CROSS-COUNTRY EVIDENCE ON THE PRELIMINARY EFFECTS OF PATENT BOX REGIMES ON PATENT ACTIVITY AND OWNERSHIP

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Abstract: *This paper evaluates the initial impacts of patent box regimes in light of their primary stated objectives: stimulating domestic innovation and retaining mobile patent income to limit base erosion. Despite their lack of nexus requirements, we find that patent box regimes yield a 3 percent increase in new patent applications for every percentage point reduction in the tax rate on patent income. We find no significant impact of these regimes on deterring outward cross-border attribution of patent ownership, or on attracting ownership of foreign inventions. Increased patenting activity hence appears focused on inventions involving co-located (domestic) patent owners and inventors.*

Keywords: patent box, tax policy, innovation, base erosion

JEL classification: K34, H25, H32

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I. INTRODUCTION

Tax policy in recent years has taken on an increasingly important role in promoting innovation, now widely perceived as the key to economic growth and productivity. Of particular prominence in the international arena are so-called "patent box" regimes,[1] which first emerged in their current form in 2000 and now apply in thirteen European countries and China. While these tax regimes differ in their precise details, they each feature a lower tax rate on income derived from the commercialization of patented products or other intellectual property (IP) relative to other sources of business income. These regimes are motivated by two broad objectives: (1) to foster domestic innovation and the creation of high-value jobs, and (2) to reduce erosion of the tax base that occurs when mobile sources of income are shifted to tax havens or other low-tax jurisdictions through intra-firm transfer pricing or cost-sharing agreements. The goal of our study is to evaluate the effects of patent box regimes in light of these motivations. Specifically, we examine how the introduction of patent box regimes at the country level has affected the extent and location of innovation and patent ownership.

Historically, tax policies for innovation focused exclusively on subsidizing expenditures on research and development (R&D). There is a large literature that examines the effects of these R&D tax incentives on the *location of R&D* (e.g., Hines, 1997).[2] Although an educated labor force and a high quality infrastructure have been documented as important factors in determining the location of R&D, these studies suggest that tax incentives, such

[1] Technically, patent box regimes are a special case of innovation box or intellectual property box regimes. Following common usage, we refer to all such regimes collectively as patent boxes.

[2] Two papers in this literature discuss how R&D tax incentives interact with lower patent box tax rates (Ernst and Spengel, 2011; Evers, Miller, and Spengel, 2014). For a literature review, see European Commission (2014).

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as generous rules surrounding the deductibility and creditability of expenditures, can affect the location of R&D activity. Ernst, Richter, and Riedel (2014) extend this literature by assessing the effects of taxation on the quality, rather than the quantity, of R&D activity. Using patent applications to construct various measures of R&D project quality, they find that tax incentives subsidizing investments in innovation increase the quantity but not the quality of R&D, while tax incentives subsidizing the income stream from successful innovation increase both quantity *and* quality.

Though patent box regimes may impact the location of R&D, by targeting the income stream from IP commercialization, these regimes may also affect the attribution of ownership across countries. The location of ownership of intangible assets determines where the associated income is taxed, and it is widely believed that intangible assets represent an exceptionally mobile source of income (Grubert, 2003; Kleinbard, 2012). Thus, such tax incentives may reward the separation of the location of ownership in successful R&D from the location of the innovative activity. Alternatively, patent box regimes may reward the co-location of development and ownership of intangible assets either if this is a requirement for receiving tax benefits, or if transferring ownership of valuable IP triggers adverse tax effects (Ernst and Spengel, 2011).

A relatively small but growing literature examines how taxation affects the location of IP ownership. Dischinger and Riedel (2011) document a negative effect of corporate tax rates on intangible asset holdings within multinational firms, while Karkinsky and Riedel (2012) and Griffith, Miller, and O'Connell (2014), find similar effects on patent

applications.[3] Böhm et al. (2015) suggest that this inverse relationship is amplified in the case of more valuable, higher-quality patents. Collectively, these studies suggest that tax incentives may distort the location of where IP is owned.

The details of how patent box regimes are implemented vary significantly across countries and, given that most regimes were adopted after 2007, little is known about the effects of these regimes on patent activity.[4] As countries with such regimes in place continue to work out the details of how the rules should be implemented and other countries consider the introduction of such policies, it is imperative to develop an understanding of the effects of such policies on taxpayer behavior. Our paper takes a first step towards understanding how patent box regimes affect two distinct patent outcomes. Specifically, we examine whether these policies increase the attractiveness of a country as a location for innovation or—not mutually exclusively—as the location of patent *ownership* (and thereby potentially mitigate outward income reallocation).

We estimate country-year regressions of patent counts on patent income tax rates alone and interacted with an indicator variable for the existence of a patent box regime to allow for heterogeneous effects of tax policy on patent activity in countries with preferential regimes vis-à-vis patent development. We examine both overall counts and counts based on differences, if any, between the inventor and owner countries listed on each patent application. These differences allow us to examine whether patenting behavior is consistent with patent box incentives with respect to co-location versus cross-border

[3] Dischinger and Riedel's (2011) measure of intangible asset holdings (from the balance sheet) represents intangible assets purchased through arm's length transactions; by comparison, Karkinsky and Riedel (2012) and Griffith, Miller, and O'Connell (2014) focus on intangible assets created within the firm.
[4] For an excellent description of the characteristics of the European patent and innovation box regimes, see Evers, Miller, and Spengel (2014).

reattributions of innovation and ownership. Finally, we conclude our analysis by extending our model to include additional indicator variables representing the presence of important implementation details in patent box regimes—expense allocation rules and eligibility rules regarding acquired IP.

Overall, we find that the implementation of a patent box regime increases the responsiveness of patent activity to tax rates on patent income, though this effect appears to be confined to patents for which the inventors and patent owners are located in the same host country. Thus, the propensity to apply for a patent among co-located owners and inventors is increasing in the generosity of the preferential tax rate in patent box regimes. Moreover, we find that the overall effect on new patent applications is further amplified in regimes characterized by more favorable treatment of R&D expenses, likely because the presence of such rules significantly decreases the *effective* tax burden on patent income, as shown in Evers, Miller, and Spengel (2014). This effect is limited to patent *owners*, consistent with a substantial proportion of innovation being done through contract R&D. The prevalence of new patent applications featuring a cross-border reattribution of patent ownership, meanwhile, appears largely insensitive to patent box incentives, such that it does not appear that patent box regimes have dramatically altered the broader set of tax motives for allocating patent income to low-tax countries.

