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The link between the Intellectual Property Rights, Innovation and Growth: A Meta-Analysis

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THE LINK BETWEEN THE INTELLECTUAL PROPERTY RIGHTS, INNOVATION AND GROWTH: A META-ANALYSIS

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Biographical Note

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Abstract

Over the past few decades, the Intellectual Property Rights (IPRs) has been through for an enormous transformation, either for political reasons or for scope extension. Therefore, the exploration of this theme became desirable for academic research and due to this the number of publications has increased considerably.

Keeping this transformation in mind, the main purpose of this dissertation is to examine the impact of IPRs protection on innovation and on economic growth.

Despite the existence of a substantial theoretical and empirical literature, there is no consensus on the effective impact of IPRs. Thus, with the purpose to achieve our goal, we conducted a meta-analysis to examine the link between IPRs, Innovation and Economic Growth.

The main aspiration is to gather a group of literate contributions that analyse the different effects of IPRs on innovation and on growth.

Keywords: Intellectual Property Rights; Innovation; R&D; Economic Growth; Meta-analysis.

Resumo

Nas últimas décadas, os Direitos de Propriedade Intelectual passaram por uma enorme transformação, quer por razões políticas quer pelo aumento da amplitude de aplicação. Logo o tema ganhou interesse de investigação académica e, por esse motivo, o número de publicações aumentou consideravelmente.

Tendo em mente essa enorme transformação, o objetivo principal desta dissertação é analisar o impacto da proteção dos Direitos de Propriedade Intelectual (IPR) na Inovação e no Crescimento Económico.

Apesar da existência de um número considerável de publicações teóricas e empíricas sobre o assunto, não consenso sobre o real efeitos dos IPRs pelo que conduzimos uma meta-análise para analisar a relação entre os IPRs, Inovação e Crescimento Económico.

O objetivo fundamental é reunir uma amostra de contribuições literárias que analisam os diferentes efeitos dos IPR na Inovação e no Crescimento.

Palavras-chave: Direitos de Propriedade Intelectual; Inovação; I&D; Crescimento Económico; Meta-Análise.

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Acronyms and Symbols

Acronyms	Description
IPRs	Intellectual Property Rights
WIPO	World Intellectual Property Organization
M-A	Meta-Analysis
MRA	Meta-Regression Analysis
TRIPS	Trade-Related Aspects of Intellectual Property Rights
OLS	Ordinary Least Squares Regression
SUR	Seemingly Unrelated Regressions
RE	Random effect
FE	Fixed effect
2SLS	Two-Stage Least Squares regression analysis
IV	Instrumental variables
GMM	Generalized Method of Moments
FAT	Funnel Asymmetry Test
REML	Restricted maximum-likelihood
PCC	Partial correlation coefficient
Inn	Innovation
GR	Growth
SD	Standard errors
NE	Number of Estimations
PCCI	PCC Inn (i.e., Partial Correlation Coefficient, by paper)
SDPCCI	SD of PCC Inn (i.e., Standard Errors of Partial Correlation Coefficient, by paper)
PCCGR	PCC GR (i.e., Partial Correlation Coefficient, by paper)
SDPCCGR	SD of PCC GR (i.e., Standard Errors of Partial Correlation Coefficient, by paper)
DS	Data Structure
CS	Cross Section
EM	Estimation Methodology

1. Introduction

Intellectual Property Rights (IPRs) have been assuming a crucial role on leverage of innovation and economic growth. As argued by R. E. Falvey, Foster, and Memedovic (2006, p. 1, p.1), "encourage innovation by granting successful inventors temporary monopoly power over their innovations".

Over the years, a large number of IPRs instruments with different purposes and application fields have arisen. Throughout the industrial history, the power to prevent others from using their intellectual creations has been strengthened in order to encourage private investment in innovation activities and promote a sustainable economic growth. As emphasised by Braga, Fink, and Sepulveda (1999), the main intention was to regulate the relationship between innovators/creators and consumers, and rewarding innovators/creators for their ideas.

Nevertheless, many authors have been inquiring whether IPRs are the effective responsible ones for inducing innovations and, as a result, economic growth. In fact, the question of how or how much IPRs stimulates innovation and economic growth has gained considerable attention among economists. The theoretical literature on this topic has increased significantly and a huge number of empirical studies have been produced as an attempt to validate the effects of IPRs on innovation and on growth.

Kanwar and Taylor (1994, 2016), cited by Adams (2011), argue that the IPRs straightness could enforce: (i) innovations and economic growth in developed countries; (ii) the transfer of technology from the North to the South in developing countries.

However, as R. Falvey, Foster, and Greenaway (2006) state, a strong IPRs protection could have a negative effect on developing countries when reduce innovative R&D activities because of imitations, which becomes their main and cheaper source of technological development. Horii and Iwaisako (2007) concluded that, in developing countries, a minor IPRs protection could encourage domestic innovative activity and thus enforce economic growth.

Particularly in the case of developing countries there is no consensus on the effect of IPRs on innovation and on economic growth. Hence, the link between IPRs, innovation, and economic growth remains ambiguous. Indeed, as noted by Hu and Png (2013), this relationship requires several trade-offs and as Arora, Ceccagnoli, and Cohen (2008) concluded, produces mixed results of difficult interpretation.

The motivation for this dissertation comes from the ambiguity of the results of the previous studies and from the diversity of approaches used to establish the link between IPRs, innovation and growth. Our main research questions are thus: Why are the conclusion of researchers so inconsistent and divergent? Bearing in mind the existing literature it is possible to establish a cohesive relationship between IPRs, innovation and growth?

More specifically, we will perform a Meta-Analysis (M-A) methodology, which "provides a more formal and objective process on reviewing an empirical literature. It employs conventional statistical methods and criteria to summarize and evaluate empirical economics." (Tom D Stanley, 2001, pp. 147-148, p.147-148). The M-A will (i) help us compare the different research results and (ii) discover if a significant and positive relationship between the empirical results reveals that the impact of IPRs on innovation is more positive in developed countries than in developing countries. Firms in developed countries understand more effectively their importance on the innovative activities, the capital available to invest is higher than in developing countries, and the effects of policies, such as subsidies, have a huge impact on the decisions.

However, the impact of IPRs on growth is significant and positive in developing countries, probably not only from the eventual encouragement of domestic investment in R&D activities, but from foreign investment and relocation of some R&D activities. Interestingly, we also found that the estimations of the impact of IPRs on innovations and growth are influenced by the type of journal in which articles are published, the number of countries used in the sample and the structure of the data.

The outline of this dissertation is organized as follows: Chapter 2 provides a brief review of the theoretical and empirical literature behind the relationship between IPRs, innovations and economic growth. In Chapter 3, the M-A methodology and the data used is exposed. Chapter 4 presents the M-A results. Chapter 5 summarizes the main conclusions, including what we wanted to do, how we did it, what we found, limitations and suggestions for future research.

2. Literature Review

The intention of this chapter is two folded. Firstly, to outline what IPRs are, their contemporary origins and their evolution to almost global rights. Secondly, to present an overview about the theoretical and empirical literature on the relationship between IPRs, innovation and growth.

2.1 Intellectual Property Rights: historical overview

In the contemporary world the main economic development challenge is based on the capability to generate and manage the knowledge appropriability, and on the distribution of wealth. Over the years, the concept of business wealth has been changing and currently the human and the knowledge capital are the most valuable intangible assets. For those reasons, IPRs had become the economic competitiveness base and the motivation for technological change.

