})_{it} + \alpha_i + \varepsilon_{it} \end{aligned} \quad (9)$$

Model II

$$\begin{aligned} \text{Firm Growth}_{it} = & \gamma \text{Firm Growth}_{it-1} + \beta_0 + \beta_1 (\text{Total patents})_{it} + \beta_2 (\text{R\&D intensity})_{it} \\ & + \beta_3 (\text{Out-license})_{it} + \beta_4 (\text{In-license})_{it} + \alpha_i + \varepsilon_{it} \end{aligned} \quad (10)$$

Model III

$$\begin{aligned} \text{Firm Growth}_{it} = & \gamma \text{Firm Growth}_{it-1} + \beta_0 + \beta_1 (\text{Total patents})_{it} + \\ & \beta_2 (\text{R\&D intensity})_{it} + \beta_3 (\text{R\&D intensity})^2 + \beta_4 (\text{Out-license})_{it} + \\ & \beta_5 (\text{In-license})_{it} + \beta_6 (\text{Size})_{it} + \alpha_i + \varepsilon_{it} \end{aligned} \quad (11)$$

Next, we present the results of the GMM (Generalized Method of Moments) dynamic estimator for the three models under consideration. Results are presented in Table 7 below.

Table 7 GMM dynamic model for explanatory variables of firm growth

<i>Dependent variable:</i> Firm growth			
<i>Independent variables:</i>	Model I	Model II	Model III
Firm growth _{it-1}	-0.0057396 (0.017956)	-0.0084947 (0.0179368)	-0.0076616 (0.0179156)
Total number of patents	-0.016035 (0.459021)	-0.0294823 (0.4605002)	-0.204654 (0.4608675)
R&D intensity	-0.0000367*** (0.0000101)	-0.0000388*** (0.0000102)	0.0000659*** (0.0000326)
In-license		16.7088*** (6.242826)	16.50125*** (6.237478)
Out-license		4.270857 (10.48882)	5.610881 (10.50437)
Size			0.2768552 (0.2404457)
(R&D intensity) ²			-1.38e-10*** (3.99e-11)
Instruments	GMM	GMM	GMM
Observations	4090	4090	4090
Wald	13.43***	21.70***	14.35**

Robust standard errors are presented within brackets. Wald tests the null hypothesis of non-common significance of the parameters of the explanatory variables against the alternative hypothesis of common significance of the parameters of the explanatory variables.

*significant at 10% | **significant at 5% | ***significant at 1%

Taking into account the results obtained with the Wald test, for the first two models at 1% significance, and for the third model at 5% significance, we can conclude that the explanatory variables are determinants of firm growth.

The parameter measuring the impact of firm growth in the previous period on the present period's growth is not statistically significant in any of the three models.

Moreover, when applying the dynamic model we can confirm there are no significant changes to the results achieved with static panel estimations, this effect being similar in the three models under consideration.

Regarding Model I, the variable of R&D intensity has a negative and significant effect on firm growth. Therefore, we fail to reject hypothesis H2.

Concerning Model II, introduction of additional variables such as in-license and out-license does not change the overall statistical significance of the estimation when compared with the static model, as the explanatory variable of R&D intensity maintains its negative and significant effect and in-license of patents still shows a positive and significant effect on firm growth. We also fail to reject hypotheses H2 and H6.

When we add firm size and squared R&D intensity to Model III, the positive and significant effect of the independent variable of R&D intensity on the dependent variable is ratified, as happens with the negative and significant effect of squared R&D intensity. In this model we also find a positive and significant effect of in-license of patents in explaining firm growth. We still fail to reject hypotheses H2, H3 and H6.

To go somewhat deeper in explaining the effects of the set of independent variables in explaining firm growth, we expanded Model III, since it is the most complete one, with the group-specific effects for NACE classification, testing it for the sub-groups of firms. In Table 8, the coefficients of the explanatory variables related to each of the four groups are presented.

**Table 8 Effects of explanatory variables on firm growth by NACE classification
Dynamic panel model (Model III)**

<i>Dependent variable: Firm growth</i>				
<i>Independent variables:</i>	Medium high-tech firms	High-tech firms		
	NACE 31	NACE 32	NACE 33	NACE 72
Firm Growth _{it-1}	-0.0921838 (0.0848246)	-0.0173099 (0.0407389)	-0.0005099 (0.0204013)	-0.2163854*** (0.0457784)
Total patents	0.3846035 (2.807704)	-1.135208 (1.094274)	0.0226633 (0.465482)	6.084914 (48.31873)
R&D intensity	-0.0000259 (0.0001184)	0.0002936*** (0.0001344)	0.0000145 (0.000022)	-0.0004694 (0.0018125)
In-license	2.524079 (7.463831)	67.40523*** (23.08888)	0.1277929 (4.457442)	2.730327 (31.77782)
Out-license	-7.350663 (18.71642)	-2.533191 (36.10568)	6.785308 (7.653061)	-
Size	0.2836974 (0-.1919845)	3.022028*** (1.314656)	0.170622 (0.1815026)	-0.1955736 (0.4066395)
(R&D intensity) ²	4.61e-11 (2.08e-10)	-6.21e-10*** (1.62e-10)	-1.36e-11 (2.70e-11)	7.69e-09 (2.95e-08)

Observations	255	755	2590	490
Wald	3.37	19.31***	1.31	22.61***

Robust standard errors are presented within brackets. The Wald test is used to test the null hypothesis of non-common significance of the parameters of the explanatory variables against the alternative hypothesis of common significance of the parameters of the explanatory variables.

significant at 10% | **significant at 5% | *significant at 1%*

Regarding the effects of the set of explanatory variables on firm growth by firm sector and considering sectors 31, 32, 33 and 72, we can conclude that for sectors 31 (medium high-tech firms) and 33 (high-tech firms) the explanatory variables show no significant effect on the dependent variable. This result is similar to the one obtained through estimation of the static model. This finding is ratified by the Wald test results, which show a significant impact of the set of explanatory variables on the explained variable, for the sector of Manufacture of radio, television and communication equipment and apparatus (NACE 32, corresponding to high-tech firms), namely, in-license of patents which has a positive and significant effect (at 1%) on firm growth, R&D intensity which shows a positive and significant impact on firm growth (at 5% for the static model and 1% for the dynamic model) and squared R&D intensity which has a negative and significant impact on firm growth (at 1%). The only effect that is different from the static model is the one relating to the impact of size on firm growth, which in the case of the dynamic model is positive and significant. Furthermore, for the sector of Computer and related activities (NACE 72 corresponding to the sector of high-tech knowledge-intensive service firms), when performing the dynamic model the lagged variable of firm growth shows a negative and significant impact (at 1%) on the explained variable, indicating that firm growth at the present moment is impacted negatively by firm growth in the previous period for computer and related activity firms. Tables 9 and 10 provide a general summary of the results.

Table 9 Summary of significant results for static and dynamic panel models

<i>Dependent variable:</i>	Static panel estimations			Dynamic panel estimations		
<i>Firm growth</i>						
<i>Independent Variables</i>	Model I	Model II	Model III	Model I	Model II	Model III
Firm growth _{it-1}	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Total patents	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
R&D intensity	+	-	+	+	-	+
In-license	n.s.	+	+	n.s.	+	+
Out-license	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Size	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
(R&D intensity) ²	n.s.	n.s.	-	n.s.	n.s.	-

Legend: n.s.: non-significant

Table 10 Summary of significant results for static and dynamic panel models by NACE classification

<i>Dependent variable: Firm growth</i>	Dynamic panel estimations			
<i>Independent Variables</i>	Medium high-tech firms	High-tech firms		
	NACE 31	NACE 32	NACE 33	NACE 72
Firm growth _{it-1}	n.s.	n.s.	n.s.	-
Total patents	n.s.	n.s.	n.s.	n.s.
R&D intensity	n.s.	+	n.s.	n.s.
In-license	n.s.	+	n.s.	n.s.
Out-license	n.s.	n.s.	n.s.	n.s.
Size	n.s.	+	n.s.	n.s.
(R&D intensity) ²	n.s.	-	n.s.	n.s.
Wald	3,37	19,31***	1,31	22,61***

Legend: n.s.: - non-significant

5. Concluding remarks

This study uses the concept of firm growth in seeking to reveal the effects of a set of explanatory variables on its dynamics. Firm growth, as a topic of research that has been the target of several studies, was analyzed here from a different perspective, e.g., by assessing the effects of corporate R&D strategy factors based on patent transactions (such as R&D intensity, patent portfolio and patent transactions) on firm growth.

The dimension and richness of the dataset used allows us to make an unusual observation of the evolution over time of 4 different NACE sectors, namely high-tech and medium high-tech sectors in a sample of 818 firms extracted from the KFS survey containing 4928 firms, in a 6-year period.

While previous studies also focused on the role played by innovation proxies, such as R&D intensity or patent portfolios on firm growth, this paper went further, to obtain, in an innovative way, information about corporate R&D strategies based on patent transactions, in-license and out-license of patents in firms, and their impact on firm growth. In addition, the study contributes to the existent literature by gathering more information on the effects of innovation proxies on firm growth, expanding the analysis to understand this effect in the high-tech and medium high-tech sectors, where the pace of technological change is usually high and tends to shorten product lifecycle, and where firms tend to rely on their IP rights and on the early-mover effect (Tuppura *et al.*, 2010).

Our results indicate that the set of explanatory variables representing corporate R&D strategy determines firm growth. Comparing the results of the three models in static and dynamic panels, we confirm there are no major or significant changes in the results achieved.

Overall, R&D intensity appears to have a highly positive impact on firm growth, in both static and dynamic estimations. The same effect is detected in the positive and significant impact of in-license of patents on firm growth.

When we add squared R&D intensity, we found an inverted U-shaped relationship between firm growth and R&D intensity.

Our results confirm that only for the sector of Manufacture of radio, television and communication equipment and apparatus (NACE 32, which corresponds to a high-tech manufacturing sector) does the activity of in-license of external patents have a positive and significant effect on firm growth and R&D intensity has a negative and significant impact on firm growth. In addition, through dynamic estimation, the effect of firm size on growth is revealed to be positive and significant.

Furthermore, the empirical evidence obtained here reveals that for the sector of computer and related activities (NACE 72, corresponding to a high-tech knowledge-intensive service sector), the lagged variable of firm growth has a negative and significant impact on firm growth, showing a negative correlation of firm growth at the present moment with that in the previous period.

In general, our study reveals the mechanisms for patent transaction that can influence firm growth, especially when considering small, young start-ups, with an average size of 2.2 employees, created in 2004 and traced for the next 6 years. In this framework, the firm's patent portfolio does not affect firm growth, nor does firm size have a major impact on its performance, except for the latter effect in firms belonging to sector 32 relating to a high-tech manufacturing sector. Another important effect is in-license of patents which is seen to be significant and positive for firms' growth path and also their R&D intensity with particular relevance in the sector of manufacture of radio, television and communication equipment and apparatus (high-tech manufacturing sector).

Future avenues of research into the role played by patent portfolios, patent transactions and R&D intensity should include examination of different sectors, especially innovative service firms, in order to shed more light on variations of growth, R&D and intangibles across industries and business activities.

Consequently, different firms should use different approaches and strategies to improve performance and subsequently grow. For instance, for small, young firms, technology transfer activities and open innovation schemes related to the transaction of patents, especially by licensing external IP rights, can be of extreme importance in fostering growth patterns.

Of particular interest is the analysis of the relationship between growth and R&D intensity, which is characterized by an inverted U-shaped relationship, being positive and significant at an initial stage but becoming negative later on in the case of this type of start-up firm, especially high-tech and medium high-tech firms.

In terms of implications for policy makers and entrepreneurs, a topic for future debate is the spillover effect of open innovation strategies, in helping young firms to consolidate their growth path. Although having a patent portfolio at an initial phase does not impact on firm growth, it is an important factor in strengthening corporate R&D strategy. This point is also confirmed by the positive and significant effect of in licensing of external patents which proved to be a determinant of growth.

References

- Acemoglu, D., Johnson, S. and Robinson, J. (2002). Reversal of fortune: geography and institutions in the making of the modern world income distribution. *Quarterly Journal of Economics*, 117, 1231-1294.
- Acemoglu, D., Johnson, S., Robinson, J. and Yunyong, T. (2003). Institutional causes, macroeconomic symptoms: volatility, crisis and growth. *Journal of Monetary Economics*, 50, 49-123.
- Agarwal, A. (2006). Engaging the inventor: exploring licensing strategies for university inventions and the role of latent knowledge. *Strategic Management Journal*, 27 (1), 63-79.
- Agarwal, A. (1994). Socio-cultural distance and the choice of joint ventures: a contingency perspective. *Journal of International Marketing*, 2, 63-80.
- Aidis, R., Estrin, S. and Mickiewicz, T. (2008). Institutions, networks and entrepreneurship development in Russia: a comparative perspective. *Journal of Business Venturing*, 23, 656-672.
- Andersen, O. (1997). Internationalization and market entry mode: a review of theories and conceptual frameworks. *Management International Review*, 37, 27-42.
- Anderson, B. and Eshima, Y. (2011). The influence of firm age and intangible resources on the relationship between entrepreneurial orientation and firm growth among Japanese SMEs. *Journal of Business Venturing*, Available online 12 November 2011, ISSN 0883-9026, 10.1016/j.jbusvent.2011.10.001.(<http://www.sciencedirect.com/science/article/pii/S0883902611000863>)
- Anderson, E. and Gatignon, H. (1986). Modes of foreign entry: a transaction cost analysis and propositions. *Journal of International Business Studies*, 11, 1-26.
- Anton, J. and Yao, D. (2004). Little patents and big secrets: managing intellectual property. *RAND Journal of Economics*, 35 (1), 1-22.
- Ardishvili, A., Cardozo, S., Harmon, S. and Vadakath, S. (1998). Towards a theory of new venture growth. Paper presented at the 1998 Babson Entrepreneurship Research Conference, Ghent, Belgium.
- Association of University Technology Managers - AUTM (2006). AUTM Licensing survey. FY, AUTM, Northbrook, IL.
- Audretsch, D., Klomp, L., Santarelli, E. and Thurik, A. (2004). Gibrat's Law: Are the Services Different?. *Review of Industrial Organization*, 24(3), 301-324.
- Auti, E. (2007). High-growth entrepreneurship. Background paper for Imperial College, London, Roundtable on High-Growth Entrepreneurship: The Policy Challenge for Europe (<http://www.sciencebusiness.net/pdf/autio.pdf>).
- Azoulay, P., Ding, W. and Stuart, T. (2006). The impact of academic patenting on (public) research output. NBER Working Paper # 11917.
- Barney, J. (1991). Firms resources and sustained competitive advantage. *Journal of Management*, 17, 99-120.
- Barringer, B., Jones, F. and Neubaum, D. (2005). A quantitative content analysis of the characteristics of rapid-growth firms and their founders. *Journal of Business Venturing*, 20, 663-687.
- Bartelsman, E., Haltiwanger, J. and Scarpetta, S. (2004). Microeconomic evidence of creative destruction in industrial and developin countries. IZA Discussion Paper, 1374, Bonn.
- Baumol, W. (1959). *Business Behaviour, Value and Growth*, Harcourt, Brace and World, New York.

- Baumol, W. (1962). On the Theory of Expansion of the Firm. *American Economic Review*, 52, 1078-1087.
- Baumol, W. (1990). Entrepreneurship: productive, unproductive, and destructive. *Journal of Political Economy*, University of Chicago Press, 98 (5), 893-921.
- Bessen, J. and Meurer, M. (2008). *Patent Failure*. Princeton University Press. Princeton.
- Bharadwaj, A., Baradwaj, S. and Konsynski, B. (1999). Information technology effects on firm performance as measured by Tobin's q. *Management Science*, 45 (June), 1008-1024.
- Birch, D. (1979). *The Job Generation Process*, unpublished report prepared by the MIT Program on Neighborhood and Regional Change for the Economic Development Administration. U.S. Department of Commerce, Washington, DC.
- Botazzi, G., Dosi, G., Lippi, M., Pammolli, F. and Riccaboni, M. (2001). Innovation and corporate growth in the evolution of the drug industry. *International Journal of Industrial Organization*, 19, 1161-1187.
- Brouthers, K. and Hennart, J. (2007). Boundaries of the firm: insights from international entry mode research. *Journal of Management*, 33, 395-425.
- Brouthers, K., Brouthers, L. and Werner, S. (1996). Dunning's eclectic theory and the smaller firm: the impact of ownership and locational advantages on the choice of entry-modes in the computer software industry. *International Business Review*, 5, 337-394.
- Brouthers, K. (1995). The influence of international risk on entry mode strategy in the computer software industry. *Management International Review*, 35, 7-28.
- Canabal, A. and White III, G. (2008). Entry mode research: past and future. *International Business Review*, 17, 267-284.
- Canibano, L., Garcia-Ayuso, M. and Sanchez, P. (2000). Accounting for intangibles: a literature review. *Journal of Accounting Literature*, 19, 102-130.
- Caves, R.E. (1998). Industrial organization and new findings on the turnover and mobility of firms. *Journal of Economic Literature*, 36, 1947-1982.
- Champernowne, D. (1973). *The distribution of Income between Persons*, Cambridge: Cambridge University Press.
- Chandler, A. (1962). *Strategy and Structure*, Cambridge: MIT Press.
- Chang, Y., Yang, P. and Chen, M. (2009). The determinants of academic research -commercial performance: towards an organizational ambidexterity perspective. *Research Policy*, 38, 936-946.
- Coad, A. and Rao, R. (2008). Innovation and firmgrowth in high-tech sectors: A quantile regression approach. *Research Policy*, Vol. 37, Issue 4, May, 633-648.
- Colombo, M. and Grilli, L. (2010). On growth drivers of high-tech start-ups: Exploring the role of founders' human capital and venture capital. *Journal of Business Venturing*, Vol. 25, Issue 6, November, 610-626.
- Cucculelli, M. and Ermini, B. (2012). New product introduction and product tenure: What effects on firm growth? *Research Policy*, Vol. 41, Issue 5, June, 808-821.
- Cuervo, A. (2005). Individual and environmental determinants of entrepreneurship. *International Entrepreneurship and Management Journal*, 1, 293-311.
- Davis, P., Desai, A. and Francis, J. (2000). Mode of international entry: an isomorphism perspective. *Journal of International Business Studies*, 31, 239-258.
- Debackere, K. and Veugelers, R. (2005). The role of academic technology transfer organizations in improving industry-science links. *Research Policy*, 34, 321-342.
- Delios, A. and Henisz, W. (2000). Japanese firms' investment strategies in merging economies. *Academy of Management Journal*, 43, 305-323.