Our study contributes to the literature in three main respects. First, by examining aggregate patent counts at the country-year level using the most current data on patent applications available, we directly evaluate the outcome of patent box regimes in terms of their tax policy goals. Second, using patent applications for both granted and non-granted patents, we are able to more fully capture the most direct responses to patent box

regimes.[5] Finally, existing studies examine only patents granted by the European Patent Office (EPO). Not only does this miss a substantial proportion of global patenting activity, it may systematically exclude innovation or ownership in certain countries. Only 17 percent of all innovations patented in Europe are patented through the EPO, and only 19 percent of all patents with European owners are patented there. In fact, patent owners located in certain European countries, such as the United Kingdom, *never* file applications with the EPO. The German patent office by itself handles three-fifths as many patent applications as the EPO.

II. TAX SYSTEMS AND INNOVATION

A. Background and Motivation

Governments have utilized tax policy to promote R&D since at least 1962, a practice that began in Canada and eventually spread to most of the Organisation for Economic Co-operation and Development (OECD) by the early-to-mid 1990s (OECD, 1996). Until relatively recently, these incentives were focused on subsidizing the cost of performing R&D through special expensing provisions and tax credits, the objective being to align private and social benefits from innovation in the presence of positive externalities.

As a result of globalization and the increased prominence of opportunities for tax-minimizing cross-border income reallocation within multinational operations, concerns have grown over the prospect of subsidizing R&D only to have the resulting intellectual property and associated earnings attributed to lower-taxed jurisdictions, such as tax

[5] Approximately 33 percent of all patent applications result in a granted patent. However, a firm's propensity to patent is reflected in patent applications, not just those that are eventually granted. Further, because of the long time lag between the application of a patent and the granting of a patent, using only granted patents would preclude an effective examination of patent box regimes, since many of them have only been implemented recently.

havens. The nature of this challenge as it pertains to patent applications across countries is highlighted in Figure 1. Patent applicants are considered to be legal patent owners, such that the country of the patent applicant-owner(s) determines the treatment of income for tax purposes (Quick and Day, 2006).[6] Differences between the country of patent ownership and the location of the underlying R&D activity—based on the country or countries of the inventor(s)—are indicative of potentially tax-motivated cross-border patent ownership reattributions.[7]

As shown in Figure 1A, even as early as 1990, the share of patents owned in tax havens (defined as in Hines (2010) and indicated by red squares and pink triangles) but developed elsewhere far exceeds the comparable rate of inward ownership reattributions among non-havens (blue and purple diamonds). By 2012 (Figure 1B), inward reattributions were more prevalent everywhere, including—perhaps most notably—among the set of patent box regime countries marked by pink triangles and purple diamonds. From the perspective of the country of invention (Figures 1C and 1D), outward ownership reattributions are more evenly distributed across countries, with larger industrial countries tending toward the lower end of the reattribution share spectrum. Somewhat surprisingly, several tax havens are represented among the countries

[6] We use the terms "owner" and "applicant" interchangeably hereinafter; see Karkinsky and Riedel (2012) for a discussion of this equivalence in the context of patents filed with the EPO. In the U.S., patents filed with the U.S. Patent Trade Office (USPTO) from 2005 through 2012 were required to include the set of inventors among the list of applicants, although inventors are not necessarily entitled to royalties as part of their employment contracts. We consequently define the country of ownership for patents filed with the USPTO over the relevant time period based on the set of applicants excluding those also listed as inventors. We treat patents filed with the Canadian, Israeli, and World Intellectual Property Organization patent offices analogously in periods where over 15 percent of patent applications feature identical inventor and applicant names, as we sometimes see a similar pattern on applications filed in those jurisdictions.

[7] We define a reattributed patent from the perspective of the inventor's (owner's) host country as a patent for which at least one of the patent owners (inventors) is located in a different country. Employing a stricter definition of reattributions based on the existence of no single country of overlap between the set of inventors and owners implies a lower share of reattributed patents everywhere without significantly changing their relative prevalence across countries.

of greatest inventive activity and engage in high rates of outward reattributions (possibly to other havens or through co-ownership with non-haven affiliates). On balance, however, tax havens are far more likely to be net beneficiaries of cross-border patent reattributions, as indicated in Figures 1E and 1F by the prevalence of havens above the 45-degree line, most notably the four tax havens marked by pink triangles that have also implemented patent box regimes (Cyprus, Liechtenstein, Luxembourg, and Malta).[8]

Although incentives based on either R&D investment or patent commercialization may encourage domestic innovative activity, the former input-based measures play no role in deterring subsequent base erosion. In contrast, given the European Union (EU) member states' inability under EU law to restrict the location of innovation for the purposes of granting preferential tax treatment to patent income,[9] these latter output-based patent box incentives may be poorly targeted at fostering *domestic* innovation, yet nevertheless prove effective in mitigating or even reversing stripping of the domestic tax base.

B. Summary and Hypotheses

Following the rationale given by policymakers for implementing patent box regimes, a basic prediction is that patent box regimes should increase patenting activity. However, as described above, important questions arise as to where and what kinds of patenting activity might increase, and whether frictions exist that could preclude these intended changes from occurring. We summarize below the set of expectations that guide our

[8] Though only suggestive, this depiction is consistent with Graetz and Doud (2012), who argue that certain patent box regimes appear to be intended primarily for the purpose of attracting mobile income and may hence be used to achieve a competitive advantage over tax havens.

[9] Recent action among EU member states suggests that this situation may change in the near future. For example, the United Kingdom and Germany reached a compromise agreement on November 11, 2014 that requires the United Kingdom's patent box regime to include a modified nexus approach. The Italian patent box regime enacted on December 22, 2014 likewise imposes nexus conditions.

empirical specifications and our choices of measures of patent activity.

From the perspective of the country of patent ownership, the introduction of a pat- ent box regime should increase the total number of applications filed as a result of increasing the expected after-tax return on income derived from patented products.[10] Naturally, these incentives should filter through to inventors, thereby likewise raising the propensity to patent inventions involving inventors located in countries with patent box regimes. This is true whether the inventors are affiliated with the owners (as employees or otherwise), or whether the inventors are contracted at arm's length. Given the lack of nexus requirements among EU regimes, however, these incentives are not unique to inventors located in the country of the patent box since the tax benefits depend on the location of the patent owner exclusively. From the perspective of the inventor country, the introduction of a patent box regime should hence only increase applications insofar as these feature both domestic inventors *and* domestic owners and, conversely, decrease applications featuring exclusively foreign owners. Meanwhile, patent box regimes may also stimulate R&D activity in foreign countries so long as the patent application includes an owner in the host country and the cost of outward reattribution of valuable IP is low.

