INTELLECTUAL PROPERTY BOX AND PROFIT SHIFTING

Abstract

Appreciating the undeniable role of innovation in productivity and growth, it is crucial to know whether IP box preferential taxation efficiently impacts R&D and whose – host or origin country or profit-shifting. With a quantitative meta-analysis approach, it checks the effects of IP box implementation on royalties' payment directions. We study IP box attractiveness for royalties paid from Poland to non-residents as a cost of IP box non-implementing in the home country. Using tax data on over 25,000 payments to non-residents in 2012-2019 applied to the knowledge-capital model, we confirm the higher attractiveness of the IP box policy than R&D hubs based on top universities' knowledge. Thus, it seems justified to implement an IP box to retain IP income in the host country. However, the unexpected effect of IP box implementation is that preferential income taxation wins over the competition with higher R&D investment and the quality confirmed by academic ranks.

1. Introduction

A 'Patent Box' tax regime (also known as Intellectual Property Box, IP Box or Knowledge Development Box) constitutes a favourable tax solution for entrepreneurs who obtain income from the commercialisation of intellectual property rights created or developed by them (Małecki and Mazurkiewicz, 2022). A Patent Box tax regime is constantly gaining popularity as a back-end instrument supporting innovation policy. It constitutes a continuation of front-end instruments, e.g., the R&D tax allowance, which is even more common in European jurisdictions. Currently, 13 of the 27 EU member states have a patent box regime: Belgium, Cyprus, France, Hungary, Ireland, Italy, Lithuania, Luxembourg, Netherlands, Poland, Portugal, Slovakia, and Spain (federal, Basque Country, and Navarra) (Tax Foundation, 2022). Also, outside the EU, the United Kingdom adopted its Patent Box rules. Their decision to adopt the IP box is supported by theoretical evidence suggesting it increases returns to successful R&D, leading to more innovation (Evers et al., 2015) that positively affects productivity and growth.

However, intellectual property box regimes are politically controversial because it is unclear whether they foster innovation yet increase potential tax avoidance (Bornemann et al., 2020). Proponents of IP box regimes justify significant reductions in statutory tax rates for intellectual property as a necessary policy measure to increase domestic innovation that is perceived to suffer from underinvestment (Holmstrom, 1989; Zhong, 2018). In contrast, opponents see IP boxes as mechanisms that allow countries to engage in harmful tax competition and to attract mobile capital without increasing domestic innovative activities. For example, former German Minister of Finance Wolfgang Schäuble criticised patent boxes as "*going against the European spirit*" (Bornemann et al., 2020). Therefore, the Organisation for Economic Cooperation and Development (OECD) countries implemented Base Erosion and Profit Shifting (BEPS) Action 5 that limits the tax benefit of IP boxes to income of innovation developed only within the country ("modified nexus approach") (OECD, 2015).

Appreciating the undeniable role of innovation in productivity and growth, it is crucial to know whether IP box preferential taxation impacts research, development and innovation (RDI) and whether it can be used to foster RDI. The latter is because the generated intellectual assets can also increase the fiscal tax revenue (Ernst and Spengel, 2011). Thus, our paper aims to identify what we can learn from the econometrical empirical studies on the relevance of the IP box to stimulating innovations. The goal is to verify the robustness of empirical evidence from the literature concerning the IP box's impact on innovations (i.e., publication selection effect) and check what determines IP box policy relevance in empirical analyses depending on the research characteristics.

Next, we apply Polish tax data on over 25,000 royalty payments to non-residents in 2012-2019 to the knowledge-capital model to compare conclusions from the meta-analysis to Polish settings before IP box implementation.

We found that the IP box policy attracts higher royalties than countries that are higher ranked in the CWUR ranking based on top universities' knowledge. Thus, it seems justified to implement an IP box to retain IP income in the host country. However, the unexpected effect of IP box implementation is that preferential income taxation wins over the competition with higher R&D investment and the quality confirmed by academic ranks.

The paper is organised as follows. Section 2 provides a brief literature review. Section 3 introduces the methodological aspects of the empirical study, the data, the measures of the variables and the econometric specifications. Section 4 presents the results and discusses the measurement model, complemented by discussions and comparisons with previous findings. The last section details the theoretical policy and managerial implications, limitations, and future research perspectives.

2. Literature review

2.1. IP BOX

Intellectual property (IP) box regimes, or patent boxes, are relatively new tax policy tools that some countries use to promote innovative activity and to attract or retain mobile income and R&D activities within the country. Theoretically, the IP box reduces the effective tax burden on successful R&D investments (Evers et al., 2015). Unlike input-based R&D tax incentives such as R&D tax credits, IP boxes target output-based successful R&D activities that generally result in commercially viable products by providing a reduction in the tax rate applicable to IP income. IP box regimes can significantly decrease the effective tax burdens on marginal R&D investments, but significant variation in tax burdens across countries exists (Evers et al., 2015). Chen et al. (2016) showed an increase in total employment but no increase in fixed asset investment after introducing the IP boxes. Bradley et al. (2015) confirm that an IP box increases the responsiveness of patent applications to tax rates on patent income, but only when inventors and patent owners are located in the same host country. The responsiveness of patent applications to tax rates on patent income is increasing due to the "generosity" of the tax rate on patent income and the favourable treatment of R&D expenses. IP boxes attract high-value patents primarily for R&D-intensive firms (Alstadsæter et al., 2018). Therefore, the IP box is effective only for firms with relatively immobile R&D activity (Merrill, 2016). Brannon and Hanlon (2015) provide survey evidence within a single jurisdiction (the U.S.) suggesting firms would consider increasing innovative activity upon implementing an IP box.

Chen et al. (2019) study whether innovation box tax incentives, which reduce tax rates on innovation-related income, are associated with tax-motivated income shifting, investment, and employment in the countries that implement these regimes. By analysing a matched sample of European multinationals' subsidiaries operating in Europe, they find evidence consistent with firms engaging in less tax-motivated income shifting out of the country after implementing innovation box regimes that provide the greatest tax benefits. They show that innovation boxes are associated with higher levels of fixed asset investment and employment relative to control observations. Finally, they demonstrate IP box effectiveness in altering the location of firms' reported income by examining the extent to which the incentives also result in real investment and employment effects. Tax-motivated reported income, investment and employment increase in IP box firm-country-years following the IP box implementation relative to a matched sample of non-innovation box firm-country-years.

Bornemann et al. (2020) investigate whether and to what extent adopting an intellectual property box increases innovative activity and how much different firms benefit financially via decreasing effective tax rates. Results indicate an overall increase in innovative activity proxied by patent applications, grants, and highly skilled employment at the expense of patent quality in Belgium. Furthermore, firms with patents, on average, enjoy 7.2% to 7.9% lower effective tax rates, with the greatest financial benefits accruing to multinational firms compared to domestic firms. Within multinational firms, those without income-shifting opportunities appear to benefit more than other multinationals with income-shifting opportunities.

Merrill (2016) explains definitions of IP box-related concepts, summing up recent discussions and offering alternative rationales for introducing an IP box, such as the Ramsey Rule, which means that patents are very tax-sensitive due to their mobility and intangibility. Thus, higher taxation results in fewer patent allocations. Therefore, countries that would like to allocate more patents should be motivated to introduce a policy that lowers taxes on R&D.