The creation and dissemination of new knowledge, innovations and social welfare encouraged the implementation of a structured IPRs regime, which promoted creative and innovative activities with economic incentives and exclusive commercial rights for the creators (Adams, 2011). This kind of protection concept and rewarding has emerged in the 4^{th} century BC, with Aristotle's and Hippodamus of Miletus' debate. However, the present governmental IPRs concept was born in the 13^{th} century in Venice, Italy, with the need to protect the knowledge embedded in their glass industry and as an approach to reward foreigners that brought new knowledge to the Venice industry (e.g., Long, 1991, cited by Braga et al. (1999)). The IPRs protection spread from Venice to other developed countries in Europe, the United States, Japan, South Korea and Taiwan.

To harmonize and to promote cooperation among states, IPRs has undergone significant changes and a huge number of international treaties and agreements were signed for that purpose. The major agreement was the Trade-Related Aspects of Intellectual Property Rights (TRIPS), negotiated between 1986 and 1994 on the Uruguay round with the goal to induce more innovation leading to an accelerated economic growth, signed by 171 developed and developing countries and managed by the World Intellectual Property Organization (WIPO).

IPRs enforce the temporary monopoly power of innovators thus encouraging innovation activities and contribute to long-run economic growth. Since the imitation cost is lower than the innovation cost (e.g., Mansfield, Schwartz, and Wagner (1981)), IPRs assure a crucial leverage power to promote the technological change. Due to that, the IPRs regimes are completely different between developed and developing countries. On developed countries, the IPRs regime protects all categories of intellectual properties with strong mechanisms and has a well-structured administration to create the right conditions that compensate large R&D investments. The main goal is to promote the long-run economic growth by encouraging creative and innovative activities (R. E. Falvey et al., 2006). In turn, on the developing countries, only a few types of IPRs are protected and in a rudimentary way. This kind of protection, or rather, the lack of it, allows foreign developed firms to invest in developing countries promoting imitation. Imitation is the main source of technological development in developing countries, a lower IPRs protection seems to be the best choice to encourage more domestic profitably activities ensuring a sustainable economic growth. Thus, the knowledge transfer from developed countries could be seen as the base and the incentive source of domestic innovative activities.

Therefore, the IPRs protection performs an important role among countries. However, it also presents some problems since the reward criteria is based on market power and the welfare gain is many times compromised (Gilbert & Shapiro, 1990). In order to enable the spillovers of technological knowledge to imitators, the scope and the duration of the protection should be restricted with the purpose of leading society to a more innovative economic development and prosperity created through a stock of knowledge – e.g., Kitch (1998), Towse and Holzhauer (2002), and Thumm (2000) cited by (Bielig, 2015). The dissemination of new knowledge and further innovations as well as growth could be compromised by the excessive IPRs protection since the spread of new ideas is limited for the excessive monopoly effects (R. E. Falvey et al., 2006).

Nevertheless, as pointed by Arrow (1962), in absence of an IPRs system, the monopoly value would be reduced or even extinguished if the owner sells the information on the market, since the knowledge would become a public good,[1] and anyone could use it for a small or any cost (e.g., Maskus and Reichman, 2005, cited by Breitwieser (2010)). Thus, the trade-off is between allowing the access to the knowledge and stimulate the investment in R&D activities.

Table 1 summarises the performed overview on IPRs.

[1] Public goods are "those goods (including policies and infrastructure) that are systematically underprovided by private market forces and for which such under-provision has important international externality effects" (Mercurio (2013) p. 360).

Table 1. Intellectual Property Rights: Overview

Authors	Argument about IPRs
Adams (2011)	The creation and dissemination of new knowledge, innovations and social welfare encouraged the creation of a structured IPRs regime
Mansfield et al. (1981)	The costs of imitation are lower than the costs of innovation
R. E. Falvey et al. (2006)	On developed countries, IPRs can promote the long-run economic growth through encouraging the creative and innovative activities. However, the excessive IPRs protection can also compromise the spread of new ideas.
Gilbert and Shapiro (1990)	Since the IPRs reward criteria is based on market power and the welfare gain it is many times compromised.
Bielig (2015)	The scope and the duration of the IPRs should be restricted, with the purpose of leading society to a more innovative economic development and prosperity, created through a knowledge stock.
Arrow (1962)	In absence of an IPRs system, the monopoly value would be reduced or even extinguished, since the knowledge would become a public good.

2.2 The economics of IPRs, innovation and economic growth

The theoretical studies about IPRs, innovation and growth were considered since Adam Smith, in 1776, although only with Robert Solow, in 1957, were contemplated under the neoclassical growth models. Nevertheless, neoclassical growth models were not able to completely explain the economic growth in the long run. Then, with Romer (1986) and Lucas (1988) a new growth theory emerged with endogenous technological change and human-capital formation. The new theory assumes that technological progress occurs through investment in R&D innovative activities, instead of an automatically and unintentionally technological progress. Nowadays, in economic theory, it is widely accepted that technological progress or innovation is the basis of progress, society transformation, globalisation and, consequently, long-run growth (Granstrand, 2003).

Thus, IPRs protection, as a means to stimulate innovation, can grant temporary monopoly rights to the innovator to solve the investment's returns from the appropriability problem. However, it can also be an obstacle to the diffusion of knowledge and reduce incentives for further innovation. The complexity of the effects of IPRs on innovation and economic growth across countries, firms and time is justified by the variety of approaches used by the authors in their studies. That suggests that theoretical and empirical literature remains divided, and there's still a lot of controversy whether IPRs effects matter. And if so, do consequences matter direct or indirectly?

Grossman and Helpman (1991) verified in their model that the observation and analysis of rival innovations could beneficiate the innovators' knowledge and expand it. In other words, a strong IPRs protection may not be the key of long-run leverage of innovation and growth. As noticed by Cho, Kim, and Shin (2015, p. 827, p.827), "the causal relationship among intellectual property rights (IPRs) protection, innovation and economic growth remains ambiguous" in both theoretical and empirical literature. The economic literature suggests that the connection from IPRs to innovation and growth is very complex and depends on a significant quantity of factors, sometimes contradictory. Thus, IPRs protection may not have a direct effect on economic growth, affecting other variants that, in turn, affect growth (Kanwar & Evenson, 2003).

For Arrow (1962), IPRs displays an important role on R&D activities. As well as for Torun and Cicekci (2007), who have considered that IPRs have a master role on the resolution of the innovation and economic growth challenges.

The IPRs importance is also validated, for example, by the result of the multiple linear regression model conducted by Bielig (2015), which estimated the economic effect of four main IPRs categories, and concluded that IPRs had a positive impact on German economy reflecting their strong economy structure and innovation system. Chen and Puttitanun (2005), using a panel data set including 64 developing countries over the 1975-2000 period, evaluated empirically the theoretical results of IPRs and innovation in developing countries, confirming both the positive impact of IPRs on innovation in developing countries and the presence of a U-shaped relationship between IPRs and levels of economic development.

Thus, regarding these two empirical studies, it is possible to detect a world composed by two types of countries: the North composed of developed and innovating countries and the South composed of developing and imitating countries (R. Falvey, Greenaway, & Foster-McGregor, 2002). As suggested by Grossman and Lai (2004), in developed countries, with a high level of globalization, strong innovation capability, large domestic market, and high market concentration, a stronger IPRs protection is useful to increase innovation and economic growth. On the other hand, in developing countries, the IPRs protection must be reduced, in order to avoid the slowdown of the innovation process, economic growth and the increase of firm costs due to lawsuits to defend domestic patents.

