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Capturing The Economic Value of Triadic Patents

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Abstract

This study provides a comprehensive analysis of patent family characteristics of triadic patents. We test specific features of triadic patent families to highlight common correlation patterns between patent value, as measured by patent forward citation data, and the structure of triadic patent families that cover the same invention at the international level. Our results suggest that the share of USPTO, EPO and JPO patents in the patent family, and the timespan between the earliest priority application and latest priority application, are positively associated with the value of inventions in the triadic patent families.

Keywords: triadic patent families, patent value, priority applications

Introduction

Patents have been used for decades to analyze particular aspects of the innovation process; In economic research, they are recognized as rich data to study technological change. They have been used to analyze technological, inventive and innovative performance (Hagedoorn and Cloodt, 2003). With their facilitated availability, there has been a sharp increase in the use of patent-based indicators by researchers and policy analysts. Patent statistics have attracted the attention of economists and policymakers as a measure of innovative performance of countries.

Using patent counts as an indicator of innovative activities however entails some limitations. These counts provide little information on the market value of inventions as

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some patents are of low value whereas others are protected in various countries, hence suggesting a higher value. The economic literature on patent value has suggested that specific patent features—technological importance, geographical scope, estimated market value— and firm value are associated with the value of patents (see Hall et al., 2005; Trajtenberg, 1990; Van Zeebroeck, 2007). The increasing number of economic studies highlight the growing demand for more measures and the need for more empirical evidence on patent value.

It is recognized that patent families can be appropriately used for this purpose. An applicant needs to file in each patent office where patent protection is sought. As a result, the priority filing of the invention followed by its subsequent patent filing in other jurisdictions forms a "patent family" which protects the same invention. Patent families can overcome the shortcomings of analyzing individual patents by encompassing a set of patents filed in various countries covering the same invention. Numerous studies use patent family data for the analysis of the globalization of inventions (Frietsch and Schmoch, 2009; Martinez, 2010; Pavitt, 1985; , but fewer studies shed light into the internal structure of patent families and different characteristics that might have an impact on the value of an invention protected within a patent family.

A specific case of patent families, referred to as "triadic families", includes those in which their members have filed for patent protection in all three (hence the triad) major patent offices—the United States Patent and Trademark Office (USPTO), the European Patent Office (EPO), and the Japanese Patent Office (JPO). These three regions are the economically most important regions in the world. Triadic family indicators are the most widely used amongst patent family indicators. This study contributes to the literature by carrying out an in-depth analysis of the understudied features of triadic patent families.

Patents that are registered in the triad regions are frequently used to assess the technological strengths of countries, since these patents are perceived to have high economic value and are thus worth being protected in the most important markets. For instance, the total number of USPTO, EPO and JPO patents which are part of the family may provide an indication of the value of the invention that is protected in several countries. This study aims to estimate the value of patents based on the characteristics of their triadic patent family and on the structure of these international patent families.

Since filing a patent in a particular country may be a signal of the market that is targeted by this new technology, we consider the relationship between the priority patent office and the value of the invention. Furthermore, this paper addresses the impact of the time elapsed between the first and the last filing a patent within the family of a specific invention. It is therefore possible to revisit some indicators of patent families and to shed light on the extent to which the structure of triadic patent families is useful to estimate value-related indicators of patented inventions.

One way of determining the value of patent family inventions is to use the number of citations received by all patents within a triadic patent family. Citations have received considerable support in the literature as indicators of patent value. For instance, Hall et al. (2005) found that patent citations are associated with market value and confirmed that forward citations have the largest correlation with market value. These citations convey information on the linkages between inventions and inventors over time and show the importance of innovations. Since patents are mostly the results of costly research, citing these innovations suggests that the cited patents are economically valuable.

Given the substantial growth in patent applications, the rise of patent application sizes, and the increase in new patenting strategies (Archontopoulos et al., 2007; Guellec and de La Potterie, 2007; Van Zeebroeck, 2009), scholars need better metrics to focus on the most important patents. According to Frakes and Wasserman (2015), there is also a concern that the patent systems have been issuing many invalid patents in recent years.

Our objective is therefore to extend the relatively less studied features of patent families and to highlight common patterns in the structure of triadic families. We employ a global approach to international inventions and propose a number of indicators to be associated with the value of patents. This study carries out a comprehensive statistical analysis on OECD data of patents emanating from Canadian inventors who filed their patents in the three most important patent offices between 1995 and 2016. This study considers measures such as the time span between the first and last priority of patent applications in the family, the count of priorities, and the number of inventors in patent families, to show that these are strongly correlated with commonly used indicators of patent value based on forward citation counts.

Moreover, since triadic patent families include patents that have at least one family member in each of these three patent offices, we investigate whether the total number of USPTO patents in the family affects the citations that patents in the family received. Similarly, we examine the role that the share of EPO and JPO patents in the family might play in the value of the patent family. This research aims to shed light on the broader dimension of patent families by comparing the innovation performance at the family level rather than at the individual patent level. We contribute to the literature by proposing different measures of patent value based on triadic patent families.

The remainder of the paper is structured as follows. The second section reviews the literature on patents as indicators of innovation and triadic patent families as an international measure of inventions, and discusses patent citations as a measure of patent value. The third section describes the data, variables and methodology used for the analysis. A descriptive analysis of our data is provided in the fourth section, while the fifth section presents the regression results. Finally, the sixth section concludes and reflects on the implications of the indicators used in this study on patent value.

Literature Review

Patents attributes and their relationship with patent value

There is no doubt about the role that innovation plays in promoting economic growth. Patents are the most important and available empirical evidence to help recognize or measure the innovation undertaken in a particular economy. New technologies are generally connected to the patenting process and most studies depend on patent data in order to identify technological maturity and technological trends. Patent information help assess the competitive potential of inventions and forecast a niche market place via its detailed analysis and monitoring (Jeong and Yoon, 2015).

To quantify the impact of innovations, we often need to implement proxies that help us understand technological progress (Crosby, 2000). Patent indicators are therefore designed to reflect innovative activities and provide an appropriate measure of technological output.

Patent studies generally show that although patent data offer several advantages, the economic value of most patents is not high as they have little commercial value. Some patents are important outputs of innovative activities, but some are less important, and therefore should not be receiving the same attention in patent count analysis. The growing size of patent databases is clear evidence of the need for approaches that focus on the potential value of patents, for instance in producing value-weighted features of patented inventions. Some of the methodologies employed for this purpose stem from academic research while others have involved companies that have a clear interest in patent valuations to determine a fair market price for patents (Banerjee et al., 2017).

Measuring patent value depends on the purpose of the evaluation, the needs of partners, investors, customers, or even on successful blocking of competitors. While many factors should be considered as relevant in assessing the value of a patent, it is necessary to deeply understand the value of the patent from a business perspective. This can help clarify decisions regarding keeping or selling an invention or negotiating licensing agreements. Grimaldi et al. (2015) used the strategic information out of patent and combined the quantitative and qualitative analyses to support such decisions for companies. The authors extracted technologic-bibliometric data and economic-strategic judgments from patent databases and interviews with managers, respectively, and combined both types of information in order to assess the value of patent portfolios.

Various patent attributes contained in patent databases are needed to support patent holders in assessing the economic value of their patents. Subsequent to the growing number of patent filings over the past two decades, many scholars (i.e. Harhoff et al., 2003; Lee, 2009; Jaff and Trajtenberg, 2002) have developed models to identify the promising patents and to predict their potential value. Some of those are mainly related to financial indicators such as stock market value, but most of the determinants found in the literature stem directly from the patent system.