Some research demonstrates how companies allocate their patents within countries by pursuing IP box policies, only to use the patent for tax reduction later (Alstadsaeter et al., 2018). There is evidence of patents being re-registered to locations with lower tax rates only due to the opportunity to benefit from lowering taxation for profit reasons. Those relocations appear not used for goals like improving research efforts but for monetary gains (Ciaramella, 2017; Alstadsaeter et al., 2018). Fatica and Gregori (2020) show that profit shifting through tax havens and countries with low taxation seems to be an essential channel in tax base erosion. As it seems, some subsidiaries of MNEs located in tax havens enjoy profits 51% higher than they would without profit shifting.

The main goal of the IP box tax incentive is to increase the attractiveness of conducting research and development activities for domestic and foreign enterprises, to change the economic model to a knowledge-based economy, and to raise awareness of intellectual property rights as potential sources of income (Sejm, 2018). Besides, implementing the Patent Box in Poland fits the *strategy for a responsible development* program. It aimed to increase interest in R&D works carried out in Poland and to constitute a kind of 'closing' of the value chain related to creating and commercialising innovative solutions from R&D works. This tax instrument was also an important initiative towards making the Polish tax system competitive and attractive for companies developing high technologies, supporting development and investment, and creating high-quality jobs in innovative sectors. Last but not least, the Polish Patent Box was supposed to make a retention function for innovative solutions. It is intended to prevent entrepreneurs from locating their intellectual property rights in countries with lower taxation so that companies can obtain income from commercialising these rights (Sejm, 2018).

Although the idea of a Patent Box in domestic tax law seems coherent and has a common basis and motives, the adopted solutions differ throughout analysed legal systems. Some of the most significant observations and remarks will be presented below.

The countries extensively analysed in the empirical research are Belgium, France, Germany, Italy, Netherlands, Spain, Sweden and the UK. Germany and Sweden offer no Patent Box tax regime imposed. Hence, these jurisdictions allow taxpayers to use R&D tax allowances only, considering that the Swedish R&D tax incentive is not very attractive compared to other countries. However, this does not prevent Sweden from being considered a very innovative economy (WIPO, 2022). Germany raised some concerns regarding the nexus approach (OECD, 2015). It is worth underlining that all analysed countries implementing Patent Box followed Action 5 of BEPS guidelines (OECD, 2022).

The characteristic solution was imposed in Spain, where one shall observe three different Patent Box regimes – singled out for Navarra, Basque Country and the remaining one for the rest. The taxpayer may claim a reduction of a tax base of 60% (del Impuesto sobre Sociedades, art. 23), which reduces the effective tax rate from 25% to 10% (7.8% in Basque Country and 8.4% in Navarra). Qualifying assets refer to positive income from the assignment of the right to use or exploit patents, utility models, complementary certificates for protecting medicines and phytosanitary products, and legally protected drawings and models derived from RDI activities technology and registered advanced software from R&D activities.

Belgium introduced a new Patent Box tax regime, compatible with BEPS Action Plan 5, since July 2016 (Code des impots sur les revenus, art. 194, 205). Qualifying assets refer to, e.g. patents and supplementary protection certificates, copyrighted computer programs (software), plants, variety rights and orphan drugs (OECD, 2022).

Neighbouring Netherlands ensured compliance of its Patent Box with Action 5 of BEPS since January 1st 2017, implementing the Nexus approach. The effective tax rate is 7%, and qualifying assets include patents, software and models. More severe conditions must be met by a taxpayer not considered a small taxpayer (net turnover below EUR 250m).

Italian Patent Box predicted a 5-year settlement period, which may be renewed and the possibility of reducing the tax rate by 50%. Consequently, the tax rate was 12% of CIT (IRES) + 1.95% IRAP (regional tax). However, on 21st October 2021, the Italian Government entirely repealed and replaced the former patent box regime (Law Decree No. 146/2021).

French Patent Box, compliant with BEPS, has been effective since January 2019 (Code General des impots, art. 238). The effective tax rate for qualifying assets is 10% and refers to patent, patentable inventions or improvements, provided they are capitalised as a fixed asset. In addition, industrial manufacturing processes and rights to plant variety may also qualify.

Last, the UK patent box regime provides an effective corporation tax rate of 10% on profits derived from qualifying patents and similar IP rights. It applies to profits arising after 1st April 2013 (Worldwide R&D Incentives Reference Guide 2022).

Table 1. Characteristics of IP box policy

	year of IP box				tax rate						share of affiliates with links to patent box location		qualifying assets											qualifying income			
country	**implementation**	**amendment**	**abolishment**	**reimplementation**	**ETR ordinary income**	**ETR IP box**	**standard**	**reduced**	**Nexus**	**patent haven**	**Nexus**	**Patent haven**	**patents**	**trademarks**	**software**	**designs & models**	**other copyrights**	**know-how**	**utility models**	**secret formulas & processes**	**Included patents acquired from related parties**	**existing patents**	**other assets**	**income - capital gains**	**Royalties income - direct**	**Royalties embedded**	**Royalties notional**
Belgium	2008	2016			21.11	-26.95	34	6.8	1	0			1	0	0	0	0	0	0	0	0	0	0	0	1	1	1
Netherlands	2007				18.75	3.75	25.5	10	1	0			1	0	1	1	0	0	0	0	0	0	1	1	1	1	1
Spain	2008	2018			22.5	-2.95	30	15	1	0			1	0	0	1	0	1	0	1	0	1	1	1	1	0	0
France	2001	2019			26.56	-6.41	38	22.5	0	1			1	0	0	0	0	0	0	0	1	1	0	1	1	0	0
UK	2013	2016			15.75	7.5	23	15.2	1	0	0.68	0.79	1	0	0	0	0	0	0	0	0	1	0	1	1	1	1
Italy	2015				18.6		31.4	22	1	0	0.69	0.77	1	0	0	0	0	1	0	0	0	0	1	1	1	0	0
Cyprus	2012	2016			11.69	2.34	10	2.5	0	1			1	1	1	1	1	1	0	1	1	1	1	1	1	0	0
Hungary	2003	2016			14.25	-2.54	18	9	0	1			1	1	1	1	1	1	0	1	1	1	1	1	1	0	0
Ireland	1973		2010	2016	12.5	0	24	0	1	0			1	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Luxembourg	2008		2016	2018	21.92	5.47	29.6	5.9	1	0			1	1	1	0	0	0	1	0	0	0	1	1	1	1	1
Malta	2010		2016	2019	26.25	0	35	1.8	0	1			1	1	1	1	1	0	0	0	1	1	1	0	1	0	0

2.2. Measures of innovation

Patent-related metrics derived from the innovation economics literature and highly-skilled employment are often used to measure firms' innovative activities (Hall et al., 2007; Hall et al., 2014; Bradley et al., 2015; Alstadsæter et al., 2018; Bornemannet al., 2020). Patents are an essential sort of intellectual asset in multinational firms and are often used as an indicator for innovative activity, for example in Acs et al. (2002), Cantwell and Piscitello (2005), Le Bas and Sierra (2002), Harhoff and Thoma (2009). Ernst and Spengel (2011) add to the literature by analysing the effects simultaneously from R&D tax incentives and corporate income tax burden on R&D investment and patenting behaviour of European corporations using a panel of firm-specific patent applications at the European Patent Office (EPO) from 1998 to 2007. In addition, Griffith, Miller and O'Connell (2014) analysed the effects of corporate income taxes on the location of patents.

Patent-related metrics of innovation include:

- the natural logarithm of patent applications (Hall et al., 2007; Hall et al., 2014; Alstadsæter et al., 2018; Bradley et al., 2015);
- the natural logarithm of patent grants as an alternative proxy for successful innovative activities (Hall et al., 2007; Hall et al., 2014);
- patent quality - a composite quality indicator accounting for three factors of patents held (forward citations, family size, and technological scope of the patent) to proxy for the quality of innovative activities (Lanjouw and Schankerman, 2004; Hall et al., 2007; Ernst et al., 2014);

Differences in patent intensity between industries with similar R&D intensity are caused by the underlying technologies that differ across industries but are similar for firms within industries (Arundel, 2001; Arundel and Kabla, 1998).