- Delmar, F. (1997). Measuring growth: methodological considerations and empirical results. Donckels R. and A. Miettinen (eds): *Entrepreneurship and SME Research: On its Way to the Next Millenium*, Ashgate, Aldershot, 199-216.
- Delmar, F., Davidsson, P. and Gartner, W. (2003). Arriving at the highgrowth firm. *Journal of Business Venturing*, 18, 189-216.
- Del Monte, A. and Papagni, E. (2002). R&D and the growth of firms: empirical analysis of a panel of Italian firms. *Research Policy* 32, 1003-1014.
- DiGregorio, D. and Shane, S. (2003) Why do some universities generate more start-ups than others? *Research Policy*, 32, 209-227.
- Djankov, S., La Pora, R., Lopex de Silanes, F. and Shleifer, A. (2002). The regulation of entry. *Quarterly Journal of Economics*, 117, 1-35.
- Druilhe, C. and Garnsey, E. (2001). Academic spin-off ventures: a resource opportunity approach. During, W., Oakey, R., Kauser, S. (Eds.), *New Technology-Based Firms in the New Millenium*. Pergamon, Oxford, UK, 175-190.
- Ericson, R. and Pakes, A. (1995). Markov-Perfect Industry Dynamics: A Framework for Empirical Work. *Review of Economic Studies*, 62, 53-82.
- Estrin, S. and Prevezer, M. (2010). A survey on institutions and new firm entry: how and why do entry rates differ in emerging markets? *Economic Systems*, 34, 289-308.
- Etzkowitz, H. (2003). Research groups as 'quasi-firms'? The invention of the entrepreneurial university. *Research Policy*, 32, 109-121.
- Etzkowitz, H. and Leydesdorff (1997). *Universities and the Global Knowledge Economy: Triple-Helix of University-Industry-Government Relations*. Printer. London.
- Fini, R., Lacetera, N. and Shane, S. (2010). Inside or outside the IP system? Business creation in academia. *Research Policy*, 39, 1060-1069.
- Ford, D. (1988). Develop your technology strategy. *Long Range Planning*, 21 (5), 85-95.
- Freel, M. (2000). Do Small Innovating Firms Outperform Non-innovators? *Small Business Economics*, 14(3), 195-210.
- Gans, J., Hsu, D. and Stern, S. (2002). When does start-up innovation spur the gale of creative destruction? *RAND Journal of Economics*, 33 (4), 571-586.
- Geisler, E. and Rubenstein, A. (1989). University-industry relationship: a review of major issues. Link, A. and Tassej, G. (eds.), *Co-operative Research and Development: The Industry-University-Government*. Kluwer. Boston.
- Geroski, P. (1995). What do we know about entry? *International Journal of Industrial organization*, 13, 421-440.
- Geroski, P. (1999). *The Growth of Firms in Theory and in Practice*. Centre for Economic Policy Research, n. 2092.
- Geroski, P. and Toker, S. (1996). The turnover of market leaders in UK manufacturing industry, 1979-86. *International Journal of Industrial Organization*, Elsevier, 14 (2), 141-158.
- Geuna, A., Salter, A. and Steinmueller, W.E. (2003). *Science and Innovation*. Edward Elgar.
- Gibrat, R. (1931). *Les Inégalités Économiques; Applications: Aux Inégalités des Richesses, a la Concentration des Entreprises, Aux Populations des Villes, Aux Statistiques des Familles, etc., d'une Loi Nouvelles, La Loi de l'Effet Proportionnel*, Paris.
- Godin, B. and Gingras, Y. (2000). The place of universities in the system of knowledge production. *Research Policy*, 29 (2), 273-278.
- Graham, S. and Sichelman, T. (2008). Why do start-ups patent? *Berkeley Technology Law Journal*, 23 (3), 1064-1097.

- Graham, S., Merges, R.P., Samuelson, P. and Sichelman, T. (2010). High technology entrepreneurs and the patent system: results of the 2008 Berkeley patent survey. *Berkeley Technology Law Journal*, 24 (4), 255-327.
- Greene, W. (2008). *Econometric analysis*. 6th ed., Upper Saddle River, N.J. : Prentice Hall.
- Greis, N., Dibner, M. and Bean, A. (1995). External partnering as a response to innovation barriers and global competition in biotechnology. *Research policy*, 24, 360-609.
- Hall, B. (2007). Patents and patent policy. *Oxford Review of Economic Policy*, 23 (4), 568-587.
- Handscombe, R. (1989). University intellectual property: its management and commercial exploitation. *International Journal of Technology Management*, 4, 563-585.
- Harzing, A. (2003). The role of culture in entry mode studies: from neglect to myopia? *Advances in International Management*, 15, 75-127.
- Helmers, C. and Rogers, M. (2011). Does patenting help high-tech start-ups? *Research Policy*, 40, 1016-1027.
- Henderson, R., Jaffe, A. and Trajtenberg, M. (1998). Universities as a source of commercial technology: a detailed analysis of university patenting 1965-1988. *Review of Economics and Statistics*, 80 (1), 119-127.
- Hennart, J. (1989). Can the 'new forms of investment' substitute for the 'old forms'? A transaction cost perspective. *Journal of International Business Studies*, 20, 211-234.
- Hitt, M., Hoskisson, R. and Kim, H. (1997). International diversification: effects on innovation and firm performance in product-diversified firms. *Academy of Management Journal*, 40 (4), 767-798.
- Hsu, D. and Ziedonis, R. (2008). Patents as quality signals for entrepreneurial ventures. In: *Academy of Management Best Paper Proceedings*.
- Hymer, S. (1976). *The international operations of national firms*. Cambridge, MA: MIT Press.
- Ijiri, Y. and Simon, H. (1977). *Skew Distributions and the Sizes of Business Firms*, Elsevier North-Holland, Amsterdam.
- Ittner, C. and Larcker, D. (1998). Are non-financial measures leading indicators of financial performance? An analysis of customer satisfaction. *Journal of Accounting Research*, 36 (supplement), 1-35.
- Jaffe, A. and Lerner, J. (2004). *Innovation and its discontents: how our broken patent system is endangering innovation and progress, and what to do about it*. Princeton University Press.
- Jaffe, A.B. and Lerner, J. (2001). Reinventing public R&D: patent policy and the commercialization of national laboratory technologies. *Rand Journal of Economics*, 32 (1), 167-198.
- Jensen, R. and Thursby, M. (2001). Proofs and prototypes for sale: the licensing of university inventions. *American Economic Review*, 91 (1), 240-259.
- Johanson, J. and Vahlne, J. (1977). The internationalization process of the firm - a model of knowledge development and increasing foreign market commitments. *Journal of International Business Studies*, 8, 23-32.
- Joshi, A. and Nerkar, A. (2010). Which technologies get up for sale and why? Knowledge asset recombinations as a predictors of outbound licensing. Paper presented at the Summer Conference 2010 on Opening Up Innovation: Strategy, Organization and Technology at Imperial College London Business School, June 16-18, 2010.
- Jovanovic, B. (1982). Selection and Evolution of industry. *Econometrica*, 50, 649-670.
- Kalecki, M. (1945). On the Gibrat distribution. *Econometrica*, 13, 161-170.
- Kasch, S. and Dowling, M. (2008). Commercialization strategies of young biotechnology firms: an empirical analysis of the US industry. *Research Policy*, 37, 1765-1777.

- Kenney, M and Patton, D. (2011). Does inventor ownership encourage university research-derived entrepreneurship? A six university comparison. *Research Policy*, 40, 1100-1112.
- Kimberley, J. (1976). Organizational Size and the Structuralist Perspective: A Review, Critique and Proposal. *Administrative Science Quarterly*, 21, 571-597.
- Kirchhoff, B. and Norton, E. (1992). Schumpeterian Creative Destruction versus Gibrat's Law: An examination of the Relationship between Firm Size and Growth. Paper presented at the 1992 ICBS 36th Annual World conference, Toronto, Canada.
- Klapper, L., Laeven, L. and Rajan, R. (2006). Entry regulation as a barrier to entrepreneurship. *Journal of Financial Economics*, 82, 591-629.
- Kogut, B. and Zander, U. (1993). Knowledge of the firm and the evolutionary theory of the multinational corporation. *Journal of International Business Studies*, 24, 625-646.
- Kogut, B. and Zander, U. (1992). Knowledge of the firm, combinative capabilities and the replication of technology. *Organization Science*, 383-397.
- Kosters, S. (2010). Subsidizing start-ups. Policy targeting and policy effectiveness. *Journal of Industry, Competition and Trade*, 10, 199-220.
- Krabel, S and Mueller, P. (2009). What drives scientists to start their own company? An empirical investigation of Max Planck Society scientists. *Research Policy*, 38, 947-956.
- Kultti, K., Takalo, T. and Toikka, J. (2007). Secrecy versus patenting. *RAND Journal of Economics*, 38 (1), 22-42.
- Kumar, N., and Siddharthan, N. (1994). Technology, Firm Size and Export Behaviour in Developing Countries: The Case of Indian Enterprises. *The Journal of Development Studies*, 31 (2), 289-309.
- Lach, S. and Schankerman, M. (2004). Royalty sharing and technology licensing in universities. *Journal of the European Economic Association*, 2, 252-264.
- Landry, R., Amara, N. and Rherrad, I. (2006). Why are some university researchers more likely to create spin-offs than others? Evidence from Canadian universities. *Research Policy*, 35, 1599-1615.
- Langinier, C. (2004). Are patents strategic barriers to entry? *Journal of Economics and Business*, 56, 349-361.
- Li, T. (1999). The impact of the marketing-R&D interface on new product export performance: a contingency analysis. *Journal of International Marketing*, 7 (1), 10-33.
- Lucas, R. Jr. (1978). On the size distribution of business firms. *The Bell Journal of Economics*, 9(2), 508-523.
- Luft, J. and Shields, M. (2003). Mapping management accounting: graphics and guidelines for theory-consistent empirical research. *Accounting Organizations and Society*, 28, 169-249.
- Makadok, R. (2001). Toward a synthesis of the resource-based and dynamic-capability views of rent creation. *Strategic Management Journal*, 22 (2001), 387-402.
- Makino, S. and neupert, K.E. (2000). National culture, transaction costs, and the choice between joint venture and wholly-owned subsidiary. *Journal of International Business Studies*, 31, 705-713.
- Mann, R. and Sager, T. (2007). Patents, venture capital, and software start-ups. *Research Policy*, 36 (2), 193-208.
- Mansfield, E. (1962). Entry, Gibrat's Law, Innovation, and the Growth of Firms. *American Economic Review*, 52(5), 1023-1051.
- Markman, G., Gianiodis, P., Phan, P. and Balkin, D. (2005). Innovation speed: transferring university technology to market. *Research Policy*, 34, 1058-1075.
- Martinelli, A., Meyer, M. and Von Tunzelmann, N. (2008). Becoming an entrepreneurial university? A case study of knowledge exchange relationships and faculty attitudes in a

- medium-sized, research-oriented university. *The Journal of Technology Transfer*, 33, 259-283.
- Mazzucato, M. (2000). *Firm Size, Innovation and Market Structure: The evolution of industry concentration and stability*, Edward Elgar Publishing, Cheltenham.
- Meyer, K. and Nguyen, H. (2005). Foreign investment strategies and sub-national institutions in emerging markets: evidence from Vietnam. *Journal of Management Studies*, 42, 63-93.
- Miller, K. (1993). Industry and country effects on managers' perceptions of environmental uncertainties. *Journal of International Business Studies*, 24, 693-714.
- Morbey, G. and Reithner, R. (1990). How R&D affects sales growth, productivity and profitability. *Journal of Engineering and Technology Management*, 11-14.
- Montagutti, E., Kuester, S. and Robertson, T. (2002). Entry strategy for radical product innovations: a conceptual model and propositional inventory. *International Journal of Research in Marketing*, 19, 21-42.
- Mowery, D., Nelson, R., Sampat, B. and Ziedonis, A. (2001). The growth of patenting and licensing by universities: an assessment of the effects of the Bayh-Dole Act of 1980. *Research Policy*, 30 (1), 99-119.
- Murray, F. (2004). The role of academic inventors in entrepreneurial firms: sharing the laboratory life. *Research Policy*, 3, 643-659.
- Nelson, R. and Winter, S. (1982). *An Evolutionary Theory of Economic Change*. Cambridge MA: Harvard University Press.
- Nerkar, A. and Shane, S. (2007). Determinants of invention commercialization: an empirical examination of academically sourced inventions. *Strategic Management Journal*, 28, 1155-1166.
- O'Gorman, C. Byrne, O. and Pandya, D. (2008). How scientists commercialize new knowledge via entrepreneurship. *Journal of Technology Transfer*, 33 (1), 23-43.
- O'Shea, R., Allen, T., Morse, K., O'Gorman, C. and Roche, F. (2007). Delineating the anatomy of an entrepreneurial university: the Massachusetts Institute of Technology experience. *R&D Management*, 37, 1-16.
- Owen-Smith, J. and Powell, W. (2003). The expanding role of university patenting in the life sciences: assessing the importance of experience and connectivity. *Research Policy*, 32, 1695-1711.
- Pagano, P. and Schivardi, F. (2003). Firm Size Distribution and Growth. *The Scandinavian Journal of Economics*, 105, 255-274.
- Pakes, A. and Ericson, R. (1998). Empirical implications of Alternative Models of Firm Dynamics. *Journal of Economic Theory*, 79, 1-45.
- Pan, Y. and Tse, D. (2000). The hierarchical model of market entry modes. *Journal of International Business Studies*, 31, 535-554.
- Parker, S., Storey, D. and Van Witteloostuijn, A. (2010). What happens to gazelles? The importance of dynamic management strategy. *Small Business Economics*, 35, 203-236.
- Penrose, T. (1959). *The theory of the growth of the firm*. Oxford: Basil Blackwell.
- Powers, J. and McDougall, P. (2005). University start-up formation and technology licensing with firms that go public: a resource-based view of academic entrepreneurship. *Journal of Business Venturing*, 20 (3), 291-311.
- Richardson, G. (1964). The Limits to a Firm's Rate of Growth. *Oxford Economic Papers*, 16, 9-23.
- Roper, S. (1997). Product innovation and small business growth: a comparison of the strategies of German, UK and Irish companies. *Small Business Economics*, 9, 523-537.

- Rosenbusch, N., Brinckmann, J. and Bausch, A. (2011). Is innovation always beneficial? A meta-analysis of the relationship between innovation and performance in SMEs. *Journal of Business Venturing*, 26, 441-457.
- Roth, A. and Jackson, W. (1995). Strategic determinants of service quality and performance: evidence from the banking industry. *Management Science*, 41, 1720-1773.
- Scherer, F. (1970) *Industrial Market Structure and Economic Performance*, Rand McNally College Publishing Company, Chicago.
- Schneider, C. and Veugelers, R. (2010). On young highly innovative companies - why they matter and how (not) to policy support them. *Industrial and Corporate Change*, 19 (4), 969-1007.
- Serrasqueiro, Z., Nunes, P., Leitão, J. and Armada, M. (2010). Are there non-linearities between SME growth and its determinants? A quantile approach. *Industrial and Corporate Change*, 19(4), 1071-1108.
- Shane, S. (2004a). Encouraging university entrepreneurship? The effect of the Bayh-Dole Act on university patenting in the United States. *Journal of Business Venturing*, 19, 127-151.
- Shane, S. (2004b). *Academic Entrepreneurship: University Spinoffs and Wealth Creation*. Edward Elgar Publishing Inc., MA.
- Shane, S. (2001). Technology regimes and new firm formation. *Management Science*, 47 (9), 1173-1190.
- Shane, S. and Khurana, R. (2003). Bringing individuals back in: the effects of career experience in new firm founding. *Industrial and Corporate Change*, 12 (3), 519-543.
- Sharma, V. and Erramilli, M. (2004). Resource-based explanation of entry-mode choice. *Journal of Marketing Theory and Practice*, 12, 1-18.
- Siegel, D., Waldman, D. and Link, A. (2003). Assessing the impact of organizational practices on the productivity of university technology transfer offices: an exploratory study. *Research Policy*, 32, 27-48.
- Simon, H. (1955). On a class of skew distribution functions. *Biometrika*, 52, 425-440.
- Smith, G. and Parr, R. (2003). *Intellectual Property: Licensing and Joint Venture Profit Strategies*. 2nd Edition. John Wiley & Sons, Inc., New Jersey.
- Stigler, G. (1958). The economies of scale. *Journal of Law and Economics*, 1, 54-71.
- Storey, D. (1994). The role of legal status in influencing bank financing and new firm growth. *Applied Economics*, 26, 129-136.
- Suárez, I. (1999). El análisis del crecimiento de la empresa desde la dirección estratégica. *Papeles de Economía Española*, 78-100.
- Sutton, J. (1997). Gibrat's Legacy. *Journal of Economic Literature*, 35 (March 1997), 40-59.
- Thursby, J., Fuller, A. and Thursby, M. (2009). US faculty patenting: inside and outside the university. *Research Policy*, 38 (1), 14-25.
- Thursby, J. and Thursby, M. (2003). Are faculty critical? Their role in university-industry licensing. NBER Working Paper # 9991.
- Thursby, J. and Thursby, M. (2002). Who is selling the ivory tower? Sources of growth in university licensing. *Management Science*, 48, 90-104.
- Tuppura, A., Hurmelinna-Laukkanen, P., Puumalainen, K. and Jantunen, A. (2010). The influence of appropriability conditions on the firm's entry timing orientation. *Journal of High Technology Management Research*, 21, 97-107.
- Tybout, R. (2000). Manufacturing firms in developing countries: how well they do, and why? *Journal of Economic Literature*, 38, 11-44.

