IP box effects in the gaming industry

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Abstract

Purpose – This paper aims to verify how the intellectual property (IP) box affects firms' effective tax rate, growth and innovation activity outcomes related to intellectual property rights.

Design/methodology/approach – Implementing the innovation box regimes into the tax system intends to encourage firms to engage in more innovative activities. In UK, Italy and Poland, the IP box tax relief was introduced in 2013, 2015 and 2019, respectively. In return, companies may reduce their tax rate to increase their investment and innovativeness. With a panel model approach – system GMM and DiD with multiple time periods – it analyses data from the Orbis database for 2011–2019 of 673 firms from the gaming industry in 11 countries and hand-collected data on intellectual property rights protection. The authors study public and private companies from the gaming sector in leading European markets and all three countries that protect intellectual property rights of software (Japan, South Korea, the USA).

Findings – Recent reforms enable gaming companies to use preferential tax treatment for IP-related income and significantly impact a firm's revenue growth.

Practical implications – Nevertheless, European gaming firms require time to leap the gap to the growth and innovativeness of countries that protect software.

Originality/value – The authors show that the IP box stimulates gaming firms to protect IP via wordmarks, figurative marks, trademarks and software patents that bring effects in five years. Despite the critics against IP box, the authors prove its lagged efficiency, especially in profitable and larger firms.

Keywords IP box, Innovation box, Effective tax rate, Gaming industry

Paper type Research paper

1. Introduction

This paper aims to study how the introduction of innovation box regimes impacts a gaming firm's effective tax rate (ETR), revenue growth and innovation activity outcomes related to intellectual property rights. Intangible assets and intellectual property are crucial in developing all multinational companies, especially gaming ones.

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Over the last 20 years, many countries have decided to implement innovation box regimes into their tax system to reduce shrinking income tax revenues. Intellectual property box (IP box) is a preferential tax on income derived from selling products or services based on intellectual property rights. Thus far, 14 out of 27 European countries have applied these regulations. These tax regimes enable companies to reduce the tax rate on income emerging from patents, licenses, and other forms of intellectual property (Evers, Miller, & Spengel, 2015; Merrill, 2016). Intellectual property box regimes are considered back-end or output-based incentives that offer entrepreneurs reduced taxation on income earned from a successful innovation (Lester, 2021). The scope of the tax base and the preferential tax rate resulting from the IP box varies between countries ranging from 4.4% in Belgium to 13.9% in Italy, and an exemption of qualified intellectual property income from 50% to 80% (Chen, De Simone, Hanlon, & Lester, 2019). The lowest tax rate resulting from the IP box regime is in Malta (outside our research sample) and equals 0%. In various countries, the IP box relief may apply to the income from patents, intellectual property created by programmers such as software or domains, or industrial property like trademarks or trade names. The primary purpose of this tax incentive is to increase the attractiveness of conducting research and development (R&D) activity, encourage entrepreneurs to search for business potential in intellectual property rights and retain income from intangible assets that could be transferred out of the country to low-tax jurisdictions.

The gaming sector is constantly growing due to the increasing interest in and access to online games. In PwC's report "Global Entertainment & Media Outlook 2020–2024" (2020), experts expect the gaming industry in the analyzed countries to grow at a compound annual growth rate (CAGR) of 3.9%–11.6% between 2019 and 2024. The global value of the gaming sector exceeds USD 159 billion, and in Poland, its revenue tops USD 596 million, with export constituting 96% of that sum (Rutkowski, Marszałkowski, & Biedermann, 2020). We used the panel data model approach (the Blundell-Bond system GMM estimator, DiD with multiple time periods, the conditional logit, and complementary log-log model) for the following proxies (dependent variables) to capture the effects of introducing the IP box in various countries: ETR, revenue growth, and IP protection use in the gaming industry. Our study encompassed the period from 2011 to 2019. We based it on data from Orbis, OECD, and KPMG databases. Our research sample covered 5384 observations of 673 listed and unlisted gaming companies from the main European markets (Germany, the UK, France, Italy, Spain, Poland, Belgium, and the Czech Republic) and all three countries where software intellectual property rights are protected (Japan, South Korea, and the USA). It is essential to remember that software is not patentable in Europe. A guideline from the European Patent Office states that computer programs are excluded from patentability under Art. 52(2) (c) and (3) if claimed as such. However, following the generally applicable criteria for Art. 52(2) and (3) (GII, 2), the exclusion does not apply to computer programs having a technical character. To have technical nature and thus not be excluded from patentability, a computer program must produce a "further technical effect" when run on a computer. A "further technical effect" is a technical effect that goes beyond the "normal" physical interactions between the program (software) and the computer (hardware) on which it runs. For example, the typical physical effects of the execution of a program, e.g. the circulation of electrical currents in the computer, are not sufficient to confer technical character to a computer program (T 1173/97 and G 3/08). In reference to Newzoo (2020), our surveyed countries were pacemakers in revenue generated from gaming activities (see Figure A1 in Appendix).

Moreover, not all of the analyzed countries introduced IP box regulations. The exceptions are Japan, the USA, South Korea, the Czech Republic, and Germany. In the UK, the scope of qualifying income is narrowly defined and limited to patents only. In other countries, income includes patents, software, know-how, models, trademarks, licensed IP, plant brands, etc. The foreign-derived intangible income (FDII) deduction in the USA applies to American taxpayers with income from export sales or services. It decreases ETR to 13.1%, compared with 21%

CIT till 2026 and 16.4% after 2026 (Cunningham, 2018). In South Korea, qualifying assets are only software protected by copyright, industrial patents, trademarks, designs, models, processes, and formulas, subject to legal protection. Depending on the tax base, the reduced tax rate varies from 5% to 12.5% for transfer and from 7.5% to 18.7% for a license (OECD Dataset Intellectual Property Regimes, 2019).

Literature shows that IP box reduces ETR more in MNEs than domestic firms (Evers *et al.*, 2015; Bornemann, Laplante, & Osswald, 2020) and boosts R&D and patent applications (Bradley, Dauchy, & Robinson, 2015; Evers *et al.*, 2015; Mohnen, Vankan, & Verspagen, 2017; Chen *et al.*, 2019; Haufler & Schindler, 2020). However, it does not touch the gaming industry not patenting in Europe, which experienced explosive but rapidly and frequently changing growth – the highest growth of sales occurs right after a successful game launch and gradually expires until the preorder boom of another game 6–8 years later. Our study contributes to the existing academic literature by confirming that IP box regulations reduce ETR by two to three percentage points and enable gaming companies to boost their revenue growth and protect their intellectual property. However, the effects of the innovation box take a few years to materialize, thus we observed lagged impacts. Nevertheless, owing to the IP box, lower tax rates stimulate them to benefit from IP protection via software patents and trademarks.

The remainder of this paper is structured as follows. Section 2 will cover the literature review and hypotheses development. We will describe the data used and the research design in Section 3. We will then present our results in Section 4. Finally, Section 5 will conclude the paper, discuss research limitations, and suggest directions for future research.

2. Literature review and hypotheses development

Intellectual property box regimes are a controversial tax policy tool because of their unclear impact on increasing business innovation and their potential to increase tax avoidance. Supporters of this regime argue that reducing the statutory tax rate for intellectual property is a policy tool crucial for boosting domestic innovation, which is underinvested (Zhong, 2018; Bornemann *et al.*, 2020). Facing increasing tax rate competition, many countries used IP box incentives to (1) attract corporate investments and employment and (2) retain taxable income that would otherwise be shifted to lower-taxed jurisdictions (Lester, 2021). On the other hand, opponents believe that IP box regimes foster adverse effects of tax competition and favor income shifting due to the preferential tax rate in different countries without increasing innovative activity in domestic ones. In response to this contentious issue of the innovation box relief, the Organization for Economic Cooperation and Development (OECD) implemented the Base Erosion and Profit Shifting (BEPS) Action 5, which reduces the IP box tax benefit to innovation-related income exclusively developed within a country (OECD, 2015). Gaessler, Hall, and Harhoff (2021) confirm that the particular design of the patent box determines to what extent IP rights are reallocated. The requirement that further invention development occur within the country to enjoy the lower tax rate seems to mitigate transfers for purely tax reasons.

Analyzing previous empirical studies (Evers *et al.*, 2015; Ohrn, 2016; Koethenbuerger, Liberini, & Stimmelmayr, 2018; Chen *et al.*, 2019; Bornemann *et al.*, 2020), we can conclude that the impact of implementing the IP box relief is multi-dimensional. Previous literature suggests that multinational enterprises (MNEs) have more opportunities to reap tax benefits than domestic companies. This is because MNEs can allocate their R&D and intangible assets in low-tax jurisdictions, distorting their locations (Karkinsky & Riedel, 2012). Intellectual property box regulations are designed to prevent the artificial relocation of R&D locations and intangible assets to combat this problem (Bradley, Robinson, & Ruf, 2021). Therefore, some studies examined how the innovation box affects locations of intangible assets or R&D, cross-border payments, and reported income (Karkinsky & Riedel, 2012; Koethenbuerger *et al.*, 2018; Chen *et al.*, 2019; Bornemann *et al.*, 2020). Other research indicates that this tax

policy tool boosts firms' innovative activities and encourages R&D investments (Bradley *et al.*, 2015; Evers *et al.*, 2015; Chen *et al.*, 2019; Haufler & Schindler, 2020). There is also empirical evidence that the innovation box notably supports a decrease in ETR (Evers *et al.*, 2015; Bornemann *et al.*, 2020).

Literature on the effect of IP boxes on innovation activity provides ambiguous conclusions. On the one hand, the IP box is positively correlated to innovation (Mohnen *et al.*, 2017), as a 1% decrease in the corporate tax rate boosts new patent applications by 3% on average (Bradley *et al.*, 2015). An average Dutch firm tends to use only a part of the tax advantage for extra R&D investment. Therefore, the innovation box additionality effect is lesser than the costs involved in foregone taxes (Mohnen *et al.*, 2017). In Belgium, on the other hand, implementing the innovation box has not increased innovation activity extraordinarily, because patent-owning firms have not been further encouraged to increase their innovation after introducing the IP box regimes (Bornemann *et al.*, 2020). The IP box regulations offer an additional tax incentive to develop intangible assets. In Belgium, implementing the innovation box decreased the marginal ETR of 1.9% on marginal R&D investments (Evers *et al.*, 2015), and ETR by 7.2% to 7.9% when developing intellectual property (Bornemann *et al.*, 2020). Still, MNEs receive more IP box tax benefits than domestic companies.

American payments to foreign affiliates increase when the IP box regulations qualify income as existing intellectual property, but this regime significantly impacts only newly developed R&D (Ohrn, 2016). A 1% change in the statutory tax rate results in an approximately 14.8% reduction in income shifting and an increase in profits by about 1.31 million euros because of higher tax benefits due to IP box regulations (Bornemann *et al.*, 2020). Moreover, MNEs without income-shifting opportunities may expect a greater ETR reduction than MNEs that transferred profits (Bornemann *et al.*, 2020). The innovation box system is associated with a lower sensitivity to reported profits to local statutory income tax rates. It means less income shifting across borders than observed in other jurisdictions. Moreover, income shifting is concentrated in countries implementing the innovation box with a relatively large tax advantage (Chen *et al.*, 2019). The number of inventors in the destination countries increases when patent box benefits are conditional on the further development of patents that were transferred there (Alstadsæter, Barrios, Nicodeme, Skonieczna, & Vezzani, 2018).