The level of highly skilled employment is an *input* factor for innovative activities calculated as the natural logarithm of the number of employees with a university degree for firm i in year t (Andrews et al., 2014).

The cost of R&D employees (Dischinger and Riedel, 2011) and R&D expenditures are also used to proxy for innovative activities. Still, a common problem is related to whether available data provide sufficient observations to use this proxy. R&D expenditures can be capitalised in the intangible assets (recognised) or costed in the P&L account (and disclose or not in the additional notes to the financial statement) (Jeny and Moldovan, 2021; Bialek-Jaworska, 2016).

Control variables include firm *size* because larger firms are likely to have more innovative activity and benefit from scale effects and *leverage* to account for firms' financial constraints (Hall et al., 2007; Balsmeier et al., 2017). Country-industry fixed effects variable controls for unobserved, time-invariant heterogeneity in patent activities across countries and industries (Dischinger and Riedel, 2011; Karkinsky and Riedel, 2012). Year-fixed effects are also included to control for unobserved, macro-level patent activity heterogeneity over time.

The coefficient on the interaction between *IP box implementation* and explanatory variables captures any incremental innovative activities of firms relative to control firms after introducing the IP box regime. If it is positive and significant, it suggests the IP box increased innovative activities. However, MNEs respond relatively less to introducing the IP box regime because of income-shifting opportunities. Using the parent and subsidiary tax rate differential captures the incentive to shift income with noise (Huizinga and Laeven, 2008; Markle, 2016). MNEs are firms that have subsidiaries in foreign countries or are part of a multinational group headquartered in a foreign country. While firms with patents, on average, enjoy lower effective tax rates after adopting the IP box, it is helpful to consider income-shifting opportunities when identifying firms that benefit from the IP box. The *intangibility* variable accounts for the ease of shifting income (Rego, 2003; Dyreng et al., 2008). The findings could assist policymakers in noticing that IP boxes result in an overall increase in innovative activity at the expense of patent quality (Bornemann et al., 2020).

In contrast, domestic firms have neither parents nor subsidiaries in foreign countries. Markle (2016) suggests that income shifting involving the parent country is especially relevant for firms in territorial tax systems such as Belgium. Suppose Belgian MNEs with an incentive to shift income out of the country respond relatively less to introducing the IP box regime. In that case, the coefficient on the triple interaction $Reform_t \times BE\_PAT_{it} \times Shift_{it}$ is expected to be significantly positive.

Results suggest that relative to control firms, patent applications in Belgium increased from 0.4% to 1.8%, patent grants rose from 0.4% to 5.1%, and patent quality declined. Within the Belgian sample, there was a substantial increase in jobs requiring university degrees for patenting firms after adopting the IP box in Belgium, ranging on average from 38.8% to 46.7% after controlling for overall employment levels. After adopting the IP box, Belgian firms with patents reduce their effective tax rates by ca. 7.2 to 7.9 pp. However, cross-sectional variation exists in the types of firms that enjoy the IP box tax benefits. ETR savings appear most pronounced for MNEs that do not have an incentive to shift income out of the country, followed by MNEs with income-shifting incentives. In contrast, domestic firms experience relatively minor reductions in ETRs after introducing the IP box regime (Bornemann et al., 2020).

3. Research methods

3.1. Meta-analysis

This section analyses the policy relevance of the research depending on the characteristics of the studies, such as the design of the dependent variable, publication in a journal or a working paper, size of the companies included in the analysis, level of data (firm, country, patent), countries covered, a method used.

A meta-analysis allows for statistical investigation of the results of multiple empirical studies addressing the same research question. Meta-regression analysis is a type of meta-analysis designed to summarise and explain the wide variation usually found among reported econometric results (Stanley et al., 2013). However, meta-regression analysis is reasonable only if the estimates are comparable across studies. As measurement units (royalty payments, patents, patent relocation), functional forms (e.g., log-log, log-level, or level-level), and estimation methods (e.g., DiD, OLS, Poisson) were found to be diversified across studies, we reached for partial correlation coefficients.

3.2. Data collection

The analysed field of literature assesses the impact on innovation through a variable indicating an IP BOX policy. Based on a set of empirical articles on the relation between IP BOX policy and innovation found on Science Direct was prepared. To be included in our investigation, an article was expected to meet two criteria. First, the study must report results from assessing the impact of the IP Box policy on innovation. Second, the analysis must provide standard errors or t-statistics and the number of observations to derive PPCs. As a result, 657 estimation outcomes retrieved from 10 studies were found. Table 2 provides a list of the selected publications. The current literature is thus relatively poor.

Table 2. List of articles included in the meta-analysis

Authors	**Years covered by the survey**	**Country**	**Publication**	**Number of estimations**
Mohnen et al. (2017)	2007-2013	The Netherlands	*Oxford Review of Economic Policy*	21
Bornemann et al. (2020)	2003-2014	Belgium, Germany, Sweden, France	*WU International Taxation Research Paper Series*	40
Alstadsæter et al. (2018)	2000-2012	Home countries: Australia, Austria, Belgium, Bermuda, Brazil, Canada, Cayman Island, China, Curacao, Denmark, Finland, France, Germany, Hong Kong, Hungary, India, Israel, Italy, Ireland, Japan, Republic of Korea, Lichtenstein, Luxembourg, Mexico, the Netherlands, Norway, Portugal, Russia, Saudi Arabia, Slovenia, Spain, Switzerland, Singapore, Sweden, Taiwan, Thailand, Turkey, United Kingdom, the U.S., Host countries: Austria, Belgium, Canada, China, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, The Republic of Korea, Lichtenstein, Lithuania, Luxembourg, The Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, United Kingdom, the U.S.	*Economic Policy*	108
Gaessler et al. (2021)	2000-2016	37 buyer and seller countries	*Research Policy*	112
Ciaramella (2017)	1997-2015	20 European countries: Albania, Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece,	SSRN	270

		Hungary, Iceland, Ireland, Italy, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Monaco, the Netherlands, Norway, Poland, Portugal, Romania, San Marino, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, the UK,		
Falk and Pen (2018)	2004-2009	the Netherlands, Belgium, Spain	*Review of Policy Research*	15
Gjymshana et al. (2021)	2013-2018	Belgium compared to France	Working paper	40
Ernst and Spengel (2011)	1998-2007	EEA member states - AT, BE, CZ, DE, DK, ES, FI, FR, GB, GR, HU, IE, IT, LU, NL, NO, PL, PT, SE, SK	*European Economic Research Discussion Paper*	15
Griffith et al. (2014)	1985-2005	Electrical industry European and US subsidiaries of parent firms located in fourteen European countries. We exclude from our analysis firms that patent infrequently, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Norway, Spain, Sweden, Switzerland, the UK, USA	*Journal of Public Economics*	12
Schwab and Todtenhaupt (2021)	2000-2012	Multinational	*Journal of Public Economics*	24
Total	**1985-2018**	**49 countries**	**Seven journals**	**657 estimations**