Developing a Schumpeterian growth model of distance to technology frontier in which economic growth in the developing country is driven by domestic innovation, Chu, Cozzi, and Galli (2014) concluded that strength of IPRs protection increases as a developing country goes forward towards the world technology frontier. Nevertheless, Boldrin and Levine (2009) determined, with their empirical study, that the IPRs protection should be reduced to increase growth and encourage creation and innovation. Ginarte and Park (1997), using an augmented Mankiw, Romer, and Weil model, concluded that a measure for IPRs protection remains insignificant in all growth equations, although having a relevant positive impact on the accumulation of physical and research capital.

This ambiguity led Cozzi (2009) to discuss a few studies and based on Tetsugen Haruyama's and Michele Boldrin's papers, concluded that innovation and growth can develop relatively well without IPRs protection since innovation could be stimulated through knowledge. Hence, it is possible to conclude, as Cho et al. (2015), that there is no consensus regarding the relationship between the variables in analysis in both specific theoretical and empirical literature. As Cozzi (2009) observes, it is also possible to find evidence of both positive and negative effect of IPRs on innovation and growth, explained by the specificity of the topic analysed by the researcher.

Table 2 summarises the main results in this subsection.

Table 2. The economics of IPRs, innovation and economic growth

Authors	Argument	IPRs impact on innovation and growth
Grossman & Helpman (1991)	A strong IPR protection may not be the key of long-run leverage of innovation and economic growth	Negative
Cho et al. (2015)	The relationship between IPRs, innovation and growth remains ambiguous	Ambiguous
Kanwar and Evenson (2003)	IPRs protection may not have a direct effect on economic growth, affecting other variants which in turn affect growth	Indirect
Arrow (1962)	IPRs displays an important role on R&D activities	Positive
Torun and Cicekci (2007)	IPRs have a master role on the resolution of the innovation and economic growth challenges.	Positive
Bielig (2015)	IPRs had a positive impact on German economy reflecting their strong economy structure and innovation system	Positive
Chen and Puttitanun (2005)	Positive impact of IPRs on innovations in developing countries and the presence of a U-shaped relationship between IPRs and levels of economic development.	Positive/U-shaped
Grossman and Lai (2004)	A stronger IPRs protection, it is useful to increase innovation and economic growth.	Positive
Chu et al. (2014)	The strength of IPRs protection increases as a developing country goes forward towards the world technology frontier	Positive
Boldrin and Levine (2009)	The IPR protection should be reduced in order to increase growth and encourage creation and innovation	Negative
Ginarte and Park (1997)	IPRs protection remains insignificant in all growth equations	Insignificant

2.3 IPRs, innovation and growth: the linkage between them

The IPRs system appears in literature as a key factor for innovation and growth, with the main purpose to reward innovators for their creations. In line with Machlup (1961), cited by (Bielig, 2015), that a time-limited monopoly promotes the growing of register of the property rights for knowledge goods, allowing the creator to exploit the economics of invention.

Invention is a highly risky activity since it is dedicated to the production of new information, as Arrow (1962) concluded. For that reason, the expected investment in R&D activities is much reduced without any kind of return insurance. Even if it is not worth patenting, the IPRs stimulate innovation and the investment in R&D activities, as is suggested by Arora et al. (2008).

The empirical studies that examine the effect of IPRs protection on innovation and growth usually point to an overall positive effect. Although most of the times on the specific case of economic growth the effect is indirect. IPRs, actually, directly enhance innovation through the investment in R&D activities, which, in turn, increases growth. Notwithstanding, in countries with an underdeveloped R&D sector, growth will not be enhanced by innovation since is not relevant enough; it is enhanced by factors like international trade or foreign direct investment (FDI). This means that IPRs do not have enough significance by themselves.

Gould and Gruben (1996) examined the impact of IPRs on growth, using a cross-country data on patent protection, trade regime, and country-specific characteristics. Using the Rapp and Rozek index as a proxy for IPRs, they regress yearly growth in real GDP per capita, in the period between 1960 and 1988, on patent protection. The first results suggested that IPRs had a positive effect on economic growth, and the significance on patent protection level was marginal. In order to solve the estimation measurement and endogeneity problems, Gould and Gruben (1996) used instrumental variables technics. However, the solution turned the significance level lower than it was initially, raising doubts about the importance of IPRs on economic growth. The results only turned positive and stronger, in more open economies, when the dependency of the trade regime of a country was examined.

Park and Ginarte (1997) studied how IPRs affect long-run economic growth. Using an IPRs strength index, they stimulated the accumulation of factor input in 60 countries, between 1960 and 1990. Using the Mankiw et al. (1992) model, they obtained a four equations system, and the estimations were performed by Seemingly Unrelated Regressions (SUR). The results suggest that IPRs have potential to improve. However, they could not get statistical significance on growth. On innovation, "IPRs matter for the R&D activities of the developed economies, but not for those of the less developed economies" (Park & Ginarte, 1997, p. 60, p.60), which means that in developing countries the most significant R&D activity is imitation.

Kanwar and Evenson (2003) focused their analysis on examining the technological change between 1981 and 1995, by using a cross-country panel data on R&D investment, patent protection and other country-specific characteristics. They estimated on four models using a R&D investments proxy of GNP, which indicates that IPRs incentivize innovation.

Using a panel data of 19 developed and 28 developing countries from 1970 to 1990 and to determine the country's rate of innovation and economic growth, Schneider (2005) examined the importance of high-technology trade, IPRs and FDI. Based on Grossman and Helpman (1991) and Barro and Sala-i-Martin (1997) models, Schneider (2005) estimated the innovation and growth rates using a fixed effects (FE) and Ordinary Least Squares (OLS) regressions. Results suggested that the IPRs level is an important factor to explain the innovation rate. Conversely, the growth rate is not explained by the IPRs level, but by the stock of physical capital and foreign technology.

Chen and Puttitanun (2005) performed an empirical analysis on 64 developing countries about the trade-off between imitation and domestic innovation. They estimated domestic innovations (IN) and growth (GDPCAP) by using the index developed by Park and Ginarte in 1996 and OLS regressions. The results suggested that IPRs have a positive impact on innovation and a U-shaped relationship on growth.

R. Falvey et al. (2006) focused on threshold regression technics, estimating an equation of growth to examine the non-linear relationship between IPRs and the level of development. Using the Ginarte and Park index, they measured the strength of IPRs on a dataset that included 79 countries and four sub-periods combined between 1975 and 1994. Their study revealed that a in a higher IPRs protection scenario, is expected to enhance a faster growth in countries with high per capita incomes, and this can also have a positive impact in the growth of the poorest countries. The relationship between IPR protection and growth in the poorest countries does not result from the encouragement of domestic R&D and innovation.

For Hudson and Minea (2013) the IPRs effects on innovation are more complex than they initially expected. They used a Panel Smooth Threshold Regressions model created by Gonzalez et al. (2005) to perform the estimation of IPRs level on innovation, using a dataset of 62 developed and developing countries. They concluded that IPRs exerts a complex effect on innovation and the relationship is essentially a U-shaped curve. They did not focus their analysis on economic growth.

In a panel of 72 developed and developing countries and 54 manufacturing industries on the period between 1981 and 2000, Hu and Png (2013) analysed the impact of changes in effective patent rights. To calculate the Effective Patent Right Index, they combined two famous indexes, the Ginarte and Park (1997) and the Fraser Institute. With their approach, they concluded that IPRs protection has a positive impact on industrial and economic growth even though it is stronger on developed countries than in developing ones.