- Ural, T. and Acaravci, S. (2006). The effects of firm's strategic factors on export and firm performance: a comparison of permanent and sporadic exporters. *Problems and Perspectives in Management*, Vol. 4, Issue 4, 42-62.
- Viner, J. (1932). Cost Curves and Supply Curves. *Zeitschrift für Nationalökonomie*, 3, 23-46.
- Wallmark, J. (1997). Inventions and patents at universities: the case of Chalmers University of Technology. *Technovation*, 17, 127-139.
- Wennekers, S. and Turik, A. (1999). Linking entrepreneurship and economic growth. *Small Business Economics*, 13 (1), 27-55.
- Wiklund, J., Baker, T. Shepherd, D. (2010). The age-effect of financial indicators as buffers against the liability of newness. *Journal of Business Venturing*, 25, 423-437.
- Williamson, O. (1967). Hierarchical Control and Optimum Firm Size. *Journal of Political Economy*, 75(2), 123-138.
- Williamson, O. (1979). Transaction-cost economics: the governance of contractual relations. *Journal of Law and Economics*, 22, 233-261.
- Williamson, O. (1985). Assessing contract. *Journal of Law, Economics and Organization*, 1, 177-208.
- Wright, M., Lockett, A., Clarysse, B. and Blinks, M. (2006). University spin-out companies and venture capital. *Research Policy*, 35, 481-501.
- Zhao, H., Luo, Y. and Suh, T. (2004). Transaction cost determinants and ownership-based entry mode choice: a meta-analytical review. *Journal of International Business Studies*, 35, 524-544.

Chapter 5

Should we stay or should we exit?

Unveiling a strategic decision choice for Gazelle and Non-gazelle firms.

Abstract

Gazelle firms are understood as a key agent in the role model of entrepreneurial economy based on knowledge. They are characterized by high-growth rates, turbulence and fast change, also being important 'new job-creators'. Understanding what drives the sustained growth success of such firms and predicting the determinants that can most affect their performance and survival in order to prevent exit over many years is therefore essential.

This paper investigates whether firms' characteristics like age, size, IP intensity (namely patents, copyrights and trademarks) and activity classification on one side, and founders' traits or attributes such as age, work experience, educational background and gender on the other, matter for business survival, avoiding the exit of start-up firms and especially gazelle firms. Using a Cox proportional hazard model, we estimate the hazard ratios of the included firm and founder control variables among a sample of 4928 firms created in 2004 and tracked by the Kauffman Foundation in the subsequent six years. The results show no significance of firm characteristics related to the firm's IP portfolio, especially for the case of trademarks, and firm size as determinants of survival rates.

The empirical evidence obtained reveals that a gazelle manufacturing firm, nine or more years old, is less prone to exit than a non-gazelle. Results reveal that among the founder's determinants, especially age and being male are significant determinants of survival rates, whereas work experience and education are not significant predictors of survival rates.

Keywords

Cox Regression Model; Exit; Gazelle firms; Survival.

1. Introduction

Several scholars conclude that the majority of entrepreneurs fail or exit during the first five years of activity (Parsa *et al.*, 2005; Verhoeven *et al.*, 2005; Hayward *et al.*, 2006; Meijaard *et al.*, 2007; Bangma & Snel, 2009). For instance, in the US, 34% of new ventures exit after 2 years, 50% after 4 years and 60% after 6 years (Hayward *et al.*, 2006). Another example is the case of the Netherlands where almost 50% of new ventures do not survive the first five years (Meijaard *et al.*, 2007; Bangma & Snel, 2009). In addition, van Gelderen *et al.* (2006) analyzed the factors behind success in starting and surviving a business creation. They based their study on Gartner's (1985) framework of new venture creation which concludes that start-up efforts are influenced by a set of characteristics of the founders, the firm, the environment surrounding the new venture and the process of creating a new venture. They point to the perceived risk of the market acting as a predictor of starting the firm versus exiting or simply abandoning the start-up creation effort.

Stam & Wennberg (2009) studied the effects of initial R&D on firm growth, defending that this can stimulate new product development at a later stage in the lifecycle of high-tech firms. Conversely, R&D is not supposed to affect the growth rate of new low-tech firms, only being a stimulus to a limited group of new high-tech and high-growth firms which are extremely important when considering innovation and entrepreneurship policies.

Recent studies on firms' performance, focusing on high-growth firms, state that a set of determinants play a central role in their survival, such as the capacity to adapt quickly in the turbulent environment of fast technological change where "gazelles" operate and develop exit strategies adjusted to this capacity, opting for routes like mergers and acquisitions (M&A), joint-ventures, etc., instead of closing (Klepper & Simons, 2005; Wieser, 2005; Coad & Rao, 2008). In addition, Baptista & Karaoz (2011) show that the process of replacing exiting firms with subsequent entrants is a factor of turbulence in high growth markets. In turn, the incumbents' displacement by new entrants is understood as the main selection force when focusing on declining markets.

These firms are responsible for most net new job generation. They are fast-growing and have an important role in the current economy, creating a lever for economic growth and real convergence.

This paper aims to analyze a set of factors that act as predictors regarding the exit rate of start-up firms (gazelles and non-gazelles), focusing on firms' characteristics and owners' attributes.

The importance of studying the predictors of exit and understanding what determines firm survival rates has been a topic of analysis for researchers such as Stuart *et al.* (1999), Baum

et al. (2000), Cohen *et al.* (2000), Gans & Stern (2003), Gulati & Higgins (2003), Ziedonis (2004), Audretsch & Lehman (2005), Colombo & Grilli (2005), Cefis & Marsili (2007), Mann & Sager (2007), Srinivasan *et al.* (2008), Wennberg *et al.* (2010), Grilli (2011) and Medrano (2012), among others.

In this context, and in line with the objectives of the present work, authors like Stuart *et al.* (1999), Baum *et al.* (2000), Cohen *et al.* (2000), Gans & Stern (2003), Gulati & Higgins (2003), Ziedonis (2004), Audretsch & Lehman (2005), Cefis & Marsili (2007), Srinivasan *et al.* (2008) and Medrano (2012) analyzed the determinant factors associated with firms' characteristics, namely the relationship between exit and firms' IPR portfolio and R&D intensity. Others focused on determinants like age (Klepper, 1996; 1997; Sorensen & Stuart, 2000; Agarwal & Gort, 2002; and Medrano, 2012) and size and their impact on the exit strategy (Dunne *et al.*, 1989; Audretsch & Mahmood, 1994; Mata & Portugal, 1994; Mitchell, 1994; Haverman, 1995; Sharma & Kesner, 1996; and Manjón-Antolín & Arauzo-Carod, 2008). Besides age and size, Serrasqueiro *et al.* (2010) and Nunes *et al.* (2012) state that liquidity and long-term debt present a positive correlation with profitability, specifically for young SMEs rather than old ones, and risk is considered a threat to the profitability of young SMEs. Furthermore, R&D expenditure is positively correlated with profitability in old SMEs.

Other authors focused on the effects of specific attributes regarding entrepreneurs/founders' characteristics on exiting and on opting for an exit strategy (Wennberg *et al.*, 2010).

Colombo & Grilli (2005) and Grilli (2011) point out that the entrepreneur's previous professional experience is related to the exit rate and the option of exiting through merger and acquisition.

Previous studies have also focused on business exit, market exit and CEO succession, analyzing mainly large publicly traded companies (Wasserman, 2003), using different approaches from economics, strategy and corporate finance, in order to assess the financial impact on firms, especially in terms of stock price or market share (Shen & Cannella, 2002).

However, it seems a branch of the literature remains little explored, that of how the founders of gazelle firms decide to exit and which exit strategies they adopt. This paper attempts to fill the caveat found in the literature, by analyzing the determinants of exit and the survival rates for "gazelle" and "non-gazelle" firms.

The paper makes several specific contributions to the literature on determinants of exit at two distinct levels, namely firm characteristics and owner attributes and also provides policy implications to prevent the exit of "gazelle" and "non-gazelle" firms.

The paper is organized as follows. Section 2 develops the theoretical underpinnings, drawing on the literature on exit, reviewing exit modes, uncovering the determinants of market exit and assessing the major impact of these determinants on “gazelle” and “non-gazelle” firms. Section 3 presents the empirical approach and discusses the results. Finally, Section 4 concludes and provides policy implications as well as guidelines for entrepreneurs and practitioners in the framework of technological entrepreneurship, namely managers of business incubators and science and technology parks.

2. Literature survey and research hypotheses

2.1 Exit as determinant of the entrepreneurial process

According to Cefis & Marsili (2011), a high percentage of new firms exit in the first years of activity. About 50% of start-ups exit before the fifth year and only a third survive beyond the tenth year of activity. Freeman *et al.* (1983) and Headd (2003) state that entrepreneurial firms opt to exit, not necessarily as a sign of failure, but rather as an exit strategy.

The process of entry and exiting a business is considered to have a major impact on industry and the economy and can be determined by firm-specific, industry-specific, country-specific or spatial factors. Other determinant factors are founded on the individual characteristics of the entrepreneur (Hessels *et al.*, 2011).

Haveman & Khaire (2004) state that exit can bring positive implications for the firm regarding new sources of capital, new resources and renewed energy, made possible through an acquisition or an IPO (initial public offering).

DeTienne (2010) defines entrepreneurial exit as the process by which entrepreneurs leave the firm they created, giving up primary ownership and the decision-making structure of the firm. Accordingly, the author focuses on exit considering each phase by exploring the development of an exit strategy, the reasoning behind exit and the set of options available. He analyzes ownership (at the level of equity and the psychological effects of ownership) as a determinant of the decision to exit.

Several modes of exit are analyzed in the previous literature, such as market exit, technological exit and firm exit (Decker & Mellewigt, 2007).

While many scholars devote their studies to the exit strategies from the firm perspective, DeTienne (2010) intends to focus on the level of the entrepreneur himself, trying to understand the major determinants of the decision to exit. Understanding the entrepreneur's

motivations, feelings and points of view is the basis for understanding the entrepreneur's choices, including the choice to exit the firm he founded (Sarasvathy, 2004).

Wasserman (2003) distinguishes entrepreneurs in privately held firms from those in publicly traded ones, since the former tend to retain greater ownership and tend to rely on a more centralized decision-making process, retaining a high percentage of control over decisions made in the firm. On the other hand, publicly traded firm entrepreneurs do not retain the same control over the firm's decision-making system.

According to Gimeno *et al.* (1997), by applying the 'Threshold Theory' to entrepreneurial exit, the entrepreneur's mindset and perceptions regarding exit might take into consideration determinant factors other than the harvested value, that is, the total pay-off for exit, including variables like exit speed or exit quality (e.g. acknowledgement that the firm will survive or that employees will be retained).

Being of major importance for the entrepreneur, the exit process concerns not only the strategy to collect the highest possible benefits when dealing with firm closure or liquidation. The process has deep psychological effects on the founders, since they devote great personal efforts to identifying the business opportunity and developing it in order to create a solid firm, sacrificing time, money and energy (Dodd, 2002; Cardon *et al.*, 2005). Several scholars focused on the positive and negative implications of exit by the founder. For instance, Haveman & Khaire (2004), argue that some positive effects of this process include the infusion of more resources, capital sources and renewed energy. Wasserman (2003) and Boeker & Wiltbank (2005) state that when the founder is replaced by a skilled management team, the firm will also benefit from improved competences in order to achieve a better position and greater economic return. Aldrich (1999) also focused on the benefits of expanding into new business areas. In turn, and regarding the negative impacts of the founder's exit, Haveman & Khaire (2004) point out the slowing down of the firm's performance, especially due to changes in work routines and employee insecurity.

Other studies focused on the impacts of entrepreneurial exit on industry, such as the effects of initial public offerings (Akhigbe *et al.*, 2003a), the competitive effects of privately held acquisitions (Akhigbe *et al.*, 2003b) and the industry effects of acquisition (Otchere & Ip, 2006).

In the view of Mason & Harrison (2006), entrepreneurial exit can impact on regional economic development, since exiting entrepreneurs are more able to engage in new venture creation, spread the technological knowledge base or act as business angels, strengthening the innovative 'milieu' of the local economy.

Table 1 summarizes the literature on the main studies focused on exit.

Table 1 Theoretical approaches to exit

AUTHORS	RESEARCH QUESTIONS
Hofer & Charan (1984)	The transition process from one founder to a skilled management team can be a potential hazard for the survival of the firm.
Ronstadt (1986)	The age of the entrepreneur is correlated with the success of the firm's creation and its survival process. Entrepreneurs who start early (as opposed to those who only start after experiencing a career as an employee) are more likely to succeed in the venture process since they are more likely to undertake firm creation and growth as a life condition. The author finds evidence of the importance of the when, who and why motives for exiting in understanding the exit processes.
Holmberg (1991)	Founders' major reactions towards harvest strategies at three critical stages: enterprise start-up; immediately prior to IPO and after IPO.
Birley & Westhead (1993)	Examined five exit routes and concluded that privately advertised sales were the most frequently used exit route.
Petty <i>et al.</i> (1994,a;b)	Studied the importance of harvest planning and timing and the implications of exit for the founder and the firm.
Rubenson & Gupta (1996)	Studied the initial succession.
Petty (1997)	The effectiveness of the exit strategy is a determinant of the value achieved from the venture.
Engel (1999)	Deals with the need for entrepreneurs to maximize the value of exit.
Butler <i>et al.</i> (2001)	Analyzed family member succession as the most likely outcome.
Boeker & Karichalil (2002)	Founder departure is determined by firm size, founder ownership, board membership and founder involvement in R&D activities.
Minor (2003)	Founders are not able to deal with the emotional implications of exit.
Wasserman (2003)	Studied the relationship between founder-CEO succession and completion of product development and each financing round.
Haveman & Khaire (2004)	Analyzed the ideology as a moderator between founder succession and firm failure.
Prisciotta & Weber (2005)	Financial measures such as increasing the liquidity of the firm to support its growth.
McGrath (2006)	Analyzed 3800 exiting firms and strategies, namely moves, strategic decisions of parent firms, mergers and acquisitions, and personal choice.
Leroy <i>et al.</i> (2007)	Determinants of exit outcomes, namely entrepreneur characteristics, business and industry variables.
Wennberg (2008)	Explores entrepreneurial exit as a multi-faceted and multi-level phenomenon.
DeTienne (2010)	Focus on exit at each phase by exploring the development of an exit strategy, the reasons for exit and the options available. Analyzes ownership (both equity and psychological effects) as a determinant of the decision to exit.
Wennberg <i>et al.</i> (2010)	Impact of human capital on exit strategies.
Amaral <i>et al.</i> (2011)	Levels of general and specific human capital and their effect on re-entering entrepreneurship over time, in a different firm, becoming serial entrepreneurs.
Grilli (2011)	Analyzes the relationship between the previous professional experience of entrepreneurs and exit strategy.
Hessels <i>et al.</i> (2011)	Explores whether and how a recent entrepreneurial exit relates to subsequent engagement.
DeTienne & Cardon (2012)	Determinants of the exit decision, using the theory of planned behavior, namely the previous experience of founder.

DeTienne (2010) distinguishes between small business founders, who create firms as survival mechanisms and entrepreneurial founders who are focused on growth. The latter are more likely to develop and plan an exit strategy. For them, in the infancy phase of the firm, the founder's high equity ownership, along with less pressure from other constituents (investors and/or venture capitalists), makes entrepreneurs more focused on day-to-day issues, such as finding a location, filling in the necessary paperwork, applying for IP protection, etc., rather than long-term strategic issues such as entrepreneurial exit. The author also suggests that some factors, like the filing of a provisional patent at such a stage of the firm's lifecycle can help the entrepreneur by adding value to the firm, thus keeping the decision of exiting away. These factors correspond to calculative forces (e.g. the chance that individuals will be able to achieve their goals).

Halldin (2012) focused on the survival of firms born globally and the extent to which employee characteristics matter for their survival rate, concluding that education has a positive and significant effect on survival rates.

According to Wennberg *et al.* (2010), the entrepreneur's exit can assume two modes, namely a career choice and liquidation of a financial investment. These perspectives are linked to two theoretical perspectives. On one hand, the expected utility perspective explores career choices, from an occupational choice approach, for instance the option between employment and self-employment which is understood as a matter of decision that aims to maximize returns regarding education. On the other hand, behavioral finance research on investment liquidation is not directly correlated with utility-maximization. This perspective is based upon the reasoning that financial gains and losses vary according to a reference point, in the sense that the utility loss from suffering a loss of a certain size can be bigger than the utility gain from achieving a gain of the same size. Additionally, the marginal utility of gains and losses decreases according to the size of the gain or loss. This approach is important in explaining exit decisions when evaluating firms' economic performance.