Additional publications were also detected. However, quite a significant group are qualitative papers dealing with various aspects or theoretical analyses. Therefore, they were not included in the meta-analysis as neither of the above criteria was satisfied since no models were estimated. Lester (2021), for instance, discussed the impact of IP Box Regimes on the merger and acquisition market. Belozyorov and Zabolotskaya (2021) described the state financing system of R&D for small and medium enterprises in Switzerland and Russia. Diaz (2019) discussed patent boxes from the perspective of trust concerns in trade and governance, given the migration of enterprises and intellectual property assets only for tax reasons. Martins (2018) addressed the following questions: was the Portuguese IP box internationally competitive in terms of the scope of qualifying assets and the tax rate compared to other EU countries? Could its legal design induce potential corporate tax avoidance? Does the new IP box framework reduce avoidance opportunities and increase tax and accounting complexity for companies and tax auditors? The Nexus approach's effect on EU Members' regulations was discussed by Faulhaber (2017). Englisch (2017) theorised whether patent boxes still make sense under the OECD-BEPS nexus approach. According to the author, the patent box has lost much of its appeal as a means to attract IP-related profits from abroad. However, it still has a potentially vital role as a defensive instrument in international tax competition. Englisch (2017) discussed the effectiveness of a patent box regime that adheres to the nexus approach in attracting or stimulating additional R&D investments. Merrill (2016) explained the IP box concept and changes adopted in 2015 to the OECD standards for determining whether IP boxes should be treated as harmful preferential tax regimes. Prud'homme and Song (2016) theoretically tested how tax incentives affect patent activity, while Miller and Pope (2015) focused on the Patent Box's policy changes in the UK. Similarly, Graetz and Doud (2013) formulated recommendations for improving R&D tax incentives.

Despite the quantitative approach, others estimated the effects of the nexus approach on mergers and acquisitions transactions (Bradley et al., 2021), corporate taxation's influence on innovative companies' performance (Makeeva et al., 2019) or the filing and trading of patents under various R&D tax incentive programs (Bösenberg and Egger, 2017). Thus, they didn't fit the scope of our research. Despite Klodt and Lang (2016) analysing the impact of the introduction of patent boxes on R&D expenditures and patent applications, it was based just on descriptive statistics, and no econometric model was estimated. Gravelle (2016) examined the effects of a patent box on encouraging R&D in the United States. Gao et al. (2016) tested if R&D success concerning patent output is associated with the level of tax reduction. d'Andria (2016), based on a theoretical model, analysed the effects of R&D tax incentives on the innovation process and market rivalry. Evers et al. (2015) considered the cost of capital and the average effective tax rate under Patent Box conditions. Bradley et al. (2015) searched for the effects of the Patent Box on the extent and location of innovation and patent ownership. Based on a principal-agent approach, d'Andria (2014) focused on taxation and incentives to innovate.
Researchers try to apply different approaches and methods of estimation to catch the potential effect of IP Box on innovation. The most natural seems to be the difference-in-differences (DiD) estimator on the interaction variable that indicates changes in innovation due to the policy reform. Other methods were also applied (see Table 3).

Table 3. List of methods of estimation

Method	Authors
Difference-in-Differences method	Mohnen et al. (2017) Gjymshana et al. (2021) Bornemann et al. (2020)
OLS regression	Alstadsæter et al. (2018) Gaessler et al. (2021) Ernst and Spengel (2011)
Logit model	Alstadsæter et al. (2018) Gaessler et al. (2021) Ernst and Spengel (2011) Griffith et al. (2014)
Multinomial logit	Gaessler et al. (2021)
Poisson random effects panel regression	Gaessler et al. (2021)
Poisson fixed effects panel regeression	Schwab and Todtenhaupt (2021)
Pseudo Poisson maximum likelihood estimator developed by Santos-Silva and Tenreyro (2006)	Falk and Peng (2018)
A negative binomial regression model	Ciaramella (2017) Falk and Peng (2018) Ernst and Spengel (2011)
FE regression	Ciaramella (2017)
Instrumental variable method	Schwab and Todtenhaupt (2021)

All three possible outcomes depended on how the research was constructed, and the dependent variable was defined (see Table 4). No effect of IP Box on innovation was detected by researchers in 306 estimations, with a positive effect–117. In contrast, a negative impact of IP Box on innovation was found in 244 computations (see Table 5).

Table 4. Definitions of dependent variables used in the literature

A dependent variable		Authors
Royalties	Embedded royalties	Alstadsæter et al. (2018)
	Royalty and license fee flows	Ciaramella (2017)
	Intangible assets (i.e., patents) location choice	Griffith, Miller and O'Connell (2014)
Patents	Ln(number of patent applications)	Bornemann et al. (2020) Gjymshana et al. (2021) Ernst and Spengel (2011)
	The number of patent applications that a particular firm submitted in a specific year; additional versions with conditions on the presence of foreign inventor, number of employees	Ernst and Spengel (2011)
	The number of patents registered	Alstadsæter et al. (2018) Schwab and Todtenhaupt (2021)
	An inverse hyperbolic sine transformation of the number of patents registered	Schwab and Todtenhaupt (2021)
	Patent filings from inventors in the country	Gaessler et al. (2021)
	Number of relocated patents	Ciaramella (2017)
	Number of patents transferred from seller country to buyer country during the year	Gaessler et al. (2021)
	Probability of international transfer of patent	Gaessler et al. (2021)
	Probability of a transfer to patent box/no patent box country	Gaessler et al. (2021)
	A patent application that a particular firm submitted in a specific year: yes/no; additionally versions with conditions on presence of foreign inventor	Ernst and Spengel (2011)
	Ln(patent grants)	Bornemann et al. (2020)
	Ln(the number of inventors per patent application)	Gjymshana et al. (2021)
	Coverage of patents	Alstadsæter et al. (2018)
	The quality-adjusted number of patents	Schwab and Todtenhaupt (2021)
	High-value patents number	Alstadsæter et al. (2018)
	Patent Quality - quality indicator developed by Lanjouw and Schankerman (2004)	Bornemann et al. (2020)
R&D	Ln(R&D person per hour)	Mohnen et al. (2017)
	Country-level business R&D spending	Gaessler et al. (2021)
	Number of FDI projects in R&D activities	Falk and Peng (2018)
	FDI inflows in R&D and related activities	Falk and Peng (2018)
	Internal R&D expenditure	Schwab and Todtenhaupt (2021)
EMPLOYEES	Natural logarithm of the number of highly-skilled employees with a university degree	Bornemann et al. (2020)
	Number of employees of a company, including its subsidiaries	Alstadsæter et al. (2018)
	Number of jobs generated over three years	Falk and Peng (2018)
RESEARCHERS	The growth rate of researchers of a company registered in the host country	Alstadsæter et al. (2018)
	Inventors shift - a binary variable taking the value one if the number of researchers registered in the host country increases. In contrast, the number of company researchers registered at the multinational group level decreases or becomes stable.	Alstadsæter et al. (2018)