Using the available information provided in patent databases, the economic literature has proposed various measures of patent value such as the length of the renewal, the number of citations, and the family size (Guellec et al., 2000; Harhoff et al., 1999; Lanjouw et al., 1994; Narin et al., 1987; Pakes and Schankerman, 1984; Scherer and Harhoff, 2000).

Metrics such as patent families and renewal decisions involve extra costs. They can be used in practice, based on the assumption that these patents (within families and/or renewed) have sufficient value to cover the costs incurred by applicants to protect their invention in different patent offices and/or to maintain them for a longer period.

Sapsalis and van Pottelsberghe (2007) studied the determinants of patent value that are related to patenting strategies. They focused on academic patents and validated these potential determinants by identifying the institutional sources of knowledge therein. Their results suggested that the type of institutions cited (i.e. in the backward citations of patents), the mix of institutions that are involved as co-assignees, and the geographical protection of patents within families all play a role in the value of patents. Harhoff et al. (2003) suggested a positive relationship between backward citations and the value of a patent. A relatively high number of such references may indicate an invention of high value since it is plausible that applicants add more references to seek a broader scope for the protection their patent.

Beside these determinants, other potential indicators mentioned in the literature are patent scope and technological classes associated with the patent. Some scholars found that patent scope positively affects the value of a patent (Lerner, 1994; Shane, 2001) while others showed an inverse correlation between patent value and the scope of a patent (Guellec and van Pottelsberghe, 2002). In the literature, the number of claims is questioned as an indicator of patent quality (Tong and Frame, 1994) as this indicator mostly measures the size of an invention and describes the detailed features of an invention rather than its value. Lanjouw and Schankerman (2004) did not find that the number of claims is related to the probability of renewing a patent.

Citations to the non-patent literature (NPL) underline the importance of scientific knowledge for the invention. Narin and Noma (1985) were pioneers in discovering the contribution of non-patent references as an indication of the interaction of science and technology. This type of prior art shows the relationship between the scientific intensity of technological activities (Callaert et al., 2006). Studies on the direct link between patent value and these citations provide mixed evidence and have received little empirical support (Meyer, 2000; Harhoff et al., 2003). In order to consider the non-patent references as a good indicator of patent value, one would have to expect that the number of NPL could help quantify the dependence of an invention on the scientific literature and thus indicate how a patent is tightly linked to science.

Taking the point of view of the cited patents, it clearly appears that the number of forward citations that a patent has received is one of the most important indicators of the value of the patent. Zeebroeck (2007) reviewed patent value indicators in the literature and the continuously increasing popularity for the number of forward citations. The patent literature has widely discussed the correlation between the value of an invention and citation indicators that can be used to approximate patent value. According to Hikkerova et al. (2014), the usefulness and the relevance of an invention for future patents can be assessed and mapped by the number of forward citations. The number of citations that a patented invention received is an indicator of subsequent technological impact of that invention. Patent applications mostly aim to secure commercial advantages. As a consequence, and these forward citations can convey information about the results of the research process to measure knowledge flows and commercial value (Jaffe and De Rassenfosse, 2017).

This has been long argued by scholars and the importance of cited patents has received considerable support (Bessen, 2008; Trajtenberg, 1990). A study of US and German patents by Harhoff et al. (1999) showed that patents with more forward citations have the higher estimated economic value. Forward citations allow for building technological linkages and reveal the potential market of a patent. The interpretation of citation analysis in patents is the same as for scientific papers, since for both it is an indicator of their importance. Forward citations have been used to address the differences in value and impact between patents, and the argument of the positive correlation between the number of times that a patent is cited and its quality and value is empirically supported by many previous studies (Fritsch et al., 2014; Hall et al., 2005; Trajtenberg, 1990). It is widely accepted that highly cited patents are the ones that receive particular interest, and therefore citations can provide an important indicator of the quality of patent (Alber et al., 1991). An analysis of patent citations by Moser et al. (2013) revealed that while examiner-added citations are not correlated with improvements in performance, in general, patent citations are robustly related to performance and are a useful and standard quality-adjusted indicator for innovations. Examiners point out that inserting more references aims to clarify or limit the patent claims.

The economics of patent families and insights into triadic patent families

A patent family is a group of patents on a single invention filed by applicants in more than one country. Data on patent families are very useful for economic and statistical studies and provides insights for the analysis of patenting strategies and inventive performance of countries. Policymakers are shifting their interest from individual patents to patent families and focusing on patent strategies and patent value in economic studies. Patent families are now commonly used as different proxies and indicators of patent value.

The patents in a family mostly claim priority—a first application in a country—under the Paris Convention for Protection of Industrial Property. Patent families are not defined by national or international laws, but by databases, and may vary from one database to another. Patent families provide information about the owner of the invention and the breadth of country coverage.

The decision to file various patents for the same invention depends on the procedures and legal rules in national and international patent systems. Hence the structure of patent families is influenced by the decisions that innovators made when they seek international patent protection. This highlights the economic drivers behind the constitution of patent families. The Paris Convention allows a single patent to claim more than one priority as long as the earliest priority date is filed within a certain period of time, which is 12 months for patents. The great advantage of this timing is that applicants have 12 months to decide in which patent offices and countries they want to keep protection to claim the same right of priority; and it is not required to file their patents in other patent offices at the time of the first filing date. This postpones the cost of applications, saves fees, and helps them to decide whether it would be worthwhile to file their patents in other patent offices.

The method used by most scholars regarding international extensions in specific countries is to file patents in the three major patent offices: USPTO, EPO and JPO. These result in what is generally known as triadic patents. As an extension, triadic patent families are defined as patents that share one or more priorities and are filed at these same three most important patent offices. Triadic families are the most widely used patent family indicators and have been used as a measure of inventive performance; they indicate that these patents have a potentially higher quality and reflect the productivity of research efforts.

Triadic patents also serve as good indicators of the level of innovative activities. These patents cover the interrelation between patent grants from USPTO and patent filings from EPO and JPO (Dernis et al., 2001). Logically, they should have a higher value to justify the fees incurred with applications in the different patent offices. Grupp (1998) has found that patents are also important if they were applied for in only two of these three major economic regions. According to Criscuolo (2006), large international patent families are related to higher value and triadic patents are economically valuable patents. Messinis (2011) studied the citations that originate from the triadic patents and confirmed that these citations are of higher value. Their finding also showed that the citation rate for triadic patents is higher than that of other non-triadic patents, hence implying that it could be considered a good indicator for the market value and technological importance of these patents. According to Chanchettii et al. (2016), the USA, Japan and the EU are the main regions to consider for high economic value patents.

Priority rights of patents

In addition to citations, the literature has attempted to identify the other indicators of the value of patents. For instance, the number of countries where the patent is filed, has been seen as significant to reflect the value of inventions (Harhoff et al. 2003). According to de Rassenfosse et al. (2013), counting the priority patent applications is the closest indicator to the date of an invention and also eliminates the geographic bias.

This priority date is the first patent application filed to protect an invention, and it is generally filed in the country of residence of the inventor. Patents are usually first filed in the national patent office of the applicants, but in the case of higher valued inventions, applicants often decide to go directly to international offices and prefer to enter into expensive regional phases of patent protection (e.g., USPTO and EPO) without national filing (first or ever). Therefore, count of all priority patent applications is of great importance and can be used as a comprehensive measure of inventiveness compared to the simple count of patents.