Similarly, the size of the patent box differential is harmful both for patent filings and business R&D when there is no requirement for further development but insignificant otherwise. Thus, introducing a patent box does not influence aggregate innovative activity if further development of the inventions contained in transferred patents is required (Gaessler *et al.*, 2021). Contrary to expectations (Gaessler *et al.*, 2021), before OECD introduced the BEPS restrictions, we could observe a somewhat negative impact of the patent box introduction on local invention and R&D. However, nexus rules reduce firms' incentives for acquiring developed intangibles and, by extension, reduce the amount of M&A activity. The inclusion of a strict nexus requirement effectively renders the IP box incentives ineffective from the perspective of stimulating M&A investment. On the one hand, demanding nexus limits the investment response, while on the other hand, it requires actual activity in exchange for tax benefits. Consequently, the nexus requirements have been a primary way for governments to regulate the amount and type of IP box benefits they provide (Lester, 2021), among others, in Poland. Thereby it affects cross-border tax competition.

However, the increasing costs of R&D capital and knowledge spillovers throw entrepreneurs into a gap between investments in tangible and intangible assets leading to underinvestment in innovative activities (Bornemann *et al.*, 2020). Therefore, many countries introduce various tax incentives, such as tax credits for R&D expenditures, to help close the wedge between investment in tangible and intangible assets (OECD, 2020) and encourage entrepreneurs to increase their R&D activity. In our study, we propose three hypotheses.

First, introducing the innovation box in countries allows the reception of tax benefits. Gaming companies that conduct R&D activities and create qualified intellectual property rights may reduce their tax liabilities. Laplante, Skaife, Swenson, and Wangerin (2019) found that a one standard deviation increase in strategic R&D classification leads to a 1.7% reduction in GAAP ETR. However, a bigger firm with a higher sales volume has a higher ETR (Jones, Baker, & Lay, 2017; Thomsen & Watrin, 2018). Although the possible result is not clear, we expect that:

H1. Gaming companies decrease the ETR after introducing IP box regimes in their countries.

Our second hypothesis examines whether innovation box regimes are efficient in supporting the revenue growth of gaming companies. Enforcing IP box rules allows gaming firms to increase their free cash flows through lower tax payments. Thus gained surplus cash may improve their investment capacity and boost R&D expenditures. Corporate productivity growth is positively correlated with R&D expenditures as R&D activity represents efforts towards achieving efficiency (Minasian, 1962, 1969). The value-added increases due to success, whereas R&D expenditures include both the cost of failed projects and the fruitful ones. Typically, returns to R&D amount to several hundreds to thousands of percent. However, increased productivity caused by R&D partially reaches consumers via lower goods' prices. Finally, lower prices will tend to decrease the firm's profits and the return rate (Minasian, 1969). Next, at another stage of the gaming firm's life cycle, the extra money can be utilized to expand production capacity and quicken revenue growth when their video games enter the market. Therefore, we formulated the following hypothesis H2:

H2. Gaming companies increase revenue growth after introducing IP box regimes.

In the third hypothesis, we examined what determines whether a gaming company protects intellectual property. Previous literature suggests that the number of patent applications is related to the corporate tax rate and indicates that an increase in the number of patent applications depends on the tax credit available through the IP box or favorable treatment of R&D expenditures (Bradley *et al.*, 2015). Moreover, Bornemann *et al.* (2020) show that the number of patent applications and patents granted increased after implementing IP box regulations in Belgium. Thus, we formulated hypothesis H3 consistent with the policy goals of innovation boxes:

H3. Introducing the innovation box relief positively impacts the R&D activities' outcomes in the gaming sector.

3. Research design

Our study examined how introducing the IP box regimes impacts a gaming firm's tax benefits, revenue growth, and innovation activity outcomes related to intellectual property rights. Therefore, we built a research sample to entail leading European (Belgian, Czech, French, German, Italian, Polish, Spanish, and British) and Japanese, South Korean, and American private and public gaming companies that substantially impact the international market. We chose a nine-year sample period from 2011 to 2019, which covers the implementation of the IP box at different times in the analyzed countries (see Figure A1 and Table A1 in the Appendix). We collect financial, employment, and ownership data retrieved from Orbis and KPMG databases. Moreover, we recovered aggregated information about the number of patents pending or granted from the Eurostat database and hand-collected individual data on registered word marks, trademarks, and figurative marks from the European Patent Office and the United States Patent and Trademark Office.

We begin with 12,872 firm-country-year observations. Because the gaming industry includes mainly private companies unlisted on stock exchanges, obtaining complete financial data was difficult and led to the estimation of unbalanced panel models. Thus, we replaced the missing data with an average value within the company. To test hypothesis H1, we use ETR measured by a ratio of tax expenses to profit before tax (PBT) (earnings before interest, taxes, depreciation, and amortization-EBITDA). Effective tax rate estimates tax benefits that companies could receive after introducing the IP box relief. To avoid situations in which a negative value of ETR would be challenging to interpret, we removed the observations that took a negative value for the profit before tax and income tax, similarly to Thomsen and Watrin (2018). The above exclusions reduced the sample to 2403 firm-year observations of 359 distinct companies concerning ETR based on PBT and 2543 firm-year observations of 362 firms using ETR based on EBITDA (see Table A2 in the Appendix). The impact of some variables on ETR can be ambiguous due to their relationship with both the denominator and the numerator. For example, depreciation or interest (forms of non-debt and debt tax shield) is related to the tax burden, while their impact may weaken after certain accounting transformations in the denominator, which is the reference point for the taxes reported. Therefore, we expected a strong negative relationship between capital intensity or leverage and ETR based on EBITDA. On the other hand, EBITDA lacks a simple interpretation and direct comparability with statutory tax rates.

To test hypothesis H2, we had to exclude observations from 2011, because otherwise, we could not calculate our dependent variable. The lagged revenues are required to calculate the *Growth* variable that measures a firm's revenue growth. Therefore, our sample consisted of 2261 firm-country-year observations of 360 firms when drawing upon ETR based on EBITDA and 5384 firm-country-year observations of 673 individual firms without ETR limitations. Moreover, to test hypothesis H3, we used panel data for the entire research period for the conditional logit model and complementary log-log model for the *IP protection* dummy variable that captures successful innovation activities' outcomes. Table A2 in the Appendix presents the distribution of firms by analyzed countries. The definitions of all variables are described in Table 1 (Table A3 in the Appendix).

Table A9 in the Appendix provides descriptive statistics. In our sample, the average value for the ETR based on profit before tax *(ETR_PBT)* was 22.9%, while the ETR based on EBITDA *(ETR_EBITDA)* was 16.9%.

Average ETR measures were lower than the average STR, which equaled 27.6%–27.8% (for details, see also Figure A4 in the Appendix). The average tangible fixed assets varied from 8% to 9.7% of total assets, while intangible assets were between 9.6% and 13%, respectively.

Figure A3 in the Appendix verifies the Kendall correlation.

We estimated the following models (1) and (1a) to investigate whether gaming companies benefit from IP box regimes (hypothesis H1) using system GMM and FE estimators, respectively. To measure the ETR, we used three proxies to verify the robustness of the results: first, a tax expense to profit before tax ratio (*ETR_PBT*); second, ETR_PBT scaled to non-negative values lower than 1 (H1); and third, tax expense in relation to EBITDA ratio (robustness check). *IP BOX* is a binary variable, which equals one for all years after introducing the IP box relief and zero otherwise.

We controlled the *size*, *leverage*, *ROA*, *intangibility*, *capital intensity*, and *inventory* variables. It is crucial to do so because larger companies have more tax planning opportunities to avoid taxes (Rego, 2003). However, larger firms also have higher political costs that act contradictory (Zimmerman, 1983; Gupta & Newberry, 1997). Higher *leverage* allows reducing the tax burden by deducting interest paid on debt from taxable income (McGuire, Omer, & Wang, 2012; Dyreng, Hanlon, Maydew, & Thornock, 2017; Thomsen & Watrin, 2018). We controlled *intangibility* to capture possibilities of income shifting (Dyreng, Hanlon, & Maydew, 2008). Given the tax preferences and total assets, an increase in *ROA* leads to an increased tax burden (Chen *et al.*, 2019; Bornemann *et al.*, 2020). Therefore, it is crucial to control profitability. *Capital intensity*

Variable	Definition
Dependent variables	
ETR_PBT	$\frac{Taxation}{Profit\ before\ tax}$
ETR_PBT_clipp	ETR_PBT scaled to non-negative values lower than 1
ETR_EBITDA	$\frac{Taxation}{EBITDA}$
Growth	$ln(Revenue_t) - ln(Revenue_{t-1})$
Patent_pp	Binary variable indicating if a patent is registered or pending, 1 – if yes, 0 – if no
Patent_tn_pp	Binary variable indicating if a patent, a game's wordmark, a firm's trademark, or figurative mark is registered or pending, 1 – if yes, 0 – otherwise
Test variable	
IP BOX	The binary variable indicating when the IP box has been implemented equals 1 – for the year of introducing the IP box and after, and 0 – otherwise
Control variables	
Capital intensity	$\frac{Tangible\ fixed\ assets}{Total\ assets}$
Intangibility	$\frac{Intangible\ fixed\ assets}{Total\ assets}$
Inventory	$\frac{Current\ assets}{Total\ assets}$
Leverage	$\frac{Long-term\ debt}{Total\ assets}$
MNE	The binary variable indicating a firm with foreign shareholders equals 1 – if the firm's foreign shareholders have more than 50% share in equity, and 0 otherwise
Employees	$ln\,(Number\ of\ employees)$
Size	$ln\,(Total\ Assets)$
ROA	$\frac{Profit\ (Loss)\ before\ interest\ and\ tax}{Total\ assets}$
Patents	Number of patent applications or patents granted by the European Patent Office (EPO), patents granted by the United States Patent and Trademark Office (USPTO), and triadic patent families
STR	Statutory Tax Rate
Kaufmann	Average of six sub-index of the Worldwide Governance Indicators that rank countries concerning six aspects of good governance: voice and accountability, political stability and violence, government effectiveness, rule of law, and control of corruption
Ownership	Categorical variable indicating the type of ownership structure that consists of 15 levels: bank; corporate; hedge fund; employees, managers, directors; financial company; private equity firms; public (listed companies); venture capital; insurance company; foundation; research institute; self-ownership; one or more named individuals or families; other unnamed shareholders aggregated, mutual and pension fund, nominee trust trustee; public authority state government

Source(s): Own elaboration

Table 1.
Definitions of variables

captures tax optimization opportunities by selecting higher or accelerated depreciation for tax purposes (Bornemann *et al.*, 2020). Finally, inventory reduces taxable income only at the time of sale (Bornemann *et al.*, 2020). On the firm level, we controlled foreign shareholders' participation in the equity (*MNE*), ownership structure, and the number of employees. In contrast, on the country level, we controlled the statutory tax rate (*STR*), good governance by a mean of Kaufmann indices (*Kaufmann*), and the number of patents pending or granted (*patents*).

$$ETR_{i,t} = \beta_0 + \sum_{j=1}^{2} \beta_j ETR_{i,t-j} + \sum_{k=0}^{2} \beta_{3+k} IP\,BOX_{c,t-k} + \beta_5 Controls_{i,t} + \beta_6 Controls_{c,t} + \beta_7 time\_dummy_{i,t} + \mu_{i,t} \quad (1)$$

$$ETR_{i,t} = \beta_0 + \beta_1 IP\,BOX_{c,t} + \beta_2 Controls_{i,t} + \beta_3 Controls_{c,t} + \mu_{i,t} \quad (1a)$$

We estimated the abovementioned models (eq. 1) at the firm-country-year level using the Blundell-Bond system GMM estimator dedicated to dynamic panel data (Blundell & Bond, 1998) and models described in equation (1a) with firm-country fixed effects on the diversity of patent activity across countries (Bornemann *et al.*, 2020; Karkinsky & Riedel, 2012). The subscripts *i*, *c*, and *t* denote firm, country, and year.