Table 5. Results summary by dependent variables, research design and peer-review

	No effect		Negative effect		Positive effect	
Dependent variable construction						
binary	17	28.81%	19	32.20%	23	38.98%
continuous	**273**	46.59%	98	16.72%	215	36.69%
discrete	**6**	50%	0	0%	**6**	50%
Journal vs working paper						
working paper – no peer review	168	46.03%	55	15.07%	142	38.90%
Journal – peer review	128	43.84%	62	21.23%	102	34.93%
Firms' size						
all	251	51.02%	73	14.84%	168	34.15%
large and medium	0	0%	5	41.67%	**7**	58.33%
very large	45	29.41%	39	25.49%	**69**	45.10%
Level of analysis						
firm	63	28.13%	53	23.66%	**108**	48.21%
affiliate	11	45.83%	1	4.17%	12	50%
city	5	33.33%	5	33.33%	5	33.33%
patent	149	48.85%	51	16.72%	105	34.43%
country	68	76.40%	7	7.87%	14	15.73%
Country						
Belgium	6	24%	10	40%	9	36%
Netherlands	9	34.62%	0	0%	17	65.38%
Spain	5	100%	0	0%	0	0%
Multinational	276	45.92%	107	17.8%	218	36.27%
Method						
difference in differences	31	30.69%	15	14.85%	**55**	54.46%
fixed effects	13	41.94%	6	19.35%	12	38.71%
instrumental variable	2	50%	0	0%	2	50%
logit	6	18.18%	13	39.39%	14	42.42%
multinomial logit	8	50%	3	18.75%	5	31.25%
negative binomial	143	44.83%	61	19.12%	115	36.05%
OLS	25	41.67%	12	20%	23	38.33%
poisson	66	75.86%	5	5.75%	16	18.39%
pseudo poisson	2	33.33%	2	33.33%	2	33.33%

Table 6. List of control variables

Variable	Authors
Number of employees	Mohnen et al. (2017) Ernst and Spengel (2011)
Industry	Mohnen et al. (2017) Borneman et al. (2020) Griffith et al. (2014)
Size is measured by a logarithm of the total assets of a firm (large firms are those associated with a total number of patent applications above the 80th percentile in each industry) or the logarithm of the total assets of an affiliate	Bornemann et al. (2020) Ernst and Spengel (2011) Griffith et al. (2014) Schwab and Todtenhaupt (2021)
Financial constraints (leverage)	Bornemann et al. (2020)
Time	Bornemann et al. (2020) Alstadsæter et al. (2018) Gaessler et al. (2021) Ciaramella (2017) Gjymshana et al. (2021) Ernst and Spengel (2011)
Country	Bornemann et al. (2020) Alstadsæter et al. (2018) Gaessler et al. (2021) Griffith et al. (2014) Ciaramella (2017)
Patent characteristics (e.g. patent value index)	Gaessler et al. (2021)
Innovation potential of the country, captured by private business R&D expenditures as a percentage of GDP; the R&D-GDP ratio; R&D expenditures)	Alstadsæter et al. (2018) Schwab and Todtenhaupt (2021) Gaessler et al. (2021) Ciaramella (2017) Griffith et al. (2014)
Intellectual property protection (e.g. index developed by Ginarte and Park (1997); index of patent protection was obtained from Park (2008); strength of the property rights protection (index 0–10) drawn from the Economic Freedom database	Alstadsæter et al. (2018) Ciaramella (2017) Falk and Peng (2018) Ernst and Spengel (2011) Griffith et al. (2014)
Real research activity (measured by the number of patents where at least one of the inventors resides in the country where the patent was registered. as a percentage of the total number of patents registered in that country by a given firm; Dummy equal to one when any of the inventors associated with the patent applications that form an idea are located in that country)	Alstadsæter et al. (2018) Griffith et al. (2014)
Market size (logarithm of GDP, logarithm of population, logarithm of city population)	Alstadsæter et al. (2018) Ciaramella (2017) Griffith et al. (2014) Gaessler et al. (2021) Falk and Peng (2018)
Control for living standard (logarithm of GDP level per capita)	Gaessler et al. (2021) Ernst and Spengel (2011) Schwab and Todtenhaupt (2021)
Characteristics of pairs of countries (Controlled Foreign Company rules between a pair of countries (dummy), distance, common official language, European Patent Office membership)	Ciaramella (2017)
City characteristics (capital city, presence of an airport in a city, cities hosting a university included in the THE-QS ranking list, cities located in countries offering R&D tax incentives, PISA score in maths and science)	Falk and Peng (2018)
Solvency (as a measure of debt)	Gjymshana et al. (2021)
Turnover (as a measure of performance)	Gjymshana et al. (2021)

Tax variables (B-Index to gauge tax-induced changes in the user cost of R&D capital, combined statutory corporate income tax rates to cover the taxation of profits from IP), effective average tax rate; CIT (Top statutory corporate income tax rate)	Ernst and Spengel (2011) Schwab and Todtenhaupt (2021)
Public R&D staff per capita calculated as the sum of full-time equivalents for personnel engaged in R&D in the public sector of the host country divided by population.	Ernst and Spengel (2011)
The number of students enrolled in tertiary education divided by population to measure the effects of available human capital	Ernst and Spengel (2011)
The openness of a country in successfully trading with the rest of the world to capture possible relations between innovation and trade performance (imports and exports in goods divided by GDP)	Ernst and Spengel (2011)
High-Tech export share as a measure to capture the effects of trade and innovation, consisting of exports in the so-defined high-tech sectors of aircraft and spacecraft, radio, television and communication, office, accounting and computing machinery, pharmaceuticals and medical, and precision and optical instruments divided by GDP	Ernst and Spengel (2011)
Government funding on BERD	Ernst and Spengel (2011)
GDP growth (Annual percentage growth rate of GDP at market prices based on constant local currency)	Schwab and Todtenhaupt (2021)
User cost of R&D capital as defined by Bloom et al. (2002)	Schwab and Todtenhaupt (2021)
The real interest rate computed from the 10-year bond rate and the GDP deflator.	Schwab and Todtenhaupt (2021)
The logarithm of the age of affiliate *i* (in years)	Schwab and Todtenhaupt (2021)
The logarithm of the ratio of tangible fixed assets and sales	Schwab and Todtenhaupt (2021)
Difference between current assets and current liabilities scaled by total assets	Schwab and Todtenhaupt (2021)
A dummy variable that is equal to one if MNC *j* has at least one affiliate in a tax haven as defined by Hines and Rice (1994)	Schwab and Todtenhaupt (2021)

4. Results of meta-analysis

4.1. Sources of heterogeneity - binary and PCC approach. Publication selection bias

As part of the analysis, we also decided to verify the so-called publication selection bias following the guidelines of Stanley (2005, 2008). Therefore, sample estimates were scaled by their standard deviations (Doucouliagos and Stanley, 2009). However, analysed research studies use different sample sizes, econometric models, and techniques. Also, the approach to dependent and reflecting IP Box policy variables construction varied between studies (see Tables 4 and 6). Due to this, PPCs (partial correlation coefficients) were as follows derived (Stanley and Doucouliagos, 2012):

$$PCC_{is} = \frac{t_{is}}{\sqrt{t_{is}^2 + df_{is}}}$$

where t_{is} is the t-statistic of regression i of study s, and df_{is} is the regression's degrees of freedom. The standard error of PCC is computed as $SEPCC_{is} = \sqrt{(1 - PCC_{is}^2)/df_{is}}$.

Figure 1 and Figure 2 provide an overview of the distribution of the PCCs. PCCs are winsorised at the first and 99th percentiles to remove the impact of outliers. The values of the PCCs vary between -0.12 and 0.15.