Data and Methodology

To investigate the relationship between the value of triadic patents, measured by the number of forward citations, and various characteristics of patents filed within triadic patent families, we brought together two large datasets that we linked using a careful matching process. The first dataset consists of the OECD triadic patent families (TPF) [3,4] database, which covers patent applications filed with the EPO, the JPO and the USPTO, sharing the same set of priorities. OECD triadic patents are an appropriate alternative to USPTO and EPO patents to assess internationalization of patenting activities (Criscuolo, 2004). The second database covers citations of patents and non-patent literature (NPL) in patents filed through the PCT (Patent Cooperation Treaty) and the USPTO.[5] We extracted the country of residence of inventors and choose the triadic patent families that have at least one inventor who resides in Canada. We aggregated all patent applications at the patent family level and exclusively considered the citation of the patent family. Our final dataset contains 9,840 patent families.

The number of forward citations constitutes the basis for our dependent variable. The forward citations are generally technologically closely related to the invention. Patents receive citations for a long period of time, so to have realistic results, we considered the total number of total citations received by the USPTO patents[6] of the patent family up to the last year of the available data (*FWCit*). As an alternative, we also considered limiting the number of citations to the first three years after the grant year (*FWCit3)*.

We estimated models of the following general form:

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[3] OECD Triadic Patent Families database, March 2017.

[4] "To account for this, the TPF database uses consolidated patent families. Any patents that are directly or indirectly linked to other patents are counted as a single patent family. For example, if patent A shares priorities 1 and 2, and patent B shares priorities 2 and 3, priorities 1 and 2 are directly linked, as are priorities 2 and 3. As they both share a direct link with priority 2, priorities 1 and 3 are indirectly linked. All patents sharing one of these three priorities are assembled in a single patent family in the OECD TPF database." Popp (2005)

[5] OECD Citations database, March 2017.

[6] We only accessed the data of citations from USPTO patents.

$$\begin{pmatrix} FWCit \\ FWCit3 \end{pmatrix} = \begin{pmatrix} BWCit \\ NLPCit \\ nbPriorities, Timespan, nbInventors, \\ countUSPTO, countEPO, countJPO, \\ countUSPTO \times nbInventors, \\ countEPO \times nbInventors, \\ countJPO \times nbInventors, \\ dPriorityUSPTO \\ , dPriorityEPO, \\ dPriorityJPO \\ dPriorityTriadic \end{pmatrix} \qquad \textbf{Eq. (1)}$$

We used a selection of the numerous indicators related specific attributes of triadic patent families used in the literature as independent variables to associate with our two dependent variables, including:

- The number of backward citations (*BWCit*) count the number of references to prior patents made during the research prior to granting the patent by the examiner (including those added by the examiners). The number of references made to the non-patent literature (*NPLCit*) was also considered. We transformed the variable *BWCit* using the reverse *Reverse(NPLCit)* to reduce skewness.

- The total number of priority applications in the family (*nbPriorities*) was also transformed using the reverse.
- We used the number of USPTO, EPO and JPO patents that belong to a triadic patent family and transformed by using the reverse of these variables.
- The total number (sum) of inventors of the patent included in the triadic patent family (*nbInventors*) was transformed using the natural logarithm.
- The time elapsed between the first and last priority dates within the triadic patent family calculated in months (*Timespan*) was transformed using the natural logarithm.

Finally, we included three dummy variables for the priority patent office (the first filing of a patent for an invention) for the families where the earliest priority was in the USPTO, EPO or JPO. The variable of *dPriorityUSPTO* equals 1 if the earliest priority date is the same as the earliest filing date at USPTO, and 0 otherwise. A similar definition is used for *dPriorityEPO* and *dPriorityJPO*. We also added another dummy variable *dpriorityTriadic* which equals 1 if one of the triadic patent offices are the priority patent office.

Our estimated models focus on assessing whether the number of forward citations, up to 2017 and for the first three years, is influenced by the structure of patent families, and which characteristics are associated with receiving a greater number of citations. We estimated Eq. (1) using a negative binomial model for the raw citation counts and a Tobit model for the natural logarithm of the citation counts. Because the negative binomial model may suffer from an excessive number of zeros, as some patents were never cited, we estimated a zero-inflated negative binomial model for robustness purposes. We estimated the regressions separately for each dependent variable and included interaction effects as described in the results section.

Descriptive Statistics

Figure 1 and Figure 2 show the patents counts from each triadic patent office for the period under study. We extracted information for the period between 1977 and 2016 and identified the first and last priority years of each patent family. These graphs show that the number of USPTO patents is larger than that of EPO and JPO patents –53% of patents are from USPTO, compared to only 24% from EPO and 23% from JPO– and differs considerably pre- and post-1990. These results are not surprising, as Canadian inventors usually prefer to protect their inventions in the US because of the greater potential of much larger and accessible markets. Canadian applicants seek international patent protection for their most valuable inventions first in the US and then in the EPO and JPO patent offices. The mean values and standard errors for the variables studied as well as the relevant correlation coefficients are presented in Appendix 1.

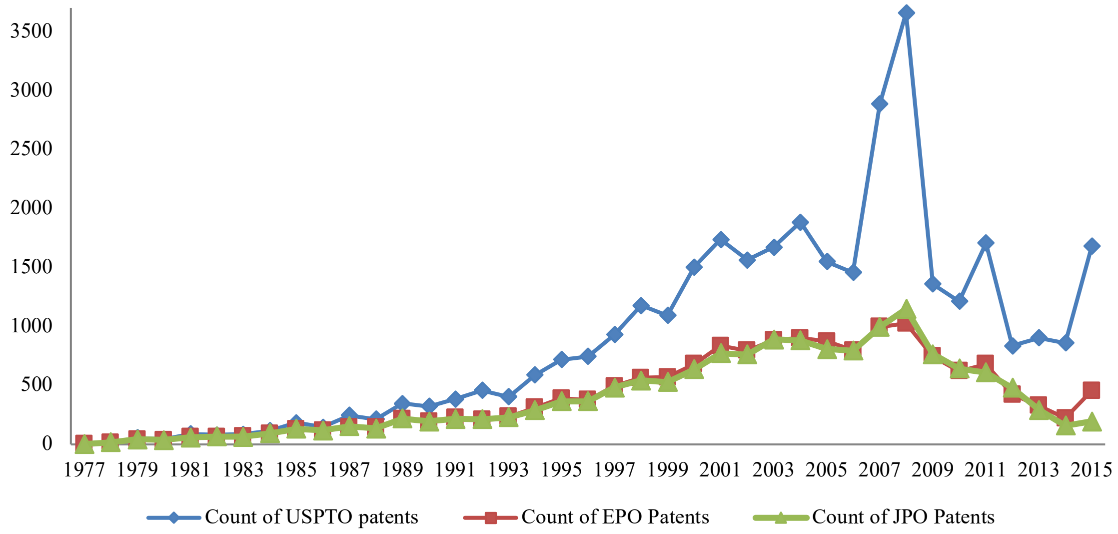

Figure 1 – ***The count of patents from each triadic patent office based on the last priority year of the family***