Next, we adopted the state-of-the-art staggered difference-in-differences (DID) framework to calculate the IP box group-time average treatment effects on ETR (Callaway & Sant'Anna, 2021). The main idea behind this approach was first to estimate the individual cohort-time-specific treatment effects, allowing for treatment effect heterogeneity, and then aggregate the individual treatment effects to generate estimates of overall treatment effects. Therefore, we applied this specific DiD procedure with multiple time periods to check the robustness of results for testing H1 using alternative research designs. Our control group consisted of firms from countries without IP boxes for software, while the treated groups were from countries that implemented IP boxes after 2011 (we need information before policy implementation). For example, the UK, which introduced the IP box in 2013, Italy in 2015, and Poland in 2019 are treated groups defined by treatment timing in our DiD framework. Finally, to better interpret the results, we aggregated group-time average treatment effects by the length of exposure, group, and time period.

To address hypothesis H2, i.e. whether IP box regimes are associated with companies' revenue growth in the gaming sector, we estimated models in eq. (2) in which revenue growth captures incremental changes in value. Moreover, we used several control variables such as *size*, *leverage*, *employees*, *intangibility*, *capital intensity*, *inventory*, *mne*, and ownership structure on a firm level and *STR*, *patents*, and *Kaufmann* on a country level. The company's size proves that larger firms that produce on a large scale are likely to have more innovative activity and benefit from economies of scale. However, we used *leverage* to address the financial constraints of companies (Hall, Thoma, & Torrisi, 2007; Balsmeier, Fleming, & Manso, 2017), but also the opportunity to decrease the cost of capital (i.e. the weighted average cost of capital WACC) in the case of public (listed) companies.

$$Growth_{i,t} = \beta_0 + \sum_{j=1}^{2} \beta_j Growth_{i,t-j} + \sum_{k=0}^{2} \beta_{3+k} IP\,BOX_{c,t-k} + \beta_6 Controls_{i,t} + \beta_7 Controls_{c,t} + \beta_8 time\_dummy_{i,t} + \mu_{i,t} \quad (2)$$

Models described by eq. (2) were estimated at the firm-country-year level using the Blundell-Bond system GMM estimator dedicated to dynamic panel data (Blundell & Bond, 1998). The subscripts *i*, *c*, and *t* denote firm, country, and year accordingly.

In hypothesis H3, we examined what significantly impacts protecting intellectual property in the gaming industry. We tested whether introducing IP box regimes increases the gaming sector's innovativeness by estimating the following conditional logit model (eq. 3) and complementary log-log regression (eq. 4).

$$Patent\_tn\_pp_{i,t} = \beta_0 + \beta_1 IP\,BOX_{c,t} + \beta_2 IP\,BOX_{c,t-5} + \beta_3 Employees_{i,t} + \beta_4 Size_{i,t} + \beta_5 STR_{c,t-2} + \beta_6 Leverage_{i,t-2} + \beta_7 Ownership_{i,t} + \beta_8 time\_dummy_{i,t} + \varepsilon_{i,t} \quad (3)$$

$$Patent\_pp_{i,t} = \beta_0 + \beta_1 IP\,BOX_{c,t} + \beta_2 IP\,BOX_{c,t-4} + \beta_3 MNE_{i,t} + \beta_4 Employees_{i,t} + \beta_5 Size_{i,t} + \beta_6 STR_{c,t} + \beta_7 Leverage_{i,t-2} + \beta_8 Ownership_{i,t} + \beta_9 time\_dummy_{i,t} + \varepsilon_{i,t} \quad (4)$$

A subscript i identifies a firm, and subscript c recognizes a country.

4. Results

Table 2 (and Table A4 in the Appendix) provides outcomes of testing hypothesis H1 of the innovation box regimes' impact on gaming companies' ETR. Columns (1)–(8) present the models' estimation results using the two-step Blundell-Bond system GMM estimator. In (1)–(4), the dependent variable is the *ETR_PBT*, whereas in (5)–(8) – *ETR_PBT_clipp*. Because GMM two-step standard errors are biased, robust standard errors are recommended. Therefore, we adopted an estimation using a robust variance-covariance matrix in even-numbered models.

Results show that implementing the IP box negatively impacted the ETR. It enabled entrepreneurs in the gaming sector to reduce their tax liability by ca. 14 pp. It seems to have maximized benefits from the IP box because the distance from the IP box tax rate to the nominal varied from over 24 pp. in Belgium to 10 pp. in Italy. It reached 18 pp. in France, 15 pp. in Spain, and 14 pp. in the UK and Poland (see Table A1 in Appendix). However, in different countries, ETR caught differences between tax base and financial income and simultaneously between tax law and balance law (accounting act). Therefore, the *ETR_PBT* varied from zero to 233% of accounting profit, whereas *ETR_PBT_clipp* changed from zero to 98%. Our results are consistent with hypothesis H1.

Moreover, all estimated models (1)–(8) show that MNEs pay fewer taxes. The results were less substantial when we approximated the ETR by *ETR_PBT_clipp* scaled to values lower than one or based on EBITDA. However, the models (7–8) estimated on a subsample excluded Belgium, France, and Spain that implemented IP boxes before 2011 and findings of models (9–10) for *ETR_EBITDA* estimated using a fixed-effects estimator (in line with the Hausman test) support hypothesis H1. The latter results for ETR_EBITDA prove that implementing the IP box enables firms to reduce their tax burden by two pp. Firms set in countries with one pp. higher statutory tax rate pay higher taxes since their ETR based on EBITDA is higher by 0.20–0.224 pp.

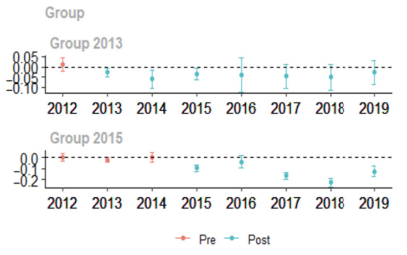
This effect catches differences among the scope of tax-deductible costs and taxable revenues in various countries.

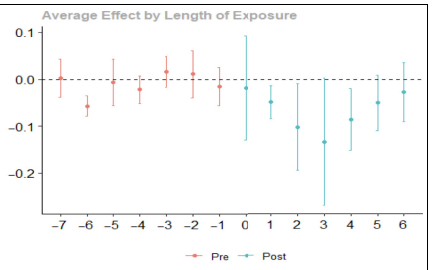
The ownership structure also significantly differentiates the ETR. Public companies pay fewer taxes as the ETR is lower by four pp., but gaming companies funded by mutual and pension funds pay more taxes (the ETR is higher by 2.3 to 2.5 pp.) (see Table A5 in the Appendix). Besides, we applied DiD with multiple time periods (Callaway & Sant'Anna, 2021) to provide robust results for testing H1. The UK (since 2013), Italy (since 2015), and Poland (since 2019) are treated groups, whereas countries without IP boxes for software (Japan, South Korea, the USA, Germany, and the Czech Republic) are a control group. Figure 1 shows group-time average treatment effects that support hypothesis H1 (see also Table A6 and Figure A2 in the Appendix). Post-treatment time period effects confirm that gaming companies decreased their ETR after introducing IP box regimes in the UK (2013 group) overall by four pp. and particularly from 2013 to 2015, whereas in Italy (2015 group) overall by 13.19 pp., and particularly in 2015 and from 2017 to 2019. Moreover, event study dynamic effects showed a decrease in ETR in the first year by five pp., in the second year by 10 pp., and in the fourth year by 9 pp. after implementing the IP box regime, overall by seven pp.

Table 2.
IP box's impact on the effective tax rate

	ETR_PBT	WC-robust ETR_PBT	Excl. BE FR ES ETR_PBT	Excl. BE FR ES WC-robust ETR_PBT	ETR_PBT_ clipp	WC-robust ETR_PBT_ clipp	Excl. BE FR ES ETR_PBT_ clipp	Excl. BE FR ES WC-robust ETR_PBT_ clipp	FE ETR_ EBITDA	FE ETR_ EBITDA
L1.dependent variable	0.0667***	0.0667	0.0551**	0.0551	0.1696***	0.1696	0.1177**	0.1177		
	(0.024)	(0.058)	(0.027)	(0.097)	(0.049)	(0.105)	(0.050)	(0.117)		
IP BOX	−0.1433***	−0.1433**	−0.1538***	−0.1538**	−0.0803***	−0.0803***	−0.0954***	−0.0954***	−0.0201***	−0.0202***
	(0.041)	(0.055)	(0.039)	(0.072)	(0.021)	(0.029)	(0.021)	(0.032)	(0.008)	(0.009)
L1.IP BOX	−0.0482**	−0.0482*	−0.0910***	−0.0910***						
	(0.022)	(0.028)	(0.022)	(0.031)						
MNE	−0.0738**	−0.0738**	−0.0665**	−0.0665*	−0.0785***	−0.0785***	−0.0721***	−0.0721***		
	(0.032)	(0.036)	(0.031)	(0.036)	(0.020)	(0.023)	(0.020)	(0.025)		
L1.ln_Patents	0.0256	0.0256	0.0688***	0.0688*	0.0162	0.0161	0.0110	0.0110		
	(0.024)	(0.032)	(0.025)	(0.037)	0.0110	(0.015)	(0.011)	(0.016)		
Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Ownership	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Time effects	YES	YES	YES	YES	YES	YES	YES	YES	NO	NO
Observations	1478	1478	1194	1194	1478	1478	1194	1194	2543	2543
Groups	285	285	219	219	285	285	219	219	362	362
Instruments	61	61	61	61	59	59	59	59	–	–
Wald test	183.03	61.25	238.71	65.41	125.87	68.21	157.00	92.05		
p-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
Sargan test	33.3707	33.3707	38.6599	38.6599	37.5799	37.5799	39.5516	39.5516		
p-value	0.3527	0.3527	0.1621	0.1621	0.1932	0.1932	0.1395	0.1395		
AR(1) test	−3.6375	−3.5081	−3.4534	−3.1186	−4.8848	−4.1753	−4.5638	−3.7709		
p-value	0.0003	0.0005	0.0006	0.0018	0.0000	0.0000	0.0000	0.0002		
AR(2) test	0.6358	0.6024	0.3291	0.2951	0.6331	0.5645	0.5623	0.4707		
p-value	0.5249	0.5469	0.7420	0.7679	0.5267	0.5724	0.5739	0.6378		
Hansen J test	7.3700	7.3700	6.8314	6.8314	138.6457	138.6457	32.3694	32.3694		
p-value	0.5987	0.5987	0.6547	0.6547	0.7175	0.7175	0.0003	0.0003		
F-statistic									2.07**	1.89***
Hausman test									89.755***	66.377***
Breusch-Pagan test									126.51***	131.43***

Note(s): Robust standard errors in parentheses; $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$
Source(s): Own elaboration



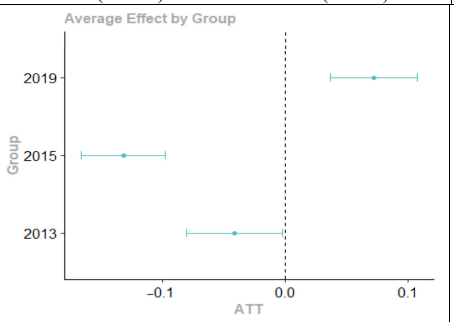


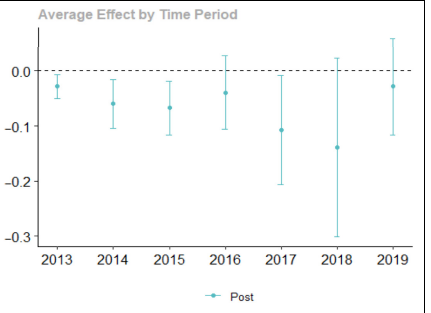
Group-Time Average Treatment Effects

UK 2012	0.0109		Italy 2012	0.0045		
	(0.0178)			(0.0178)		
2013	**−0.028**	***	2013	−0.0242	***	
	(0.011)			(0.011)		
2014	**−0.0601**	***	2014	0.001		
	(0.0234)			(0.0228)		
2015	**−0.0365**	***	2015	**−0.0988**	***	
	(0.0151)			(0.0151)		
2016	−0.0402		2016	−0.0383		
	(0.0431)			(0.0279)		
2017	−0.0471		2017	**−0.1679**	***	
	(0.0306)			(0.0145)		
2018	−0.0508		2018	**−0.2276**	***	
	(0.0333)			(0.0196)		
2019	−0.028		2019	**−0.1266**	***	
	(0.0299)			(0.0251)		