Ang, Cheng, and Wu (2014), Chu et al. (2014) and Yang, Huang, and Lin (2014) performed their studies in the same year, even with different approaches, but all having the same result: IPRs have a positive impact on innovation and growth. Ang et al. (2014) used high-technology firms' data, based in China, to examine the impact of IPRs on financing R&D. To deal with endogeneity problem they employed a firm FE and the Generalized Method of Moments (GMM) panel. On other hand, Chu et al. (2014) using a panel of 92 developed and developing countries from 1970 and 2005, as already stated, developed a Schumpeterian growth model of distance to technology frontier in which economic growth in the developing country is driven by domestic innovation. Yang et al. (2014) performed their estimation based on 42 developed and developing countries panel dataset, on the period between 1997 and 2006, using a panel threshold model.

Bielig (2015) found a result that supported the inconsistency of the relationship between IPRs and economic growth. Depending of the IPRs categories, the relationship could either be positive or negative. Bielig (2015) performed his examination on patents, utility models, trademarks and designs stocks on the German GDP, in the period between 1999 and 2009, using three regression functions.

Sweet and Maggio (2015) analysed the impact of IPRs on innovation using the Ginarte and Park (1997) index on 94 countries in the period between 1965 and 2005. The results of OLS and GMM models suggested that IPRs protection has a positive impact on innovation on countries with a higher level of complexity and development.

Zhang, Du, and Park (2015) motivated by law-and-finance literature, even if the empirical evidence of IPRs-Growth relationship remains inconclusive, found a stronger evidence of a positive relationship between IPRs, innovation and economic growth. Using a Ginarte and Park index, they considered 98 countries.

Most recently, Papageorgiadis and Sharma (2016) analysed a panel of 48 countries between 1998 and 2011. To explain the enforcement related with the component of the patent system and with the strength of patent regulation, they used the Ginarte and Park (1997) index.

The analysed literature suggests that the effects of IPRs are not completely clear. Most of the times the conclusion presents a direct and positive impact of IPRs on innovation, although the effect on growth depends of other variables such as country' characteristics or even economy openness. On developed countries, where the income is higher, the investment in R&D activities are the major source of innovation stimulation and, consequently, economic growth. Developing countries, more dependent on technological transfers from developed countries, have their economic growth dependent essentially on imitation activities.

Table 3 summarises the main results in this subsection.

Table 3: The linkage between IPR, Innovation and Growth

Author	Study Motivation	Relationship between IPR and	
		Innovation	Growth
Ang et al. (2014)	The impact of local enforcement of IPRs laws on the financing of and investing in R&D	Positive	Positive
Bielig (2015)	The relationship between the development of registered IPRs and the economic development in Germany	N/A	Both
Chen and Puttitanun (2005)	The trade-off between imitation and domestic innovation in a developing country's choice of IPRs	Positive	U-shaped
Chu et al. (2014)	The evolution of IPRs in developing countries.	Positive	Positive
Falvey et al. (2006a)	The impact of IPRs on economic growth	Positive	Positive
Gould & Gruben (1996)	The role of IPRs in economic growth	N/A	Positive
Hu & Png (2013)	The impact of changes in effective IPRs	N/A	Positive
Hudson & Minea (2013)	The effect of IPRs on innovation	U-shaped	N/A
Kanwar & Evenson (2003)	If more stringent protection of IPRs does encourage innovation	Positive	N/A
Papageorgiadis & Sharma (2016)	The relationship between IPRs and Innovation	Positive	N/A
Park & Ginarte (1997)	The IPRs effects on long-run economic Growth	Positive	Positive
Schneider (2005)	The role of high-technology trade, IPRs and FDI in determining a country's rate of innovation and economic growth.	Positive	Indirect

Sweet & Maggio (2015)	The impact of a more rigorous IPRs systems on innovation	Positive	N/A
Yang et al. (2014)	The role of IPRs protection on stimulating innovations across countries.	Positive	N/A
Zhang et al. (2015)	The weak IPR–growth evidence in previous studies may be due to a neglect of the role of finance markets and private IPRs.	Positive	Indirect

3. Methodology

In this dissertation, a M-A was employed to study and assess the empirical relationship between IPRs, innovation and growth. As we have seen in the previous section, research results are contradictory. With the application of this methodology we intend to summarize and systematize the empirical results of published and unpublished empirical literature about this issue, as a supplement to the previous literature review.

On subsection 3.1), M-A concepts and methodology are presented. The M-R analysis is conceptualized in section 3.2) and correspondent functions and data are also. On subsection 3.3), a selection of studies for the M-A analysis and definition of the effect size are conferred. Finally, a publication bias and an estimation of the average effect: Test and Correction are shown in section 3.4).

3.1. Meta-Analysis: concepts and methodology

The M-A is, as Glass (1976, p.3) stated, "the analysis of analyses". It is a methodology that "provides a more formal and objective process on reviewing empirical literature. It employs conventional statistical methods and criteria to summarize and evaluate empirical economics" (Tom D Stanley, 2001, pp. 147-148, p.147-148). It is a method that synthesizes and explains a literature sample related with a codified topic, and provides to the researcher a cohesive result (Nijkamp & Poot, 2004). It was a relevant impact in medicine (Glass, 2000), but it is also a very popular concept in social sciences and education.

It gained an enormous relevance in economics since its main purpose is to harmonize the empirical economic survey results, combining the findings of diverse studies that use different data sets and methodologies, offering a coherent and consensual explanatory result and more insights by confronting the conjectures with the actual research. The M-A is performed in the most varied economic fields since the numbers of empirical literature substantially increased and usually the results are not always consensual. Since 1989, the M-A was recognized by the American Statistical Society as an important asset in research areas and has been gaining a huge respect in the research community – e.g., Hunt (1997), cited by Tom D Stanley (2001). Nijkamp and Poot (2004) estimated that until 2002, M-A was used about 100 times in the economics field. Using the same approach, reviewing all available data on Web of Science until 2016, we found 1080 economics publications that used M-A. Thus, we can conclude that the application of this methodology in the economics field rose almost 10 times only in 15 years.

Though, and as any methodology, the M-A was criticized. According to Cooper and Hedges (2009), cited by (Brendel, 2011), it presents four limitations:

- Comparing apples to oranges due to the combination and comparison of studies with adverse data. Glass (2000) sustained that only the comparison of different things is "worthy of true scientists" and the comparison of equivalent things "is trivial."
- Garbage in garbage out is a limitation related to the possibility of the inclusion in the analysis studies with doubtful quality. However, the quality concept is too subjective and dependent on the researcher criteria.
- The file drawer problem is connected to the difficulty finding unpublished research due to non-significant findings, very often superior as published research. On M-A it is important to include these files to determine effect sizes for research and also to account and control the publication bias.
- Publication bias, which exists when authors or journals adopt a publication trend, either related with the direction of the results or statistical significance. Thus, to help to reduce the bias in the effect sizes, it would be relevant to analyse, as much as possible, unpublished literature.

Therefore, in order to minimize the effects of second and third limitations, White (1994), cited by Nijkamp and Poot (2004), concluded that the researchers must respect the selection process, the precision and the coverage of the data. Precision related with the high quality of the selected documents, and coverage related with the representativeness of published and unpublished literature. Despite the limitations, while comparing traditional methods of literature reviews, pointed by Lipsey and Wilson (2001), the "meta-analysis changed the focus to the direction and magnitude of the effects across studies" (Stewart (2017), p.7). It combines different sample sizes and results, which provides a more precise understanding than separate estimates, allowing the recognition of the major trends and variations across the studies. The main goal is to understand the relationship between variables and the effect one has on the others, in order to explain the variability of its' results.