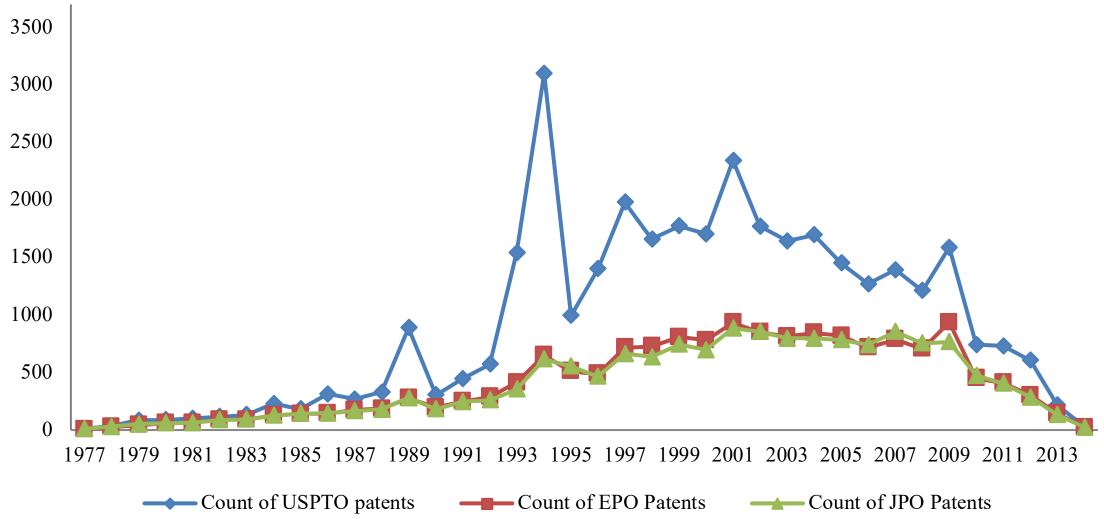

Figure 2 – ***The count of patents from each triadic patent office based on the first priority year of the family***

Results and Discussion

Our investigation of the influence of the structure of triadic patent families in which Canadian inventors are involved comprises the estimation of different regression models: negative binomial, zero-inflated negative binomial, and Tobit models. To avoid multicollinearity problems linked with highly correlated independent variables, we estimated nine models (model 1 to 9) using different combination of these variables, i.e. segregating the highly correlated variables in separate regressions. We also included interaction effects for the variables that were highly correlated, to expand our understanding of the moderating relationships among those variables.

The results are similar for the negative binomial and zero inflated negative binomial models, in addition to being almost identical for the total number of forward citations overall and in the first three years. The results of the negative binomial and Tobit models are presented in the body of this paper whereas the zero-inflated results are found in Appendix 2.

Table 1 and Table 2 show the estimates of the different patent family characteristics based on the number of forward citations for the first three years (Table 3 and Table 4 show the equivalent results for the overall number of citations). We find a positive impact of the number of backward citations on the number of forward citations, but the number of non-patent literature citations has a negative impact on the invention value indicator. Please note that we used the inverse to transform the variable and it shows the positive effect which means non-patent literature citations have the negative impact. Column 1 reports a positive impact of the multiple priorities of triadic families on the citations received, and by extension on patent value.

We find robust evidence that the time span between the first and last filing applications is positively correlated with the value of the invention in the triadic patent family. Filing multiple patent applications allows inventors to gently adjust the scope of an invention within a patent family. These results are in line with the findings of Dechezleprêtre et al. (2017) who found a positive correlation between the first and last filing priority within a patent family and the value of the invention, measured by various variables such as family size, number of citations, being a triadic family, PCT membership and grant status. In longer timespans, inventors are more likely to be able to optimize the scope of protection over time.

Due to the high correlation between the number of USPTO patents and the number of inventors, we include these variables in different models. In model 2, we include only the number of inventors. Our findings confirm that the number of inventors is positively associated with the number of forward citations. In models 7,8 and 9, we add an interactive term between the number of USPTO patents and the number of inventors: the coefficient of the number of inventors and the count of USPTO patents remain the same and the effect of the interactive variables is negative. Interpreting the coefficients when introducing the interaction of two continuous variables is facilitated by graphical representation. In our case, the effect of the number of inventors on patent family value depending on the level of the number of USPTO patents. In Figure 3, the slopes show the impact of inventor counts on the number of forward citations for a few key values[7] of USPTO patents. Same as the positive coefficient found in the regression results (model 2 and 7), the graph shows that as the number of inventors increases, the effect on the number of citations is positive and becomes greater. This implies an important role for greater collaboration between inventors.

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[7] We used the minimum and mean values of the number of USPTO patents within the family to plot the graph.

Table 1 – Regression results for the total number of forward citations in the first three years using negative binomial models

FWCit3	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
ln(BWCit)	0.6019***	0.6184***	0.6399***	0.5122***	0.5937***	0.6741***	0.4367***	0.5494***	0.5933***
	(0.0138)	(0.0139)	(0.0138)	(0.0134)	(0.0136)	(0.0130)	(0.0147)	(0.0141)	(0.0137)
Inverse(NPLcit)	0.1950***	0.2444***	0.1330**	0.2394***	0.1435***	0.1580***	0.3551***	0.2689***	0.2853***
	(0.0530)	(0.0524)	(0.0544)	(0.0523)	(0.0538)	(0.0537)	(0.0500)	(0.0516)	(0.0515)
Inverse(nbPriorities)	-4.4567***								
	(0.1338)								
Inverse(CountUSPTO)				-5.1613***			-1.9189***		
				(0.1155)			(0.2617)		
Inverse (CountEPO)					-4.9579***			-3.3998***	
					(0.1619)			(0.3839)	
Inverse (CountJPO)						-4.8424***			-4.4267***
						(0.1592)			(0.3683)
ln(Timespan)			0.3490***						
			(0.0133)						
ln(nbInventors)		0.8183***					0.7201***	0.5740***	0.4263***
		(0.0248)					(0.0426)	(0.0688)	(0.0664)
Inverse(CountUSPTO)							-1.3589***		
× ln(nbInventors)							(0.1454)		
Inverse(CountEPO)								0.0262	
× ln(nbInventors								(0.1614)	
Inverse(CountJPO)									0.4434***
× ln(nbInventors									(0.1523)
dPriorityTriadic	-0.3926***	-0.4745***	-0.5536***	-0.2848***	-0.4858***	-0.4586***	-0.2281***	-0.3560***	-0.3139***
	(0.0367)	(0.0361)	(0.0372)	(0.0359)	(0.0362)	(0.0364)	(0.0349)	(0.0357)	(0.0357)
constant	1.7993***	-1.4029***	-0.2564***	1.7715***	2.2654***	2.0608***	0.1565	0.5005***	0.7990***
	(0.0778)	(0.0723)	(0.0605)	(0.0690)	(0.0934)	(0.0881)	(0.1090)	(0.1853)	(0.1777)
ln(alpha)	9835	9835	9835	9835	9835	9835	9835	9835	9835
	-20253	-20266	-20467	-19941	-20311	-20302	-19762	-20069	-20023
Nb observations	6212***	6186***	5785***	6836***	6096***	6114***	7193***	6580***	6672***
Loglikelihood	0.1330	0.1324	0.1238	0.1463	0.1305	0.1309	0.1540	0.1408	0.1428
χ^2	0.6019***	0.6184***	0.6399***	0.5122***	0.5937***	0.6741***	0.4367***	0.5494***	0.5933***
Pseudo R^2	(0.0138)	(0.0139)	(0.0138)	(0.0134)	(0.0136)	(0.0130)	(0.0147)	(0.0141)	(0.0137)

Notes: ***, **, * show significance at the 1%, 5% and 10% levels. Standard errors are presented at parentheses.