ATT Dynamic Effects

−7	0.0024		0	−0.0182	
				(0.0568)	
−6	−0.0573	***	**1**	**−0.0492**	**
	(0.011)			(0.0181)	
−5	−0.0066		**2**	**−0.1022**	**
	(0.0252)			(0.0472)	
−4	−0.0223		3	−0.1339	
	(0.0151)			(0.0695)	
−3	0.0158		**4**	**−0.0869**	**
	(0.0166)			(0.0338)	
−2	0.0106		5	−0.0508	
	(0.0258)			(0.0302)	
−1	−0.0157		6	−0.028	
	(0.0208)			(0.0321)	
			Overall	**−0.067**	**
				(0.0304)	





Overall ATTs based on group aggregation

2013 UK	**−0.0415**	***
	(0.0182)	
2015 Italy	**−0.1319**	***
	(0.016)	
2019 Poland	0.0721	***
	(0.0165)	
Overall	−0.0337	***
	(0.0107)	

Overall ATTs based on calendar time aggregation

2013	**−0.028**	**	2017	**−0.1075**	**
	(0.011)			(0.050)	
2014	**−0.0601**	***	2018	−0.1392	*
	(0.023)			(0.083)	
2015	**−0.0676**	***	2019	−0.0275	
	(0.025)			(0.045)	
2016	−0.0393		Overall	**−0.067**	**
	(0.034)			(0.027)	

Note(s): Robust standard errors in parentheses; *$p < 0.1$; **$p < 0.05$; ***$p < 0.01$ based on simultaneous confidence band. Group 2013 – the UK, Group 2015 – Italy, Group 2019 – Poland

Source(s): Own elaboration

Figure 1.
IP box's impact on ETR: DiD with multiple time periods results

Moreover, calendar time aggregation estimates show an average negative effect of participating in the treatment in a particular period for all groups that participated in the treatment in that time period overall and for five years from 2013 to 2017. Finally, Figure 1 (and Table A6) shows adverse group-time average treatment effects for the UK and Italy that are contrary to Poland. This is because Poland requires more time to materialize the effects of the IP box introduced in the last year (2019) covered by our research sample.

Table 3 delivers the outcomes of testing hypothesis H2 using a system GMM dynamic panel data model (columns (1)–(2) for the total sample, columns (3)–(4) for the subsample excluded countries that introduced the IP box before 2011, columns (5)–(8) for narrower sample due to ETR restrictions, with the last two columns excluding Belgium, France, and Spain). It answers how implementing the IP box regime affects a gaming firm's revenue growth (for more details, see Table A7 in the Appendix).

Gaming companies reduce their tax rate and tax liabilities thanks to IP box, but the tax savings and free cash flows require time to materialize and increase their revenue growth compared to their competitors from the countries with the highest revenue in the gaming industry. Although the parameter at the IP box variable is significant and negative in most models, the coefficients at the lagged or lead IP box dummy variable are positive and significant. Models estimated using system GMM on subsamples excluding Belgium, France, and Spain provide robust results. It means that gaming companies in countries implementing the IP box regulations after 2011 have a higher revenue growth by 0.16 to 0.37 pp., but the effects require time to materialize. This is partly because of higher inventory increases by unsold games. Thus, we have no basis for rejecting hypothesis H2. Larger companies with higher capital intensity and intangibility in countries with higher statutory tax rates and lower governance quality note higher revenue growth. Although the total number of patent applications (*patents*) at a country level positively influences revenue growth, their impact diminishes (or becomes adverse when lagged) after logarithmic transformation in GMM models (see Table A7 in the Appendix).

In hypothesis H3, we tested whether the introduction of the IP box is connected to boosting innovative activity outcomes. We measured the innovation by the scale of the intellectual property protection by gaming firms via trademarks, wordmarks, and figurative marks registered (models 9–11) or patent-pending (models 12–13 – only software patents registered in USPTO, models 9–11 – all IP protection). Table 3 (and Table A8 in the Appendix) presents the results estimated using conditional logit and complementary log-log models.

Our findings prove that implementing these regulations decreases the probability of intellectual property protection by registering in the Patent Office (models 12–13). However, IP box regulations encourage gaming companies to register their intangible assets as trademarks or protect their word or figurative marks. Still, the effects require time to materialize (models 9–11). Consequently, we have no basis for rejecting hypothesis H3 based on the findings of conditional logit. Moreover, our results show that larger firms with more employees are more likely to protect the intellectual property of their R&D activity's outcomes, contrary to gaming companies funded by hedge funds. In contrast, those owned by financial companies, individuals, or families are more likely to use patent protection or register their word marks, figurative marks, or trademarks. The fact that software is subject to patent only in the USA, Japan, and South Korea where IP box regimes have not been implemented influenced our results. Thus, based on the parameter at the *STR* variable, we conclude that taxes stimulate firms to benefit from IP protection in the gaming industry, primarily via software patents and trademarks.

5. Conclusions

We examined how introducing innovation box regulations affects the gaming sector's ETR, revenue growth, and innovation activity outcomes. We found evidence that IP box regulations are associated with lower ETR as gaming firms reduced their ETR by two pp. for

Table 3.
Effect of IP box on firm's growth and innovative activity: system GMM, conditional logit, and complementary log-log models' results

	Two-step	One-step robust	Excl BE FR ES Two-step	Excl BE FR ES Two-step robust	One-step	One-step robust	Excl BE FR ES Two-step	Excl BE FR ES Two-step robust	Conditional (FE) logistic regression			Complementary log-log	
	Growth	Growth	Growth	Growth	Growth	Growth	Growth	Growth	Patent_tn_pp	Patent_tn_pp	Patent_tn_pp	Patent_pp	Patent_pp
L1.y	−0.2551***	−0.1978***	−0.2702***	−0.2702***	−0.1935***	−0.1935***	−0.1178**	−0.1178					
	(0.032)	(0.044)	(0.042)	(0.056)	(0.041)	(0.055)	(0.046)	(0.078)					
L2.y	−0.1295***	−0.1019***	−0.1137***	−0.1137**	−0.1024**	−0.10248	−0.0548	−0.0548					
	(0.027)	(0.034)	(0.037)	(0.047)	(0.041)	(0.060)	(0.038)	(0.079)					
IP BOX	−0.2271**	−0.2245*	0.1062	0.1062	−0.4597***	−0.4597**	−0.2915***	−0.2915**	0.4381	0.4055	0.8955	−0.7967	−1.0370**
	(0.112)	(0.128)	(0.125)	(0.127)	(0.149)	(0.207)	(0.083)	(0.132)	(1.120)	(1.121)	(1.096)	(0.539)	(0.508)
F1.IP BOX			0.3733**	0.3733**									
			(0.168)	(0.183)									
L1.IP BOX	−0.0489	−0.0671	−0.0737	−0.0737	0.3766**	0.3766*	0.4521***	0.4521*					
	(0.178)	(0.192)	(0.179)	(0.185)	(0.149)	(0.206)	(0.159)	(0.249)					
L2.IP BOX	0.0740**	0.0975**	0.0374	0.0374	−0.2084	−0.2084	−0.1050*	−0.1050					
	(0.036)	(0.044)	(0.047)	(0.051)	(0.147)	(0.136)	(0.061)	(0.077)					
L3.IP BOX					0.1338	0.1338							
					(0.090)	(0.092)							
L4.IP BOX												−1.3437**	
												(0.637)	
L5.IP BOX									1.9494**	1.9091**	1.8510**		
									(0.778)	(0.770)	(0.754)		
STR	−0.9434	−0.6583	−1.7416**	−1.7416**								12.0923***	13.8349***
	(0.708)	(0.896)	(0.829)	(0.874)								(3.281)	(3.392)
L2.STR	2.2249**	2.7544**	−0.5470	−0.5470	3.8669***	3.8669*	2.0844**	2.0844	38.635**	40.2068**			
	(0.907)	(1.076)	(1.055)	(1.242)	(1.383)	(2.158)	(0.974)	(1.459)	(18.453)	(18.522)			
L1.Patents					0.3557***	0.3557***	0.2646***	0.2646***					
					(0.118)	(0.103)	(0.073)	(0.097)					
L2.ln_Patents	−0.0943**	−0.1010	−0.1343**	−0.1343**									
	(0.041)	(0.066)	(0.056)	(0.068)									
Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Ownership	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Time effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	4038	4038	2865	2865	1061	1061	1064	1064	6057	6057	6057	6057	4200
Groups	673	673	573	573	270	270	224	224					
Instruments	58	58	50	50	52	52	56	56					
Wald test	199.64	127.81	131.95	100.99	178.72	172.48	5626.30	747.87				448.95	513.95

(*continued*)

Table 3.

	Two-step	One-step robust	Excl BE FR ES Two-step	Excl BE FR ES Two-step robust	One-step	One-step robust	Excl BE FR ES Two-step	Excl BE FR ES Two-step robust	Conditional (FE) logistic regression			Complementary log-log	
	Growth	Growth	Growth	Growth	Growth	Growth	Growth	Growth	Patent_tn_pp	Patent_tn_pp	Patent_tn_pp	Patent_pp	Patent_pp
p-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000				0.0000	0.0000
Sargan test	27.8450	27.8450	9.7696	9.7696	30.9723	30.9723	35.5607	34.9131					
p-value	0.1809	0.1809	0.8340	0.8340	0.0556	0.0556	0.0457	0.0531					
AR(1) test	−9.8449	−9.3283	−7.8938	−7.0402	−5.2057	−5.2057	−6.714	−5.0413					
AR(2) test	−1.9307	−1.432	−1.3076	−1.2333	−1.2897	−1.2897	−1.6266	−1.0117					
p-value	0.0535	0.1521	0.1910	0.2175	0.1972	0.1972	0.1038	0.3117					
Hansen J test	19.8998	19.8998	75.0158	75.0158	3.4997	3.4997	51.9128	51.9128					
p-value	0.0107	0.0107	0.0000	0.0000	0.8353	0.8353	0.0000	0.0000					
LR									31.92***	31.40***	26.75***		
Log-likelihood									−71.68***	−71.94***	−74.26***	−271.35***	−335.58***
Pseudo R2									0.1821	0.1792	0.1526		

Note(s): Robust standard errors in parentheses; $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$
Source(s): Own elaboration

earnings before interest, depreciation, and amortization. However, considering the debt tax shield, their ETR decreased on average by eight pp. (for *ETR_PBT_clipp*) and 9.5 pp. when we excluded Belgium, France, and Spain. Notably, immediately after entering the IP box in Italy, ETR dropped by 13.2 pp., but only by four pp. in the UK Furthermore, the results vary across the ownership structure. Public gaming companies had a lower ETR, but private firms set up by mutual and pension funds, nominees, trusts, and trustees had a significantly higher ETR based on EBITDA.