To the extent that patent box regimes are intended to enable a country to compete more effectively with tax havens as a place to locate mobile sources of income, cross-border ownership reattribution decisions involving tax havens may be especially sensitive to the

[10] With the exception of the Benelux countries, Liechtenstein, and Malta, most patent box regimes do not distinguish between new and existing IP for purposes of determining eligibility for the preferential tax rate (Evers, Miller, and Spengel, 2014). As such, it is important to note that patent box incentives apply equally to the propensity to patent existing inventions, including those that might formerly have been protected as trade secrets. Therefore, a change in the number of patent applications following enactment of a patent box regime need not necessarily imply an increase in new innovative activity.

introduction of these preferential regimes.[11] This should be particularly relevant for a relatively generous patent box regime, as measured by the differential between the statutory corporate income tax rate and the preferential tax rate applicable to patent income. From the perspective of the inventor country, the anticipated decrease in patents attributed to foreign owners might therefore be greater in the case of patent applications traditionally filed with at least one owner in a tax haven versus applications filed with none. Likewise—though less common—reattribution of patents whose inventors are located in a tax haven to an owner located in a patent box country should increase in frequency due to a reduction in the tax advantage of preserving ownership in the haven. So long as patents held in tax havens continue to face lower tax rates on patent income, havens may nevertheless remain relatively attractive, however, and hence the net effect on patent activity and ownership reattributions is ambiguous.

III. EMPIRICAL SPECIFICATION

We test the foregoing predictions using a panel of country-year observations for the period 1990–2012. We use different counts of patent applications as the dependent variable across specifications to capture the differing incentives for the co-location of patent development and ownership versus cross-border patent reattributions.[12] All independent variables correspond to the country in which the dependent variable is measured (i.e., either the owner or inventor country). Of key interest is the effect of the statutory tax rate applicable to patent income (*Patent Income Tax Rate*) following the

[11] This effect is likely to be further compounded where controlled foreign corporation rules intended to discourage income reallocation to tax havens are more restrictive and impose a discrete cost on ownership reattributions that apply only to havens.

[12] We also consider patent applications scaled by 2000 patent stocks to more directly account for differences in countries' innovation intensity. These yield qualitatively similar results, which are available from the authors upon request.

introduction of patent box regimes, which differs only from the corporate tax rate in countries and years where patent boxes have been implemented (i.e., *I[Patent Box]=1*). We hence focus our attention on the interaction, *I[Patent Box]* × *Patent Income Tax Rate*, to test whether the semi-elasticity of patent activity with respect to the tax rate differs according to the source of changes in the taxation of patent income (i.e., whether changes arise through the introduction of a patent box regime or through a change in the ordinary corporate income tax rate).

Notwithstanding policymakers' intent to target patent activity specifically in this way, we might also expect this elasticity to differ because, as discussed in Evers, Miller, and Spengel (2014), specific provisions of patent box regimes may be more decisive for the effective tax burden than the patent tax rate alone. If these other features are important, we might therefore anticipate a stronger association between tax rates and patenting activity in countries with patent box regimes. We conclude our analysis by examining two such features of patent box regimes based on broad differences in the treatment of current expenses and eligibility of acquired IP by augmenting our model with a further interaction between an indicator for the presence of each such feature and the patent tax rate, as described in further detail below.

Additional tax-related controls in all of our empirical specifications include binary indicators for the application of a territorial tax regime (*I[Territorial]*)—which may generally favor reallocation of intangible assets toward lower-taxed jurisdictions—and whether royalty payment receipts are taxed abroad at a rate in excess of the tax rate on

patent income (*I[High Royalty Tax]*).[13,14] Differences in the magnitude of year-to-year fluctuations in patent activity due to country size are accounted for by taking natural logs of the dependent variable in each specification, while general country size and other time-invariant country characteristics are accounted for using country fixed effects. We control for remaining time-varying characteristics using measures of real GDP per capita, population, and an index of the quality of patent protection. Year fixed effects account for global macroeconomic developments related to patent activity.

IV. DATA

A. Data Sources

We use information from Bureau van Dijk and PATSTAT for all patent applications filed with any patent office in the world over the years 1990 through 2012 to construct our measures of new patent applications. We begin our sample period in 1990 as this represents the earliest year for which we have complete country-level tax system and tax rate data needed for our analysis. Given an average of 2.37 years between patent application and publication, we end our sample period in 2012—two years prior to the end of our data on published documents. The first patent box regime—implemented in France in 2000—thus falls near the midpoint of our sample period, whereas we necessarily miss the most recent patent box adoptions in the United Kingdom (2013), Portugal (2014), and Italy (2015).

[13] This approach assumes that royalty withholding taxes are fully creditable against taxes on patent income in the country of the royalty recipient, so that the patent income tax rate should be irrelevant when foreign taxes on royalty payments to the patent owner are relatively high.

[14] In additional unreported tests, we also control for the after-tax cost of R&D using a measure computed in an analogous manner to the OECD B-Index (Dauchy, 2013) in order to account for within-country variation in input-based R&D tax incentives over time. These measures are only available starting in 1998 for a subset of OECD countries. Once country and year fixed effects are included, the cost of R&D capital has no perceptible effect on patent activity in our main specifications.

Information about patent box regimes, including data on preferential tax rates and additional specific provisions regarding the treatment of current expenses and acquired IP, come primarily from Evers, Miller, and Spengel (2014) and Merrill and Shanahan (2012). Additional tax systems and rate information are drawn from a combination of sources, including Comtax and corporate tax guides compiled by Ernst and Young and PwC.[15] General macroeconomic characteristics are drawn from World Bank (2014). An index of the quality of patent protections is taken from Park (2008) and is interpolated linearly between quinquennial observations.

We begin with a sample of 19,091,989 patent applications with a non-missing application year, inventor country, and applicant country over our sample period. We aggregate these at the country-year level to obtain country-level measures of new patent flows. This yields 3,665 and 2,425 country-year observations representing 268 and 213 countries based on the location of patent inventors and owners, respectively. Matching this sample to all other country information yields a final sample for our analyses of 1,487 and 1,289 observations spanning 71 and 70 countries by inventor and owner countries, respectively. We count all patent applications within each country-year, as well as subsets of applications filed in each country-year that exhibit particular reattribution patterns consistent with our predictions summarized in Section II.B.[16]

[15] Ernst & Young, "Worldwide Corporate Tax Guide", EYGM Limited, http://www.ey.com/GL/en/Services/ Tax/Worldwide-Corporate-Tax-Guide---Country-list.

[16] In order to avoid putting disproportionate weight on patent applications involving multiple owners or inventors we allocate owner and inventor interests on a pro-rata basis at the country level. Multiple patent inventors or applicants within the same country are therefore consolidated into a single entity for the purpose of computing patent stocks and flows, whereas a patent application featuring owners (inventors) in two different countries would be counted as contributing 0.5 patents to the stock of patents held (invented) in each country.