To illustrate the use of M-A over the years, a few examples can be noted: Jarrell and Stanley (1990) employed M-A to corroborate and extend H. Gregg Lewis's landmarks' research in 1986 research on the union-nonunion wage gap; Tom D Stanley (2001) evaluated the Ricardian equivalence; Gorg and Strobl (2001) assessed the effects of multinational companies on domestic productivity; Nijkamp and Poot (2004) clarified if the public sector enhances or not long-run economic growth; Doucouliagos and Ulubasoglu (2008) meta-analyzed the literature on the relationship between democracy and growth; Ugur (2014) conducted a M-A of the corruption effects on economic growth; Havranek et al. (2016) reviewed the effects of natural resources on growth.

In M-A, it is of great relevance to use a systematic approach to reach, as much as possible, a complete research of published and unpublished papers. As stated by Lipsey and Wilson (2001), it is important to ensure a good relationship between the collected meta-analysed studies, with the aim to find arguments of resemblance among them. It is the kind of methodology capable to generalize the knowledge gained through individual researches, to combine huge numbers of studies, to present much more eruditely the originated results, to find a relationship between different variables. Frequently, the M-A results are the basis of future researches due to the pointing out of some research gaps.

3.2. Meta-Regression Analysis

Meta-Regression Analysis (MRA) is a specific technique employed in M-A, which aims to explain the heterogeneity in the effect sizes reported by the primary studies. MRA involves the estimation of a standard regression model as follows – e.g., Tom D Stanley and Jarrell (1989):

$$b_j = \beta + \sum_{k=1}^{K} \alpha_k Z_{kj} + e_j, (j = 1, 2, \dots, L) \quad (1)$$

where: b_j is the reported estimate of the phenomenon β of interest in study j in a literature comprised of L studies; Z_{kj} corresponds to the K meta-independent variables that measures relevant characteristics of the empirical studies (e.g., estimation techniques, sample period, data structure) and explain the variation in b_j across them; a_k are the meta-regression coefficients that complements the studies characteristics on b_j; and e_j is the regression error. Thus, equation (1) can be estimated in order to evaluate how the studies' characteristics influence the estimation of the effect sizes.

Our MRA will be conducted using the Tom D Stanley (2001) board outline compound in 5 steps to explain the results variation of the empirical literature on the effects of IPRs on innovation and on growth. As follows:

Step #1: Include All Relevant Studies from a Standard Database;

Step #2: Choose a Summary Statistic and Reduce the Evidence to a Common Metric;

Step #3: Choose Moderator Variables;

Step #4: Conduct a Meta-regression Analysis;

Step #5: Subject the Meta-Regression Analysis to Specification Testing.

3.3. Studies' selection for the meta-analysis and definition of the effect size

Before the application of the M-A it is important to perform a careful selection of the papers that will be included in the databases. On this process of bibliometric synthesis, we have used the platform Web of Science (https://webofknowledge.com/). In the first stage, an exhaustive search of literature was performed, on the impact of IPRs on innovation and growth. In this platform, we searched, in the title and abstract of published papers and working papers, for any reference on "Intellectual Property Rights" and "Innovation" and "Growth", "IPR and Innovation and Growth"; "IPR and Innovation", "IPR and Growth", "IPR and R&D and Growth" since the 1900s.

From our research, conducted in April 2017, we obtained more than 1000 papers in total, of which nearly 400 were selected from the "economics" field. Nevertheless, taking in mind the goal of our study, the exclusive use of literature with empirical studies of the impact of IPRs on innovation and growth, only 84 were reviewed. From those, we obtained 12 empirical studies that fulfil our purposes and they were included in our bibliometric synthesis, since only these filled the criteria for our M-A (Table 4).

Table 4. Bibliometric Synthesis

Author	Title	Journal
Ang et al. (2014)	Does enforcement of intellectual property rights matter in China? Evidence from financing and investment choices in the high-tech industry	Review of Economics and Statistics
Chen & Puttitanun (2005)	Intellectual property rights and innovation in developing countries	Journal of Development Economics
Chu et al. (2014)	Stage-dependent intellectual property rights	Journal of Development Economics
Falvey et al. (2006a)	Intellectual property rights and economic growth	Review of Development Economics
Gould & Gruben (1996)	The role of intellectual property rights in economic growth	Journal of Development Economics
Hu & Png (2013)	Patent rights and economic growth: evidence from cross-country panels of manufacturing industries	Oxford Economic Papers
Kanwar & Evenson (2003)	Does intellectual property protection spur technological change?	Oxford Economic Papers

Park & Ginarte (1997)	Intellectual property rights and economic growth	Contemporary Economic Policy
Schneider (2005)	International trade, economic growth and intellectual property rights: A panel data study of developed and developing countries	Journal of Development Economics
Sweet & Maggio (2015)	Do Stronger Intellectual Property Rights Increase Innovation?	Word Development
Yang et al. (2014)	Do stronger intellectual property rights induce more innovations? A cross-country analysis	Hitotsubashi Journal of Economics
Zhang et al. (2015)	How Private Property Protection Influences the Impact of Intellectual Property Rights on Economic Growth?	Global Economic Review

The main purpose at the beginning of the MRA process, by including all empirical studies, published and unpublished, is to reduce the potential bias effect. The summary measures that we use in the M-A are the coefficients reported in the primary studies for the estimate of the effect of IPR on growth and on innovation. Given that the primary studies use different measures of IPR, innovation and growth, it is necessary to use a metric that turns data comparable. Following Ugur (2013), we will use the partial correlation coefficient (PCC), which will be our effect size. The PCC, r_i, and its standard errors, se_{ri}, are calculated based on the following equations:

$$r_i = t_i / \sqrt{t_i^2 + df_i} \quad (2)$$

and

$$se_{ri} = \sqrt{(1 - r_i^2)/df_i} \quad (3)$$

where t_i represents the t-statistic associated to each coefficient estimate reported in the primary study, and df_i represents the degrees of freedom used in the respective estimation. We used from paper to paper all the reported coefficients and respective standard errors. This resulted in a total of 188 estimations of our IPRs impacts on Innovation and 112 estimations of our IPRs impacts on Growth. Table 5 presents the most relevant paper characteristics, main results and estimation methodologies.

Table 5. Classification of Articles or Papers

Article	Impact	NE	PCCI	SDPC CI	PCC GR	SDPC CGR	countries	DS	EM
Ang et al. (2014)	Innovation	20	0.0054	0.0086			Developing	Panel	Poisson / GMM / OLS / IV

Chen & Puttitanun (2005)	Innovation	4	0.1324	0.0798			Mixed	Panel	OLS
Chu et al. (2014)	Growth	3			-0.1001	0.0435	Developing	Panel	FE / 2SLS
Falvey et al. (2006a)	Growth	18			0.0941	0.0648	Mixed	Panel	FE
Gould & Gruben (1996)	Growth	4			0.1787	0.1057	Mixed	CS	OLS / IV
Hu & Png (2013)	Growth	16			0.0721	0.0392	Mixed	Panel	OLS / IV
Kanwar & Evenson (2003)	Innovation	9	0.3169	0.1220			Mixed	Panel	RE
Park & Ginarte (1997)	Innovation/ Growth	4/4	0.3954	0.1388	-0.0700	0.1554	Mixed	Panel	SUR
Schneider (2005)	Innovation/ Growth	48/6	0.1230	0.1040	0.1010	0.1029	Mixed	Panel	OLS / FE / Pooled
Sweet & Maggio (2015)	Innovation	43	0.0609	0.0469			Mixed	Panel	OLS / SGMM
Yang et al. (2014)	Innovation	45	0.2368	0.1149			Mixed	Panel	FE / RE / threshold
Zhang et al. (2015)	Innovation/ Growth	15/61	0.3818	0.1268	0.1466	0.1382	Mixed	CS	OLS

Notes: **NE** means number of estimations; **PCCI** means PCC Inn (i.e., partial correlation coefficient, by paper); **SDPCCI** means SD of PCC Inn (i.e., standard errors of partial correlation coefficient, by paper); **PCCGR** means PCC GR (i.e., partial correlation coefficient, by paper); **SDPCCGR** means SD of PCC GR (i.e., standard errors of partial correlation coefficient, by paper); **DS** means data structure; **CS** means cross section; **EM** means estimation methodology; **2SLS** means Two-Stage Least Squares regression analysis; **RE** means random effect; **FE** means fixed effect; **IV** means instrumental variables.