Table 2 – Regression results for the totalnumber of forward citations in the first three years using Tobit models

FWCit3	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
ln(BWCit)	0.5094***	0.5662***	0.5272***	0.4826***	0.5065***	0.5250***	0.4457***	0.4964***	0.5108***
	(0.0128)	(0.0125)	(0.0131)	(0.0124)	(0.0128)	(0.0127)	(0.0125)	(0.0126)	(0.0125)
Inverse(NPLcit)	0.2665***	0.3188***	0.2613***	0.3423***	0.3044***	0.2945***	0.3997***	0.3713***	0.3700***
	(0.0445)	(0.0448)	(0.0454)	(0.0433)	(0.0445)	(0.0444)	(0.0424)	(0.0436)	(0.0436)
Inverse(nbPriorities)	-3.3409***								
	(0.1207)								
Inverse(CountUSPTO)				-3.6337***			-0.4453*		
				(0.1045)			(0.2432)		
Inverse (CountEPO)					-4.0318***			-1.3259***	
					(0.1430)			(0.3425)	
Inverse (CountJPO)						-4.0852***			-1.8023***
						(0.1438)			(0.3430)
ln(Timespan)			0.2560***						
			(0.0113)						
ln(nbInventors)		0.5927***					0.6627***	0.6682***	0.6130***
		(0.0225)					(0.0419)	(0.0616)	(0.0632)
Inverse(CountUSPTO) × ln(nbInventors)							-1.5678***		
							(0.1328)		
Inverse(CountEPO) × ln(nbInventors								-0.7374***	
								(0.1442)	
Inverse(CountJPO) × ln(nbInventors									-0.5680***
									(0.1474)
dPriorityTriadic	-0.0403	-0.1407***	-0.1194***	-0.1042***	-0.1258***	-0.1072***	-0.0780***	-0.0937***	-0.0756**
	(0.0312)	(0.0306)	(0.0314)	(0.0296)	(0.0304)	(0.0306)	(0.0289)	(0.0298)	(0.0299)
constant	0.8374***	-1.6007***	-0.7781***	0.7611***	1.2595***	1.2541***	-0.5982***	-0.5526***	-0.3950**
	(0.0686)	(0.0649)	(0.0517)	(0.0588)	(0.0789)	(0.0783)	(0.1046)	(0.1655)	(0.1646)
Nb observations	9835	9835	9835	9835	9835	9835	9835	9835	9835
Loglikelihood	-12646	-12682	-12761	-12444	-12635	-12627	-12322	-12507	-12495
χ^2	2853.7***	2781.8***	2623.8***	3257.0***	2875.2***	2890.1***	3501.9***	3131.2***	3154.2***
Pseudo R^2	0.1014	0.0988	0.0932	0.1157	0.1022	0.1027	0.1244	0.1113	0.1121

Notes: ***, **, * show significance at the 1%, 5% and 10% levels. Standard errors are presented at parentheses.

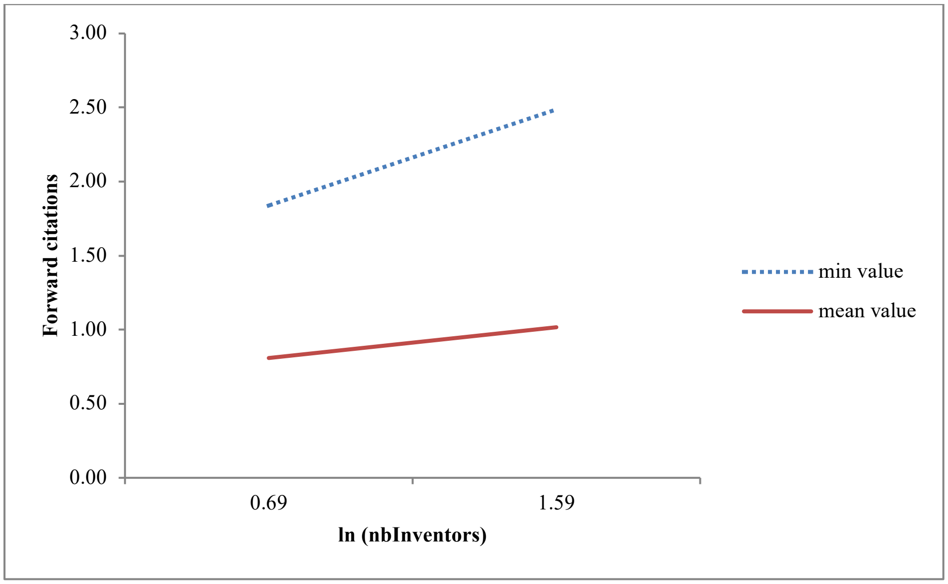
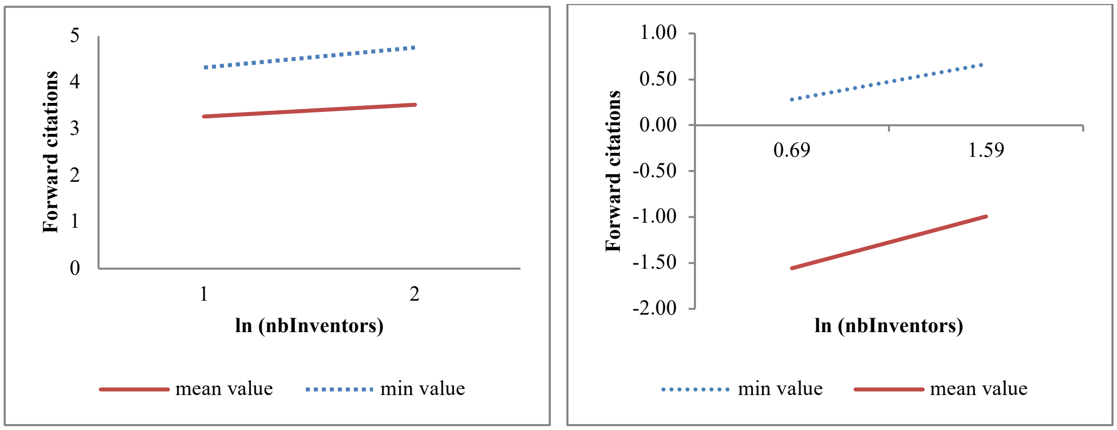


Figure 3 – The effect of the number of inventors on the number of forward citations (moderating effect of USPTO patents using the interactive variable of the count of USPTO patents and the number of inventors)

This analysis allows us to determine whether the total number of patents from each of the three major patent offices is considered important in its relation with an invention's value. We find a positive and strongly significant correlation between the number of USPTO patents and a higher patent value, despite the fact that the USPTO is the priority patent office for only 25% of patents.

The shares of USPTO, EPO and JPO patents in the patent family are also correlated. Thus, we include only one of them in the model at the same time. We observe a positive impact of the number of EPO patents and a negative impact of the interactive variable. A cautious interpretation is called for here, as there is a positive effect of the number of EPO patents on the forward citations that patents received at the family level. The results are the same for the count of JPO patents in the family when we introduce the interactive variables (see column 8). Figures 4 and 5 present the graphs for the positive and significant impact of number of inventors on patent family value as highlighted by the positive slopes in these figures.



(a) *(b)*

Figure 4 – The effect of the number of inventors on the number of forward citations -moderating effect of EPO patents (using the interactive variable of the count of EPO patents and the number of inventors) (a) and JPO patents (b).

Turning now to the alternative measures of patent family value, i.e. the overall number of forward citations of the patent family, enables us to validate the earlier results for the number of forward citations during the first three years. Table 3 presents the estimated models using the negative binomial model, and Table 4 displays the Tobit model results. The results reveal that the number of references (backward citations) is positively associated with the total number of forward citations, and the number of non-patent literature references still yields a negative impact or no impact. Our results on the positive impact of backward citations in triadic patents are also in line with the previous studies (Hall et al., 2005; Trajtenberg et al., 1997). In all regressions, we find a significant positive influence of the number of priorities, the timespan between the first and the last application date of a patent in a triadic patent family and the number of inventors on the number of forward citations. These are a robust set of parameters that reflect the value of an invention within the triadic patent families.

Additionally, we come to the same conclusion concerning the effect of the count of patents from the three main patent offices on the number of forward citations overall and for the first three years. This result shows that increasing the number of patents from the three major patent offices leads to an increased economic value of the invention. Therefore, while triadic patents appear to the best candidate to assess the innovative performance of countries, the characteristics of these patent families also play a significant role in explaining the higher value of the invention of the patent family.