2.2 Exit strategies and firm context

The theoretical background on exit has been generally focused on financial conditions that determine the exit strategy. Previous studies analyzed different exit strategies dependent on a set of financial and personal constraints, namely IPO, strategic sale and buyout by Venture Capital Funds.

DeTienne & Cardon (2008) consider IPO, the first route, as the most risky exit strategy, since it involves selling shares and getting a position on the stock market and also, as defended by Higgins (2009), succession performance is subject to rigid financial constraints set by financial

institutions. Nevertheless, Babich & Sobel (2004) state that the IPO route is the exit strategy where high-tech entrepreneurs can benefit from highest financial returns.

The second route deals with strategic sale of the firm where the buyer can be a competitor. According to Haunschild (1994), this type of exit strategy can be financially interesting to the entrepreneur in order to achieve high revenue from the sale, with the competitor being willing to pay a premium on the possible synergies he can create in having both companies and in exploring the additional assets bought with the firm. Despite this set of benefits, as argued by Pepper & Larson (2006), strategic sale can be a difficult process since finding the strategic fit, as the synergies are also called, can be hard and depend upon commitment, organizational culture, trust and the symbolic impact of timing.

The third route is related to the buy-out of Venture Capital Funds. These funds present considerable financial sources and in good performance conditions, by placing skilled people to manage the new firms, are expected to bring successful performance standards. These funds are dedicated to criteria other than the previously mentioned synergies, such as the entrepreneur's profile, previous experience, characteristics of the technology and/or service, target market and financial scenarios (MacMillan, 1985). Since the ultimate goal of the Venture Capitalist is to obtain high revenue on the investment, the founder can opt for other exit strategies, such as selling to a private buyer or IPO.

For firms that intend to exploit their specific or technological assets such as patents by exiting, sale or mergers and acquisitions can be a viable strategy (Gans & Stern, 2003). According to these authors, for new ventures owning patents or other related IP rights, these can work as valuable drivers to capture economic return, either by competing in the market through commercialization of the patents as products, or by selling them to competitors or even by exploiting the assets via licensing agreements. Furthermore, young firms, in the absence of available resources to support the costs of patenting, choose to use these assets to trade technology with competitors or by selling the entire company.

In the view of Cefis & Marsili (2007), entrepreneurial firms tend to use innovation practices to support the exit process. Additionally, they tend to exit by choosing the strategy of mergers and acquisitions, this being more applicable to firms innovating products than those innovating processes.

According to the prospect theory, which helps to understand the differences between firms presenting high performance standards and those with poor performance, high-performance firms are expected to exit in a gain situation, therefore performing above the reference point. As for low-performance firms, a loss situation is expected, since they perform below the reference point.

Kyle *et al.* (2006) analyzed the external contextual events that force the investor to liquidate and proposed a model that takes these exogenous conditions into consideration. This model suggests that in gain situations, investments are rapidly converted into cash, although in loss situations liquidation is postponed.

Thus, exit in the form of sales or liquidation is supposed to occur either in winning or losing situations. In the case of a losing pattern of sales or liquidation, this reflects poor performance. When delaying loss situations, exogenous forced events, such as bankruptcy, are associated with poor performance liquidation.

In both high-performance and lowperformance situations, and from the perspective of the reference point, Wennberg *et al.* (2010) present the following four types of exit routes: (i) harvest sale of a profitable business, which is considered by Certo *et al.* (2001) as being one of the goals of new venture creation, where the search for wealth and the sale of a firm that performs well is a good investment for the entrepreneur who, by selling the business, can collect the outcomes of the venture and allow the firm to survive; (ii) distress sale of a firm in a situation of financial distress, which is supposed to occur when the entrepreneur understands that the firm is performing below equilibrium conditions and sale of the business is the best solution to avoid bankruptcy or liquidation (Birley & Westhead, 1993; DeTienne & Cardon, 2006); (iii) harvest liquidation of a profitable business occurs when the firm in a profitable situation closes and the capital involved is distributed among the owners and investors, usually being triggered by divorce, career change or retirement of the entrepreneur(s), desire of expediency, aging or obsolescence of technology or inability to find a strategic buyer; and (iv) liquidation of a firm under financial distress, as pointed out by Pretorius & Le Roux (2007), which corresponds to a failure situation, usually leading entrepreneurs to inject additional equity into the firm in order to avoid bankruptcy, opting for liquidation by selling the assets and paying the creditors.

DeTienne (2010) stresses the link between the firm's lifecycle and the exit strategies pursued by the entrepreneur. This author claims that exit strategy depends on the stage of the entrepreneurial process the firm is passing through. Therefore, exit can take place at any phase of the process. Rather than an additional stage, it is considered to be a part of each stage of the firm's lifecycle.

The same author also points out the need to develop an exit strategy while the firm is passing through every phase of existence, and this should be planned at the initial stage when the entrepreneur has greater freedom. Moreover, as defended by DeTienne & Cardon (2008), the plans and decisions made at the initial stage will have a determinant role in the development of the firm and also in the success of the exit process.

Cardon *et al.* (2005) stress that not every entrepreneur takes the decision to exit based on financial premises. The type of entrepreneurship he defines as being a way of life is based on foundation decisions linked to ideologies. In this line of reasoning, the entrepreneur is not supposed to choose an exit strategy based on selling. He is not even supposed to have developed an exit strategy, being expected to pass the company to a relative. Cardon *et al.* (2005) also refer to the decision of the founder not to abandon the company, and to hand over the control process to more skilled people, this being a valid exit route. This is supported by Robbins (2010), who defines the entrepreneur's lifestyle as having only one goal, that of making enough money to support the lifestyle he is used to. This entrepreneur is not worried about the right strategy to exit.

2.3 Determinants of exit

Esteve-Pérez *et al.* (2010) state that with firm exit being part of the evolutionary path of an industry, firms can exit in several ways, through bankruptcy, voluntary liquidation or merger and acquisition. Each type of exit strategy is caused by a different set of determinants. Nevertheless, exiting from the market does not imply a sign of failure, since while still profitable, firms can opt to merge with other firms or voluntarily close the business.

The same authors analyzed a set of determinant factors of exit, regarding the exit route. On one hand, the risk of liquidation decreases with size, also being lower for medium-aged firms. The probability of liquidation is lower with increased labour productivity, R&D and advertising activities. The latter two determinants did not reveal a significant relationship with the exit strategy.

Chang (2011) examined how industry-specific characteristics are correlated with entry and exit patterns. He argues that rates of entry are positively correlated with the industry price-cost margin and, in turn, exit rates are negatively correlated with industry price-cost margin. Firms' exogenous and endogenous features are also correlated with exit rates, namely fixed costs, the industry's market size and firms' capacity to adapt to the turbulent technological environment, such as the rate of change in technological environments and firms' propensity to innovate. The same author focused on closedown exits but did not analyze alternative routes like moving to another market or business area or transferring capacity to another industry. Considering these alternative strategies, it can be relevant to study the relationship between exit and a set of determinant factors related to firms' innovation practices.

Other authors devoted their attention and research efforts to the analysis of founders' specific characteristics, which are also linked to entry and exit patterns. In this connection, according to DeTienne & Cardon (2008), the set of decisions made by high-tech firms depend

upon several personal traits of the founders, namely their intentions, motivations and educational background. In this sense, the exit strategies adopted by these entrepreneurs are influenced by their cognition and knowledge. Intentions are related to entrepreneurs' future goals, being developed in the stages of firm conception and gestation. Among the theories regarding intentions, two stand out, the theory of planned behaviour developed by Ajzen (1991) and Shapiro's theory of Entrepreneurial Events (Shapiro & Sokol, 1982). The former explains entrepreneurial intentions based on subjective norms and perceived feasibility. The latter concerns the attitude towards the act, i.e., the entrepreneur's desire to perform the behavior and start the business. Krueger *et al.* (2000) compare both theories to explain the intention of performing in an entrepreneurial way and conclude that subjective norms are not significant in explaining entrepreneurial intention.

Motivation is linked to the set of norms, values and core reasons at the basis of the decision to create a business, also being part of the exit decisions. Based on the Theory for the Need of Achievement (McClelland, 1961), motivation has become a determinant of entrepreneurship in the sense that it involves high levels of responsibility, the capacity to deal with risks and the need to receive feedback and follow-up on performance. Motivation is an important factor in the decision to start a venture and also to exit from it (DeTienne, 2010). Therefore, an entrepreneur will have different exit strategies according to different motivations. In addition, motivation, enthusiasm and human capital factors are key determinants of the entrepreneur's intuition and orientation towards innovating activities, allowing the firm to reach improved performance standards (Leitão & Franco, 2010).

The educational background of the entrepreneur has to do essentially with the entrepreneurial education followed by the firm owner, and if he has a deeper understanding of firm processes, this will affect the decisions and strategies developed to exit. Halldin (2012) also advocates that employees' characteristics determine firms' survival rates, especially regarding their educational backgrounds.

Current literature focuses on considerations of theoretical background relating to 'Human Capital Theory' (Becker, 1964), the entrepreneur's decision to create a business and his efforts to keep it alive and avoid exit. Thus:

H1: Educated founders are expected to make firms survive for longer.

Several scholars defend a positive and significant relationship between the entrepreneur's previous entrepreneurial experience and the survival rate, this decreasing the probability of exiting and increasing the chances of success (Taylor, 1999; Ucbasaran *et al.*, 2003; Politis, 2005). Repeat entrepreneurs are more likely to have more personal financial resources to

invest or re-invest, greater access to external financial support and are more able to create new businesses with higher growth potential (Colombo & Grilli, 2005). In the view of Tyebjee & Bruno (1984), experienced entrepreneurs are more able to develop high performance ventures and to plan and proceed to more efficient exit strategies.

In the study by Wennberg *et al.* (2010), the authors conclude that experienced entrepreneurs will choose among exit routes the harvest sale strategy as the best way to benefit from the exit situation, since they are more able to create value and to harvest this value.

Regarding age, the same study reveals that this variable is not such a determinant of the set of skills, that is, the entrepreneur's ability, but is a determinant of his willingness to exit, especially through the harvest sale. When considering education, the study points to an interesting conclusion, namely the higher the level of education the greater the tendency to exit by means of distress liquidation. The authors justify this pattern by the high levels of confidence in this type of entrepreneur, who are reluctant to accept failure and delay the firm's closure. The relationship between exit and taking an outside job is confirmed, since this works as a means of reducing costs and avoids liquidation.

The exit process can also work as an entrepreneurial learning process reflecting the concept of entrepreneurial engagement. This concept relates to a process including diverse levels of engagement, such as intentions to establish a firm or start-up activity (Grilo & Thurik, 2005; 2008).

Westhead *et al.* (2005) argue that serial entrepreneurs have the capacity to enter and exit repeatedly, acting as key drivers for the economy and industry, due to their previous experience and external learning spillovers. The authors also suggest that serial entrepreneurs are more prone to enter a new business after exiting another due to additional skills and knowledge achieved in previous experiences. Thus:

H2: Experienced founders are expected to make firms survive for longer.

For other authors (Wagner, 2003; Schutjens & Stam, 2006; Stam *et al.*, 2008; Amaral *et al.*, 2011), education, age and gender are significant determinant factors explaining exit and subsequent reengagement in the entrepreneurial process, with highly educated, young males being those most likely to reengage in entrepreneurial activity after a previous exit. On the contrary, Amaral *et al.* (2011) reveal that education is not so deterministic as age or gender, highly educated individuals being more likely to delay reengagement.

Landier & Thesmar (2009) introduce the concept of the stigma of failure, this being converted in additional capacities and likely reentry following exit. This model deals with the fact that entrepreneurs choose to continue or abandon a project and raise funds to proceed with a new project. In addition, the authors defend that repeat entrepreneurs, sequential and portfolio entrepreneurs with prior business experience, are more optimistic than novice entrepreneurs.

Hessels *et al.* (2011) point to a significant relationship between entrepreneurial exit and subsequent recognition of new opportunities, acquiring additional skills and increased potential with the intention to get involved in a new venture. Additionally, the fact of an entrepreneur being male, knowing another entrepreneur, having informal investor experience and the fear of failure are determinant factors of entrepreneurial reengagement following recent exit. Thus:

H3: Older founders are expected to make firms survive for longer.

H4: Male founders are expected to make firms survive for longer.

Grilli (2011) analyzed the relationship between the human capital of the founder and the exit process in a context of intense negative industry-specific crisis. The econometric analysis provided empirical evidence that during a severe industry crisis (that is, early 2000 to 2003), entrepreneurs with a substantial amount of prior work experience may pursue an exit strategy. The study suggests that founders with highly specialized work experience and know-how tend to opt for specific exit routes such as mergers and acquisitions, rather than business closure which is more common in entrepreneurs with a higher level of general work experience.

2.4 What drives gazelle and non-gazelle firms to exit?

Srinivasan *et al.* (2008) state that new firms have an important role in job creation both in the US and in Europe, these being responsible for over 70% of net new jobs in the former and about 40% in the latter in the 1990s (Bednarzik, 2000). Besides, in the US, new firms have owned more than 67% of all innovations and 95% of radical innovations since World War II (Kauffman Center for Entrepreneurial Leadership, 1999). Regarding exit rates, US firms range from 62% in the first six years to 90% in the first ten years. Although entrepreneurial activity is lower in Europe than in the US, Europe has twice the failure rate.

At this point, it is interesting to reflect on the concept of these high-growth firms. The “gazelles” concept was introduced by Birch (1979) relating to a small group of high-growth

firms responsible for creating most of the net new jobs in the economy, contrasting with the few large companies, the so-called “elephants”, which generate a large employment share, although few of these jobs are new. Another type of firm is termed as “mice”, describing firms that grow very slowly and remain small, contributing only marginally to employment growth.

For this study, it is important to take the definition of “gazelles” somewhat deeper. Birch *et al.* (1995) defined this type of firm as being companies that achieved a minimum of 20% sales growth each year over the interval, starting from a base-year revenue of at least \$100,000. This concept is related to the fact that these companies grow at a specific pace, showing a particular annual growth rate or more for a certain number of years. For the authors, this kind of firm is neither small nor large. They tend to be evenly balanced, allowing them to produce great innovation and rapid job growth.

Delmar *et al.* (2003) defined the concept by developing 19 measures associated with growth and sources of variability. These sources cover metrics like sales, employment and profitability, or subjective assessments by the owners. Another important issue in defining “gazelles” concerns fast growth. Regarding sales, for instance, the norm is to consider 20-30% per annum as a minimum. As for time, the period over which fast growth is achieved is taken into consideration. Some studies use a three-year period as a reference, others consider the importance of a ten-year lifespan. Furthermore, it is important to consider whether fast growth will be achieved every year or if it can fluctuate and so consider the mean for the period under consideration (Delmar *et al.*, 2003; Garnsey *et al.*, 2006). On average, these firms grow very rapidly on their first years, followed by decline or by a considerable slowing-down of growth rates (Hull & Arnold, 2008).

Parker *et al.* (2010) stress the importance of understanding the consistency of growth, if sales growth should be organic or achieved by acquiring other businesses.

Bishop *et al.* (2009) also state that this type of fast-growing firm, although more concentrated in technologically sophisticated sectors, can be found in other sectors. This is the case in the UK where only about 7% of “gazelles” are from high-tech sectors.

Henrekson (2008) argues that “gazelles” are responsible for generating the majority of new jobs, being on average younger and smaller than other firms, but not necessarily so, young age being more of a determinant than size for new job creation and rapid growth.

According to Ahmad (2006), the OECD defines “gazelles” as young (less than five years old), high-growth firms, characterized by an average employment growth rate above 20 percent per year over a three-year period and with 10 or more employees at the start of the period.

Acs *et al.* (2008) argue that new establishments of firms with 20 to 499 employees or new firms of this size show a positive effect on job creation, which increases after one year, reaching a maximum after five years before decreasing again. Gazelle-firms tend to increase their productivity levels rapidly after entry due to their size and specific characteristics. These firms are able to challenge existing firms and foster competition with other established firms. Furthermore, they have lower exit rates. Thus:

H5: Gazelle firms are expected to survive longer than non-gazelle firms.

Being a gazelle-firm is a temporary condition in the firm's lifecycle, as explained by Hölzl (2009), due to the patterns these firms follow, since some settle down to remain SMEs, while others become large firms, and others fail and exit.

Authors such as Wieser (2005) or Coad & Rao (2008) argue that innovation plays a key role in these high-flyer firms. Gazelle-firms tend to be more productive and also grow faster than non-innovators.

According to Klepper & Simons (2005), "gazelles" are part of a set of firms showing a fast rate of growth and which in the presence of shakeouts typical in growing industries, instead of just closing down, exit preferentially towards mergers and acquisitions. Gazelles are considered to be innovative in a Schumpeterian way since they create new markets and jobs while destroying others. These firms tend to replace incumbent firms using competitive advantage in the form of technological and organizational innovation.

This paper aims to develop an analysis of these high growth firms, in order to understand whether their exiting behavior is determined by a set of firm and founder factors affecting their survival rate.

According to Storey (1994), a set of factors can influence the corporate strategy implemented by this type of firm. On the one hand, the pre-start characteristics of the business (those related to the founders/owners) and factors related to the industry's characteristics, such as sector, location, innovation performance, IPR portfolio and legal form, and on the other hand, the post-start characteristics of the business (e.g., its market strategy over the firm's lifecycle, which can include exit strategies).

In terms of previous investigation regarding the exit of these firms, there has been much study of the entrepreneur's characteristics and of economic factors that play a role in the strategies chosen, but little attention has been paid to the role of IPR as quality signals for technology-intensive new ventures at the stage of liquidation or successful exit.