Dependent Variables

Of particular interest in our study is the relationship between inventor and applicant countries appearing on the same patent applications, which we use as a marker of inward or outward patent ownership reattribution. Beyond the question of whether ownership is assigned to a different country than the one in which the innovation was created, we further consider patents whose owners and inventors are split (in either direction) between tax havens and non-havens. When evaluating the aggregate effects of introducing a patent box regime, we therefore examine the following dependent variables across model specifications (wherever relevant to our predictions derived from the motives for introducing patent boxes discussed above):

- *Log_Inv* (*Log_Own*) = log of new patent applications, based on inventor (owner) country only
- *Log_NoReattribute* = log of new patent applications, based equivalently on inventor and owner country, where all applicants and inventors are located in the same country
- *Log_Inv_Reattribute* (*Log_Own_Reattribute*) = log of new patent applications, based on inventor (owner) country, where at least one applicant and one inventor are located in different countries
- *Log_Inv_Reattribute_Haven* (*Log_Own_Reattribute_Haven*) = log of new patent applications, based on inventor (owner) country, where at least one applicant and one inventor are located in different countries, with at least one such mismatch featuring an owner (inventor) in a tax haven

- *Log_Inv_Reattribute_NonHaven* (*Log_Own_Reattribute_NonHaven*) = log of new patent applications, based on inventor (owner) country, where at least one applicant and one inventor are located in different countries, with no mismatched owners (inventors) located in a tax haven

Table 1 reports descriptive statistics for each of these measures of patent activity (in levels) for our main estimation sample by patent box status of inventor and owner countries (Panels A and B, respectively). Patent box status is defined as of 2012, and differences in average country-level characteristics over the full 1990–2012 period across regime groupings are evaluated using a *t*-test of differences in means assuming unequal variances across groups. These figures indicate that patent box and non-patent box regimes differ significantly in most respects, but notably not in terms of total patent applications or applications involving owners and inventors located entirely within the same country. Instead, where patent activity does differ is among the set of patents featuring inward or outward patent reattributions involving tax havens, consistent with patent boxes being implemented in countries where cross-border reattributions are a greater concern.

V. RESULTS

A. Suggestive Evidence

Figure 2 characterizes trends in patent activity for each of the patent box regimes implemented during our sample period. Annual percent changes in patent applications at both the inventor and owner levels are shown over an 11-year period, centered whenever possible on the year of patent box implementation, and are shown for each country relative to the corresponding trends in patent activity in the rest of the world (excluding

the set of all patent box regimes). As shown, virtually all countries appear to exhibit declining rates of aggregate patent activity immediately following the start of their patent box regimes. Only Hungary, Luxembourg, Spain, and Liechtenstein show any evidence of increasing patent activity relative to the rest-of-world group in subsequent years, though even this pattern is not exclusively a feature of the post-patent- box period. This suggests at best a very modest positive effect of patent box regimes on patent applications in the aggregate, albeit in a manner that fails to take account of additional country characteristics or variation in regime generosity.

B. Aggregate Patent Counts

Table 2 presents estimates of the effects of the existence and generosity of patent box regimes on the log of aggregate patent flows measured at the level of the inventor and owner countries. With respect to the inventor country, Column 1 shows that the propensity for domestic inventions to be patented is significantly lower after a patent box regime is implemented. This result is largely consistent with the trends depicted in Figure 2. However, accounting for differences in the size of tax reductions on patent income among patent box regimes, the results presented in Column 2 show that the propensity to apply for patents is more responsive to differences in patent-specific preferential tax rates than ordinary corporate income tax rates, as evidenced by the negative coefficient on *I[Patent Box]* × *Patent Income Tax Rate*. A one percentage point reduction in the preferential tax rate for patent income is thus associated with a 3.0 percent increase in new patent applications among domestic inventors. A very similar pattern of results likewise appears when looking at the estimated effects of aggregate patent counts from the perspective of the owner country (Columns 3 and 4). As patent box regimes reward

patent ownership, their introduction also appears to increase the number of patent owners in the home country as the generosity of the preferential regime increases.

C. Patent Reattributions

Despite nearly identical point estimates on the semi-elasticity of patent activity by inventor or owner country, the former results do not preclude important shifts in patent ownership reattribution patterns. Table 3 presents results focusing specifically on the effects of patent box regimes on the frequency of cross-border reattributions versus host-country co-location. We present the estimated effects from the perspective of the inventor country in Columns 1–3, followed by estimated effects from the perspective of the owner in Columns 5 and 6. Column 4 considers the set of patents for which owners and inventors are all located in the host country (*Log_NoReattribute*), such that inventors and owners are subject to identical country characteristics and tax incentives. As not all reattribution patterns are of interest (e.g., inward reattributions from non-havens), we limit Table 3 to only the relevant complement of outcomes.

Column 1 shows the results of estimating the effect of patent box regimes on *Log_Inv_Reattribute*, or the propensity to own inventions outside the country in which the invention took place. Similarly, Columns 2 and 3 distinguish when ownership is attributed outside the inventor country to a tax haven or non-haven, respectively. If these regimes effectively deter profit shifting through cross-border patent reattribution—especially to tax havens—and create incentives for innovative companies to remain in the host country, we would expect to see a positive (or less negative) coefficient on *I[Patent Box] × Patent Income Tax Rate*. The more generous the patent box regime, the weaker the incentive to engage in patent activity that attributes ownership to a different country

than that of the inventor. Despite a lack of statistical precision, this prediction is broadly consistent with the magnitude of the point estimates across Columns 1–3, which imply virtually zero impact of patent box regimes on total out- ward reattributions (Column 1) or reattributions toward non-havens (Column 3), while implying a large positive effect of patent income tax rates on the number of inventions developed in patent box countries and owned in tax havens. By process of elimination, this suggests that the increase in inventor activity in patent box regimes resulting from reduced tax rates on patent income from Table 2 must be primarily due to host-country co-location of patent development and ownership. Indeed, though the effect is again measured imprecisely, Column 4 reveals a relatively large negative effect of *I[Patent Box]* × *Patent Income Tax Rate* on the number of new patent applications featuring no inward or outward patent reattributions.

From the perspective of the owner country, we might expect patent ownership in patent box regimes to increase regardless of the location of inventors. Mirroring the results by inventor country (with appropriate caveats for the absence of statistically significant interaction effects), the results of Columns (4–6) suggest that the increase in patent ownership counts presented in Column 4 of Table 2 cannot be explained by inward reattributions and least of all, perhaps, from tax havens. Hence, somewhat contrary to expectations given the EU patent box regimes' lack of nexus requirements, it appears that the primary effect of these regimes to date has been the promotion of domestic patenting activity, with no measurable impact on base erosion.