Table 3 – Regression results for the total number of forward citations using negative binomial models

Total_fwci	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ln(BWCit)	0.6669***	0.6986***	0.6889***	0.6231***	0.6532***	0.7078***	0.5562***	0.6327***	0.6734***
	(0.0125)	(0.0124)	(0.0124)	(0.0123)	(0.0123)	(0.0118)	(0.0132)	(0.0127)	(0.0124)
Inverse(NPLcit)	-0.1411***	-0.1234***	-0.1732***	-0.0810*	-0.1610***	-0.1501***	-0.0237	-0.0960**	-0.0815*
	(0.0449)	(0.0451)	(0.0455)	(0.0444)	(0.0451)	(0.0452)	(0.0432)	(0.0444)	(0.0445)
Inverse(nbPriorities)	-3.2958***								
	(0.1179)								
Inverse(CountUSPTO)				-3.7285***			-0.5362**		
				(0.0990)			(0.2406)		
Inverse (CountEPO)					-3.9125***			-2.0546***	
					(0.1429)			(0.3580)	
Inverse (CountJPO)						-3.8042***			-2.7876***
						(0.1400)			(0.3446)
ln(Timespan)			0.2671***						
			(0.0113)						
ln(nbInventors)		0.5189***					0.5723***	0.4785***	0.3597***
		(0.0211)					(0.0415)	(0.0662)	(0.0642)
Inverse(CountUSPTO) × ln(nbInventors)							-1.7297***		
							(0.1323)		
Inverse(CountEPO) × ln(nbInventors								-0.4400***	
								(0.1519)	
Inverse(CountJPO) × ln(nbInventors									-0.0872
									(0.1450)
dPriorityTriadic	-0.1663***	-0.2531***	-0.2676***	-0.0797***	-0.2173***	-0.2049***	-0.0570*	-0.1629***	-0.1389***
	(0.0311)	(0.0310)	(0.0311)	(0.0306)	(0.0307)	(0.0307)	(0.0302)	(0.0307)	(0.0307)
constant	2.5531***	0.3314***	1.0004***	2.4562***	2.9862***	2.8380***	1.3406***	1.6360***	1.8254***
	(0.0682)	(0.0615)	(0.0506)	(0.0590)	(0.0812)	(0.0773)	(0.1018)	(0.1734)	(0.1664)
ln(alpha)	0.5835***	0.6043***	0.6111***	0.5222***	0.5801***	0.5828***	0.4931***	0.5591***	0.5574***
	(0.0157)	(0.0157)	(0.0156)	(0.0160)	(0.0158)	(0.0157)	(0.0161)	(0.0158)	(0.0158)
Nb observations	9835	9835	9835	9835	9835	9835	9835	9835	9835
Loglikelihood	-30153	-30252	-30270	-29896	-30146	-30146	-29783	-30057	-30042
χ^2	7308***	7109***	7073***	7821***	7322***	7322***	8048***	7499***	7529***
Pseudo R^2	0.1081	0.1051	0.1046	0.1157	0.1083	0.1083	0.1190	0.1109	0.1114

Notes: ***, **, * show significance at the 1%, 5% and 10% levels. Standard errors are presented at parentheses.

Table 4 – Regression results for the totalnumber of forward citations using OLS models[8]

Total_fwci	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ln(BWCit)	33.8233 *** (2.6417)	36.4621 *** (2.5496)	34.6115 *** (2.6448)	34.8928 *** (2.6437)	33.5584*** (2.6409)	34.3235*** (2.6120)	22.1296 *** (2.6452)	25.5045 *** (2.5948)	23.9997 *** (2.5439)
Inverse(NPLcit)	-21.1014 ** (9.3860)	-7.2520 (9.3667)	-21.2409 ** (9.4091)	-19.9607 ** (9.4388)	-18.1382* (9.4131)	-18.0120* (9.3971)	-1.1497 (9.1659)	-4.1148 (9.1626)	-1.4016 (9.0826)
Inverse(nbPriorities)	-230.6965 *** (25.8529)								
Inverse(CountUSPTO)				-166.4017 *** (22.7720)			1058.9704 *** (53.3003)		
Inverse (CountEPO)					-290.7741*** (31.1525)			1361.6716 *** (74.2033)	
Inverse (CountJPO)						-315.6250*** (31.2736)			1545.592 *** (73.654)
ln(Timespan)			18.1537 *** (2.3692)						
ln(nbInventors)		75.0981 *** (4.7543)					249.8818 *** (9.4666)	344.3911 *** (13.5868)	394.2983 *** (13.815)
Inverse(CountUSPTO) × ln(nbInventors)							-642.0123 *** (28.9438)		
Inverse(CountEPO) × ln(nbInventors								-688.6589 *** (31.3817)	
Inverse(CountJPO) × ln(nbInventors									-812.002 *** (31.833)
dPriorityTriadic	-16.6069 ** (6.5404)	-16.5933 *** (6.3538)	-21.4881 *** (6.4659)	-24.5003 *** (6.4104)	-22.2824*** (6.4066)	-20.0831*** (6.4250)	-15.6680 ** (6.2174)	-19.2131 *** (6.2291)	-19.2813 *** (6.1954)
constant	87.8909 *** (14.5371)	-143.8254 *** (13.2006)	-23.1836 ** (10.2553)	51.3983 *** (12.7489)	122.0335*** (16.9952)	131.1930*** (16.8897)	-448.1206 *** (23.1220)	-697.2698 *** (35.9484)	-772.9754 *** (35.472)
Nb observations	9835	9835	9835	9835	9835	9835	9835	9835	9835
Loglikelihood	-69866	-69782	-69876	-69879	-69862	-69855	-69541	-69544	-69459
Pseudo R^2	0.0379	0.0541	0.0358	0.0353	0.0386	0.0400	0.0992	0.0988	0.1142

Notes: ***, **, * show significance at the 1%, 5% and 10% levels. Standard errors are presented at parentheses

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[8] Our data is not censored for total number of citations to use the tobit model.

Concluding Remarks

Understanding the impact of the structure of patent families (i.e. the set of patents used to protect the same invention across several patent offices) on patent value is useful to economic studies in general, but to policy makers in particular. With this in mind, this study compares the innovative activity protected by triadic patent families to shed light on the role that some of the general characteristics of this type of patent family plays in understanding the economic value of inventions.

The task of assessing the value of patents is difficult, and there is a need to use more direct and indirect measures for patented innovations. Because of the faster global increase in the number of patents, more patent metrics are required to use for comparison purposes and identifying the patents with the highest value. In this respect, patent families—and more specifically, triadic patent families—are one of solutions for these shortcomings, as they can be used as a measure of the international diffusion of technologies.

The increasing availability of detailed patent statistics provides useful and exploitable measures of technological change. Our analysis aimed to identify whether filing patents in the triad of major patent offices is an indicator of their higher value using a number of indicators that can act as proxies to measure patent value. By exploiting a feature of triadic patent families, we highlighted common patterns in the structure of these international patent families. Our results suggest that the number of patents filed in a specific patent office correlates with patent citations.

Our findings confirm that some characteristics of patent families are associated with the invention's value. The number of inventors in the patent family is a signal of collaboration between inventors. This enables a more precise measure of innovative activities that results from a superior knowledge flow of inventors and increases the value of the invention.

The time span between the first and last priority filing within a triadic patent family appears to be important in terms of the value of the inventions and reflects the maturation process of the inventions embodied in a patent family. Our empirical results also suggest that the number of patents protecting the inventions in the USPTO, EPO and JPO patent offices within a patent family offers a proxy of the value of the inventions. These international patent filings are heavily determined by the productivity of the inventors.