The relationship between firm lifecycle and innovation intensity is relevant in explaining exit rates (Klepper, 1996, 1997; Medrano, 2012). At the first stage, that of exploration, the intensiveness of product innovation is extremely important. At the second, that of growth, the risk of failure is higher, associated with higher rates of market growth and lower intensity in terms of product innovation, which tends to slow-down. At the third stage, of maturity, market entry is rarer, market position is stable and process innovation is of vital importance.

Klepper (1997) stated that the existence of inter sub-market spillovers responsible for generating the innovative sub-products needed for certain industry niches is important to prevent firm exit, the study of innovation in firms' formative stages being relevant to relate the innovation rate (measured through patent citation counts) to firm survival.

Audretsch & Lehmann (2005) analyzed the young, high-tech firms listed in the German Neuer Markt and concluded on a positive correlation between highly cited patents and exiting via merger and acquisition, suggesting that high quality patents signal valuable intangible assets and knowledge intensity.

Buddelmeyer *et al.* (2010) state that although firms compete through developing new technologies, innovation brings serious risks and can increase the likelihood of exit. Hence, the degree of uncertainty embodied in different innovation proxies used to measure innovative capacity can shape the patterns of firm survival.

Recent studies focused on the determinant effect of firms' innovative behavior and the evolution of firms' survival rates (for instance, the study by Cantner *et al.*, 2011, which analyzed the historical evolution of the German automobile industry regarding its innovative performance) and the effects of high-quality patents (measured by forward citations and international patents filed) on the survival rate of US internet-based and software firms between 1998 and 2003 (Wagner & Cockburn, 2010).

In terms of exit routes via dissolution or acquisition, Srinivasan *et al.* (2008) do not find a direct relationship between exit strategy and diversification of a firm's product-market portfolio. Thus, the greater the diversification of the firm's portfolio combined with more patents the shorter the time to dissolution, while the combination of greater diversity with more trademarks reveals a tendency to lengthen the time to dissolution, revealing that the firm is pursuing a strategy of organic, internal growth, fighting against acquisition. The authors also state that a more diversified patent portfolio tends to shorten the time to acquisition, diversity of trademarks being associated with a shorter time to acquisition.

In this vein, increasing the diversification of new firms' product-market portfolios (either in patents or trademarks) can be a signal of these firms' openness to early acquisition. The study also concludes that a firm aiming to pursue sustainability through organic growth,

implements a corporate strategy based on a narrower product-market portfolio. On the contrary, if the firm intends to expand its product-market portfolio, it is important to develop a leveraged strategy between trademarks, rather than the set of patents, in order to secure sustainable survival.

In the view of Hsu & Ziedonis (2007), the entrepreneurial process can also be influenced by the intangible assets owned by the entrepreneur. In this sense, patents enable the entrepreneur to acquire financial resources over the different stages of the firm's lifecycle, including the exit stage.

For instance, according to Hsu (2004), Hochberg *et al.* (2007) and Hallen (2008), each patent application filed by new firms increases the attraction of initial funding from prominent venture capitalists. Moreover, possession of a large patent portfolio increases the value of liquidity when exiting via an initial public offering (IPO), especially in the case of the biotechnology industry (Stuart *et al.*, 1999; Baum *et al.*, 2000; Gulati & Higgins, 2003). Firms with previous successful IPO experiences are more likely to undergo more successful IPO exits in new ventures than first time entrepreneurs or founders with previous experience of failure.

Ownership of patents and other IP rights can give the inventor additional bargaining power when transferring or selling them to third parties, improving the chances of successful exit or survival (Cohen *et al.*, 2000; Ziedonis, 2004).

Not only as a means of securing a successful exit strategy, patents are important tools able to convey crucial information to external investors regarding the research stream of the start-up (Long, 2002). This is consistent with the perspective of Hallen (2008), who points out the importance of the entrepreneurial lineage when compared to on-going venture achievements through exploring outsiders' resources.

Cefis & Marsili (2007) state that innovation plays a key role in the decision to exit and in the corresponding exit mode. The authors defend that by using their ability to generate innovations, new firms take advantage of these assets when facing an exit strategy, benefiting from economic returns when a merger or acquisition occurs, the resources being transferred to another firm.

In low-tech firms, innovation can be considered an advantage in order to maintain market positioning, regarding the capacity to change and improve production processes. Young firms that are unable to innovate or have low production costs are extremely exposed to newness and more likely to fail. For these firms, innovation can be crucial, creating conditions for a successful exit. For instance, new firms that tend to generate product innovations can be the target of profitable acquisitions.

On the contrary, in high-tech firms, innovation only gives access to a fast race with incumbent firms and not the possibility of securing their position or achieving success (Cefis & Marsili, 2011). For these firms, concentrating on radical innovations, rather than only on incremental innovations, can bring a competitive advantage regarding differentiation from competitors, also leading to an incremental risk of failure, since they are more exposed to uncertainty.

In the same line, and following the evolutionary approaches to industrial dynamics, Sorensen & Stuart (2000) argue that firms with better competences in matters of innovation are more able to survive, their ability to innovate and environmental fit improving with age. The authors also argue that older firms, although more efficient at innovating, do not take so many risks in developing innovative efforts into new and more distant fields of knowledge. Thus:

H6: Patenting firms are expected to survive longer than non-patenting firms.

H7: Firms that register and deal with copyrights are expected to survive longer than others.

H8: Firms that register and deal with trademarks are expected to survive longer than others.

Lerner & Tirole (2006) argue that successful entrepreneurs with previous IPO experience are more likely to get engaged in successful IPO exit strategies. In addition, Buenstorf (2007), in an analysis performed on 143 laser firms between 1964 and 2003, found that pre-entry background affects the rate of survival and exit.

Hsu & Ziedonis (2007) analyzed the patenting and venture financing activities of 370 US semiconductor start-ups that received over 800 rounds of funding, in the period 1980-2005. They conclude that although ownership of a larger patent portfolio can improve the success of exit through IPO, the same correlation is not found in the case of having prominent alliance partners or corporate investors with a successful exit using an IPO strategy (Stuart *et al.*, 1999; Mann & Sager, 2007). The findings of the previously cited studies are not in line with other studies performed with different industry sectors, namely the biotechnology sector (Stuart *et al.*, 1999; Gulati & Higgins, 2003), since these authors confirm the positive and significant relationship between having a large patent portfolio and exiting successfully via an IPO. Furthermore, they reveal a positive but not significant relationship between third party affiliations and achieving a successful IPO, since they conclude that having prominent partner alliances or corporate investors has little impact on the likelihood of semiconductor start-ups

exiting via IPO, as opposed to firms in the biotechnology sector. The authors point to the importance of the specificities of industry sectors in the use of patents as determinants of firms' paths, including firm age and the different stages of the firm's lifecycle, from creation to exit.

The work of Hsu & Ziedonis (2007) also reflects on the importance of patents as quality signals regarding the age of the firm, especially for new ventures in the initial stages, since more experienced entrepreneurs are more able to signal quality and attract resources without IP assets. Interestingly, their research does not find that patents present a greater signaling effect for new incumbents than for more experienced ones.

Medrano (2012) analyzes the importance of innovation and age in firm survival, using information on high-quality patents in laser source technology and patents owned in co-authorship with university inventors. The same author concludes that high-quality patents (measured by the number of forward citations) show a positive and significant relationship with firm survival. Moreover, new firms that start without inherited innovative capabilities are supposed to compensate for this lack of appropriate pre-entry experience with investment in high quality innovation. The study also finds that co-authorship with university inventors is not crucial for firm survival, since only a small percentage of them are active source producers for firms.

Agarwal & Gort (2002) consider that both firm and industry characteristics, including knowledge stock and age, are vital to limit the chances of firm exit. Furthermore, age is also a determinant factor of firm survival. At this stage, it is important to consider the level of technological intensity and the stage of the industry's lifecycle. In this connection, Manjón-Antolín & Arauzo-Carod (2008) also consider that age is important in determining firms' successful survival, concluding that new firms face higher risks of failure than older ones. Thus:

H9: Older firms are expected to survive longer than younger firms.

In this sense, new, smaller firms face higher risks of failure than older, bigger ones (Manjón-Antolín & Arauzo-Carod, 2008). This is consistent with the previous literature on size as a determinant of exit. Scholars such as Dunne *et al.* (1989), Audretsch & Mahmood (1994), Mata & Portugal (1994), Mitchell (1994), Haverman (1995), Sharma & Kesner (1996) defend that large firms tend to have higher survival rates than their smaller counterparts, due to the efficient scale needed to operate, increased access to funds, increased capacity to diversify and differentiated managerial ability.

Another perspective was defended by Montgomery (1994) concerning the issues of diversification and firm expansion, and consequently improved performance and survival. The author presented three main theories supporting this relationship, namely market-power view, which is in line with profit maximization, resource-based approach, consistent with the efficient use of resources, and agency approach, which is purely managerial, concluding that the relationship is neither linear nor direct. Montgomery (1994) pointed out that at the time diversification increases, firm profitability and expansion decreases. In addition, firms with more specialized diversification tended to expand more than firms with wider diversification strategies (Montgomery & Wernerfelt, 1988).

Furthermore, Montgomery & Hariharan (1991) argued that fast growing firms with extant resource bases dedicated to marketing and R&D were more likely to pursue diversified expansion and tended to penetrate more efficient and demanding markets compatible with their own capability profiles. Thus:

H10: Large, diversified firms are expected to survive longer than small firms.

Bojnec & Xavier (2007), in a study of Slovenian manufacturing firms, concluded that the most significant determinants of firm exit, in manufacturing firms, are the firm's export orientation, capital intensity, innovation expenditure, firm profitability and the growth of the sector's real sales. These determinants reduce exit, while others, such as private ownership and lower firm cost efficiency increase it.

Carree *et al.* (2011), in a study of twelve different sectors in Italian provinces over eleven years, claimed that exit rate is determined by entry in the previous year in the same sector, previous exit having a different effect on manufacturing firms and service firms. The authors argue that firms' deaths and births in the same industry can have a determinant effect on the rate of firm exit. Concerning service firms, the fact of exiting in related sectors in the same province leads to higher rates of exit, due to the loss of clients and suppliers. Firm exit is also driven positively by firms' location, namely the existence in the region of industrial districts, and higher IP rights activity can reduce the rate of failure.

The authors include as industry-specific determinants of firm exit, lagged firm exit from, and entry in, the same industry and the other industries, and lagged number of firms in the same industry, among others. They conclude that firm deaths and births in the same industry affect the exit rate in subsequent periods, some differences emerging across industries, with the displacement effect of firm entry being stronger in manufacturing than in service firms.

Their results agree with the previous findings of Santarelli & Piergiovanni (1995), who argue that the effect of exit in business service firms is strongly dependent on the demand for non-standardized and non-industry-specific services, in particular in manufacturing. Their results reveal that the effect of industrial heterogeneity must be considered as well as the spillover effect of exits.

Thus:

H11: Manufacturing firms are expected to survive longer than non-manufacturing firms.

3. Research method and conceptual model

In order to focus on the determinants of firm survival, and specifically that of gazelle firms, this paper intends to analyze, on one hand, founder/owner attributes, such as age, work experience, educational background and gender and, on the other, firms' characteristics, namely age, size, IP intensity (e.g., patents, copyrights and trademarks) and being a manufacturing firm.

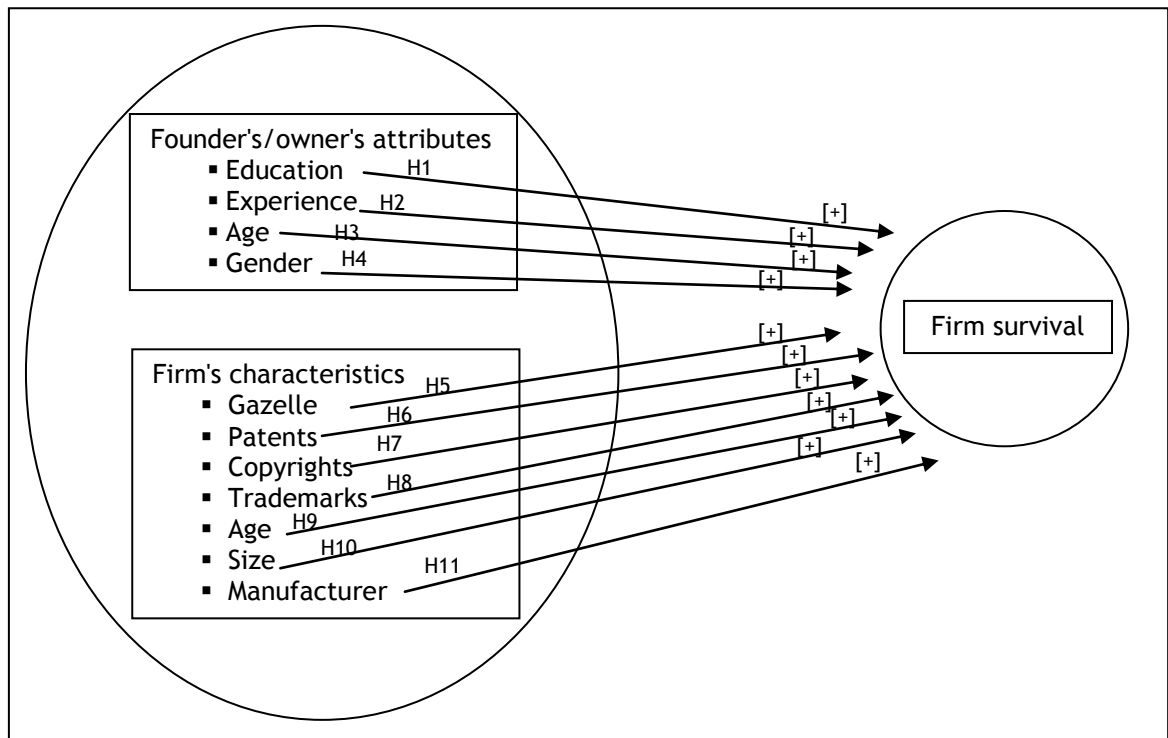
The importance of studying the determinants of exit has been a topic of analysis for many researchers such as Stuart *et al.* (1999), Baum *et al.* (2000), Cohen *et al.* (2000), Gans & Stern (2003), Gulati & Higgins (2003), Ziedonis (2004), Audretsch & Lehman (2005), Colombo & Grilli (2005), Cefis & Marsili (2007), Mann & Sager (2007), Srinivasan *et al.* (2008), Wennberg *et al.* (2010), Grilli (2011) and Medrano (2012), among others, whose principal focus lies in the effects of specific attributes when considering firms' characteristics in the exit mode.

Other authors focused on the effects of specific attributes regarding entrepreneur/founder characteristics on the exit route (Wagner, 2003; Colombo & Grilli, 2005; Schutjens & Stam, 2006; Stam *et al.*, 2008; Wennberg *et al.*, 2010; Amaral *et al.*, 2011; Grilli, 2011).

Below, we hypothesize the above determining factors of exit, from a conceptual model approach. Eleven hypotheses are therefore presented regarding a set of determinants, such as firm age, size, being a manufacturer, patents, copyrights and trademarks, founder age, founder's work experience, founder's educational background, the founder being male, and gazelle status, and their effect on survival rates.

The following steps go towards proposing a conceptual model and describe the data and variables.

Fig. 1 Determinant factors of firm survival: a conceptual model



3.1 The model

To assess the risk of exit and, on the other hand, the survival rate for a gazelle firm, while taking into consideration the importance of a set of determinant factors related to founder attributes, namely founder's age, work experience, educational background, gender and a set of characteristics connected with the firm, such as age, size, being a manufacturing firm, patents, copyrights and trademarks, gazelle status, and their effect on closure, we used as a survival analysis tool, the semi-parametric regression model called Cox Regression (Cox, 1972). This model is considered appropriate to study survival from the prediction perspective, since it gives estimation of the risk reasons under study. Furthermore, it is possible to evaluate the impact of some risk factors or prognostic factors in the time up to occurrence of the event of interest, which in this study corresponds to firm closure.

The hazard function - $h_{(t)}$ - in the Cox model (Cox, 1972; Miller Jr., 1981; Cox & Oakes, 1984; Harris & Albert, 1991; Lee, 1992; Andersen *et al.*, 1993; Crowley & Breslow, 1994) is considered to be a dependent variable and the risks of death from a certain cause are the result of a non-specified function of time (common to all observations) and a known function which is the linear combination of the covariates X_i ($i = 1, 2, \dots, k$). The hazard function ($h_{(t)}$) is given by the covariates expressed as follows:

$$h(t / X_1, X_2, \dots, X_k) = h_0(t) \exp(\beta_1 X_1 + \beta_2 X_2 + \dots + \beta_k X_k) \quad (1)$$

where $h_{0(t)}$ is the non-parametric part of the model, and when the intention is to estimate prognostic factors, there is no need to define it, since it is common to all individuals. The regression coefficients (β_i) are estimated by partial maximum likelihood.

When dividing the two sides of the equation by $h_{0(t)}$, the following is obtained:

$$h(t / X_1, X_2, \dots, X_k) = \exp(\beta_1 X_1 + \beta_2 X_2 + \dots + \beta_k X_k) h_0(t) \quad (2)$$

The coefficient $h(t / X_1, X_2, \dots, X_k)/h_0(t)$ corresponds to the function of risk reasons, $HR(i)^{15}$, relative hazard function or prognostic index (Altman & Andersen, 1989): $HR(i) = HR_i = \exp(\beta_1 X_{i1} + \beta_2 X_{i2} + \dots + \beta_k X_{ik})$. This formula is also useful in making estimations regarding the reason among risk functions (HR) for each of the independent variables (X_i), assuming that all the other $X_{i j}$ are constant, $HR(X_i) = \exp(\beta_i)$.