The estimates of IPRs effects on Innovation vary between a minimum of -0.7129 (Sweet & Maggio, 2015) and a maximum of 0.8240 (Yang et al., 2014), with 28 negative values and 160 positives. 82 estimations of the 188 were obtained using a mixed sample of developing and developed countries, which means that the remaining 106 used one or the other group of countries. Our sample contains 173 estimations from panel studies and 15 from cross-section studies. The cross-section studies employed an OLS estimator, while the panel studies used diverse types of estimators.

On Growth, the estimates of IPRs effects, vary between a minimum of -0.2867 and a maximum of 0.7402, both by Zhang et al. (2015), with 19 negatives values and 93 positives. 100 estimations of the 112 were obtained using a mixed sample of developing and developed countries, which means that the remaining 12 used one or the other group of countries. Our sample contains 47 estimations from panel studies and 65 from cross-section studies. The cross-section studies employed an OLS estimator and IV, while the panel studies used diverse types of estimators.

3.4. Publication bias and Estimation of Average Effect

The first step before performing a MRA, as referred by Neves et al. (2016) should be to test whether a publication trend was adopted by the authors or journals, either related with the direction of the results or statistical significance. Because the trend could suggest one kind of effect, reflecting only the most favourable results. Thus, the test assumes a major relevance to confirm whether or not, a publication bias in published literature exists, analysing the link between IPRs, innovation and growth.

In a simple way, this question can be rehashed using a *funnel plot* that is, as explained by Egger et al. (1997), cited by Neves, Afonso, and Silva (2016), a scatter diagram that analyses the relationship between the effect sizes in the horizontal axis (the partial correlation coefficient between IPRs and innovation/growth) and the inverse value of the estimate of its standard error, as a precision measure, in the vertical axis. On this scatter diagram, the absence of publication bias is characterized by a symmetric inverted funnel shape, with the values varying randomly and systematically, around the "true effect"[2] (Benos & Zotou, 2014). On the other hand, if publication bias exists, the funnel plot should be asymmetric especially at the bottom. Thus, the (a)symmetry of the funnel allows to assess the existence of publication bias.

- For Innovation:

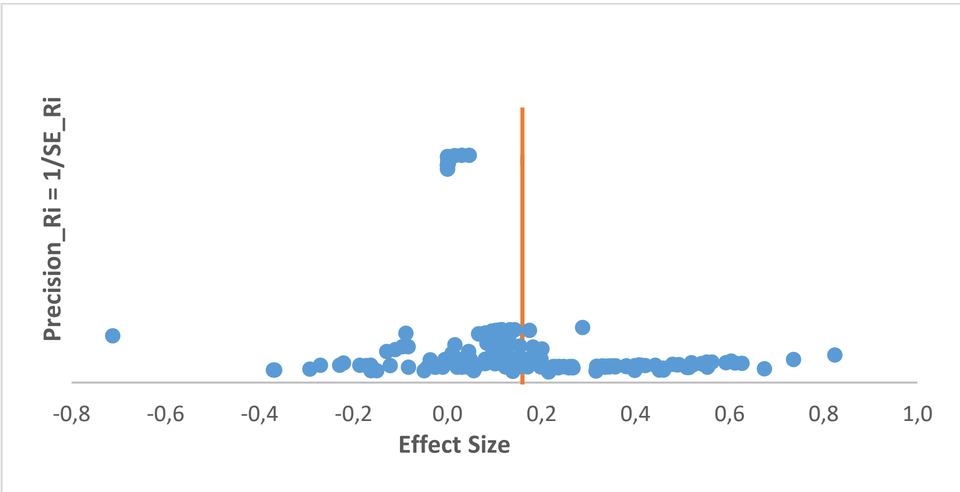

Figure 1. IPRs effect on Innovation Funnel Plot

[2] "True effect" or average.

Figure 1 presents the *funnel plot* for our IPRs effects on innovation meta-sample: Precision_Ri = 1/SE_Ri. The horizontal axis presents the estimated partial correlation coefficient between IPRs and innovation and in the vertical axis, the inverse value of the estimate of its standard error as a precision measure. The visual inspection suggests the inexistence of publication bias towards a certain trend, as the figure appears to be fairly symmetric around the "True effect" size. The symmetry around the positive average could mean a positive "True effect" of the IPRs on innovation.

Even though the graph shape and symmetry, the process is subjective, very vulnerable and not enough to guarantee a "true effect" of the IPRs on innovation, because visual inspections can sometimes be misleading and may not give accuracy on the (in)existence of publication bias (Lau, Ioannidis, Terrin, Schmid, & Olkin, 2006). Thus, we also performed the Funnel Asymmetry Test (FAT), which is similar to the funnel plot but with more robustness, to formally test the (a)symmetry of the *funnel plot*, using a simple regression of the effect sizes on the respective standard errors, represented by the equation below:

$$r_i = \propto_0 + \alpha_i se_{ri} + \mu_i \quad (4)$$

The presence of publication bias compels the authors of studies with higher standard errors to look more intensively for a greater effect size estimates with the purpose of reporting statistically significant results. Thus, if a publication bias exists, r_i it will be correlated with standard errors SE_{ri}; if not, regardless of the SE_{ri}, the reported estimates will vary randomly around the effect $\propto_0$ (T. D. Stanley, 2005).

However, the equation (4) presents a heteroscedasticity problem, which can be solved by dividing both sides by SE_{ri} (Stanley, 2005), which yields:

$$t_i = \propto_0 precision_{ri} + \propto_1 + e_i \quad (5)$$

where $precision_{ri} = 1/SE_{ri}$ and $t_i = \phi_i/SEi$ *t*-statistic associated with ϕ_i reported in the primary studies. Thus, $\propto_1 \neq 0$ in equation (5) means a presence of publication bias (FAT), while the value of $\propto_0$ is the average effect size beyond publication bias (PET).

Nonetheless, the heteroscedasticity is not the only problem we faces when we tried to estimate the equation (4) by OLS. The presence of statistical dependence can also produce biased estimates, once a bigger probability of correlation exists between the estimation when several observations are drawn from the same study, because the studies share the same datasets, specifications or estimation procedures (e.g., Hunter and Schmidt, 1990; Nelson and Kennedy, 2009, cited by Neves and Sequeira (2018)). One way to deal with this problem is to use hierarchical linear models, which correct the standard errors for within-study correlation and estimate the regression coefficients, allowing for the presence of heterogeneity between studies.

In hierarchical models, observations are grouped according to their characteristics whereby the variation within and between the groups can be the cause for differences in individual observations. Generically, the hierarchical linear univariate model can be written as:

$$Y_{i,j} = (\beta_0 + \gamma_{0j}) + (\beta_1 + \gamma_{1j})X_{ij} + \varepsilon_{1j} \tag{6}$$

This generic version allows us to intercept and slope to vary randomly across groups, where subscript i represents the observation and j represents the groups; β_0 is the fixed-effects intercepted and β_1 the fixed-effects slope; γ_{0j} is the group-specific intercept and γ_{1j} is the group-specific slope, which are assumed to follow a normal distribution (Neves & Sequeira, 2018). In the context of a M-A, the observations are grouped by study. The results of the estimations of equation (5) using hierarchical models are presented at the Table 6.