Moreover, introducing IP box regulation allowed gaming companies to increase their revenue growth by 0.1 to 0.7% points after two years, including firms with financial losses, compared to 0.37 pp. in the year before the introduction of the IP box. Profitable firms increased their revenue growth in one year by 0.377 pp. and 0.45 pp. when we excluded Belgium, France, and Spain. The benefits of this relief in the form of additional free cash flows require time to provide revenue growth sufficient to rise to the level of the top gaming companies from the countries that have not implemented the IP box. Therefore, revenue growth decreased immediately in the year when the IP box was introduced. Despite the IP box, the gaming industry still has lower sales growth than outside Europe. Our results show that larger firms grow faster than small firms in the gaming industry. Despite implementing the IP box, the gaming industry's growth rate distance between developed and developing countries was still significant. In countries that have not introduced IP box, like the USA, South Korea, Japan, Germany, and the Czech Republic, firms grow faster than in countries where IP box regimes are in force (see Figure A5 in the Appendix). The largest and most recognizable digital game distribution platforms, such as Origin, Steam, or Epic Games, which allow users to purchase games of worldwide production, are based in the USA. There is only one such platform in Poland, GOG.com, set up by CD Project, the largest gaming company listed on the Warsaw Stock Exchange in 2019–2020.

6. Discussion

We confirm the IP box's lagged effect on protecting intellectual property. It positively relates to firms' intellectual property registration, but effects require at least five years to materialize. However, the IP box does not encourage firms to patent R&D outcomes properly. Our results are weaker than those provided by Bradley *et al.* (2015) and Bornemann *et al.* (2020), because software patenting is available only outside Europe, in the USA, Japan and South Korea. These countries require patenting software without having introduced IP box regimes. Meanwhile, European countries are still trying to leap the gap using the IP box, but they will need more time and R&D incentives to succeed. Finally, we found that lower taxes resulting from IP box stimulate firms to benefit from IP protection in the gaming industry, primarily via the game's wordmarks, figurative marks, trademarks and software patents. This aligns with Bradley *et al.* (2015). However, effects require ca. five years to materialize. Moreover, although innovation scholars and the OECD are critical of the IP box, we provided evidence of its lagged efficiency, which is more significant and occurs earlier in profitable and large firms.

Our study has some limitations because IP box regulations vary between countries, the sample period was short, and there was no control for R&D subsidization although the number of subsidies is growing yearly (Haufler & Schindler, 2020).

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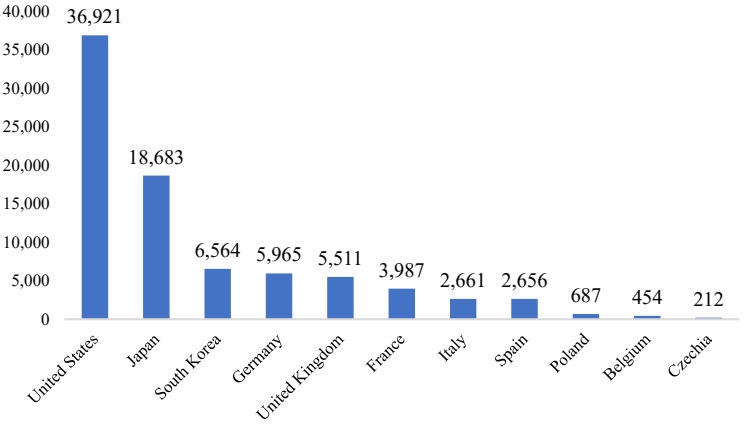
Appendix



Source(s): Own elaboration based on Newzoo Top 10 Countries/Markets by Game Revenues (2020)

Figure A1.
Top Countries by Game Revenue for 2020 (USD mln)

Country	Year of introduction	IP qualifying assets	IP box tax rate (%)	Statutory CIT rate (%)
Belgium	2007	Patents, Software	4.44	29
France	2000	Patents, Software	10	28
Italy	2015	Patents, Software	13.95	24
Poland	2019	Patents, Software	5	19
Spain	2008	Patents, Software	10	25
UK	2013	Patents	10	19

Source(s): OECD Dataset Intellectual Property Regimes (2019) Tax Foundation Report: Patent Box Regimes in Europe (2020); KPMG Corporate Tax Rate (2021)

Table A1.
Summary of European IP box

Country	IP box	Number of companies for testing hypothesis H1 based on PBT	H1 based on EBITDA	H2 restrictions put on ETR	H2-H3 without ETR limitations
Belgium	Yes	28	28	28	28
Czech Republic	No	20	16	16	26
France	Yes	38	41	41	45
Germany	No	15	15	15	55
Italy	Yes	21	21	21	23
Japan	No	74	75	74	76
Poland	Yes	45	43	43	51
South Korea	No	20	21	20	22
Spain	Yes	25	26	26	27
Great Britain	Yes	65	67	67	308
USA	No	8	9	9	12
TOTAL		359	362	360	673

Note(s): Five countries (the Czech Republic, Germany, Japan, South Korea, and the USA) did not introduce the IP Box regulations in our sample. In South Korea and the USA, tax regulations concerning R&D and intellectual property activities are implemented but differ significantly from the European Intellectual Property Box regimes

Source(s): Own elaboration

Table A2. Distribution companies by country

Variable	Definition
Dependent variables	
ETR_PBT	$\frac{Taxation}{Profit\ before\ tax}$
ETR_PBT_clipp	ETR_PBT scaled to non-negative values lower than 1
ETR_EBITDA	$\frac{Taxation}{EBITDA}$
Growth	$ln(Revenue_t) - ln(Revenue_{t-1})$
Patent_pp	Binary variable indicating if a patent is registered or pending, 1 - if yes, 0 – if no
Patent_tn_pp	Binary variable indicating if a patent, a game's wordmark, a firm's trademark or figurative mark is registered or pending, 1 - if yes, 0 – otherwise
Test variable	
IP BOX	Binary variable indicating when IP Box has been implemented equals 1 – for the year of introducing IP Box and after, and 0 – otherwise
Control variables	
Capital intensity	$\frac{Tangible\ fixed\ assets}{Total\ assets}$
Intangibility	$\frac{Intangible\ fixed\ assets}{Total\ assets}$
Inventory	$\frac{Current\ assets}{Total\ assets}$
Leverage	$\frac{Long-term\ debt}{Total\ assets}$
MNE	The binary variable indicating a firm with foreign shareholders equals 1 – if the firm's foreign shareholders have more than 50% share in equity, and 0 otherwise
Employees	$ln\ (Number\ of\ employees)$
Size	$ln\ (Total\ Assets)$
ROA	$\frac{Profit\ (Loss)\ before\ interest\ and\ tax}{Total\ assets}$
Patents	Number of patent applications or patents granted by the European Patent Office (EPO), patents granted by the United States Patent and Trademark Office (USPTO) and triadic patent families
STR	Statutory Tax Rate
Kaufmann	Average of six sub-index of the Worldwide Governance Indicators that rank countries concerning six aspects of good governance: Voice and Accountability, Political Stability and Violence, Government Effectiveness, Rule of Law, and Control of Corruption
Ownership	Categorical variable indicating the type of ownership structure that consists of 15 levels: Bank; Corporate; Hedge fund; Employees, managers, directors; Financial company; Private equity firms; Public (listed companies); Venture capital; Insurance company; Foundation; Research Institute; Self-ownership; One or more named individuals or families; Other unnamed shareholders aggregated, Mutual and pension fund, nominee trust trustee; Public authority state government

Table A3.
Definitions of variables

Table A4.
IP box's impact on Effective Tax Rate (ETR_PBT) – system GMM results

	ETR_PBT Coef (Std. Err.)	WC-robust ETR_PBT Coef (Std. Err.)	Excl. BE, FR & ES ETR_PBT Coef (Std. Err.)	Excl. BE, FR & ES WC-robust ETR_PBT Coef (Std. Err.)	ETR_PBT_clipp Coef (Std. Err.)	WC-robust ETR_PBT_clipp Coef (Std. Err.)	Excl. BE, FR& ES ETR_PBT_clipp Coef (Std. Err.)	Excl. BE, FR& ES WC-robust ETR_PBT_clipp Coef (Std. Err.)
L1.ETR_PBT/L1.ETR_PBT_clipp	0.0667***	0.0667	0.0551**	0.0551	0.1696***	0.1696	0.1177**	0.1177
	(0.024)	(0.058)	(0.027)	(0.097)	(0.049)	(0.105)	(0.050)	(0.117)
L2.ETR_PBT	0.0024	0.0024	−0.0115	−0.0115	0.0418	0.0418	0.0368	0.0368
	(0.018)	(0.044)	(0.018)	(0.064)	(0.038)	(0.076)	(0.039)	(0.090)
IP BOX	−0.1433***	−0.1433**	−0.1538***	−0.1538**	−0.0803***	−0.0803***	−0.0954***	−0.0954***
	(0.041)	(0.055)	(0.039)	(0.072)	(0.021)	(0.029)	(0.021)	(0.032)
L1.IP BOX	−0.0482**	−0.0482*	−0.0910***	−0.0910***				
	(0.022)	(0.028)	(0.022)	(0.031)				
L2.IP BOX	0.0292	0.0292	0.0258	0.0258				
	(0.027)	(0.030)	(0.026)	(0.038)				
ROA	−0.0005	−0.0005	−0.0001	−0.0001	−0.0001	−0.0005	−0.0004	−0.0004
	(0.0004)	(0.0005)	(0.0004)	(0.001)	(0.000)	(0.0004)	(0.0001)	(0.0005)
MNE	−0.0738**	−0.0738**	−0.0665**	−0.0665*	−0.0785***	−0.0785***	−0.0721***	−0.0721***
	(0.032)	(0.036)	(0.031)	(0.036)	(0.020)	(0.023)	(0.020)	(0.025)
L1.Capital intensity	−0.0061	−0.0061	0.0167	0.0167	0.0138	0.0138	0.0839	0.0839
	(0.052)	(0.070)	(0.061)	(0.088)	(0.051)	(0.057)	(0.056)	(0.064)
Intangibility	0.1989*	0.1989	0.3485**	0.3485	0.1031	0.1031	0.1219	0.1219
	(0.105)	(0.194)	(0.148)	(0.319)	(0.064)	(0.081)	(0.089)	(0.138)
L1.Inventory	−0.0012	−0.0012	−0.0035	−0.0035	−0.0027	−0.0027	−0.0053	−0.0053
	(0.004)	(0.004)	(0.004)	(0.004)	(0.002)	(0.003)	(0.004)	(0.007)
Employees	−0.0553**	−0.0553	−0.0927***	−0.0927	−0.0250*	−0.0250	−0.0473**	−0.0473
	(0.023)	(0.038)	(0.028)	(0.060)	(0.015)	(0.023)	(0.023)	(0.035)
Leverage	−0.0680*	−0.0680	−0.0589	−0.0589	−0.0679**	−0.0679*	−0.0365	−0.0365
	(0.034)	(0.043)	(0.054)	(0.074)	(0.030)	(0.037)	(0.042)	(0.058)

(*continued*)

Table A4.