The assumption here is that different individuals have different proportional risk functions and this is why these risk functions do not change over time¹⁶.

Thus, we consider a hazard function, where the dependent variable and the risks of exiting ($h_{(exit)}$) for a given cause are the product of a non-specified function of time (common to all observations in the period 2004-2010) and a known function, the linear combination of the covariates X_i , with $i =$ being founder's educational background; founder's work experience; founder's age; founder's gender; the firm's gazelle status; firm's patents; firm's copyrights; firm's trademarks; firm's age; firm's size and the firm being engaged in manufacture). The hazard function - $h_{(exit)}$ - is expressed as follows:

$$h(t / \text{founder's educational background, founder's work experience, founder's age, founder's male gender, gazelle status, firm's patents, copyrights and trademarks, firm's age, firm's size, manufacturing firm}) = h_0(t) \exp(\beta_1 \text{founder's educational background} + \beta_2 \text{founder's work experience} + \beta_3 \text{founder's age} + \beta_4 \text{male founder} + \beta_5 \text{gazelle status} + \beta_6 \text{firm's patents} + \beta_7 \text{firm's copyrights} + \beta_8 \text{firm's trademarks} + \beta_9 \text{firm's age} + \beta_{10} \text{firm's size} + \beta_{11} \text{manufacturing firm}) \quad (3)$$

¹⁵ HR corresponds to the Hazard Risk.

¹⁶ When dealing with non-constant and non-proportional risks during the period, Cox with time-dependent covariate should be used (Cox & Oakes, 1984).

The main motivation of this analysis is to assess the influence of a set of covariates on the probability of gazelle and non-gazelle firms exiting. For this purpose, a multivariate model of firms' life duration is used, considering a linear model for the log hazard. In the model, the baseline hazard $h_0(t)$ is equivalent to the hazard rate that corresponds to the X_i s being equal to 0. Since a semi-parametric Cox model is used, the baseline hazard can assume any form while the covariates enter the model in a linear way.

3.2. Dataset and variables

This paper uses the Kauffman Firm Survey (KFS)¹⁷, which is a panel study of 4,928 firms founded in 2004 and tracked over their early years of operation. This longitudinal panel was created from a random sample of the Dun & Bradstreet (D&B) database of new businesses established in 2004, including almost two hundred and fifty thousand businesses. This dataset included new firms founded by an individual owner or a team, purchases of existing firms by a new ownership team, and purchases of franchises, excluding wholly-owned subsidiaries of existing businesses, businesses inherited from someone else and non-profit organizations.

The variables included in the Cox proportional hazard model are described in Table 2 below. The focus of the present paper being on firm and founder characteristics and their importance for firm survival and avoidance of exit, the variables of interest in the dataset are exit, age, size, patents, copyrights, trademarks, founder's age, founder's experience, founder's educational background, being male, being a gazelle, year and activity. Some of the variables were computed, namely size, gazelle status and activity, using other variables such as employment growth, being a manufacturing firm and number of employees¹⁸. These measures are expected to influence positively the chances of firm survival, especially that of gazelles.

¹⁷ Acknowledgement: Selected data are taken from the Kauffman Firm Survey release 6.0. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the Ewing Marion Kauffman Foundation.

¹⁸ Taking as a reference the OECD classification of gazelles, and according to Ahmad (2006), the variable related to gazelles was created by computing the mean value of employment growth rates in the first three years and dividing the dataset in two subsamples, one that presents a value above 20% (taking a value equal to 1) and another that corresponds to 20% or less (taking a value equal to 0). The employment growth for each year rate was computed, using the number of employees variable.

Table 2 Description of variables included in the Cox proportional hazard model

Variables	Definitions
Exit	A dummy indicating if the firm exits during the survey period
Founder's educational background	A dummy indicating whether the founder has a university degree or not
Founder's experience	Number of years of founder's previous professional experience in the same industry
Founder's age	A dummy indicating whether the founder is under or over 35 years old
Male founder	A dummy indicating whether the founder is male or not
Gazelle firm	A dummy indicating whether the firm is a gazelle or not
Firm's patents	A dummy indicating whether the firm has patents or not
Firm's copyrights	A dummy indicating whether the firm has copyrights or not
Firm's trademarks	A dummy indicating whether the firm has trademarks or not
Firm's age	Average age of the firm
Firm's size	A dummy indicating whether the firm has more or fewer than 10 employees
Manufacturing firm	A dummy indicating whether the firm is a manufacturer or a service ¹⁹

4. Results and discussion

For the set of variables under analysis, a summary of the descriptive statistics is presented in Table 3.

The dataset has 29,585 observations corresponding to 6 years of survey. Summarizing the main characteristics of the sample of firms, they present a mean age of approximately 4 years, having 1 employee, on average, 1 patent, 1 copyright and 0.16 trademarks, being mainly non-gazelle firms. Approximately 41% are manufacturing firms and the percentage of exit in the period under analysis is 1.8%. As for founders, they are mainly male (83%), under 35 years old (89%), with a mean of 9 years of experience in industry, and mainly without a university degree (only about 19.4% have a university degree).

¹⁹ This classification is according to the North American Industry Classification System (NAICS) for industry identification purposes. NAICS uses a six digit hierarchical coding system to classify all economic activity into twenty industry, e.g. manufacturing sectors. Five sectors are mainly goods-producing sectors and fifteen are entirely services-producing sectors.

The status variable (exit) identifies whether the event has occurred in a given case. If the event has not occurred, the case is said to be censored. Our analysis shows that for the 29,585 observations, we have 535 censored cases that are not used in computation of the regression coefficients, but are used to compute the baseline hazard. These censored cases are firms that have not survived.

Table 3 presented below reports the descriptive statistics and correlations for the twelve variables. It is important to note that regarding the influence of firm age, the results show a consistently negative association with firm size, copyrights, trademarks, founder's age, work experience, educational background, and being a gazelle, showing a positive relationship with being male, a manufacturing firm and exit. It should also be stressed that concerning the relationship between firm size and firm age, the Pearson correlation coefficient indicates a negative and significant relationship. In addition, firm size shows a positive and significant association with almost all variables, namely the firm patents, copyrights and trademarks, the founder's age, work experience, educational background, being male, being a manufacturing firm, exit and being a gazelle.

The variable of the total number of patents owned by the firm presents a positive and significant relationship (at 1%) with the variables of size, copyrights, trademarks, founder's work experience, educational background, being a manufacturing firm and being a gazelle. It reveals a positive and significant relationship (at 5%) with being male.

The findings show an important correlation between the variable of copyrights and size, patents, trademarks, founder's age, work experience, educational background and gazelle status, presenting a positive and significant association. Copyrights also denote a negative and significant correlation with firm age, male gender and being a manufacturer.

Another highly ranked variable is the trademark variable, which shows a positive and significant relationship with firm size, firm patents and copyrights, founder's age, work experience, educational background, being a manufacturer and gazelle status. It shows a negative and significant correlation with firm age and being male.

Furthermore, the variable of founder age also indicates strong negative and significant correlations with the other variables, namely firm size, founder's work experience, educational background, being male, being a manufacturer and exit. This variable shows a strong and positive association with size, copyrights, trademarks and gazelle status.

Considering the founder's work experience, this shows a positive and significant association with the variables of size, patents, copyrights, trademarks, founder's educational background and gazelle status.

In turn, the founder's educational background is significantly and positively associated with firm size, patents, copyrights, trademarks, the founder's work experience and gazelle status.

Being male reveals a positive and significant relationship (at 1%) with firm age and being a manufacturer. It shows a positive and significant relationship (at 5%) with firm patents.

When considering the fact of being a manufacturer, we can state this has a strong association with almost all variables, being positive with firm age, size, patents, trademarks, male gender and gazelle status, and negative with copyrights, founder's age, work experience and educational background.

Exit has a positive and significant association with firm age. On the other hand, it has a significant relationship, although negative, with firm size, the founder's work experience and gazelle status.

Finally, the effects of age and exit on gazelle status are significant and positive. The relationship between gazelle status and size, patents, copyrights, trademarks, the founder's age, work experience and educational background and being a manufacturing firm are significant and negative.

Table 3 Descriptive statistics of the variables included in the survival model

	Mean	St. Dev.	Age	Size	Patents	Copyrights	Trademarks	Founder's age	Founder's work experience	Founder's educational background	Male gender	Manufacturing firm	Exit	Gazelle
Age	3.890	1.920	1											
Size	0.800	1.950	-0.088**	1										
Patents	0.080	1.060	-0.006	0.107**	1									
Copyrights	0.630	8.340	-0.063**	0.072**	0.182**	1								
Trademarks	0.160	0.970	-0.054**	0.180**	0.268**	0.369**	1							
Founder's age	1.230	1.780	-0.112**	0.063**	0.002	0.046**	0.42**	1						
Founder's work experience	8.970	10.760	-0.159**	0.179**	0.083**	0.111**	0.115**	-0.066**	1					
Founder's educational background	0.190	0.390	-0.074**	0.102**	0.145**	0.151**	0.145**	-0.017**	0.260**	1				
Male gender	0.830	0.380	0.150**	0.000	0.015*	-0.037**	-0.027**	-0.068**	-0.036**	-0.112**	1			
Manufacturing firm	0.210	0.410	0.021**	0.073**	0.092**	-0.058**	0.033**	-0.025**	-0.046**	-0.128**	0.050**	1		
Exit	0.020	0.130	0.105**	-0.006	0.004	-0.006	-0.002	-0.009	-0.019**	-0.005	0.010	0.009	1	
Gazelle	0.020	0.150	-0.170**	0.286**	0.016**	0.024**	0.039**	0.045**	0.059**	0.043**	-0.011	0.023**	-0.020**	1

Notes: N=4928; **p<0.01

The results of the Cox proportional hazard estimations are presented in Table 4, showing the hazard ratios, using an Efron approximation to compute ties. When the hazard ratio is higher than one there is a less likelihood of survival, while a hazard ratio under one corresponds to a greater likelihood of survival.

Table 4 Results of the Cox proportional hazard estimations

Variable	Hazard ratios [Probability]
<i>Founder level variables</i>	
Founder’s educational background	1.384** [0.014]
Founder’s experience	1.014*** [0.001]
Founder’s age	0.843*** [0.004]
Founder’s male gender	0.918** [0.016]
<i>Firm level variables</i>	
Gazelle firms	0.404** [0.044]
Firm's patents	0.998*** [0.006]
Firm's copyrights	0.998*** [0.001]
Firm's trademarks	1.008** [0.006]
Firm's age	0.527*** [0.005]
Firm's size	1.069*** [0.003]
Manufacturing firm	0.883** [0.015]
<i>A time dummy variable is included in all estimations. Robust standard errors are presented within brackets. ***significant at 1% **significant at 5% *significant at 10%</i>	

Assessing the results we confirm significant hazard ratios. For the firm variables, except for the variables of firm trademarks and firm size, all the others show a significant impact on hazard ratios, namely firm's gazelle status, firm patents, firm copyrights, firm age and firm's manufacturing status. Therefore, we reject hypotheses H8 and H10, as these determinants are not beneficial for survival,

being determinant predictors of exit. In turn, we cannot reject hypotheses H5, H6, H7, H9 and H11, since their hazard ratios are all below one, therefore positively affecting survival as expected and thus not being determinants of exit. Concerning the founder level variables, founder's age and male gender found support, hazard ratios being under one, determining survival positively, and thus we cannot reject hypotheses H3 and H4. Regarding founder's educational background and founder's experience, we reject hypotheses H1 and H2, due to the fact that their hazard ratios are above one, not being beneficial for survival and therefore relevant for firm exit.

Summing up, we conclude that the main determinant factors of firm survival are age, manufacturing status, patents, copyrights and gazelle status for the industry level characteristics. Additionally, analysis of the set of attributes related to entrepreneur/founder characteristics reveals that the major impact comes from age and being male. In Table 5, the results obtained are contrasted with the empirical evidence previously found in the literature.

Table 5 Determinant factors of firm survival

HYPOTHESES	EMPIRICAL EVIDENCE		RESULTS OBTAINED
	SIGNAL	AUTHORS	4928 firms
<i>H₁</i> : Firms with more educated founders are expected to survive longer than others.	+	Wagner, 2003; Schutjens & Stam, 2006; Detienne & Cardon, 2008; Stam <i>et al.</i> , 2008; Amaral <i>et al.</i> , 2011	Non-significant
<i>H₂</i> : Firms with more experienced founders are expected to survive longer than others.	+	Tyebjee & Bruno, 1984; Taylor, 1999; Ucbasaran <i>et al.</i> , 2003; Jorgensen, 2005; Politis, 2005; Westhead <i>et al.</i> , 2005; Wennberg <i>et al.</i> , 2010; Grilli, 2011; Detienne & Cardon, 2012	Non-significant
<i>H₃</i> : Firms with older founders are expected to survive longer than others.	+	Wagner, 2003; Schutjens & Stam, 2006; Stam <i>et al.</i> , 2008; Amaral <i>et al.</i> , 2011	+
<i>H₄</i> : Firms with male founders are expected to survive longer than others.	+	Wagner, 2003; Schutjens & Stam, 2006; Stam <i>et al.</i> , 2008; Amaral <i>et al.</i> , 2011	+
<i>H₅</i> : Gazelle firms are expected to survive longer than non-gazelle firms.	+	Storey, 1994; Acs <i>et al.</i> , 2008	+
<i>H₆</i> : Patenting firms are expected to survive longer than non-patenting firms.	+	Klepper, 1997; Cohen <i>et al.</i> , 2000; Sorensen & Stuart, 2000; Ziedonis, 2004; Bojnec & Xavier, 2007; Cefis &	+

		Marsili, 2007; Hsu & Ziedonis, 2007; Srinivasan, 2008; Wagner & Cockburn, 2010; Cantner, Krueger & von Rhein, 2011; Carree <i>et al.</i> , 2011; Chang, 2011; Medrano, 2012	
<i>H</i> ₇ : Firms that register more copyrights are expected to survive longer than others.	+	Cohen <i>et al.</i> , 2000; Sorensen & Stuart, 2000; Ziedonis, 2004; Bojnec & Xavier, 2007; Cefis & Marsili, 2007; Hsu & Ziedonis, 2007; Srinivasan, 2008; Carree <i>et al.</i> , 2011; Chang, 2011	+
<i>H</i> ₈ : Firms that register more trademarks are expected to survive longer than others.	+	Cohen <i>et al.</i> , 2000; Sorensen & Stuart, 2000; Ziedonis, 2004; Bojnec & Xavier, 2007; Cefis & Marsili, 2007; Hsu & Ziedonis, 2007; Srinivasan, 2008; Carree <i>et al.</i> , 2011; Chang, 2011	Non-significant
<i>H</i> ₉ : Older firms are expected to survive longer than younger firms.	+	Agarwal & Gort, 2002; Manjón-Antolín & Arauzo-Carod, 2008; Carree <i>et al.</i> , 2011	+
<i>H</i> ₁₀ : Bigger firms are expected to survive longer than smaller firms.	+	Dunne <i>et al.</i> , 1989; Audretsch & Mahmood, 1994; Mata & Portugal, 1994; Mitchell, 1994; Haverman, 1995; Sharma & Kesner, 1996; Manjón-Antolín & Arauzo-Carod, 2008	Non-significant
<i>H</i> ₁₁ : Manufacturing firms are expected to survive longer than service firms.	+	Santarelli & Piergiovanni, 1995; Bojnec & Xavier, 2007; Carree <i>et al.</i> , 2011	+

5. Concluding remarks

Our empirical findings reveal that, consistent with prior research, surviving firms do, indeed, exhibit different characteristics from exiting firms. Moreover, in the sample of 4928 firms, only 639 are considered gazelles and from this group none exited during the survey period. In the non-gazelle group (4289), 535 firms exited in the period 2004-2010. It can therefore be stated that gazelle firms tend to survive longer than non-gazelles, possibly due to their resilience.

The determinant factors with a major impact on firm survival are age, manufacturing status, patents, copyrights and gazelle status, concerning the firm's characteristics. In turn, age and male gender influence the decision to exit, according to owners' attributes.

Our results reveal that gazelle firms are expected to survive longer allied to innovation intensity, since evidence was found that factors such as firms' IPR portfolio (mainly patents and copyrights) influence significantly the survival ratios. Manufacturing status is also determinant concerning the impact on firms' survival rate. Regarding firm characteristics, such as size and trademarks and concerning the founder's attributes, such as work experience and educational background, in the estimated model, they do not perform well as predictors of survival ratios.

The paper contributes to the literature by distinguishing the factors that influence the decision to exit, for gazelle firms and non-gazelle firms. Our findings reveal that a gazelle firm does not show the same tendency to exit as non-gazelles, since the former are more resilient, in the sense they are faster to adapt their activities to changes in industry or market turbulence.

5.1 Limitations, implications and future research

This paper tackles firms' business exit, especially that of gazelle firms. Using a Cox regression model, we assess the determinant factors of firm survival among a sample of 4928 firms created in 2004-2010, according to data collected from the Kaufman Foundation Survey. The results obtained allow us to conclude that a manufacturing gazelle has less chance of exiting than a non-gazelle firm. Other determinants related to the firm context, such as patents, copyrights and age or the founder's attributes, such as age and gender are also predictors explaining survival rates. It was found that small firms with an average age of 4 years, whose founders, mainly male, have no university degree and are more than 35 years old, were significantly more likely to survive than other types of firms.