D. Other Features of Patent Box Regimes

Turning to additional determinants of the breadth and generosity of patent box regimes,

we conclude by allowing the effect of preferential patent income tax rates to differ according to two specific features of IP box regimes on patent activity: (1) expense allocation rules, and (2) the treatment of acquired IP. These results are presented in Tables 4 and 5 from the perspective of inventor and owner countries, respectively. We define an indicator *I[Gross Expensing]* which equals one in regimes that allow the deductibility of current R&D expenses against gross income and zero otherwise (e.g., where deductibility is only allowed against the lower patent income tax rate). *I[Gross Expensing]=1* implies more favorable treatment and may result in negative effective tax burdens on IP income as demonstrated in Evers, Miller, and Spengel (2014), thereby amplifying the potential effects of the statutory reduction in patent income tax rates. Restrictions on the eligibility of acquired IP, meanwhile, may limit firms' ability to forego (risky) new patent development in favor of merely specializing in successful IP commercialization through patent acquisitions. *I[Acquired IP]* is set to equal one in the less restrictive regimes that grant equivalent treatment to owners of acquired and self-developed IP.[17]

Table 4 shows that differing tax benefits stemming from patent box provisions regarding the allocation of expenses or patent acquisitions do not significantly affect inventors' propensity to apply for patents, nor do these affect the likelihood of reattributing ownership to a different country than the one in which the innovative activity took place. Insofar as we cannot distinguish self-developed from acquired IP in the data, the results in Columns 3–4 represent a relatively indirect test of firms' incentives to acquire patents with a higher probability of commercial success rather than engage in new and uncertain

[17] I[Gross Expensing]=1 only applies in Belgium and Hungary (and since 2014, Portugal, which we do not include in our analysis). I[Acquired IP]=1 applies to Cyprus, France, Hungary, Liechtenstein, and Malta.

R&D (and thereby influence inventor activity). The insignificant effect associated with eligibility of acquired IP in Columns 3–4 is therefore relatively unsurprising. Nevertheless, the sign and magnitude of the estimates on the triple interaction of *I[Patent Box] × Patent Income Tax Rate × I[Acquired IP]* is consistent with the more permissive regimes allowing substitution between self-developed and acquired IP and hence lower rates of domestic inventor activity.

The effect of expense allocation rules on the location of inventor activity is a priori more ambiguous. To the extent that inventors are directly eligible to deduct R&D expenses for tax purposes, deductibility against gross income should favor increased patent inventor activity. However, if legal patent owners ultimately incur R&D expenses (e.g., as in the case of contractual R&D agreements), taxable income reported in the inventor country may not be affected by expense allocation rules. The insignificant interaction effects of *I[Patent Box] × Patent Income Tax Rate × I[Gross Expensing]* shown in Columns 1–2 may therefore reflect the importance of contract R&D in patent development.

Reinforcing this interpretation, Columns 1–3 of Table 5 show that the existence of favorable expense allocation rules increases the responsiveness of patent activity to preferential tax rates on patent income based on the country of patent ownership — especially for patents featuring co-located owners and inventors (Column 2). Taken together, these results imply that expense allocation rules are more likely to operate through the taxable income of the patent owner rather than the patent inventor. In terms of eligibility rules for acquired IP, these have no statistically significant impact on patent applications in the country of ownership. Given the nature of the hypothesized mechanism, we would not necessarily expect to observe any differential impact of these

provisions on net patent counts if patent owners substitute perfectly between self-developed and acquired IP. Distinguishing between both types of patents by leveraging information on firm-level acquisitions is the focus of another project.

VI. CONCLUSION

Patent box regimes lie at the forefront of the set of tax policy levers employed by policymakers to stimulate domestic innovation and combat erosion of the tax base due to cross-border reallocation of high-valued intangible assets. Despite their lack of explicit nexus requirements, the foregoing results suggest that these regimes may have been sufficiently generous to meet the former objective—increasing new patent applications by an average of roughly 3 percent for every 1 percentage point decrease in the tax rate on patent income—without having a measurable impact on the propensity for patents to be owned and invented in different countries. To the extent that the latter reflects a symptom of tax-motivated income reallocation, especially where tax havens are involved, it thus appears that patent box regimes have been relatively less successful at meeting their second objective of deterring cross-border patent reattributions, at least over the short period of time that most of these regimes have been in place. The characteristics of patent box regimes differ in several respects. However, only the asymmetric treatment of R&D expenses for cost and income recognition purposes and the gap between patent and ordinary income tax rates significantly affect patent activity.

Importantly, it should be noted that an increase in patent applications following implementation of patent box regimes does not necessarily imply an increase in *de novo* innovation. Indeed, given the time required to develop new technologies and processes, it is reasonable to expect that the primary margin for responding to patent box incentives in

the very near term would be through patenting of pre-existing unpatented IP. With most patent box regimes still in their infancy, our results should thus be viewed as limited to characterizing the effects of these regimes on observable *patenting* activity. Addressing how much of this activity is attributable to newly incentivized R&D remains a question for future research.