These findings are greatly subject to the dependent variables that we used. Patent citation has been a widely established measure of patent value. Our results show that characteristics of triadic patent families reflect the innovation developments that allow inventors to assess market potentials. Inventors seek protection of their inventions in three major markets through multiple patent filing, and these patent applications give them the opportunity to gradually define the overall scope of their inventions over time.

Nonetheless, this study has a few limitations. First, the distribution of patent value is highly skewed, very few patents will generate great value for their owners, but the vast majority of patents have little or no value. Our analysis therefore concentrated on a very small proportion of the patents filed over the years. Second, in studying international families, the inventions that are of high value in Canada but were not transferred abroad were not considered. For example, while US market is the largest market for many products, filing a patent only in the USPTO does not imply that the invention has a low value.

Our findings have several implications with regards to patent indicators as proxies for patent value measures. Based on the findings of this study, we propose a number of recommendations regarding patent value indicators as well as some policy implications that can be drawn from the results. These recommendations may lead to narrower patent families, which would have higher economic value. Among the high number of patent filings at the main patent offices, policies call for approaches with supplementary insights into more indicators, to find those with the highest innovation performances. In innovation and patent strategies, it would indeed be interesting to confirm the role of other indirect measures of patent families. Because of the cautions regarding the use of other, more crude or simplistic patent indicators, if these more complete indicators of the international footprint of specific inventions were appropriately used, they would provide a more readily available source of information for policymakers on which to base their actions.

Our study clearly calls for more empirical validations, and future research should further explore the relationship between the value of patents and other characteristics of triadic patent families. Future advancements could explore the triadic patent families' characteristics in different fields and measure their impact on the patent value. Another useful research avenue should study the difference between the detailed structure of patent families when their priority office is one of the USPTO, EPO and JPO. The results might shed light on specific regional differences in the structure of triadic patent family and the value of the invention. Finally, analyzing the patent families which include applications in at least two patent offices would be fruitful for future studies.

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Appendices

Table A1 – Descriptive statistics

Variable	*Obs*	*Mean*	*Std. Dev.*	*Min*	*Max*
FWCit	9,835	21.8395	300.1218	0	19931
FWCit3	9,835	8.0820	124.6782	0	7343
BWCit	9,835	11.2900	51.9470	0	2652
NPLcit	9,835	3.2889	34.4058	0	2326
nbPriorities	9,835	2.4131	17.4295	1	1401
CountUSPTO	9,835	3.5523	26.2745	1	2244
CountEPO	9,835	1.6246	4.6852	1	299
CountJPO	9,835	1.5675	3.7519	1	271
Timespan	9,835	6.6629	18.1697	0	310
nbInventors	9,835	5.5238	11.0082	1	489
dPriorityEPO	9,835	0.0174	0.1307	0	1
dPriorityUSPTO	9,835	0.3369	0.4727	0	1
dPriorityJPO	9,835	0.0157	0.1242	0	1
dPriorityTriadic	9,835	0.3509	0.4773	0	1

Table A2 – Correlation matrix

Variable		1	2	3	4	5	6	7	8	9	10	11	12	13	14
FWCit	1	1													
FWCit3	2	0.8426	1												
ln(BWCit)	3	0.5506	0.4492	1											
Inverse (NPLcit)	4	-0.185	-0.1217	-0.2979	1										
Inverse (nbPriorities)	5	-0.3461	-0.4024	-0.2316	0.1673	1									
Inverse(countUSPTO)	6	-0.3942	-0.4651	-0.2631	0.2062	0.5762	1								
Inverse(countEPO)	7	-0.3718	-0.4228	-0.2622	0.1991	0.5904	0.5946	1							
Inverse(countJPO)	8	-0.3374	-0.3989	-0.2091	0.1784	0.5177	0.5424	0.6868	1						
ln(Timespan)	9	0.3297	0.3571	0.2484	-0.1825	-0.8696	-0.5401	-0.5427	-0.4529	1					
ln(nbInventors)	10	0.2364	0.3429	0.0973	-0.1752	-0.4571	-0.5378	-0.4818	-0.4543	0.3978	1				
dPriorityEPO	11	-0.0638	-0.0404	-0.0368	0.0489	0.0623	0.0475	-0.006	0.0384	-0.0623	-0.0252	1			
dPriorityUSPTO	12	0.0512	-0.0168	0.1906	-0.0097	0.1889	0.0795	0.1013	0.1232	-0.1332	-0.1287	0.0237	1		
dPriorityJPO	13	-0.032	-0.016	-0.0074	0.0266	0.0307	0.0332	0.0032	0.0175	-0.0267	-0.0073	0.6975	0.0141	1	
dPriorityTriadic	14	0.0465	-0.0188	0.188	-0.0055	0.1931	0.0842	0.0915	0.1248	-0.1371	-0.1266	0.1809	0.9694	0.1715	1

Table B1 – Regression results for the total number of forward citations using zero-inflated negative binomial models

FWCit	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
ln(BWCit)	0.6216 ***	0.6471 ***	0.6505 ***	0.5766 ***	0.6127***	0.6741***	0.4864 ***	0.5777 ***
	(0.0225)	(0.0214)	(0.0235)	(0.0213)	(0.0289)	(0.0268)	(0.0195)	(0.0243)
Inverse(NPLcit)	-0.1607 **	-0.1418 *	-0.1989 **	-0.1142 *	-0.1946**	-0.1816**	-0.0438	-0.1204 *
	(0.0746)	(0.0738)	(0.0866)	(0.0674)	(0.0760)	(0.0790)	(0.0628)	(0.0718)
Inverse(nbPriorities)	-3.3270 ***							
	(0.2119)							
Inverse(CountUSPTO)				-3.7337 ***			-0.2176	
				(0.1689)			(0.3432)	
Inverse (CountEPO)					-3.8674***			-1.7025 ***
					(0.2764)			(0.5338)
Inverse (CountJPO)						-3.6774***		
						(0.2668)		
ln(Timespan)			0.2669 ***					
			(0.0202)					
ln(nbInventors)		0.5380 ***					0.6241 ***	0.5441 ***
		(0.0380)					(0.0628)	(0.1032)
Inverse(CountUSPTO) × ln(nbInventors)							-1.9228 ***	
							(0.1896)	
Inverse(CountEPO) × ln(nbInventors								-0.5538 **
								(0.2488)
Inverse(CountJPO) × ln(nbInventors								
dPriorityTriadic	-0.2092 ***	-0.2918 ***	-0.3193 ***	-0.1161 ***	-0.2662***	-0.2575***	-0.0836 **	-0.2070 ***
	(0.0479)	(0.0450)	(0.0511)	(0.0438)	(0.0542)	(0.0535)	(0.0413)	(0.0466)
constant	2.7192 ***	0.4667 ***	1.1466 ***	2.6245 ***	3.1246***	2.9212***	1.4465 ***	1.6332 ***
	(0.1286)	(0.1043)	(0.0992)	(0.1054)	(0.1521)	(0.1496)	(0.1594)	(0.2507)
Inflate								
ln(BWCit)	-2.3908 ***	-2.2073 ***	-2.1122 ***	-2.3439 ***	-2.2359***	-2.1933***	-2.6428 ***	-2.3357 ***
	(0.5418)	(0.3627)	(0.6300)	(0.3890)	(0.5842)	(0.6903)	(0.4116)	(0.4205)
Inverse(NPLcit)	-0.7393	-0.8078 *	-0.9588	-1.1403 **	-1.1715*	-1.2470**	-0.9038 **	-0.9999 **
	(0.5632)	(0.4424)	(0.6071)	(0.4828)	(0.6209)	(0.5932)	(0.4313)	(0.4826)
Inverse(nbPriorities)	1.9877 *							
	(1.1017)							
Inverse(CountUSPTO)				2.2291 *			3.1949	
				(1.1744)			(2.3227)	
Inverse (CountEPO)					5.8713			10.5829
					(3.9085)			(6.6124)
Inverse (CountJPO)						7.5191***		
						(2.7486)		
ln(Timespan)			-0.1994 *					
			(0.1146)					
ln(nbInventors)		-0.1068					-0.0179	1.1198
		(0.1530)					(0.4984)	(1.2885)