Alternative avenues of research also remain wide open in this field. Rapid-growth firms are a key player in modern knowledge economies, marked by high turbulence and fast change, and are also important 'new job promoters'. Understanding what drives the sustainable growth of such firms and predicting the determinants that can most affect their performance and survival, in order to prevent exit over many years, is therefore essential. To prevent the decision to exit, policy makers should focus on the hazard factors and on non-hazard effects and promote adjusted policies and measures to strengthen the predictors associated with exit hazard such as founder's previous work experience and educational background, on one hand, and on the other, develop strategies to enhance the strategic factors that revealed low predictor hazard rates, such as the firm's innovation portfolio (mainly focusing on patenting/copyright intensity).

Finally, although our paper makes a contribution to analysis of a set of determinants that allow firms to survive longer and therefore avoid exit, we should point out some of the limitations in the dataset. Since the dataset only tracks firms from 2004 to 2010, it would be of interest to complete the study with a wider longitudinal panel in order to better understand firm lifespan and exit. Future research could also focus on analyzing other datasets to promote further understanding of the determinants of failure. Other characteristics and determinant factors should be analyzed, gathering data from alternative primary sources, regarding corporate R&D strategy and the entrepreneur's innovation behavior. On one hand, this includes cooperation with the external environment, competition relationships, patenting patterns, such as co-inventorship with diversified stakeholders and international patenting patterns. On the other hand, the psychological and behavioral characteristics of the entrepreneur which may influence the leadership process of technological and corporate change within the context of a resilient firm type, such as gazelle firms, deserve further research.

References

- Acs, Z. J., Parsons, W. & Tracy, S. (2008). High Impact Firms: Gazelles Revisited. Office of Advocacy. US. Small Business Administration.
- Ahmad, N. (2006). A Proposed Framework for Business Demographic Statistics. OECD Statistics Working Paper Series, STD/DOC 3, Paris.
- Agarwal, R. and Gort, M. (2002). Firm and Product Life Cycles and Firm Survival. *American Economic Review (Papers and Proceedings)*, 92, 184-190.
- Akhigbe, A., Borde, S.F., Whyte, A.M. (2003a). Does an industry effect exist for initial public offerings? *Financial Review*, 38 (4), 531-551.
- Akhigbe, A., Madura, J., Martin, A.D. (2003b). Are competitive industry signals greater when acquiring privately-held firms? *American Business Review*, 21 (2), 30-40.
- Ajzen, I. (1991). The Theory of Planned Behavior. *Organizational Behavior and Human Decision Processes*, 50, 179-211.
- Aldrich, H. (1999). *Organizations Evolving*. Sage Publications, London.
- Amaral, A.M., Baptista, R. and Lima, F. (2011). Serial entrepreneurship: impact of human capital on time to re-entry. *Small Business Economics*, Volume 37, Number 1, 1-21.
- Andersen, P., Borgan, O.; Gill, R. and Keiding, N. (1993). *Statistical Models Based on Counting Process*. New York: Springer-Verlag.
- Ardichvili, A., Cardozo, R., Ray, S. (2003). A theory of entrepreneurial opportunity identification and development. *Journal of Business Venturing*, 18 (1), 105-123.
- Audretsch, D. and Lehmann, E. (2005). The Effects of Experience, Ownership, and Knowledge on IPO Survival: Empirical Evidence from Germany. *Review of Accounting and Finance*, 4, 13-33.
- Audretsch, D., and T. Mahmood (1994). The Rate of Hazard Confronting New Firms and Plants in US Manufacturing, *Review of Industrial Organization*, 9, 41-56.
- Babich, V., & Sobel, M. J. (2004). Pre-IPO Operational and Financial Decisions. *Management Science*, 50 (7), 123-140.
- Bangma, K., Snel, D. (2009). *Bedrijvendynamiek en werkgelegenheid, periode 1987-2008*. Zoetermeer: El
- Baptista, R. and Karaoz, M. (2011). Turbulence in Growing and Declining Industries. *Small Business Economics*, 36, 249-270.
- Baum, J., Calabrese, T. and Silverman, B. (2000). Don't Go It Alone: Alliance Network Composition and Startups' Performance in Canadian Biotechnology, *Strategic Management Journal*, 21, 267-294.
- Becker, G.S. (1964). *Human Capital: A Theoretical and Empirical Analysis, with Special Reference to Education*. Chicago University Press, Chicago.
- Bednarzik, R. (2000). The role of entrepreneurship in U.S. and European job growth. *Monthly Labor Review*, 123 (7), 3-16.
- Birch, D. (1979). *The Job Generation Process*. MIT Program on Neighborhood and Regional Change, Massachusetts Institute of Technology, Cambridge, MA.
- Birch, D., Haggerty, A. and Parsons, W. (1995), *Who's Creating Jobs?* Boston: Cognetics Inc.
- Birley, S., Westhead, P. (1993). The owner-managers exit route. *Entrepreneurship and Business Development*, 123-140.

- Bishop, K., Mason, G. and Robinson, C. (2009). Firm growth and its effects on economic and social outcomes: Literature and statistical review. Report to the National Endowment for Science Technology and the Arts. London: NIESR.
- Boeker, W., Karichalil, R. (2002). Entrepreneurial transitions: factors influencing founder departure. *Academy of Management Journal*, 45 (3), 818-826.
- Boeker, W., Wiltbank, R. (2005). New venture evolution and managerial capabilities. *Organization Science*, 16 (2), 123-133.
- Bojnec, S. Xavier, A. (2007). Determinants of firm exit in Slovenian manufacturing. *Industrial Management and Data Systems*, 107 (5), 715-727.
- Buddelmeyer, H., Jensen, P. and Webster, E. (2010). Innovation and the determinants of company survival. *Oxford Economic Papers*, 62(2), 261-285.
- Buenstorf, G. (2007). Evolution on the Shoulders of Giants: Entrepreneurship and Firm Survival in the German Laser Industry. *Review of Industrial Organization*, 30, 179-202.
- Butler, J., Phan, P., Saxberg, B., Lee, S. (2001). Entrepreneurial succession, firm growth and performance. *Journal of Enterprising Culture*, 9 (4), 407-436.
- Cantner, U., Krueger, J. and von Rhein, K. (2011). Knowledge Compensation in the German Automobile Industry. *Applied Economics*, 43, 2941-2951.
- Cardon, M.S., Zietsma, C., Saporito, P., Matherne, B.P., Davis, C. (2005). A tale of passion: new insights into entrepreneurship from a parenthood metaphor. *Journal of Business Venturing*, 20 (1), 23-45.
- Carree, M., Verheul, I. and Santarelli, E. (2011). Sectoral patterns of firm exit in Italian provinces. *Journal of Evolutionary Economics*, 21, 499-517.
- Cefis E, Marsili O (2007). Going, going, gone. Innovation and exit in manufacturing firms. ERIM Report Series. Reference No. ERS-2007-015-ORG.
- Cefis, E., Marsili, O. (2011). Born to flip. Exit decisions of entrepreneurial firms in high-tech and low-tech industries. *Journal of Evolutionary Economics*, 21, 473-498.
- Certo, S., Covin, J., Daily, C., Dalton, D. (2001). Wealth and effects of founder management among IPO-stage new ventures. *Strategic Management Journal*, 22 (6/7), 641-658.
- Chang, M. (2011). Entry, exit and the endogenous market structure in technologically turbulent industries. *Eastern Economic Journal*, 37, 51-84.
- Choi, Y.R., Shepherd, D.A. (2004). Entrepreneurs' decisions to exploit opportunities. *Journal of Management*, 30 (3), 377-395.
- Clarysse, B., Moray, N. (2004). A process study of entrepreneurial team formation: the case of a research-based spin-off. *Journal of Business Venturing*, 19 (1), 55-79.
- Coad, A. and Rao, R. (2008). Innovation and firm growth in high-tech sectors: A quantile regression approach. *Research Policy*, 37 (4), 633-648.
- Cohen, W., Goto, A., Nagata, A., Nelson, R. and Walsh, J. (2002). R&D spillovers, patents and the incentives to innovate in Japan and the United States. *Research Policy*, 31 (8-9), December, 1349-1367.
- Colombo, M.G., Grilli, L. (2005). Founders' human capital and the growth of new technology-based firms: a competence-based view. *Research Policy*, 34 (6), 795-816.
- Cox, D. (1972). Regression models and life tables (with discussion). *Journal of the Royal Statistical Society: Series B*, 34, 187-220.
- Cox, D. and Oakes, D. (1984). *Analysis of Survival Data*. London: Chapman & Hall.
- Crowley, J. and Breslow, N. (1994). Statistical analysis of survival data. *Annual Review of Public Health*, 5, 385-411.
- Decker, C., Mellewigt, T. (2007). Thirty years after Michael E. Porter: What do we know about business exit? *Academy of Management Perspectives*, 21 (2), 41-55.

- Delmar, F., Davidsson, P. and Gartner, W. (2003). Arriving at the high growth firm. *Journal of Business Venturing*, 18, 189-216.
- DeTienne, D. and Cardon, M. (2006). Entrepreneurial exit as an important component of the entrepreneurial process: strategies and design. Paper presented at the Babson College Entrepreneurship Research Conference, Bloomington.
- DeTienne, D. and Cardon, M. (2008). The Impact of New Venture Design on Entrepreneurial Exit. Babson College, Babson College Entrepreneurship Research Conference (BCERC) 2008.
- DeTienne, D. and Cardon, M. (2012). Impact of founder experience on exit intentions. *Small Business Economics*, 38 (4), 351-374.
- DeTienne, D. (2010) Entrepreneurial exit as a critical component of the entrepreneurial process: Theoretical development. *Journal of Business Venturing*, 25, 203-215.
- Dodd, S. (2002). Metaphors and meaning: a grounded cultural model of us entrepreneurship. *Journal of Business Venturing*, 17 (5), 519-535.
- Dunne, T., Roberts, M. and Samuelson, L. (1989). The Growth and Failure of U.S. Manufacturing Plants. *Quarterly Journal of Economics*, 104, 671 - 698.
- Engel, P. (1999). *What's your Exit Strategy?: 7 Ways to Maximize the Value of the Business You've Built*. Prima Publishing, Rocklin, CA.
- Esteve-Pérez, S., Sanchis-Llopis, A. and Sanchis-Llopis, J. (2010). A competing risks analysis of firms' exit. *Empirical Economics*, 38, 281-304.
- Freeman J, Carroll GR, Hannan MT (1983) The liability of newness: age dependence in organizational death rates. *American Sociology Review*, 48, 692-710.
- Gans J., Stern S. (2003) The product market and the market for "Ideas": commercialization strategies for technology entrepreneurs. *Research Policy*, 32, 333-350.
- Garnsey, E., Stam, E. and Heffernan, P. (2006). New firm growth: exploring processes and paths. *Industry and Innovation*, 13, 1-20.
- Gimeno, J., Folta, T., Cooper, A., Woo, C. (1997). Survival of the fittest? Entrepreneurial human capital and the persistence of underperforming firms. *Administrative Science Quarterly* 42 (4), 750-783.
- Grilli, L. (2011) When the going gets tough, do the tough get going? The pre-entry work experience of founders and high-tech start-up survival during an industry crisis. *International Small Business Journal*, December 2011, 29 (6), 626-647.
- Grilo, I., Thurik, A.R. (2005). Entrepreneurial engagement levels in the European Union. *International Journal of Entrepreneurship Education*, 3(2), 143-168.
- Grilo, I., Thurik, A.R. (2008). Determinants of entrepreneurial engagement levels in Europe and the US. *Industrial Corporate Change*, 17(6), 1113-114.
- Gulati, R. and Higgins, M. (2003). Which Ties Matter When? The Contingent Effects of Interorganizational Partnerships on IPO Success. *Strategic Management Journal*, 24, 127-144.
- Halldin, T. (2012). Firm internationalization and born global firms: On the causes and consequences of export market entry. Doctoral thesis. KTH, School of Industrial Engineering and Management (ITM), Industrial Economics and Management (Dept.), Economics, ISBN: 978-91-7501-262-9.
- Hallen, B. (2008). The Causes and Consequences of the Initial Network Positions of New Organizations: From Whom Do Entrepreneurs Receive Investments? *Administrative Science Quarterly*, December, 53 (4), 685-718.
- Harris, E. and Albert, A. (1991). *Survivorship Analysis for Clinical Studies*. New York: Marcel Dekker Incorporation.

- Haveman, H.A., Khaire, M.V. (2004). Survival beyond succession? The contingent impact of founder succession on organizational failure. *Journal of Business Venturing*, 19 (3), 437-463.
- Hayward, M., Shepherd, D. and Griffin, D. (2006). A hubris theory of entrepreneurship. *Management Science*, 52 (2), 160-172.
- Haunschild, P. R. (1994). How Much is That Company Worth?: Interorganizational Relationships, Uncertainty and Acquisitions Premiums. *Administrative Science Quarterly* 39 (3), 391-411.
- Haverman, H. (1995). The Demographic Metabolism of Organizations: Industry Dynamics, Turnover, and Tenure Distributions, *Administrative Science Quarterly*, 40, 586-618.
- Headd, B. (2003). Redefining business success: distinguishing between closure and failure. *Small Business Economics*, 21, 51-61.
- Henreckson, M. (2008). Gazelles as Job Creators—A Survey and Interpretation of the Evidence, *Small Business Economics*, (in press).
- Hessels, J., Grilo, I., Thurik, R., Zwan, P. (2011). Entrepreneurial exit and entrepreneurial engagement. *Journal of Evolutionary Economics*, 21, 447-471.
- Hochberg, Y., Ljungqvist, A. and Lu, Y. (2007). Whom You Know Matters: Venture Capital Networks and Investment Performance. *Journal of Finance*, 62 (1), 251-301.
- Hofer, C.W., Charan, R. (1984). The transition to professional management: mission impossible? *American Journal of Small Business*, 9 (1), 1-11.
- Hözl, W. (2009). Is the R&D behaviour of fast-growing SMEs different? Evidence from CIS III data for 16 countries. *Small Business Economics*, 33 (1), 59-75.
- Hsu, D. (2004). What do Entrepreneurs Pay for Venture Capital Affiliation? *Journal of Finance*, 59, 1805-1844.
- Holmberg, S. (1991). Value creation and capture: entrepreneurship harvest and IPO strategies. In: Churchill, N. (ed.), *Frontiers of Entrepreneurship Research*. Babson College, Wellesley, MA, 191-204.
- Hull, L. and Arnold, R. (2008). *New Zealand firm growth as change in turnover*. Wellington, NZ: Ministry of Economic Development.
- Kauffman Center for Entrepreneurial Leadership (1999). *Global Entrepreneurship Monitor: National Entrepreneurship Assessment*, United States of America. Kansas City, MO.
- Klepper, S. (1996). Entry, Exit, Growth, and Innovation over the Product Life Cycle. *American Economic Review*, 86, 562-583.
- Klepper, S. (1997). Industry Life Cycles. *Industrial and Corporate Change*, 6, 145-181.
- Klepper, S. and Simons, K. (2005). Industry Shakeouts and Technological Change. *International Journal of Industrial Organization* 23 (1-2), 23-43.
- Kyle, A.S., Ou-Yang, H., Xiong, W. (2006). Prospect theory and liquidation decisions. *Journal of Economic Theory*, 129 (1), 273-288.
- Korunka, C., Frank, H., Lueger, M., Mugler, J. (2003). The entrepreneurial personality in the context of resources, environment, and the startup process – a configurational approach. *Entrepreneurship Theory and Practice*, 28 (1), 23-42.
- Kreuger, N. , Reilly, M. and Carsrud, A. (2000). Competing Models of Entrepreneurial Intentions. *Journal of Business Venturing*, 15, 411-432.
- Landier, A. and Thesmar, D. (2009). Financial contracting with optimistic entrepreneurs. *Review of Financial Studies*, 22, 117-150.
- Lee, E. (1992). *Statistical Methods for Survival Data Analysis*. 2nd Ed. New York: John Wiley & Sons.