	ETR_PBT Coef (Std. Err.)	WC-robust ETR_PBT Coef (Std. Err.)	Excl. BE, FR & ES ETR_PBT Coef (Std. Err.)	Excl. BE, FR & ES WC-robust ETR_PBT Coef (Std. Err.)	ETR_PBT_ clipp Coef (Std. Err.)	WC-robust ETR_PBT_ clipp Coef (Std. Err.)	Excl. BE, FR& ES ETR_PBT_ clipp Coef (Std. Err.)	Excl. BE, FR& ES WC-robust ETR_PBT_ clipp Coef (Std. Err.)
L1.Size	−0.0070	−0.0070	−0.0052	−0.0052	−0.0051	−0.0051	−0.0005	−0.0005
	(0.005)	(0.006)	(0.005)	(0.008)	0.0041	(0.005)	(0.004)	(0.006)
Kaufmann	0.0752	0.0752	−0.0859	−0.0859	0.0683	0.0683	0.0666	0.0666
	(0.104)	(0.158)	(0.114)	(0.215)	0.0664	(0.090)	(0.074)	(0.115)
L1.ln_Patents	0.0256	0.0256	0.0688***	0.0688*	0.0162	0.0161	0.0110	0.0110
	(0.024)	(0.032)	(0.025)	(0.037)	0.0110	(0.015)	(0.011)	(0.016)
Ownership effects	YES	YES	YES	YES	YES	YES	YES	YES
Time effects	YES	YES	YES	YES	YES	YES	YES	YES
Number of observations	1,478	1,478	1,194	1,194	1,478	1,478	1,194	1,194
Number of groups	285	285	219	219	285	285	219	219
Number of instruments	61	61	61	61	59	59	59	59
Wald test	183.03***	61.25***	238.71***	65.41***	125.87***	68.21***	157.00***	92.05***
Sargan test	33.3707	33.3707	38.6599	38.6599	37.5799	37.5799	39.5516	39.5516
p-value	0.3527	0.3527	0.1621	0.1621	0.1932	0.1932	0.1395	0.1395
Arellano-Bond test for zero autocorrelation in first-differenced errors								
AR(1)	−3.6375	−3.5081	−3.4534	−3.1186	−4.8848	−4.1753	−4.5638	−3.7709
p-value	0.0003	0.0005	0.0006	0.0018	0.0000	0.0000	0.0000	0.0002
AR(2)	0.6358	0.6024	0.3291	0.2951	0.6331	0.5645	0.5623	0.4707
p-value	0.5249	0.5469	0.7420	0.7679	0.5267	0.5724	0.5739	0.6378

Note(s): $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$
Source(s): Own elaboration

	(1)	(2)
IP_BOX	−0.0201***	−0.0202**
	(0.0084)	(0.0092)
ROA	0.0003**	0.0003**
	(0.0002)	(0.0002)
MNE	−0.0069	−0.0012
	(0.0162)	(0.0167)
Capital intensity	0.0031	0.0007
	(0.0382)	(0.0386)
Intangibility	−0.0195	−0.0213
	(0.0333)	(0.0337)
Inventory	0.0141	0.0102
	(0.0245)	(0.0249)
Employees	−0.0048	−0.0044
	(0.0068)	(0.0070)
Leverage	−0.0339*	−0.0307
	(0.0191)	(0.0199)
Size	0.0013	0.0016
	(0.0031)	(0.0031)
STR	0.2002***	0.2240**
	(0.0938)	(0.1189)
Kaufmann	0.0536*	0.1628*
	(0.0335)	(0.1084)
Patents	−0.0088	0.0111
	(0.0294)	(0.0378)
Ownership effects	YES	YES
Private equity firm	0.0088	0.0097
	(0.0127)	(0.0130)
Public company	−0.0429*	−0.0407*
	(0.0215)	(0.0212)
Mutual & pension fund	0.0229**	0.0255**
nominee trust trustee	(0.0143)	(0.0145)
State-owned enterprise	0.0210	0.0215
	(0.0187)	(0.0181)
Country x Kaufmann	NO	YES
Number of observations	2,543	2,543
Number of groups	362	362
R^2 within	2.53%	4.55%
F-statistic	2.07**	1.89***
Hausman test	89.755***	66.377***
Breusch-Pagan test	126.51***	131.43***

Note(s): $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$
Source(s): Own elaboration

Table A5.
IP box's impact on Effective Tax Rate (ETR_EBITDA) – Fixed-effects (FE) results

Group-time average treatment effects			Dynamic effects	
Group	Time	ATT(g,t) (Std. Err.)	Event time	ATT (Std. Err.)
2013 UK	2012	0.0109	−7	0.0024
		(0.0178)		(0.0205)
2013 UK	2013	−0.028***	−6	−0.0573***
		(0.011)		(0.011)
2013 UK	2014	−0.0601***	−5	−0.0066
		(0.0234)		(0.0252)
2013 UK	2015	−0.0365***	−4	−0.0223
		(0.0151)		(0.0151)
2013 UK	2016	−0.0402	−3	0.0158
		(0.0431)		(0.0166)
2013 UK	2017	−0.0471	−2	0.0106
		(0.0306)		(0.0258)
2013 UK	2018	−0.0508	−1	−0.0157
		(0.0333)		(0.0208)
2013 UK	2019	−0.028	0	−0.0182
		(0.0299)		(0.0568)
2015 Italy	2012	0.0045	*1*	−0.0492**
		(0.0178)		(0.0181)
2015 Italy	2013	−0.0242***	*2*	−0.1022**
		(0.011)		(0.0472)
2015 Italy	2014	0.001	3	−0.1339
		(0.0228)		(0.0695)
2015 Italy	2015	−0.0988***	*4*	−0.0869**
		(0.0151)		(0.0338)
2015 Italy	2016	−0.0383	5	−0.0508
		(0.0279)		(0.0302)
2015 Italy	2017	−0.1679***	6	−0.028
		(0.0145)		(0.0321)
2015 Italy	2018	−0.2276***	Overall	
		(0.0196)		−0.067**
2015 Italy	2019	−0.1266***		(0.0304)
		(0.0251)		
Overall summary of ATT's based on calendar time aggregation				
	2013	−0.028**		
		(0.011)		
	2014	−0.0601***		
		(0.023)		
	2015	−0.0676***		
		(0.025)		
	2016	−0.0393		
		(0.034)		
	2017	−0.1075**		
		(0.050)		
	2018	−0.1392*		
		(0.083)		
	2019	−0.0275		
		(0.045)		
	Overall	−0.067**		
		(0.027)		
Overall summary of ATT's based on group/cohort aggregation				
2013 UK		−0.0415***		
		(0.0182)		

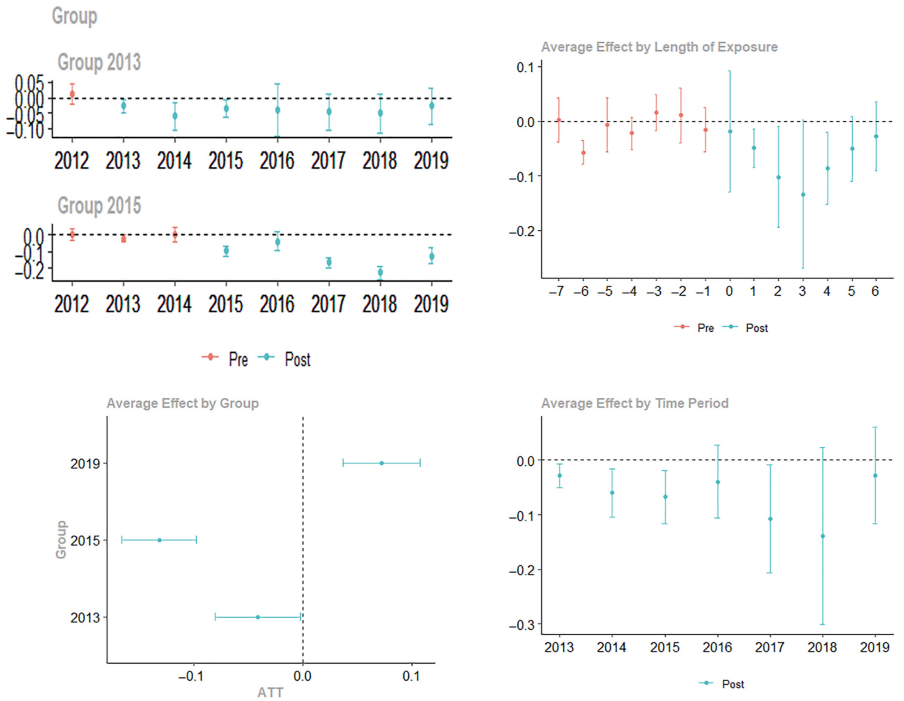
Table A6.
IP box's impact on ETR – Group-time average treatment and event-study effects

(*continued*)

Group-time average treatment effects			Dynamic effects	
Group	Time	ATT(g,t) (Std. Err.)	Event time	ATT (Std. Err.)
2015 Italy		−0.1319*** (0.016)		
2019 Poland		0.0721*** (0.0165)		
Overall		−0.0337*** (0.0107)		

Note(s): $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$
$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$ based on simultaneous confidence band
Source(s): Own elaboration

Table A6.



Note(s): Group 2013 - the UK, Group 2015 – Italy, Group 2019 - Poland
Source(s): Own elaboration

Figure A2.
IP box's impact on ETR – DiD with multiple time periods results

Table A7.
Effect of IP box on firm's revenue growth–system GMM results

	Two-step	One-step robust	Excl. BE, FR, ES Two-step	Excl. BE, FR, ES Two-step robust	One-step	One-step robust	Excl. BE, FR, ES Two-step	Excl. BE, FR, ES Two-step robust
L1.Revenue_Growth	−0.2551***	−0.1978***	−0.2702***	−0.2702***	−0.1935***	−0.1935***	−0.1178**	−0.1178
	(0.032)	(0.044)	(0.042)	(0.056)	(0.041)	(0.055)	(0.046)	(0.078)
L2.Revenue_Growth	−0.1295***	−0.1019***	−0.1137***	−0.1137**	−0.1024**	−0.1024*	−0.0548	−0.0548
	(0.027)	(0.034)	(0.037)	(0.047)	(0.041)	(0.060)	(0.038)	(0.079)
IP BOX	−0.2271**	−0.2245*	0.1062	0.1062	−0.4597***	−0.4597**	−0.2915***	−0.2915**
	(0.112)	(0.128)	(0.125)	(0.127)	(0.149)	(0.207)	(0.083)	(0.132)
F1.IP BOX			0.3733**	0.3733**				
			(0.168)	(0.183)				
L1.IP BOX	−0.0489	−0.0671	−0.0737	−0.0737	0.3766**	0.3766*	0.4521***	0.4521*
	(0.178)	(0.192)	(0.179)	(0.185)	(0.149)	(0.206)	(0.159)	(0.249)
L2.IP BOX	0.0740**	0.0975**	0.0374	0.0374	−0.2084	−0.2084	−0.1050*	−0.1050
	(0.036)	(0.044)	(0.047)	(0.051)	(0.147)	(0.136)	(0.061)	(0.077)
L3.IP BOX					0.1338	0.1338		
					(0.090)	(0.092)		
Capital intensity	0.1217*	0.1543**	0.1441**	0.1441**	0.7530**		0.2346	0.2652
	(0.0686)	(0.0720)	(0.0678)	(0.0700)	(0.310)		(0.297)	(0.410)
L1.Capital intensity						0.7530**	0.5245*	0.5245
						(0.324)	(0.311)	(0.431)
Intangibility	−0.0931	−0.1027	−0.0770	−0.0770	0.0081***	0.0081*	0.0206***	0.0206***
	(0.150)	(0.160)	(0.209)	(0.217)	(0.002)	(0.005)	(0.002)	(0.004)
L1.Intangibility	0.2789	0.4047**	0.3029	0.3029				
	(0.171)	(0.184)	(0.239)	(0.262)				
Inventory	0.0328	0.0361	−0.0835	−0.0835				
	(0.080)	(0.092)	(0.084)	(0.089)				
L1.Inventory	0.0939	0.1144	0.1314*	0.1344*	0.0001	0.0001	0.0002***	0.0002**
	(0.069)	(0.078)	(0.072)	(0.075)	(0.0001)	(0.0001)	(0.000)	(0.0001)
Leverage	−0.2072**	−0.2033**	−0.1441*	−0.1441*				
	(0.097)	(0.010)	(0.084)	(0.084)				

(*continued*)

Table A7.