Figure 1. PCCs over time

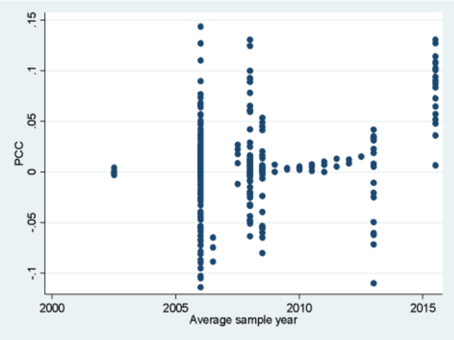


Figure 2. Density of the PCCs

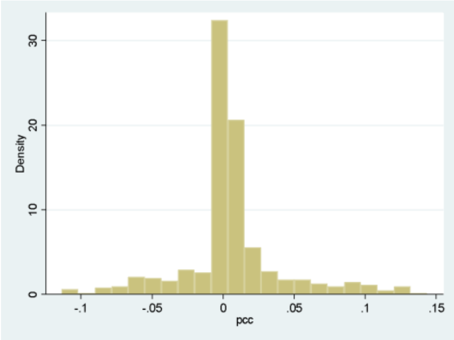
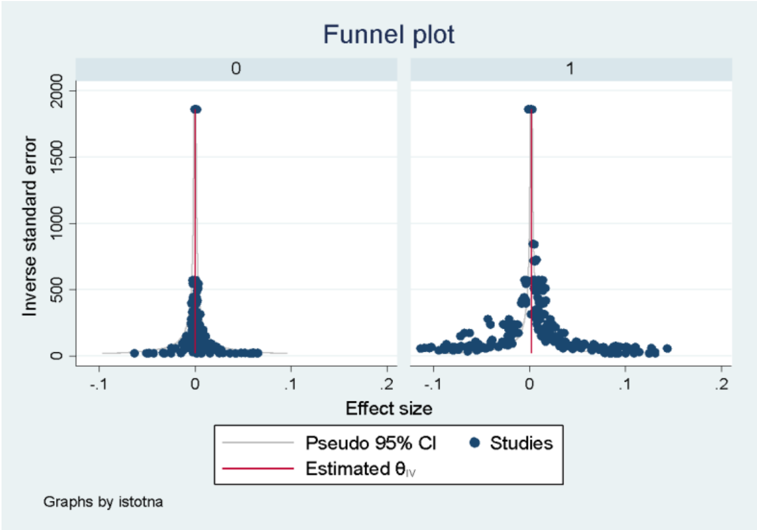


Figure 3. Funnel plot of the PCCs



Note: This funnel plot maps the PCC against its inverse of the standard error. The left panel presents nonsignificant estimates at the 5% significance level. The right panel indicates significant estimates for IP Box policy.

Table 7 presents the degree to which results vary with various methodological choices. Model 1 investigates the sources of heterogeneity for binary dependent variables, indicating whether the IP Box policy was statistically significant for innovation. It turned out that the way the dependent variable was constructed was not substantial. With the inclusion of more years and observations, the likelihood of finding the significant impact of IP Box policy on innovation increases. Studies conducted at the country and patent levels are less likely to confirm policy than firm-level research. For studies conducted with the fixed effects estimator on panel data, a higher probability of obtaining a significant relationship between IP Box policy and innovation can be observed than in the case of research based on the difference-in-differences method. The opposite was found when comparing studies using Poisson and difference-in-differences. The remaining characteristics of the studies were found to be insignificant at the 10% significance level. Model 2 investigates the sources of heterogeneity for the PCC as the dependent variable. In this approach, the likelihood of finding the significant impact of IP Box policy on innovation increases with the use of newer data. Additionally, publication in journals with IF resulted in more significant levels of analysis and methods. Model 2 also allows for verification of publication selection bias. Statistically substantial estimates on the variable

$SEPCC$ are consistent with the presence of publication bias. The results are robust to not winsorising estimates; see Appendix A1-2 and Table A1.

Table 7. Sources of heterogeneity (binary dependent variable) and PCC approach

Explanatory variable	(1) binary		(2) PCC	
$SEPCC$ (Publication bias)			0.00005	**
			(0.00002)	
Dependent variable construction (basic level - binary)				
continuous	0.0219		-0.0046	
	(0.7389)		(0.0124)	
discrete	0.0929		-0.0227	
	(1.2791)		(0.0168)	
Mean year in the sample	0.0643		0.0148	***
	(0.0782)		(0.0019)	
Number of years included	0.1199	**	0.0014	***
	(0.0557)		(0.0011)	
Publication (journal vs working paper)	0.1713		0.0476	**
	(0.7245)		(0.0189)	
Impact factor	0.0615		-0.0185	***
	(0.2225)		(0.0068)	
Number of observations (logarithm)	0.1419	*	-0.0043	
	(0.0819)		(0.0031)	
Level of analysis (basic level - firm)				
affiliate	-0.2898		0.0088	
	(0.9719)		(0.0150)	
city	0.7834		-0.0198	
	(0.8441)		(0.0261)	
patent	-1.8563	***	-0.0389	***
	(0.6487)		(0.0117)	
country	-2.2838	*	0.0376	***
	(1.1757)		(0.0384)	
Method of analysis (basic level - difference in				
fixed effects	0.2484	*	0.0523	***
	(0.8880)		(0.0176)	
instrumental variable	-1.5470		0.0429	**
	(1.4922)		(0.0203)	
logit	0.2390		0.0618	
	(1.3082)		(0.0434)	
multinomial logit	-1.3573		0.0690	
	(1.7648)		(0.0433)	
negative binomial	-0.4910		0.0517	***
	(0.6647)		(0.0155)	
OLS	-0.0258		0.0774	***
	(0.7225)		(0.0227)	
poisson	-1.5989	*	0.0634	**
	(0.8452)		(0.0250)	
pseudo poisson	-0.5164		0.0255	
	(1.2973)		(0.0302)	
Number of observations	657		522	
Test for joint significance	93.41	0.000	10.14	0.000
Ramsey RESET Test			2.56	0.002

* p < 0.1, ** p < 0.05, *** p < 0.01, in parentheses deviations of estimators (standard errors).

5. Panel tax data analysis of IP box impact on royalties paid to non-residents

5.1. Research design

The data analysed comes from the Polish Ministry of Finance and is from the IFT-2R withholding tax declaration from 2012 to 2019 on passive income paid by Polish payers to foreign taxpayers (firms and individuals) – non-residents that do not have their headquarters or management board in Poland. The Knowledge-Capital model explains the operations of MNEs and looks both at horizontally and vertically integrated companies, considering labour and capital production factor differences among countries, as well as impacts of market size and distance as a proxy for trade costs and country size similarities (Markusen, 2002; Cieślik, 2019; Białek-Jaworska, 2021; Białek-Jaworska and Klapkiv, 2021). Our dependent variable is *royalties,* a logarithm of the sum of all passive income flows from patents' licenses and royalties reported in the IFT-2R declaration to one recipient from abroad. We have two five test variables that are designed to verify our hypothesis. *IP_box* is a discrete variable, taking a value of 0 for no IP Box policy existing in a country in that year, 1 for a primary IP box existing and 2 for an amendment IP box. Other test variables are more related to activity in the R&D sector, such as *patents* in a country and the number of top universities in a country (Falk and Peng, 2018). R&D expenditures in total spent by different sectors, including business, government and higher education, are also treated separately in our models to better understand funding (Griffith et al., 2014; Ciaramella, 2017). Finally, we test the time preceding IP box implementation in Poland (2018 and 2019) to check the initial market reaction to the expected fiscal policy changes. Our most crucial control explanatory variables come from understanding the Knowledge-Capital model, which is human and physical capital endowment differences between a pair of countries (*hdiff, kdiff*), the similarity of the countries to each other, and the market's total size. The *hdiff* variable comes from human capital indexes based on the length and return rate to education, and so the difference between Poland and a country that is a destination of royalty payment. *Kdiff* is an expression of the logarithm of physical capital per worker difference between countries, Poland and the receiving one. The *sum* variable is the size of the markets together, showing the combined GDP of Poland and the destination country, while *sdi* is an indicator of the similarity of both economies. We also use *distance* to measure trade costs (Markunsen, 2002; Cieślik, 2019; Białek-Jaworska and Klapkiv, 2021). The remaining explanatory variables are related to the country's general business and economic situation, like trade freedom and financial freedom, Kauffman Indices (Gumpert et al., 2016). Table 8 describes definitions of variables.