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DISCLOSURES

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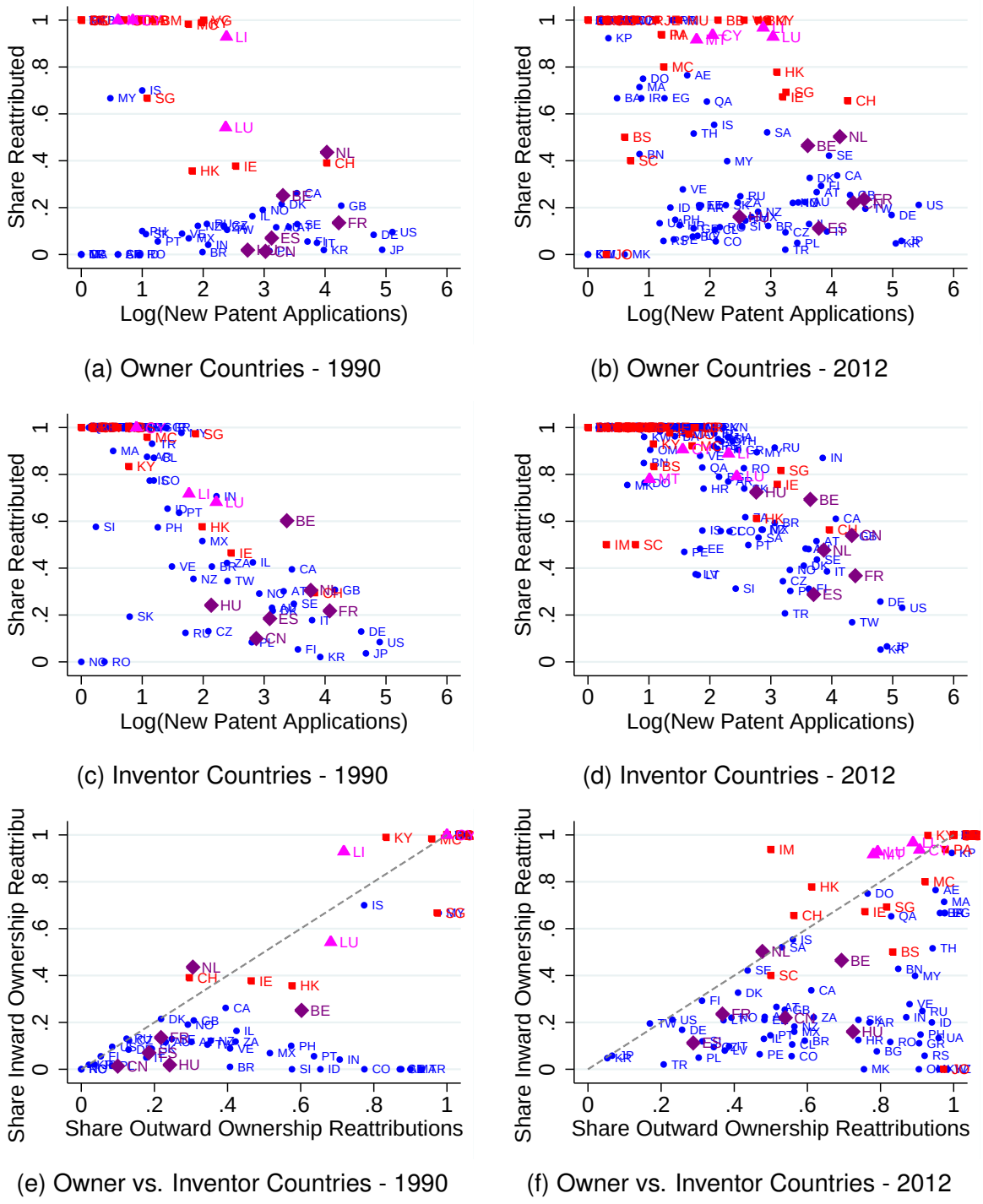
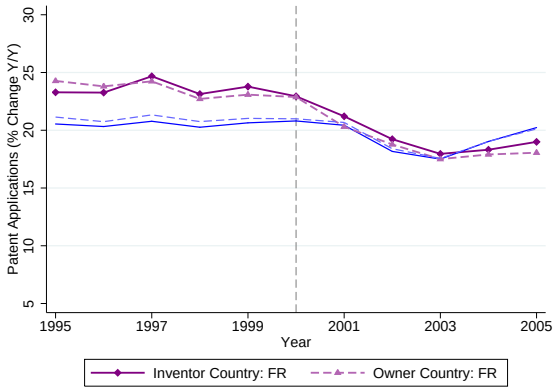
Figure 1: Patent Activity and Cross-Border Reattributions by Owner and Inventor Countries: 1990 Versus 2012

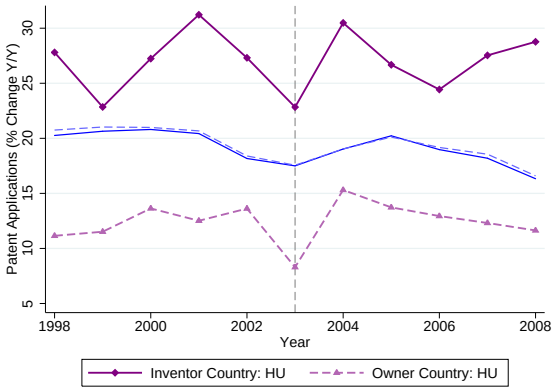


Patent box regimes are defined as of their status in 2012, and include Belgium (BE), China (CN), Cyprus (CY), Spain (ES), France (FR), Hungary (HU), Liechtenstein (LI), Luxembourg (LU), Malta (MT), and the Netherlands (NL). Tax havens are defined according to Hines (2010).

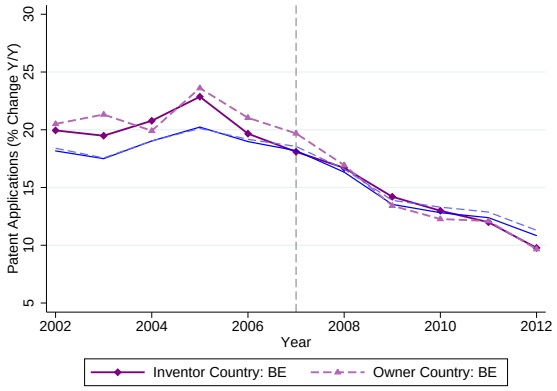
Figure 2: IP Box Patent Activity by Country