	Two-step	One-step robust	Excl. BE, FR, ES Two-step	Excl. BE, FR, ES Two-step robust	One-step	One-step robust	Excl. BE, FR, ES Two-step	Excl. BE, FR, ES Two-step robust
L1.Leverage	0.1843**	0.1752*	0.0035	0.0035	0.2782**	0.2782***	0.1588	0.1588
	(0.079)	(0.095)	(0.077)	(0.079)	(0.131)	(0.075)	(0.223)	(0.296)
Size	0.0965***	0.1212***	0.0978***	0.0978***	0.2936***	0.2936***	0.2742***	0.2742***
	(0.022)	(0.024)	(0.025)	(0.026)	(0.032)	(0.078)	(0.041)	(0.073)
STR	−0.9434	−0.6583	−1.7416**	−1.7416**				
	(0.708)	(0.896)	(0.829)	(0.874)				
L1.STR					2.0789*	2.0789	1.6387	1.6387
					(1.213)	(1.337)	(1.051)	(1.391)
L2.STR	2.2249**	2.7544**	−0.5470	−0.5470	3.8669***	3.8669*	2.0844**	2.0844
	(0.907)	(1.076)	(1.055)	(1.242)	(1.383)	(2.158)	(0.974)	(1.459)
ln_Patents	−0.0838	−0.1319	−0.1675	−0.1675				
	(0.086)	(0.143)	(0.106)	(0.131)				
L1.Patents					0.3557***	0.3557***	0.2646***	0.2646***
					(0.118)	(0.103)	(0.073)	(0.097)
L2.ln_Patents	−0.0943**	−0.1010	−0.1343**	−0.1343**				
	(0.041)	(0.066)	(0.056)	(0.068)				
Country	0.0136	−0.0093	0.2549*	0.2549				
	(0.064)	(0.109)	(0.151)	(0.348)				
Kaufmann					−1.2608***	−1.2608**	−0.5324*	−0.5324
					(0.373)	(0.582)	(0.308)	(0.379)
Ownership_Corporate	0.0262	0.0516	0.0390	0.0390	−0.1286*	−0.1286**	−0.0892*	−0.0892
	(0.044)	(0.048)	(0.058)	(0.061)	(0.068)	(0.054)	(0.046)	(0.063)
Ownership_Hedge_fund	0.0654	0.0730	0.0743	0.0743	0.1186	0.1186	−0.0516	−0.0516
	(0.077)	(0.079)	(0.092)	(0.093)	(0.216)	(0.086)	(0.094)	(0.103)
Ownership_Private_equity_firm	−0.0085	0.0246	0.0559	0.0559	0.0454	0.0454	0.0200	0.0200
	(0.050)	(0.057)	(0.069)	(0.071)	(0.098)	(0.053)	(0.052)	(0.068)
Ownership_Public company	0.0506	0.0078			0.1648	0.1648	0.2180*	0.2180
	(0.188)	(0.201)			(0.195)	(0.129)	(0.113)	(0.149)

(*continued*)

Table A7.

	Two-step	One-step robust	Excl. BE, FR, ES Two-step	Excl. BE, FR, ES Two-step robust	One-step	One-step robust	Excl. BE, FR, ES Two-step	Excl. BE, FR, ES Two-step robust
Ownership_Venture_Capital	−0.0339	−0.0900	0.0906	0.0906	−0.0251	−0.0251	−0.0813	−0.0813
	(0.097)	(0.119)	(0.061)	(0.063)	(0.136)	(0.082)	(0.084)	(0.109)
Ownership_Insurance_	−0.0624	−0.0822	−0.1301	−0.1301	−0.0465	−0.0465	−0.0121	−0.0121
company	(0.124)	(0.140)	(0.137)	(0.152)	(0.125)	(0.088)	(0.081)	(0.101)
Ownership_Foundation_	0.0567	0.0475	0.0751	0.0751	0.0843	0.0843	0.0527	0.0527
research_instit	(0.073)	(0.078)	(0.084)	(0.102)	(0.247)	(0.094)	(0.064)	(0.068)
Ownership_Self_ownership	−0.0658	−0.0806	−0.1261	−0.1261	−0.1074	−0.1074	−0.0541	−0.0541
	(0.065)	(0.075)	(0.078)	(0.083)	(0.123)	(0.065)	(0.055)	(0.065)
ownership_Family firms_	0.0164	0.0194	−0.0356	−0.0356	0.0938	0.0938	0.0695	0.0695
individuals	(0.041)	(0.045)	(0.064)	(0.065)	(0.071)	(0.083)	(0.054)	(0.075)
ownership_Unnamed_	−0.1191	−0.0917	−0.3404	−0.3404	−0.1681	−0.1681	−0.2445	−0.2445
shareholders	(0.188)	(0.219)	(0.224)	(0.281)	(0.211)	(0.141)	(0.169)	(0.171)
ownership_Mutual &	0.0226	0.0450	0.0375	0.0375	0.0264	0.0264	−0.0063	−0.0063
pension fund	(0.082)	(0.092)	(0.087)	(0.094)	(0.101)	(0.085)	(0.065)	(0.079)
ownership_State-owned	0.1647	0.1639	0.0269	0.0269	0.0446	0.0446	0.1130	0.1130
enterprises	(0.150)	(0.158)	(0.201)	(0.201)	(0.156)	(0.123)	(0.122)	(0.157)
year2014	0.0328	0.0363	0.0627	0.0627			−0.0588	−0.0588
	(0.039)	(0.048)	(0.039)	(0.041)			(0.077)	(0.104)
year2015	−0.0262	−0.0408	0.0052	0.0052	0.0361	0.0361	0.0020	0.0020
	(0.037)	(0.043)	(0.037)	(0.044)	(0.073)	(0.096)	(0.068)	(0.091)
year2016	−0.0125	−0.0165	−0.0379	−0.0379	−0.0600	−0.0600	−0.0592	−0.0592
	(0.027)	(0.033)	(0.024)	(0.025)	(0.065)	(0.078)	(0.056)	(0.073)
year2017	0.0032	0.0336	−0.0160	−0.0160	−0.0304	−0.0304	−0.0342	−0.0342
	(0.025)	(0.029)	(0.020)	(0.021)	(0.056)	(0.075)	(0.047)	(0.064)
year2018	0.0675***	0.0652***			0.0097	0.0097	0.0249	0.0249
	(0.022)	(0.025)			(0.050)	(0.054)	(0.043)	(0.054)
Number of observations	4,038	4,038	2,865	2,865	1,061	1,061	1,064	1,064
Number of groups	673	673	573	573	270	270	224	224

(*continued*)

	Two-step	One-step robust	Excl. BE, FR, ES Two-step	Excl. BE, FR, ES Two-step robust	One-step	One-step robust	Excl. BE, FR, ES Two-step	Excl. BE, FR, ES Two-step robust
Number of instruments	58	58	50	50	52	52	56	56
Wald test	199.64***	127.81***	131.95	100.99***	178.72***	172.48***	5626.30***	747.87***
Sargan test	27.8450	27.8450	9.7696	9.7696	30.9723	30.9723	35.5607	34.9131
p-value	0.1809	0.1809	0.8340	0.8340	0.0556	0.0556	0.0457	0.0531
Arellano-Bond test AR(1)	−9.8449	−9.3283	−7.8938	−7.0402	−5.2057	−5.2057	−6.714	−5.0413
p-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
AR(2)	−1.9307	−1.432	−1.3076	−1.2333	−1.2897	−1.2897	−1.6266	−1.0117
p-value	0.0535	0.1521	0.1910	0.2175	0.1972	0.1972	0.1038	0.3117

Note(s): $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$
Source(s): Own elaboration

Table A7.

	Conditional (fixed-effects) logistic regression			Complementary log-log regression Excl. BE, FR, ES	
	Patent_tn_ pp	Patent_tn_ pp	Patent_tn_ pp	Patent_pp Robust	Patent_pp Robust
IP BOX	0.4381	0.4055	0.8955	−0.7967	−1.0370**
	(1.120)	(1.121)	(1.096)	(0.539)	(0.508)
L4.IP BOX				−1.3437**	
				(0.637)	
L5.IP BOX	1.9494**	1.9091**	1.8510**		
	(0.778)	(0.770)	(0.754)		
MNE				0.6486	0.6240*
				(0.417)	(0.358)
Employees	1.0440	1.0384	0.9971	0.3519***	0.2671**
	(0.681)	(0.676)	(0.654)	(0.097)	(0.122)
Size	0.3998	0.3741	0.3769		
	(0.458)	(0.456)	(0.454)		
STR				12.0923***	13.8349***
				(3.281)	(3.392)
L2.STR	38.6350**	40.2068**			
	(18.453)	(18.522)			
L2.Leverage	−0.8419		−1.1042	−0.9845	−0.8497
	(1.155)		(1.123)	(0.747)	(0.806)
Ownership_Family firms_ individuals	1.0952*	1.0798*	0.6720	0.3641	0.1923
	(0.649)	(0.646)	(0.605)	(0.290)	(0.252)
Ownership_Bank				1.0711**	0.8280*
				(0.492)	(0.442)
Ownership_Financial_company				1.6664***	1.7358***
				(0.474)	(0.383)
Ownership_Hedge_fund				−0.8673**	−1.1651***
				(0.396)	(0.322)
Ownership_Private_equity_firm	−1.1688	−1.1582	−0.8898	0.1261	0.2084
	(0.794)	(0.792)	(0.790)	(0.335)	(0.349)
Ownership_State-owned enterprise	1.0867	1.1031	0.8362	0.6390	0.3495
	(1.403)	(1.404)	(1.340)	(0.400)	(0.377)
Ownership_Mutual pension fund	−0.5471	−0.5060	−0.3299	−0.0858	0.2777
	(0.858)	(0.850)	(0.839)	(0.352)	(0.305)
Ownership_Corporate				−0.2135	−0.0346
				(0.373)	(0.367)
Ownership_Employees_managers_ directors				0.0623	0.3788
				(0.479)	(0.504)
Ownership_Foundation_research_ Institute				−0.5761	−0.6452
				(0.459)	(0.473)
Ownership_Insurance_company				−0.3702	−0.2396
				(0.348)	(0.345)
Ownership_Unnamed_ shareholders				−0.1798	−0.7624
				(0.686)	(1.116)
Ownership_Public company				0.6354	0.6466
				(0.527)	(0.601)
Ownership_Self_ownership				−0.1292	−0.2778
				(0.335)	(0.354)
Ownership_Venture_Capital				0.4334	0.4837
				(0.369)	(0.338)
year2013					−9.3018***
					(1.267)
year2014					−8.7229***
					(1.222)
year2015				−8.1185***	−8.5180***
				(1.047)	(1.153)
year2016	−0.5780	−0.6209	−0.0699	−7.7972***	−8.0648***
	(0.534)	(0.533)	(0.471)	(0.983)	(1.075)

Table A8.
IP box effects on innovative activity – conditional logit and complementary log-log model

(*continued*)

	Conditional (fixed-effects) logistic regression			Complementary log-log regression Excl. BE, FR, ES	
	Patent_tn_pp	Patent_tn_pp	Patent_tn_pp	Patent_pp Robust	Patent_pp Robust
year2017	−0.7836	−0.7665	−0.4397	−7.6886***	−8.0202***
	(0.518)	(0.513)	(0.491)	(0.969)	(1.089)
year2018	−0.9021**	−0.8774**	−0.7456*	−7.8413***	−8.0833***
	(0.448)	(0.443)	(0.443)	(0.936)	(1.027)
year2019				−7.7613***	−8.0730***
				(0.942)	(1.038)
Number of observations	6,057	6,057	6,057	6,057	4,200
LR	31.92	31.40	26.75		
p-value	0.0025	0.0017	0.0084		
Wald test				448.95***	513.95***
Log-likelihood	−71.68***	−71.94***	−74.26***	−271.35***	−335.58***
Pseudo *R*2	0.1821	0.1792	0.1526		

Note(s): $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$
Source(s): Own elaboration

Table A8.