Table 6. Estimation of equation (5), for innovation – Dependent variable, *t*

Coefficients for:	
Precision	0.5151***
	(0.1370)
Constant	-3.4502***
	(1.0900)
RE variances	
Var (Precision)	0.0817
	[0.0147; 0.4548]
Var (Constant)	1.1771
	[0.0019; 721.3751]
Var(residuals)	5.3501
	[4.2529; 6.7304]
N. obs (N. Studies)	188 (8)
log likelihood	-441.0878
Wald test (a_0=0)	14.13***
LR test (HM vs. OLS)	9.60***

Notes: Estimation by maximum likelihood. Standard errors for coefficient estimators are in parentheses (). 95% confidence intervals for random effects variances are in brackets []. Level of significance: *** for p-value<0.01; ** for p-value<0.05;* for p-value<0.1. N. Obs. is number of observations; N. studies is number of studies. RE variances mean Random Effects variances.

The upper part of the table presents the estimates of the coefficients of the FAT-PET regression. The middle part reports the variances of the random components of coefficients and of the residuals. The last line presents the result of the likelihood ratio (LR) the test of the use of hierarchical models against the use of traditional models. This test clearly shows that the former is preferred to the latter.

As reflected in Table 6, the coefficient related with inverted standard error, or precision, is positive and statistically significant, which means that, on average, IPR has a positive effect on innovation. The coefficient related with the constant it is also statistically significant, for a significance level lower than 1%, which, contrarily to the indications from our visual inspection of the funnel plot, means an existence of publication bias on this empirical literature. These kind of problems are easily explained by the journalistic trends for publishing studies with positive and statistic significant results of IPRs effect on innovation. Regarding this, in the following estimations we will keep the constant, in order to capture the possible bias effect.

- For Growth:

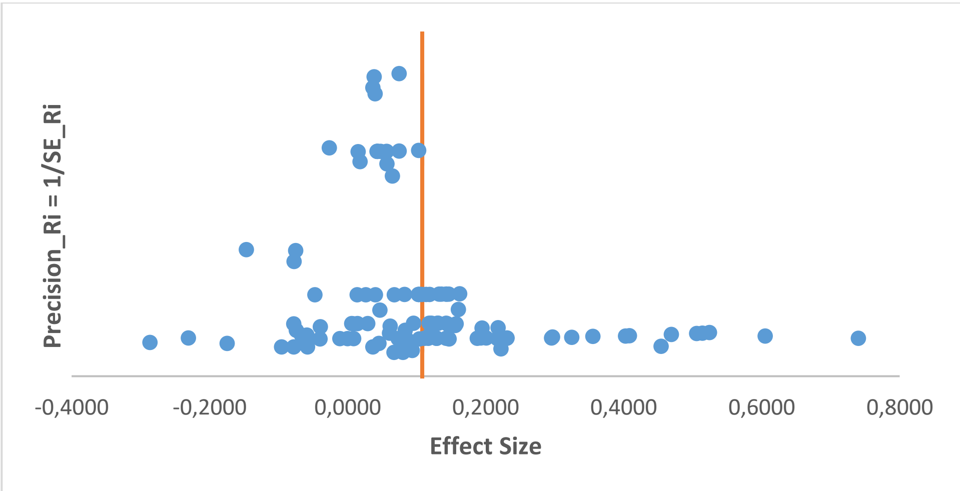

Figure 2. Growth Funnel Plot

Figure 2 also presents a *funnel plot* for our growth meta-sample. In this case, the visual inspection allows us to conclude no evidence of publication bias in favour of a certain trend, since the figure appears to be fairly symmetric around the "true effect" size. Even though, and in order to give more robustness to the analysis, we also perform the FAT-PET regression. The results are presented at the Table 7.

Table 7. Estimation of equation (5), for growth: Dependent variable: t

Coefficients for:	
Precision	0.0122
	(0.0506)
Constant	0.6284
	(0.5248)
RE variances	
Var (Precision)	0.0046
	[0.009; 0.0228]
Var (Constant)	0.000
	[-; -]
Var(residuals)	1.6366
	[1.2461; 2.1493]
N. obs (N. Studies)	112 (7)
log likelihood	-193.1826
Wald test (a_0=0)	0.8086*
LR test (HM vs. OLS)	9.49**

Notes: see Table 6.

In Table 7, the coefficient related with precision is positive and non-statistically significant, which means a positive but non-significant average effect of the IPRs on growth exists. On growth, the coefficient related with the constant is also non-statistically significant, which means a non-existence of publication bias on the empirical literature, in this case, as suggested by the visual inspection of the *funnel plot*.

4. Multivariate Meta-Regression Analysis

In this section, we estimated the Multivariate Meta-regression in order to assess how differences in studies' characteristics explain the heterogeneity in effect sizes. We captured these differences through primary studies characteristics and dummy variables, which were classified as analytical or empirical dimensions.

The moderating variables that are believed to better explain the link between IPRs, innovation and growth are: (1) a dummy variable that takes the value 1 if the article was published in journal of the first quartile of the ranking; (2/3) the number and type of countries considered on the primary studies estimations, (4) a dummy variable that takes the value 1 if the data structure used was panel and 0 if it was cross section; and, (5) the primary estimation employing IV methods.

Table 8. Moderating variables

Variable	Type	Measure
Q1Journal	Dummy	1 if the study was published in a journal of the first quartile of the ranking; 0 otherwise
Numberofctr	Count	Number of countries in each estimation
Developing	Dummy	1 if the sample includes only developing countries; 0 otherwise
Developed	Dummy	1 if the sample includes only developed countries; 0 otherwise
DataStructure	Dummy	1 if the sample is a panel database; 0 otherwise
IV	Dummy	1 if the estimation is with IV methods; 0 otherwise

On the Tables 9 and 10 we can find the estimation results. In column (1) the baseline regression is presented, in which the hierarchical specification is estimated by maximum-likelihood. Columns (2), (3) and (4) present robustness estimations: column (2) estimates the same model using restricted maximum-likelihood (this procedure may reduce the bias of the maximum-likelihood, since our sample is relatively small); column (3) excludes the outliers;[3] column (4) estimates the model by OLS with clustered-robust standard errors.

- Innovation MRA:

[3] With this we intend to confirm that the estimation results are consistent and a non-existence of an abnormal distance of some values from the rest of the series. To identify the outliers we use a box plot that uses the median and the lower and upper quartiles (defined as the 25th and 75th percentiles). The lower quartile is Q1 and the upper quartile is Q3. Thus, for a weak outliers the values should lower than the lower inner fence Q1 - 1,5 (Q3 - Q1), and higher than upper inner fence Q3 + 1,5 (Q3 - Q1).

Table 9. Estimation of multivariate meta-regression on innovation.