- Leitão, J. & Franco, M. (2010). On the evaluation of the performance of SMEs from a human and organisational capital perspective. *International Journal of Entrepreneurship and Small Business*, 10 (1), 108-130.
- Leroy, H., Manigart, S., Meuleman, M. (2007). Exit processes of micro-businesses: the decision to transfer. Paper presented at the International Conference on Small Business.
- Long, C. (2002). Patent Signals, *University of Chicago Law Review*, 69, 625-679.
- MacMillan, I. (1985). Criteria Used by Venture Capitalists to Evaluate New Venture Proposals. *Journal of Business Venturing*, 1, 119-128.
- Maertz, C. and Campion, M. (2004). Profiles in quitting: integrating process and content turnover theory. *Academy of Management Journal*, 47 (4), 566-582.
- Manjón-Antolín, M. and Arauzo-Carod, J. (2008). Firm Survival: Methods and Evidence, *Empirica*, 35, 1-24.
- Mason, C. and Harrison, R. (2006). After the exit: acquisitions, entrepreneurial recycling and regional economic development. *Regional Studies*, 40 (1), 55-73.
- Mata, J. and Portugal, P. (1994). Life Duration of New Firms. *Journal of Industrial Economics*, 42, 227-246.
- McClelland, D. (1961). *The Achieving Society* NJ: Van Nostrand: Princeton.
- McGrath, R. (2006). Rumors of my mortality have been greatly exaggerated: reconsidering the mortality hypothesis. Paper presented at the Academy of Management, Atlanta, GA.
- Medrano E. (2012). Patent Citations, University Inventor Patents, and Survival in the German Laser Source Industry (1960-2005). *Jena Economic Research Papers 2012-009*.
- Meijaard, J., van Eck van der Sluijs, L., Stam, E. (2007). *Stoppen binnen vijf jaar*. Zoetermeer: EIM.
- Miller Jr. (1981). *Survival Analysis*. New York: John Wiley & Sons.
- Minor, N. (2003). *Deciding to Sell Your Business: The Key to Wealth and Freedom*. Business Enterprise Press, Denver, CO.
- Mitchell, W. (1994). The Dynamics of Evolving Markets: The Effects of Business Sales and Age on Dissolutions and Divestitures. *Administrative Science Quarterly*, 38, 575 - 602.
- Montgomery, C. (1994). Corporate Diversification. *Journal of Economic Perspectives*, 8 (3), (summer 1994), 163-178.
- Montgomery, C. and Hariharan, S. (1991). Diversified Expansion by Large Established Firms. *Journal of Economic Behavior and Organization*, 15 (1), 71-89.
- Montgomery, C. and Wernerfelt, B. (1988). Tobin's q and the Importance of Focus in Firm Performance. *American Economic Review*, 78, no. 1 (March 1988).
- Nunes, P., Viveiros, A and Serrasqueiro, Z. (2012). Are the determinants of young SME profitability different? Empirical evidence using dynamic estimators. *Journal of Business Economics and Management*, 13 (3), 443-470.
- Otchere, I., Ip, E. (2006). Intra-industry effects of completed and cancelled cross border acquisitions in Australia: a test of the acquisition probability hypothesis. *Pacific-Basin Finance Journal*. 14 (2), 209-230.
- Parker, S., Storey, D. and van Witteloostuijn, A. (2010). What happens to gazelles? The importance of dynamic management strategy. *Small Business Economy*, 35, 203-226.
- Parsa, H., Self, J., Njite, D., and King, T. (2005). Why restaurants fail. *Cornell Hotel and Restaurant Administration Quarterly*, 46, 304-22.
- Pepper, G. and Larson, G. (2006). Overcoming Information Communication Technology Problems in a Post-Acquisition Organization. *Organizational Dynamics*, 35 (2), 160-169.

- Petty, J., Bygrave, W., Shulman, J. (1994a). Harvesting the entrepreneurial venture: a time for creating value. *Journal of Applied Corporate Finance*, 7, 48-58.
- Petty, J., Shulman, J., Bygrave, W. (1994b). Mergers and acquisitions: a means of harvesting the venture. *Managerial Finance*, 20 (1), 43-52.
- Petty, J. (1997). Harvesting firm value: process and results. In: Sexton, D.L., Smilor, R.W. (eds.), *Entrepreneurship 2000*. Upstart Publishing Company, Chicago, IL.
- Politis, D. (2005). The process of entrepreneurial learning, a conceptual framework. *Entrepreneurship Theory & Practice*, 29 (4), 399-424.
- Pretorius, M., Le Roux, I. (2007). Multiple failure or repeat entrepreneurship. Paper presented June 8th at the Babson College Entrepreneurship Research Conference, Madrid.
- Prisciotta, D. and Weber, R. (2005). Raising capital and developing exit strategies for the closely held business owner: a tutorial for financial professionals. *Journal of Financial Service Professionals*, 59 (3), 61-72.
- Rigby, J., Bleda, M., Morrison, K. and Kim, J. (2007). Mini-Study 1: Gazelles, PRO INNO EUROPE: INNO GRIPS, A project for DG Enterprise, Brussels.
- Robbins, S. (2010). Exit Strategies for Your Business. From <http://www.entrepreneur.com/management/operations/article78512.html>
- Ronstadt, R. (1986). Exit, stage left: why entrepreneurs end their entrepreneurial careers before retirement. *Journal of Business Venturing*, 1 (3), 323-338.
- Rubenson, G. and Gupta, A. (1996). The initial succession: a contingency model of founder tenure. *Entrepreneurship Theory and Practice* 21 (2), 21-35.
- Sarasvathy, S. (2004). The questions we ask and the questions we care about: reformulating some problems in entrepreneurship research. *Journal of Business Venturing*, 19 (5), 707-717.
- Schutjens, V. and Stam, E. (2006). Starting a new: entrepreneurial intentions and realizations subsequent to business closure. Discussion papers on Entrepreneurship, Growth and Public Policy, No. 2006-10, Max Planck Institute of Economics, Jena.
- Serrasqueiro, Z. and Nunes, P. (2010). Non-linear relationships between growth opportunities and debt: Evidence from quoted Portuguese companies. *Journal of Business Research*, 63 (8), 870-878.
- Shapiro, A. and Sokol, L. (1982). *Some Social Dimensions of Entrepreneurship*. Englewood Cliffs NJ: Prentice-Hall.
- Shane, S. and Cable, D. (2002). Network ties, reputation, and the financing of new ventures. *Management Science*, 48 (3), 364-381.
- Sharma, A. and Kesner, I. (1996). Diversifying Entry: Some Ex Ante Explanations for Post-Entry Survival and Growth. *Academy of Management Journal*, 39, 635 - 677.
- Shen, W. and Cannella, A. (2002). Revisiting the performance consequences of CEO succession: the impacts of successor type, post-succession senior executive turnover, and departing CEO tenure. *Academy of Management Journal*, 45 (4), 717-733.
- Sorensen J. and Stuart, T. (2000). Aging, obsolescence, and organizational innovation. *Administrative Science Quarterly*, 45, 81-112.
- Srinivasan, R., Lilien, G. and Rangaswamy, A. (2008). Survival of high tech firms: The effects of diversity of product-market portfolios, patents, and trademarks. *International Journal of Research in Marketing*, 25, 119-128.
- Stam, E. and Wennberg, K. (2009). The roles of R&D in new firm growth. *Small Business Economics*, 33 (1), 77-89.
- Stam E., Audretsch, D. and Meijaard, J. (2008). Renascent entrepreneurship. *Journal of Evolutionary Economics*, 18(3-4), 493-507.

- Stuart, T., Hoang, H. and Hybels, R. (1999). Interorganizational Endorsements and the Performance of Entrepreneurial Ventures. *Administrative Science Quarterly*, 44, 315-349.
- Taylor, M. (1999). Survival of the fittest? An analysis of self-employment duration in Britain. *Economic Journal*, 109, March, 140-155.
- Tyebjee, T. and Bruno, A. (1984). A model of venture capitalist investment activity. *Management Science*, 30 (9), 1051-1066.
- Ucbasaran, D., Wright, M. and Westhead, P. (2003). Longitudinal study of habitual entrepreneurs, starters and acquirers. *Entrepreneurship and Regional Development*, 15 (3), 207-228.
- van Gelderen, M., Thurik, R. and Bosma, N. (2006). Success and Risk Factors in the Pre-Startup Phase. *Small Business Economics*, 26 (4), 319-335.
- Verhoeven, W., Gibcus, P. and de Jong-´t Hart, P. (2005). *Bedrijvendynamiek in Nederland: goed of slecht?* Zoetermeer: EIM.
- Wagner, J. (2003). Taking a second chance: entrepreneurial re-starters in Germany. *Applied Economics Quarterly*, 49(3), 255-27.
- Wagner, S. and Cockburn, I. (2010). Patents and the Survival of Internet-related IPOs, *Research Policy*, 39, 214-228.
- Wasserman, N. (2003). Founder-CEO succession and the paradox of entrepreneurial success. *Organization Science*, 14 (2), 149-172.
- Wennberg, K. (2008). *Entrepreneurial Exit*. Forthcoming in J.P. Dana (ed.) *Edward Elgar Encyclopedia of Entrepreneurship*. Cheltenham: Edward Elgar.
- Wennberg, K., Wiklund, J., DeTienne, D.R. and Cardon, M. (2010). Reconceptualizing entrepreneurial exit: Divergent exit routes and their drivers, *Journal of Business Venturing*, 25 (4), 361-375.
- Westhead, P., Ucbasaran, D., Wright, M. and Binks, M. (2005). Novice, serial, and portfolio entrepreneur behaviour and contributions. *Small Business Economics*, 25 (2), 109-132.
- Wieser, R. (2005). Research and Development, Productivity and Spillovers: Empirical Evidence at the Firm level. *Journal of Economic Surveys*, 19 (4), 587-621.
- Ziedonis, R. (2004). Don't Fence Me In: Fragmented Markets for Technology and the Patent Acquisition Strategies of Firms. *Management Science*, 50, 804-820.

Conclusions

This doctoral thesis is focused on the entrepreneurial processes of technology transfer and patenting exploitation. Being structured in 5 chapters, each of them was dedicated to one basic pattern of this type of entrepreneurial processes. It contributes to the literature of R&D and technology management, since it identifies and analyzes, under an innovative lens, a set of entrepreneurial processes leading to innovative creation, especially in the academic context, IPR protection, patenting and commercialization and successful exploitation of the technology, even if all the processes are conducted with the strategic aim of selling the company and exiting, in a successful way. It started with an introducing chapter on the umbrella topic of technology transfer and innovation and went along several related problematic, like the determinants of academic patent's value, the drivers of firms' innovative behavior to assess their patent intensiveness based on cooperation relationships, the effect of R&D strategic factors based on patent transactions on the firm's growth and the determinant factors of firm exit.

The first chapter, which intends to be an introductory paper, reviewed the literature on the dynamics of technology transfer, by exploring the existent studies on valuation and commercialization of academic patents. It has analyzed technology transfer acting as an innovation engine which is capable to promote interactions among academic, governmental and industrial agents.

Innovation was hereby analyzed as the result of a mediator process between the firm and the environment, allowing for a successful exploitation of an idea spread and used as knowledge economically useful. In this sense, technology transfer activities emerge between technology providers and industry, as an important response to the increasing importance of knowledge in national and regional innovation systems, fostering the creative capacity of inventors and as transfer actor of knowledge.

From the literature survey, a caveat is found in the sense there is a need for developing further research on the management of entrepreneurial processes oriented to technology transfer and patenting, across the stages of the firm's lifecycle, especially in the context of academic entrepreneurship. In this sense, the present doctoral thesis contributes to the literature on R&D and technology management by assessing the importance of technology transfer and patenting, in different stages like the creation of academic spin-offs, the implementation of cooperation relationships, the exploration of corporate R&D oriented to growth and the survival mode funded on high-growth patterns.

For addressing the referred caveat, in the second chapter, and after reviewing the literature on the dynamics of technology transfer conjoined with the valuation and commercialization of academic patents, the spin-off condition's variable is used for assessing the academic patents' value, as a mechanism to exploit the patent opposing to other non-spin-off forms, such as licensing.

By using two ' samples of academic patents (one from the Carnegie Mellon University, US and another from the Cambridge University, UK) and a negative binomial regression model, we found that the spin-off condition has not an important effect on the academic patent's value, for both cases. In addition, other factors appeared as significant determinants on the value of the academic patent, namely, the size of the patent family, the time to maturity and the geographical scope of the patent. The first two factors denoted a positive and significant effect on the academic patent's value and the last one a negative and significant effect. Furthermore, the technical field has a positive and significant effect on the patent's value, especially for the Cambridge University's case.

The effect of disaggregating the spin-off condition deserves a remark for both cases. For the Cambridge University's sample, we must point out the negative effect of time to maturity and the positive impact of the technical field on patent's value. For the Carnegie Mellon University's sample, one must analyze the importance of the geographical scope of the patent, which impacts in a negative and significant way on the patent's value.

In the third chapter, the determinants of firms' innovative behavior are analyzed in order to unveil their patent intensity behavior based on coopetition relationships. This paper makes use of a dataset of 3682 manufacturing firms and 1221 service firms that participated in the European Community Innovation Survey (CIS), 2008. It makes use of a probit analysis separately for manufacturing and service firms in order to analyze the determinant factors of firms' capacity to generate innovations, being influenced by public policies targeted at driving innovations among firms, cooperation with scientific stakeholders and development of the capacity to generate and transfer new products.

The results obtained reveal that the influence of manufacturing and service firms' capacity to generate product and service innovations is determined by coopetition arrangements between competitors and other R&D stakeholders, and also the firm's capacity to introduce innovations into the market. Moreover, it is also disclosed that for service firms the impact of introducing process innovations inside the firm and the existence of internal R&D activities have a positive and significant effect on the capacity to generate additional innovations.

In the fourth chapter, the set of factors that help to characterize the corporate R&D strategy is analyzed, under the framework of the firm's growth dynamics. Accordingly to the umbrella research topic, that is, technology transfer and patenting, the corporate R&D strategy factors

under analysis are based on patent transactions, such as R&D intensity, patent portfolio and patent transactions.

From the Kaufman Foundation Survey (KFS)'s dataset that contains 4928 firms, during the 2004-2010 period, were extracted 818 firms of the high-tech and medium high-tech sectors that were analyzed by using a panel data approach.

This empirical approach went a little bit further obtaining information about corporate R&D strategies based on patent transactions, such as the in-license and out-license of patents in firms, and their impact on firm's growth. Thus, it contributes to the literature on R&D and technology management by providing further insights and knowledge about the effects of innovation proxies on firm's growth, especially in the context of high-tech and medium high-tech sectors, which are characterized by a high pace of technological change and shorter lifecycle products.

Empirical evidences also reveal that R&D intensity plays a high and positive impact on firm's growth. In addition to this, the in-license of patents denotes a positive and significant impact on the firm's growth. When the squared R&D intensity is added, the existence of a U-inverted relationship between firm's growth and R&D intensity is verified. It should be stressed that for the sector of manufacture of radio, television and communication equipment and apparatus (which corresponds to a high-tech manufacturing sector), on the one hand, is detected a positive and significant effect of the in-license of external patents on firm's growth, and on the other hand, the R&D intensity has a negative and significant effect on the firm's growth. Through the dynamic estimation the effect of firm's size on firm's growth was assessed as being positive and significant. Another important conclusion regarding the sector of computer and related activities (also an high-tech knowledge intensive service sector), has to do with the lagged variable of firm's growth that denotes a negative and significant impact on firm's growth, showing a negative correlation of the firm's growth at the present moment with the firm's growth at a previous moment.

In the fifth chapter, the exit strategies are analyzed, by contrasting a sample of gazelle firms and non-gazelle firms. By making use of a Cox regression model, the determinant factors of firm survival among a sample of 4928 firms created in the cohort 2004-2010 are assessed accordingly to the data collected from the KFS. The results obtained reveal that a manufacturing gazelle has less chances of exiting than a non-gazelle firm. Furthermore, other determinants like the firm's patents and copyrights or the founder's attributes, such as age and gender are also determinant predictors to explain the survival rates. Conversely, the study showed us that small firms with an average age of 4 years, whose founders, mainly males, in average terms, with no university degree and with more than 35 years old, are significantly more predictive of surviving than other firms. Manufacturing gazelle firms are

also expected to survive longer aligned with a corporate strategy oriented to innovation intensity. In this context, the IPR portfolio of the firm (mainly patents and copyrights) has a significant effect on the survival ratios.

In terms of major implications of the set of chapters hereby presented, it's vital that public policies reflect the understanding of the determinants of entrepreneurship and the needed mechanisms to sustain it in order to determine the success of academic entrepreneurship, acting as a productive driver of endogenous growth. Several implications are aligned with this, namely the ones that are targeted at the need for defining a corporate R&D strategy, including IP. Accordingly, the results revealed in the present doctoral thesis suggest a careful design of a patenting methodology that reflects on in depth cost-benefit analysis applied to the scope of the IP asset, that is to say, the geographical extensions and the increase of the size and diversity of the patent family, for allowing assertive decision taking about litigations, oppositions, renewal and extension processes.

The results now presented also provide a set of implications that can be derived to the universities management, namely, the need for defining internal regulations for IP rights, knowledge and technology transfer practices, valorization of knowledge and pre-incubation of academic spin-offs.

For policy-makers that regulate and design the public policies targeted at fostering firm's innovative capacities and open innovation flows, it's of major importance that they know and understand the determinants behind firms' capacity for generating innovations, and their effects on innovative performance. Consequently, it's important to manage properly the innovative behavior among cooperation partners, namely their patenting performance, in order to ease the set of synergetic relationships, taking into consideration all the needed measures to avoid the appropriability risks.

Managers must undertake the needed strategies to improve performance and growth, considering a corporate strategy to catalyze open innovation workflows, accordingly to the different stages of the firm's lifecycle, in what concerns IP rights.

In terms of limitations, several difficulties regarding the lack of data were experienced. For instance, in chapter 2 the datasets were completed by using data from both technology transfer offices and by gathering additional information on "Espacenet". Nevertheless, it was not possible to test additional determinant factors, namely, the existence of a pre-incubation structure, the use of formal mechanisms to support and accelerate IP exploitation and the international patent classification, in disaggregated terms, since this data is not available. Furthermore, in chapter 3, additional limitations were faced since the European CIS Survey, 2008, reveals lack of important information regarding the innovative capacity of firms, in terms of patenting behavior and other IP rights. In addition, there was a limited access to the

Portuguese dataset, which does not provide the possibility of producing cross-country analyses, in the European context. In Chapters 4 and 5, the KFS dataset is used, gathering several data on a big sample of firms along a six year period. This dataset only relates to start-ups, being this one limitation for assessing the determinants of growth and exit. It would be interesting to obtain information on other types of firms and other countries firms.

Future avenues for research around the problematic of the role played by the IP rights portfolios, IP transactions and R&D intensity can be linked to a sectorial approach, regarding manufacturing and services, providing insightful perspectives regarding growth variations, R&D and intangibles across different activities.

Other open fields for research that we couldn't cover in this work, due to the limitations in what concerns the availability of data, are the academic spin-offs and rapid-growth firms which are characterized by high turbulence and fast change, being of extreme importance to understand the growth drivers to avoid exit and sustain an improved performance. To prevent the decision of exiting, policies must be focused on the hazard factors and non-hazard drivers and adjust measures to avoid firm's deaths and to stimulate endogenous growth.