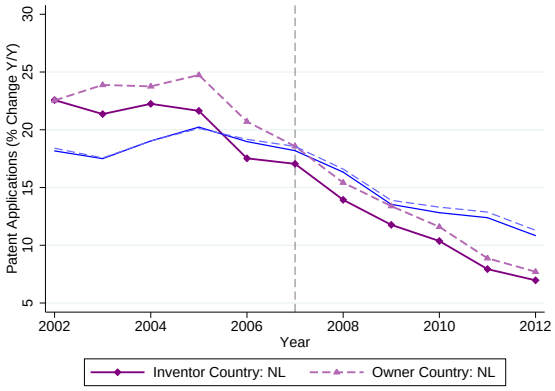
(a) France



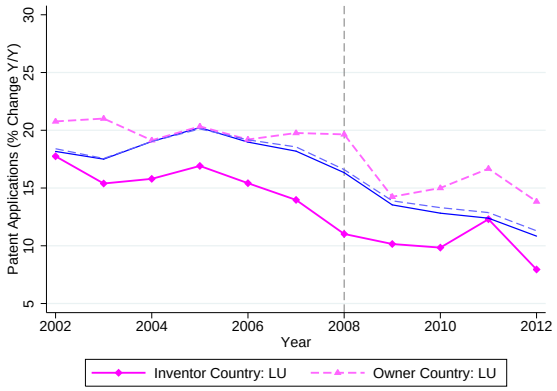
(b) Hungary



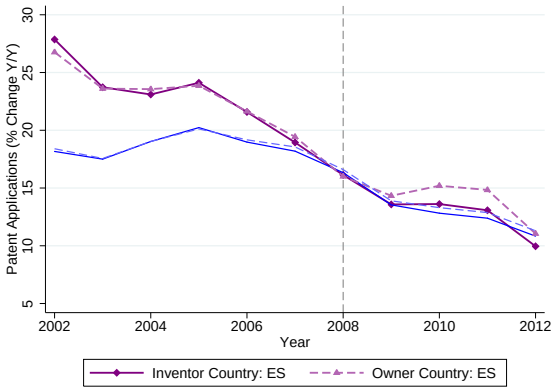
(c) Belgium



(d) Netherlands



(e) Luxembourg



(f) Spain

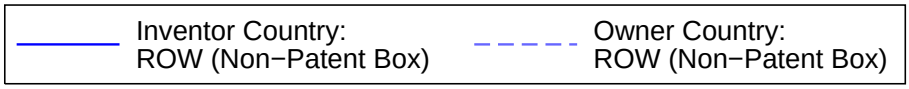
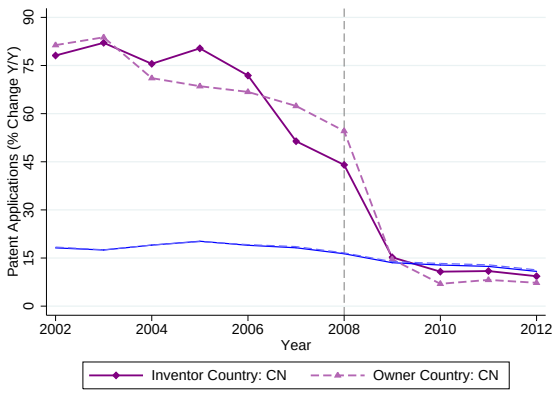
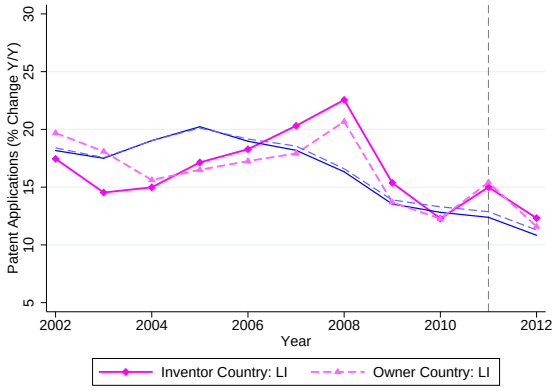


Figure 2: IP Box Patent Activity by Country (continued)

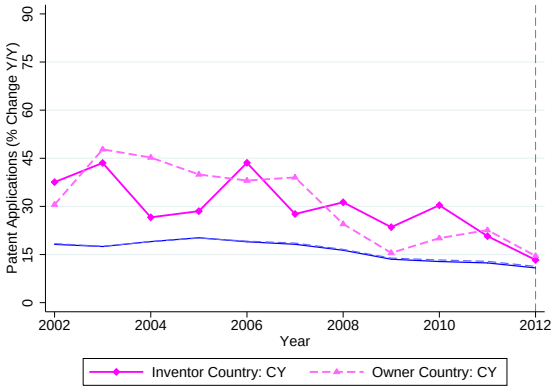


(g) China

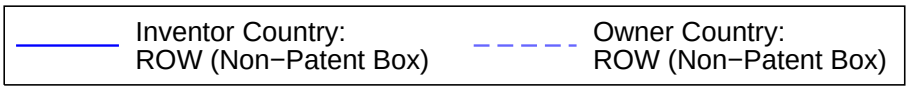
(h) Malta



(i) Liechtenstein



(j) Cyprus



Dashed vertical lines represent the year of patent box implementation. Changes in the ROW (rest-of-world) patent stock are computed based on the sum of patent applications for all countries with no patent box regime in place as of 2012, such that the group composition is fixed over time.

TABLE 1: Average Country Characteristics (1990-2012), by Inventor and Owner Country, Patent Box vs. Non-Patent Box Regimes

	Non-Patent Box	Patent Box	Difference
Panel A. Inventor Country	*(N=1299)*	*(N=188)*	
Patent Stock (2000)	42445	32911	9534*
New Patent Applications	7226	8734	-1508
New Patent Applications - Domestic Only	5620	5958	-338
New Patent Applications - Foreign Reattributions	1606	2776	-1170***
New Patent Applications - Haven Reattributions	230	358	-128**
Patent Income Tax Rate (Percent)	30.9	25.5	5.5***
I[Territorial] (Percent)	66.3	85.6	-19.4***
I[High Royalty Tax] (Percent)	7.5	8	-0.5
Real GDP per Capita (PPP Thousands)	20.5	31.5	-11.1***
Population (Millions)	61	171	-111***
Patent Protection Index	3.37	3.95	-0.58***
Panel B. Owner Country	*(N=1096)*	*(N=193)*	
Patent Stock (2000)	78607	43221	35387***
New Patent Applications	13422	11510	1913
New Patent Applications - Domestic Only	11384	9129	2255
New Patent Applications - Foreign Reattributions	2038	2380	-343
New Patent Applications - Haven Reattributions	129	95.4	33.2*
Patent Income Tax Rate (Percent)	30.7	25.7	5.0***
I[Territorial] (Percent)	67.2	83.4	-16.2***
I[High Royalty Tax] (Percent)	7.1	7.8	-0.7
Real GDP per Capita (PPP Thousands)	22.9	31.2	-8.3***
Population (Millions)	64.4	167	-103***
Patent Protection Index	3.53	3.89	-0.36***

Notes: Determination of regime status is based on patent boxes implemented through 2012. Patent Stocks (2000) is the accumulated sum of new patent applications, as of 2000, excluding expired patents (older than twenty years). New Patent Applications is the sum of all patents applied in a given year. Domestic Only refers to patents with co-located inventors and owners. Foreign Reattributions refer to non-matching inventor or owner countries as defined in Section IV. Haven Reattributions refers to the subset of these foreign reattributions involving a tax haven. All other variables are as defined in Section III. Asterisks denote significance at the 1% (***), 5% (**), and 10% (*) levels based on t-tests of differences in means assuming unequal variances across groups.

TABLE 2: Effect of Patent Box Regimes on Patent Intensity, by Inventor and Owner Country

	Inventor Country		Owner Country	
Independent variables	*Log_Inv*		*Log_Own*	
I[Patent Box]	-0.362***		-0.297	
	(0.106)		(0.200)	
Patent Income Tax Rate		-0.003		-0.001
		(0.005)		(0.009)
I[Patent Box] x Patent Income Tax Rate		-0.030***		-0.031*
		(0.010)		(0.019)
I[Territorial]	-0.340**	-0.336**	-0.383*	-0.380*
	(0.141)	(0.141)	(0.196)	(0.196)
I[High Royalty Tax]	-0.143	-0.195	-0.089	-0.104
	(0.124)	(0.137)	(0.156)	(0.151)
Real GDP per Capita	-0.007	-0.007	0.054**	0.054**
	(0.013)	(0.013)	(0.024)	(0.024)
Population	0.006***	0.006**	0.005**	0.005**
	(0.002)	(0.002)	(0.002)	(0.002)
Patent Protection Index	0.446***	0.453***	0.572***	0.567***
	(0.108)	(0.106)	(0.164)	(0.163)
Constant	6.289***	6.421***	3.928***	3.988***
	(0.574)	(0.647)	(1.022)	(1.125)
Observations	1,487	1,487	1,289	1,289
R-Squared	0.973	0.973	0.968	0.968

Notes: All regressions include year and country fixed effects. The dependent variable is the log of total new patent applications from the perspective of the inventor or owner countries. Asterisks denote significance at the 1% (***), 5% (**), and 10% (*) levels. Heteroskedasticity robust standard errors adjusted for country clusters are in parentheses.