We estimate models using the Arellano-Bond Generalised Method of Moments (GMM) estimator with instrumental variables for dynamic panel data analysis. We chose the Generalised Methods of Moments estimator due to a possible issue of the endogeneity of variables. With the Sargan test and the Hansen test run, we could ensure no overidentification problem and exogeneity of instrumental variables used in the models. Our instrumental variables are dividends and airlines' passive income paid to non-residents, strictly exogenous and non-correlated with the dependent variable (Arellano and Bond, 1991).

Table 8. Definition of variables

Variable	Definition	Sign	Source
Dependent Variable royalties	Royalties (licence and patents passive income) paid or transferred to non-residents (withholding taxpayers) from Polish taxpayers (individuals and companies)		IFT-2R Polish Ministry of Finance
Test Variables ip_box	A discrete variable indicates whether there is an active IP box policy in the country that year. It takes the value of 0 for no IP box, 1 for an existing primary IP box, and 2 for amendments to IP box regulation.	+	OECD, Individual countries' government websites
patents	Annual patent applications to the European Patent Office	+	
uni_top_500	Number of Universities in a country that figure in the top 500 in CWUR ranking of universities in that year	+	CWUR University Index
all_sectors_R&D	Investment in R&D from all sectors as % of GDP, including higher education, business and government	+	
HE_R&D	The higher education sector's investment in R&D as % of GDP	+	
business_R&D	Investment in R&D from the business sector as % of GDP	+	Eurostat
government_R&D	Investment in R&D from the governmental sector as % of GDP	+	
IP box pre-implemen tation in Poland	A dummy variable that takes one for the years 2018 and 2019 and 0 otherwise	-	
Control Variables distance	Distance between Warsaw (capital city of Poland) and the capital city of a beneficiary country	-	Indo.com - Home
SDI	Helpman's size dispersion index is calculated using data on output-side real GDP at chained purchasing power parity (PPP) rates and expressed in constant 2011 USS dollars for a paired host and home (origin) countries.	+	
ln_kdiff	the logarithm of capital per worker difference calculated using the national capital stocks expressed in PPPs in constant 2011 USD and the number of workers employed	+	
hdiff	the logarithm of the differences in human capital endowments calculated using the human capital indexes for the source and host countries that are based on the average years of schooling and return to education	+	PWT 10.0 Penn World Tables
sum	the combined market size in origin and host countries measured by the logarithm of the sum of GDP of partner countries at purchaser's prices; GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the product's value. It is calculated without deductions for the depreciation of fabricated assets or depleting natural resources. Data are in current USS dollars. GDP dollar figures are converted from domestic currencies using single-year official exchange rates.	+	
ln_wht	ln(withholding tax paid by the Polish payer in total from all types of passive payments according to the IFT-2R return)	-	IFT-2R Ministry of Finance
property rights	an assessment of the ability of individuals to accumulate private property secured by clear laws that are fully enforced by the state	+	
tax_haven	a binary variable taking a value of 1 for countries listed on the EU list of tax havens and 0 otherwise	+	Gumpert, Hines, and Schnitzer, 2016
tax_haven_MF	a binary variable taking a value of 1 for countries listed in the Polish Minister of Finance Regulation applying harmful tax competition amended in 2017 and 0 otherwise	+	Polish Ministry of Finance regulations
tax_burden	tax burden ratio in the country of the beneficiary of the passive income payment	-	
labour_freedom	Free movement of workers indicator	+	Heritage foundation
trade_freedom	Free trade Index	+	www.Heritage.org
financial_freedom	Financial Freedom of Transaction Index	+	
market_capitalization	The market capitalisation of the stock exchange	+	
rule_of_law	the rule of law captures perceptions of the extent to which agents have confidence in and abide by the rules of society, in particular, the quality of contract enforcement, property rights, the police, and the courts, the likelihood of crime and violence	-	Worldwide Governance Indicators (Kaufmann Index)
regulatory quality	Regulatory Quality capturing the overall quality of laws passed in the country and whether regulations can be bypassed.	-	
Instrumental Variables			IFT-2R
Dividends	Dividends paid from Poland to non-residents	N/A	Polish Ministry of
Airlines	Airlines fare payments from Poland to non-residents	N/A	Finance

5.2. Results

Table 9 provides the dynamic panel data analysis results of determinants of royalties paid to non-residents. Positive significant coefficients at the *IP_box* variable confirm IP box policy attractiveness for royalty payments destination. The insignificance of coefficients at the *EU_list_of_tax_havens* in models (1)-(2) identifies higher and more substantial incentives given by IP box policy than tax havens. However, a lower tax burden matters in the choice of destination and location of intangibles, including patents. The significant positive coefficient at the *patents* variable in models (1)-(3) supports this conclusion, except for the last model, where we control R&D spending by higher education institutions. Thus, there is no evidence that R&D made in academia encourages royalties. Even more, higher royalties go to countries with low-ranked universities.

On the contrary, more substantial R&D spending by businesses and the government results in higher licence payments. Considering the period of IP box implementation in Poland, models (1) and (4) confirm that a good decision has been made by introducing an IP box in Poland. The preliminary effects of the policy to prevent capital outflow, but with the nexus approach, are positive, as implementing a preferential tax rate (IP box) in Poland reduces the attractiveness of the IP box in force abroad. Positive significant coefficients at labour freedom show the cost of late introducing IP box by the host country in potential labour outflow as higher royalties go to countries with higher labour freedom. Larger economies with better educated human capital attract more licence payments. Next, findings show that countries with higher market capitalisation, lower quality rule of law and lower withholding tax receive more royalties. Because coefficients at *hdiff* and *kdiff* variables are not positive simultaneously, the efficiency-seeking motive leads to fewer royalty payments than the market-access motive. Vertically integrated service MNEs receive higher royalties than capital-intensive sectors, i.e., high technology manufacturing, which get more licence transfers when integrated horizontally. Host and home countries' similarities and trade costs (distance) do not matter for royalties.

Table 9. Determinates of royalties - results of GMM with instrumental variables

	(1)		(2)		(3)		(4)	
L1.y	0.1744	***	0.1524	**	0.1993	***	0.2160	**
	(0.0615)		(0.0635)		(0.0718)		(0.0965)	
IP_box	**11.686**	***	**11.8299**	***	**9.2003**	***	**7.2463**	**
	(2.7484)		(2.7071)		(2.9084)		(2.8994)	
patents	0.0004	***	0.0004	***	0.0003	*	0.2957	
	(0.0001)		(0.0001)		(0.0002)		(0.4616)	
uni_top_500	-0.255		-0.1511		-0.5094	**	-0.4660	**
	(0.1886)		(0.1882)		(0.2267)		(0.1934)	
all_sectors_R&D	8.8365	**						
	(3.477)							
business_R&D			12.0641	***				
			(4.2703)					
government_R&D					-20.382			
					(31.281			
higher_education_R&D							-1.1390	
							(19.336	
EU list of tax_havens	-2.5059		-5.2922		28.391	***	31.3456	**
	(12.981		(12.678		(10.581		(14.443	
tax_burden	-0.6453	**	-0.666	**	-1.1745	***	-1.0354	***
	(0.2757)		(0.2687)		(0.2507)		(0.2949)	
IP box pre-implementation (2018-2019)	-2.0699	*	-1.6855		-1.7931		-2.1698	**
	(1.0927)		(1.1042)		(1.2536)		(1.0975)	