		Robustness estimations		
	Meta-regression	REML	No outliers	OLS with clustered robust standard errors
	(1)	(2)	(3)	(4)
Coefficients for:				
Q1Journal	-0.8167***	-1.2081***	-0.3143***	-0.2554***
	(0.1487)	(0.3337)	(0.0781)	(0.0519)
Numberofctr	0.0013	0.0049***	0.0007	-0.0015
	(0.0009)	(0.0015)	(0.0006)	(0.0008)
Developing	-0.1433***	-0.1041**	-0.1073***	-0.2355***
	(0.0411)	(0.0460)	(0.0297)	(0.0586)
Developed	0.1751***	0.1875***	0.1624***	0.0957
	(0.0375)	(0.0390)	(0.0263)	(0.0789)
DataStructure	0.3006	1.0369**	-0.0763	-0.1931***
	(0.2250)	(0.4873)	(0.1065)	(0.0439)
IV	-0.0113	-0.0106	-0.0087*	-0.0133
	(0.0071)	(0.0068)	(0.0052)	(0.0109)
Precision	0.6677***	0.0566	0.5002***	0.7531***
	(0.2263)	(0.4417)	(0.1189)	(0.1409)
_cons	-3.7082***	-3.4706	-1.1797**	-1.5763**
	(1.0554)	(2.3515)	(0.5245)	(0.4619)
RE variances				
Var (Precision)	0.0000	0.0805	0.0000	
	[0.000; 0.0008]	[0.0077; 0.8401]	[0.0000; 0.0000]	
Var (Constant)	3.3932	25.5133	0.4367	
	[0.1403; 82.0464]	[5.4588; 119.2431]	[0.0776; 2.4594]	
Var (residuals)	3.5834	3.2825	1.9466	
	[2.8133; 4.5644]	[2.6421; 4.0781]	[1.5716; 2.4113]	
N. obs. (N.Studies)	185 (8)	185 (8)	181 (8)	185 (8)
Log likelihood	-391.7505	-407.6193	-323.4342	
Wald test	144,61***	127.88***	141.25***	
LR test	6.44**	25.81***	3.54	
R^2				0.3897
Root MSE				2.092

Notes: see Table 6.

Our basic specification shows a negative and highly significant effect of the value of Q1Journal, which means that the most important journals tend to publish papers that report a negative effect of IPRs on innovation.

Additionally, the type of country is a very relevant factor on primary studies. The value of developing countries shows, as expected, a negative and highly significant effect in all four regressions, since IPR protection policies in developing countries are low or non-existent and investment in innovative activities is low, and it is preferable to imitate external innovations, as stated by R. Falvey et al. (2006). The Horii and Iwaisako (2007) conclusion that a minor IPRs protection could encourage the domestic innovation, it is feasible also in our MRA. On the other hand, in developed countries the effect is positive and highly significant, resulting from policies and an environment conducive to domestic innovation and, consequently, the protection of innovations, also as stated by Kanwar and Taylor (1994, 2016), cited by Adams (2011). Thus, we can conclude, as Grossman and Lai (2004), that in developing countries a strong IPRs protection can slowdown the domestic innovation process. However, in developed countries we have the opposite effect.

Given these results, we can obtain strongly-consistent (statistically significant in all four columns) on the effect-size variations to be the type of journal and the type of countries included in the sample (developing or developed).

On the contrary, differences in the number of countries, data structure and the estimation methods are not relevant in explaining the variation of the effect size, as the respective moderating variables are insignificant in most or in all regressions.

- Growth MRA:

Table 10. Estimation of multivariate meta-regression on growth.

		Robustness tests		
	Meta-regression	**REML**	**No outliers**	**OLS with clustered robust standard errors**
	(1)	(2)	(3)	(4)
Coefficients for:	.			
Q1Journal	-0.1098**	-0,0704	-0.1364**	-0.1023
	(0.0533)	(0.0889)	(0.0658)	(0.0559)
Numberofctr	-0.0028***	-0.0031***	-0.0029***	-0.0017
	(0.0008)	(0.0010)	(0.0008)	(0.0009)
Developing	0.1294***	0.1356***	0.1497***	0.061
	(0.0365)	(0.0383)	(0.0427)	(0.0761)
Developed	-0.0896*	-0.0762	-0.0763	-0.1596**
	(0.0490)	(0.0506)	(0.0507)	(0.0455)
DataStructure	-0.2846***	-0.2975***	-0.3082***	-0.0587

	(0.0868)	(0.1119)	(0.0927)	(0.0796)
IV	-0.0230	-0.0176	-0.0096	0.0032
	(0.0534)	(0.0544)	(0.0560)	(0.0458)
Precision	0.5278***	0.6328***	0.5549***	0.196
	(0.1321)	(0.1856)	(0.1390)	(0.1349)
_cons	-0.4933	-1.7307*	-0.5682	0.7045
	(0.7241)	(0.9183)	(0.7678)	(0.8150)
RE variances				
Var (Precision)	0.0000	0.0099	0.0000	
	[0.000; 0.6559]	[0.0007; 0.1318]	[0.0000; 18.9678]	
Var (Constant)	0.8292	0.2506	1.014	
	[0.2246; 3.0619]	[0.0000; 6666.4780]	[0.2624; 3.9186]	
Var (residuals)	1.1215	1.1680	1.1133	
	[0.8551;1.4708]	[0.8858;1.5401]	[0.8469; 1.4635]	
N. obs. (N.Studies)	112 (7)	112 (7)	111 (7)	112 (7)
Log likelihood	-172.6697	-191.4301	-171.2667	
Wald test	55.14***	46.21***	50.62***	
LR test	15.07***	24.08***	13.43***	
R^2				0.3061
Root MSE				1.2549

Notes: see Table 6.

As in the previous meta-regression our basic specification shows a negative and significant effect of the dummy Q1Journal. We can also observe a negative and highly significant effect of the value of the number of countries that were considered in primary studies, meaning that studies which use larger samples tend to report lower effects of IPR on growth.

The value of developing countries shows, as expected, a positive and highly significant effect; the guaranty of an IPR protection policies can incentivize the investment in domestic innovation, which can be positively reflected in growth rates. On the other hand, in developed countries, the effect is negative and less significant, reflecting the idea that IPR have a negative effect on economic growth in developed countries, although weaker in magnitude. As suggested by Ang et al. (2014), Park and Ginarte (1997) and Bielig (2015), the enforcement of IPRs has the potential to improve a long-run economic growth, through the investment in R&D activities, even though the main R&D activity in developing countries is imitation.

Concerning the data structures used in primary studies, we found that the IPRs effect on growth tends to be lower when a panel data is used.

Given these results, we can obtain strongly-consistent sources of the effect size variations to be the Q1Journal, number of countries, developing countries and data structure. On the contrary, the use of IV estimation techniques is not relevant in explaining the variation in effect sizes.

5. Conclusions

Our goal was to explore the empirical trend on the relationship between IPRs, innovation and growth. We began by understanding the growing importance of IPRs protection on innovation encouragement, and also its influence on growth. Then, by using a M-A for the first time in the literature, we conducted a quantitative analysis of the existent empirical literature on the effect of the IPRs on Innovation and on Growth. Our approach allowed us to summarize and to systematize the empirical results of literature and drawing more precise conclusions in divergent research fields as ours.

One important conclusion of the MRA, related with the effect of IPRs on Innovation, is that the results are influenced by the publication bias, which means that Editors tend to publish studies with more significant results. After correcting for this type of bias, we found that the average effect of IPRs on innovation is positive. However, the average effect on growth is not significant.

It was confirmed that the effect of IPRs on Innovation is influenced by the type of the countries in analysis. The impact of IPRs on innovation is positive and very significant in developed countries, due to the fact that firms in these countries understand more effectively the importance that IPRs have on the innovative activities, the capital available to invest is higher than in developing countries, and also due to the effects of policies, as for subsidies which have a huge impact on the decisions.

The estimates of the effects of IPRs on Growth are influenced by some characteristics of the empirical studies, such as the structure of the data, the country type and the number of countries analysed. Conclusively, IPRs have a significant and positive impact on growth in developing countries, probably not from the encouragement of domestic investment in R&D activities, but from foreign investment and relocation of R&D activities.

For future investigations, it is worth emphasize the need of a major quantity of empirical articles and also that use a more complex and diverse data structures is used. It would also be interesting to assess the influence that the effects of policies have on the results.

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