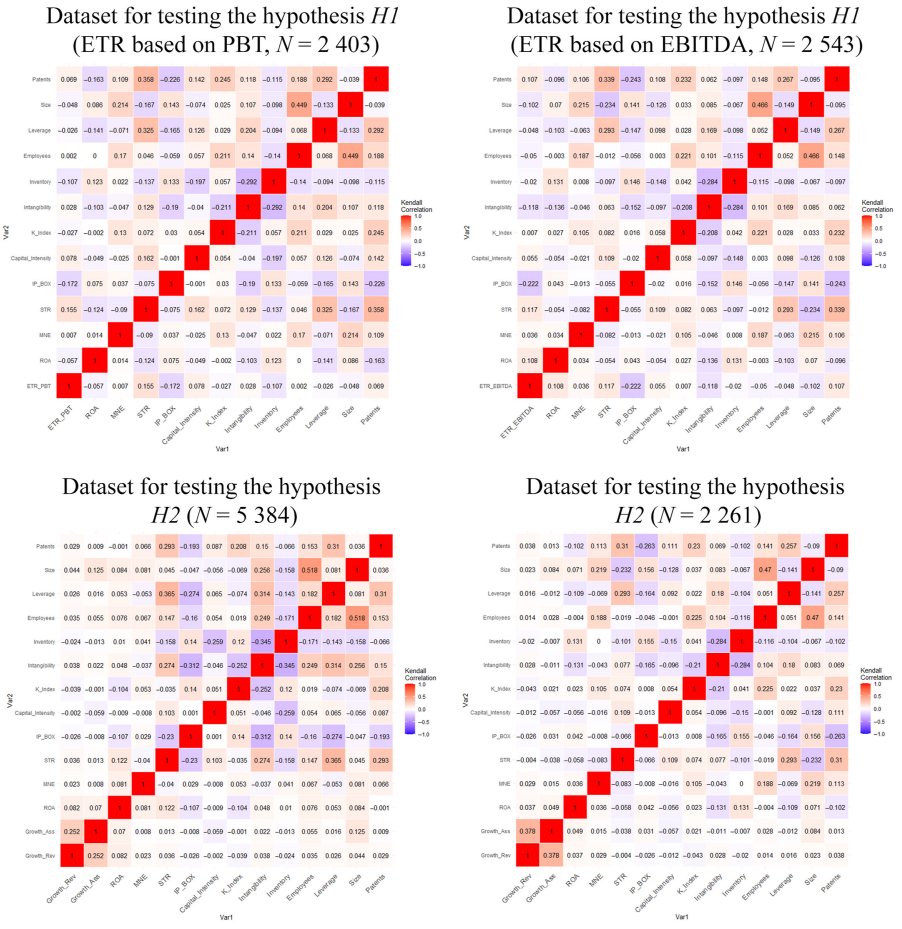
	Min	p25	Median	p75	Max	Mean	St. Dev
H1 (panel data, N = 2,403)							
ETR_PBT	0.000	0.078	0.198	0.315	0.988	0.229	0.199
ROA	−95.622	3.437	10.699	25.933	100.000	15.605	22.423
STR	0.190	0.200	0.295	0.333	0.407	0.276	0.066
Kaufmann	0.470	0.884	1.266	1.366	1.582	1.142	0.295
Employees	0.000	0.693	1.771	3.135	9.679	2.000	1.778
Size	−6.787	4.272	5.491	7.208	15.006	5.961	2.655
Capital_Intensity	0.000	0.010	0.031	0.084	1.000	0.081	0.133
Intangibility	−0.001	0.000	0.008	0.123	0.946	0.105	0.186
Inventory	0.000	0.389	0.855	0.975	1.000	0.673	0.356
Leverage	0.000	0.000	0.000	0.034	1.000	0.069	0.164
Patents	0.000	0.039	0.142	0.372	1.000	0.212	0.200
Robustness Check of H1 (panel data, N = 2,543)							
ETR_EBITDA	0.000	0.014	0.143	0.269	0.999	0.169	0.169
ROA	−95.622	0.994	8.892	22.285	95.938	12.270	21.802
STR	0.190	0.210	0.297	0.333	0.407	0.278	0.066
Kaufmann	0.470	0.864	1.249	1.366	1.582	1.132	0.296
Employees	0.000	0.693	1.825	3.296	9.806	2.100	1.798
Size	−2.139	4.401	5.712	7.572	15.098	6.161	2.442
Capital_Intensity	0.000	0.012	0.033	0.091	0.980	0.086	0.136
Intangibility	−0.001	0.000	0.017	0.179	0.095	0.130	0.203
Inventory	0.000	0.360	0.783	0.966	1.000	0.647	0.353
Leverage	0.000	0.000	0.000	0.048	0.992	0.074	0.168
Patents	0.000	0.039	0.142	0.372	1.000	0.218	0.206
H2 (panel data without ETR limitations, N = 5,384)							
Revenue_Growth	−5.712	0.000	0.000	0.000	5.789	0.017	0.531
Assets_Growth	−5.979	−0.150	0.000	0.267	5.858	0.051	0.821
ROA	−99.585	0.000	0.000	8.901	100.000	3.334	21.750

(*continued*)

Table A9.
Descriptive statistics

	Min	p25	Median	p75	Max	Mean	St. Dev
STR	0.190	0.190	0.230	0.300	0.400	0.249	0.061
Kaufmann	0.470	1.106	1.370	1.435	1.582	1.242	0.276
Employees	0.000	0.000	1.200	2.700	10.000	1.619	1.655
Size	−6.787	3.543	5.049	6.749	15.098	5.032	3.086
Capital_Intensity	0.000	0.008	0.032	0.097	1.000	0.097	0.167
Intangibility	−0.001	0.000	0.000	0.074	0.985	0.096	0.195
Inventory	0.000	0.547	0.907	0.985	1.000	0.737	0.324
Leverage	0.000	0.000	0.000	0.000	1.000	0.060	0.164
Patents	0.000	0.140	0.142	0.253	1.000	0.203	0.184
H2 (panel data with restrictions put on ETR, N = 2,261)							
Revenue_Growth	−6.686	−0.032	0.000	0.171	6.284	0.074	0.554
Assets_Growth	−5.000	−0.030	0.030	0.300	5.000	0.109	0.622
ROA	−95.622	0.998	8.817	22.128	95.938	12.255	21.920
STR	0.190	0.200	0.296	0.333	0.400	0.275	0.064
Kaufmann	0.470	0.864	1.266	1.370	1.582	1.133	0.300
Employees	0.000	0.693	1.825	3.296	9.806	2.104	1.800
Size	−2.139	4.407	5.775	7.636	15.098	6.184	2.453
Capital_Intensity	0.000	0.011	0.032	0.090	0.980	0.085	0.135
Intangibility	−0.001	0.000	0.016	0.177	0.946	0.129	0.203
Inventory	0.000	0.362	0.785	0.967	1.000	0.648	0.354
Leverage	0.000	0.000	0.000	0.048	0.992	0.074	0.168
Patents	0.000	0.039	0.142	0.372	1.000	0.213	0.200
H3 (conditional logit data, N = 6,057)							
IP Protection	0.000	0.000	0.000	0.000	1.000	0.038	0.191
Employees	0.000	0.000	1.200	2.657	9.806	1.617	1.651
Size	−6.788	3.526	5.030	6.699	15.098	5.013	3.071
STR	0.190	0.190	0.240	0.3000	0.407	0.253	0.062

Table A9.



Source(s): Own elaboration

Figure A3.
Tau Kendall correlation matrices

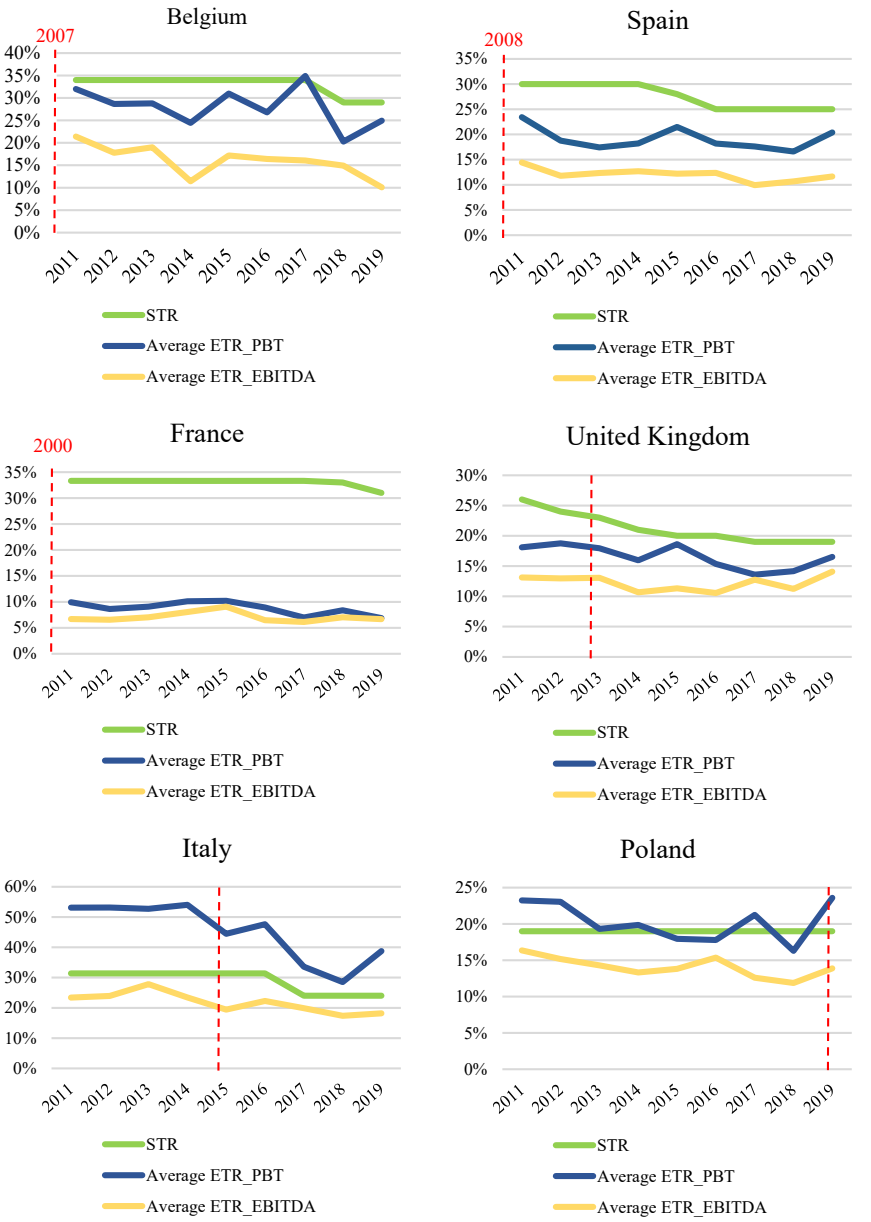
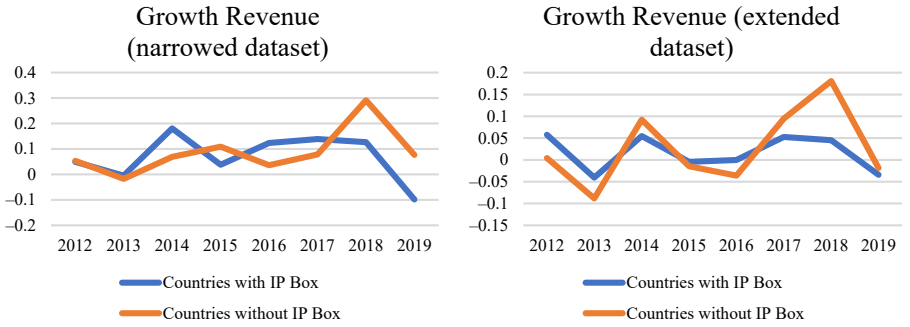


Figure A4.
The average effective tax rate

Note(s): The red line indicates the date of the implementation of IP Box regulations
Source(s): Own elaboration



Source(s): Own elaboration

Figure A5.
The average values of revenue growth

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