sum	17.756	***	15.0428	***	29.285	***	26.5599	***
	(4.1183)		(4.1131)		(4.8148)		(5.4737)	
sdi	28.308		40.9192		-39.552		-0.9938	
	(34.301)		(35.247		(35.58)		(28.326	
ln_kdiff	-16.138	***	-13.103	***	-25.054	***	-24.002	***
	(4.6839)		(4.4813)		(5.6976)		(7.4469)	
hdiff	8.6829	**	9.0222	**	4.4818		3.7684	
	(3.7471)		(3.7407)		(3.4544)		(3.9847)	
distance	-0.0022		-0.0029		-0.003		-0.0013	
	(0.0025)		(0.0025)		(0.0037)		(0.0027)	
ln_wht	-0.3462	***	-0.3596	***	-0.1932		-0.1694	
	(0.125)		(0.1264)		(0.1398)		(0.1496)	
rule_of_law	-13.533	***	-14.155	***	-13.733	***	-13.922	***
	(3.5549)		(3.6016)		(3.3868)		(3.4842)	
tax_haven_MF	2.6566		3.5641		-21.708		-3.643	
	(19.324		(18.724		(19.727		(24.407	
labour_freedom	0.3612	***	0.3352	***	0.3807	***	0.3388	***
	(0.1213)		(0.1234)		(0.1322)		(0.1298)	
market_capitalization	0.0433	**	0.0462	**	0.0392	*	0.0191	
	(0.0202)		(0.0201)		(0.0228)		(0.028)	
trade_freedom	-0.4942		-0.4788		-0.2038		-0.0886	
	(0.415)		(0.4172)		(0.4343)		(0.4486)	
financial_freedom	-0.0572		-0.0671		0.0712		0.0598	
	(0.1467)		(0.1554)		(0.1311)		(0.1679)	
N observations	25,567		25,567		25,710		25,710	
N groups	11,089		11,089		11,131		11,131	
N instruments	67		67		67		67	
Arellano-Bond test	-2.65	0.01	-2.61	0	-1.09	0.3	-2.05	0.00
AR(2)	-0.14	0.89	0.24	0.8	-0.96	0.3	-1.11	0.26
Hansen test of overidentified restrictions	61.15	0.08	59.89	0.1	57.96	0.1	53.63	0.23
Hansen test GMM iv levels exogeneity test	37.12	0.29	38.58	0.2	37.83	0.3	33.23	0.45
Hansen test GMM iv levels difference	24.03	0.05	21.31	0.1	20.13	0.1	20.40	0.11
Hansen test iv excl. groups exogeneity test	60.15	0.08	58.66	0.1	57.48	0.1	53.14	0.21
Hansen test iv differences exogeneity test	0.99	0.32	1.23	0.3	0.48	0.5	0.49	0.48

* p < 0.1, ** p < 0.05, *** p < 0.01, in parentheses deviations of estimators (standard errors).

6. Conclusions and Discussion

Our results contribute to the literature on preferential R&D taxation and provide valuable implications for practice. Although almost half of the EU members implemented a patent box regime, this tool is politically controversial. Our findings confirm the grounds for these doubts about whether the cost of fostering innovation in the form of an increase in tax avoidance (Bornemann et al., 2020), harmful tax competition, and attracting mobile capital without increasing domestic innovative activities are worth the price. Because we provided evidence of selection bias when investigating the sources of heterogeneity for the PCC as the dependent variable, the assessment became more evident. Furthermore, we show that the likelihood of finding the significant impact of IP Box policy on innovation increases with the use of newer data, publication in journals with Impact Factor and consideration of more levels of analysis and fixed-effects estimations. This may mean that the effects of the IP box are only visible after many years (lagged). Or that the policy has proved more effective after eliminating its inefficiencies by introducing a nexus indicator in the design of the preferential tax rate, sealing the tax system through BEPS instruments, etc. Dynamic panel tax data analysis confirms that royalties go to destinations that have already implemented IP box instruments more than academic hubs and scientific centres, which are higher in the CWUR ranking based on top universities' knowledge. Knowledge of this significant evidence makes it clear what costs not to adopt the innovation box regime and points out who benefits more from this policy. Despite theoretical evidence suggesting the IP box increases returns to successful R&D, leading to more innovation (Evers et al., 2015), it adds more to the productivity and growth of home countries due to attracting royalties through a lower tax burden. Although it seems justified to implement an IP box to retain IP income in the host country, it does not solve the underinvestment of the domestic (host country) innovation issue, contrary to the hopes and expectations of Holmstrom (1989) and Zhong (2018). The unexpected effect of IP box implementation is that preferential income taxation wins over the competition with higher R&D investment and the quality confirmed by academic ranks.

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Robustness test

This robustness test fully confirms the main results. A statistically significant estimate on the variable SEPCC is found again, which is consistent with the presence of publication bias. All other variables significant in the primary model are also substantial.

Figure A1. Density of the PCCs

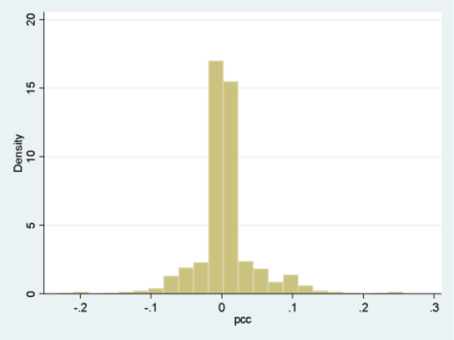
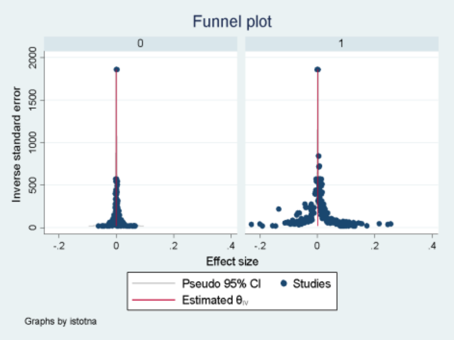


Figure A2. Funnel plot of the PCCs



Note: PCC is not winsorised.

Table A1. **Sources of heterogeneity PCC approach - not winsorising estimates**

Explanatory variable		
SEPCC (Publication bias)	0.0001	*
	(0.0000)	
Dependent variable construction (basic level -		
continuous	-0.0046	
	(0.0125)	
discrete	-0.0288	
	(0.0171)	
Mean year in the sample	0.0145	***
	(0.0020)	
Number of years included	0.0044	***
	(0.0014)	
Publication (journal vs working paper)	0.0456	**
	(0.0201)	
Impact factor	-0.0184	**
	(0.0073)	
Number of observations (logarithm)	-0.0041	
	(0.0042)	
Level of analysis (basic level - firm)		
affiliate	-0.0021	
	(0.0163)	
city	0.0199	
	(0.0603)	
patent	-0.0411	***
	(0.0120)	
country	0.0219	
	(0.0416)	

Method of analysis (basic level - difference in		
fixed effects	0.0566	***
	(0.0179)	
instrumental variable	0.0541	**
	(0.0218)	
logit	0.0627	
	(0.0433)	
multinomial logit	0.0695	
	(0.0432)	
negative binomial	0.0530	***
	(0.0156)	
OLS	0.0753	***
	(0.0228)	
poisson	0.0809	***
	(0.0279)	
pseudo poisson	0.0517	
	(0.0733)	
Number of observations	534	
Test F for joint significance	9.29	0.000
Ramsey RESET Test	1.35	0.170

Note: The dependent variable is the not winsorised PCC; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$; in parentheses deviations of estimators (standard errors).