Inverse(CountUSPTO)							-0.9617	
× ln(nbInventors)							(1.3778)	
Inverse(CountEPO)								-2.5552
× ln(nbInventors								(2.6217)
Inverse(CountJPO)								
× ln(nbInventors								
dPriorityTriadic	-1.5031	-1.2512*	-2.9349	-0.8139	-1.7328	-2.9595	-0.4534	-1.1288
	(1.0168)	(0.7318)	(5.8627)	(0.6854)	(2.1286)	(6.0940)	(0.3233)	(0.6978)
constant	-1.5520**	-0.4053	-0.4590	-1.2026***	-3.1002*	-3.9364***	-0.9941	-5.2096
	(0.6341)	(0.5161)	(0.5612)	(0.4651)	(1.5945)	(1.3691)	(1.0960)	(3.3100)
ln(alpha)	0.5152***	0.5251***	0.5483***	0.4495***	0.5129***	0.5281***	0.4000***	0.4764***
	(0.0236)	(0.0231)	(0.0244)	(0.0220)	(0.0255)	(0.0250)	(0.0220)	(0.0235)
Nb observations	9835	9835	9835	9835	9835	9835	9835	9835
Loglikelihood	-30098.5	-30190.0	-30223.0	-29840.1	-30089.4	-30101.3	-29695.5	-29982.5
χ^2	1588.4	1650.3	1524.0	2004.5	1332.0	1485.9	2581.6	1555.3

Notes: ***, **, * show significance at the 1%, 5% and 10% levels. Standard errors are presented at parentheses.

Table B2 – Regression results for the totalnumber of forward citations in the first three years using zero-inflated negative binomial models

FWCit3	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
ln(BWCit)	0.5459 ***	0.5422 ***	0.5917 ***	0.4524 ***	0.5442***	0.6351***	0.3315 ***	0.4768 ***	0.5214 ***
	(0.0270)	(0.0232)	(0.0284)	(0.0452)	(0.0352)	(0.0326)	(0.0231)	(0.0259)	(0.0230)
Inverse(NPLcit)	0.0970	0.1501 *	0.0197	0.1139	0.0156	0.0414	0.2423 ***	0.1540 *	0.1735 **
	(0.0859)	(0.0838)	(0.1028)	(0.0796)	(0.0932)	(0.1019)	(0.0711)	(0.0832)	(0.0788)
Inverse(nbPriorities)	-4.4591 ***								
	(0.2321)								
Inverse(CountUSPTO)				-5.2409 ***			-1.9579 ***		
				(0.3721)			(0.3691)		
Inverse (CountEPO)					-4.8602***			-3.1602 ***	
					(0.3243)			(0.5402)	
Inverse (CountJPO)						-4.6495***			-4.1746 ***
						(0.2999)			(0.5375)
ln(Timespan)			0.3415 ***						
			(0.0253)						
ln(nbInventors)		0.8537 ***					0.7689 ***	0.6191 ***	0.4671 ***
		(0.0415)					(0.0636)	(0.0948)	(0.0950)
Inverse(CountUSPTO) × ln(nbInventors)							-1.3980 ***		
							(0.2089)		
Inverse(CountEPO) × ln(nbInventors								0.0346	
								(0.2440)	
Inverse(CountJPO) × ln(nbInventors									0.4942 **
									(0.2347)
dPriorityTriadic	-0.4945 ***	-0.5862 ***	-0.6561 ***	-0.3725 ***	-0.5894***	-0.5491***	-0.2892 ***	-0.4778 ***	-0.4344 ***
	(0.0504)	(0.0482)	(0.0529)	(0.1197)	(0.0609)	(0.0622)	(0.0475)	(0.0492)	(0.0473)
constant	2.0866 ***	-1.1210 ***	0.0324	2.1091 ***	2.5217***	2.2287***	0.5146 ***	0.6702 ***	0.9322 ***
	(0.1467)	(0.1224)	(0.1199)	(0.1683)	(0.1692)	(0.1775)	(0.1674)	(0.2540)	(0.2544)
Inflate									
ln(BWCit)	-1.2508 ***	-1.2639 ***	-1.1586 ***	-1.3937 **	-1.1786***	-1.0910***	-1.4919 ***	-1.2151 ***	-1.1626 ***
	(0.1377)	(0.0973)	(0.1388)	(0.5476)	(0.1413)	(0.1507)	(0.1300)	(0.1094)	(0.1027)
Inverse(NPLcit)	-1.5222 ***	-1.3151 ***	-1.7764 ***	-1.7767 ***	-1.8528***	-2.0313***	-1.4226 ***	-1.5538 ***	-1.5630 ***
	(0.3415)	(0.2973)	(0.3470)	(0.5896)	(0.3435)	(0.3745)	(0.3045)	(0.2880)	(0.2909)
Inverse(nbPriorities)	1.5867 *								
	(0.9364)								
Inverse(CountUSPTO)				0.1784			-3.8229 *		
				(4.3370)			(2.2724)		
Inverse (CountEPO)					3.6620**			0.8718	
					(1.5987)			(2.9993)	
Inverse (CountJPO)						4.4521***			-0.9066
						(1.4142)			(2.7310)
ln(Timespan)			-0.2393 *						
			(0.1243)						
ln(nbInventors)		0.1107					-0.4807	-0.4199	-0.7714
		(0.1165)					(0.3001)	(0.6016)	(0.5711)

Inverse(CountUSPTO)							2.0738 *		
× ln(nbInventors)							(1.1008)		
Inverse(CountEPO)								1.5308	
× ln(nbInventors								(1.2921)	
Inverse(CountJPO)									2.6122 **
× ln(nbInventors									(1.2205)
dPriorityTriadic	-16.4592 ***	-15.1807 ***	-16.7238 ***	-2.5208	-15.7367 ***	-16.2763 ***	-0.8087 *	-14.0901 ***	-14.6920 ***
	(0.3266)	(0.9368)	(0.2681)	(9.9794)	(0.3620)	(0.2863)	(0.4218)	(1.8274)	(1.5762)
constant	-0.3352	0.2136	0.5936 *	0.5099	-1.1532	-1.6537 **	1.6243 **	-0.2695	0.2539
	(0.4322)	(0.4013)	(0.3286)	(1.2860)	(0.7365)	(0.7316)	(0.7599)	(1.4733)	(1.3676)
ln(alpha)	0.6699 ***	0.6276 ***	0.7488 ***	0.5396 ***	0.6859 ***	0.7112 ***	0.4143 ***	0.5620 ***	0.5552 ***
	(0.0294)	(0.0299)	(0.0294)	(0.0360)	(0.0360)	(0.0354)	(0.0293)	(0.0310)	(0.0292)
Nb observations	9835	9835	9835	9835	9835	9835	9835	9835	9835
Loglikelihood	-20207.4	-20189.3	-20426.3	-19886.6	-20265.3	-20272.9	-19662.6	-19987.7	-19949.5
χ^2	1603.3	1863.3	1492.6	1822.0	1384.6	1592.1	2433.4	1941.6	2069.1

Notes: ***, **, * show significance at the 1%, 5% and 10% levels. Standard errors are presented at parentheses.