TABLE 3: Effect of Patent Box Regimes on Patent (Re)attribution vs. Domestic Co-location, by Inventor and Owner Country

	Inventor Country				Owner Country	
	Cross-Border Attribution			Domestic	Cross-Border Attribution	
	All Foreign	Tax Haven	Non-Tax Haven	Co-Location	All Foreign	Tax Haven
Independent variables	(1)	(2)	(3)	(4)	(5)	(6)
Patent Income Tax Rate	-0.004	0.002	-0.003	0.006	0.000	0.008
	(0.005)	(0.007)	(0.005)	(0.010)	(0.008)	(0.007)
I[Patent Box] x Patent Income Tax Rate	-0.008	0.022	-0.009	-0.024	0.016	0.024
	(0.017)	(0.017)	(0.017)	(0.020)	(0.021)	(0.017)
I[Territorial]	-0.198**	-0.156	-0.174**	-0.331*	-0.166	0.281**
	(0.084)	(0.126)	(0.086)	(0.193)	(0.141)	(0.123)
I[High Royalty Tax]	-0.145	-0.083	-0.100	-0.207	0.083	0.436*
	(0.153)	(0.190)	(0.129)	(0.168)	(0.185)	(0.250)
Real GDP	-0.002	0.043***	-0.006	0.044*	0.076***	0.052*
	(0.011)	(0.012)	(0.011)	(0.024)	(0.028)	(0.028)
Population	0.007**	0.009***	0.007**	0.004*	0.011***	0.009***
	(0.003)	(0.003)	(0.002)	(0.002)	(0.003)	(0.003)
Patent Protection Index	0.378***	0.383**	0.394***	0.636***	0.542***	0.007
	(0.103)	(0.168)	(0.104)	(0.141)	(0.175)	(0.171)
Constant	5.414***	2.210***	5.171***	3.765***	1.288	1.903
	(0.568)	(0.669)	(0.562)	(1.101)	(1.207)	(1.279)
Observations	1,486	1,181	1,480	1,167	1,226	773
R-Squared	0.963	0.910	0.962	0.964	0.954	0.912

Notes: See notes to Table 2. Dependent variables are defined as in Section IV.B as *Log_Inv_Reattribute*, *Log_Inv_Reattribute_Haven*, *Log_Inv_ Reattribute_NonHaven*, *Log_NoReattribute*, *Log_Own_Reattribute*, and *Log_Own_Reattribute_Haven* for Columns (1) to (6), respectively.

TABLE 4: Effect of Patent Box Regime Provisions on Inventor Country Patent Activity

	IP Box Provision			
	I[Gross Expensing]		*I[Acquired IP]*	
Independent variables	All	Cross-Border Attribution	All	Cross-Border Attribution
Patent Income Tax Rate	-0.004	-0.004	-0.004	-0.005
	(0.005)	(0.005)	(0.005)	(0.005)
I[Patent Box] x Patent Income Tax Rate	-0.027**	-0.005	-0.052**	-0.044
	(0.011)	(0.019)	(0.026)	(0.028)
I[Patent Box] x Patent Income Tax Rate x IP Box Provision	-0.023	-0.018	0.028	0.047
	(0.023)	(0.039)	(0.025)	(0.032)
I[Territorial]	-0.339**	-0.200**	-0.329**	-0.186**
	(0.141)	(0.084)	(0.142)	(0.088)
I[High Royalty Tax]	-0.206	-0.154	-0.187	-0.131
	(0.138)	(0.152)	(0.138)	(0.153)
Real GDP per Capita	-0.007	-0.002	-0.008	-0.002
	(0.013)	(0.011)	(0.013)	(0.011)
Population	0.006**	0.007**	0.006***	0.007***
	(0.002)	(0.002)	(0.002)	(0.002)
Patent Protection Index	0.455***	0.379***	0.448***	0.369***
	(0.106)	(0.103)	(0.106)	(0.102)
Constant	6.433***	5.423***	6.466***	5.487***
	(0.645)	(0.562)	(0.649)	(0.560)
Observations	1,487	1,486	1,487	1,486
R-Squared	0.973	0.963	0.973	0.963

Notes: See notes to Table 2. Dependent variables are defined as in Section IV.B as *Log_Inv* and *Log_Inv_Reattribute*.

TABLE 5: Effect of Patent Box Regime Provisions on Owner Country Patent Activity

	IP Box Provision					
		I[Gross Expensing]			*I[Acquired IP]*	
Independent variables	All	Domestic Co-Location	Cross-Border Attribution	All	Domestic Co-Location	Cross-Border Attribution
Patent Income Tax Rate	-0.003	0.005	-0.001	-0.001	0.007	-0.000
	(0.009)	(0.010)	(0.008)	(0.009)	(0.011)	(0.008)
I[Patent Box] x Patent Income Tax Rate	-0.017	-0.009	0.024	-0.028	-0.009	-0.006
	(0.013)	(0.014)	(0.023)	(0.031)	(0.033)	(0.027)
I[Patent Box] x Patent Income Tax Rate x IP Box Provision	*-0.088***	*-0.093***	*-0.050***	*-0.004*	*-0.019*	*0.028*
	(0.020)	*(0.024)*	*(0.024)*	*(0.031)*	*(0.033)*	*(0.032)*
I[Territorial]	-0.389*	-0.342*	-0.171	-0.381*	-0.335*	-0.158
	(0.198)	(0.195)	(0.142)	(0.196)	(0.193)	(0.141)
I[High Royalty Tax]	-0.152	-0.266	0.055	-0.105	-0.215	0.094
	(0.143)	(0.163)	(0.183)	(0.150)	(0.164)	(0.188)
Real GDP per Capita	0.054**	0.044*	0.076***	0.054**	0.045*	0.076***
	(0.024)	(0.023)	(0.028)	(0.024)	(0.024)	(0.028)
Population	0.005**	0.004*	0.011***	0.005**	0.004*	0.011***
	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.003)
Patent Protection Index	0.572***	0.642***	0.545***	0.568***	0.642***	0.534***
	(0.162)	(0.139)	(0.175)	(0.163)	(0.141)	(0.174)
Constant	4.043***	3.841***	1.320	3.981***	3.718***	1.349
	(1.119)	(1.097)	(1.205)	(1.137)	(1.115)	(1.214)
Observations	1,289	1,167	1,226	1,289	1,167	1,226
R-Squared	0.968	0.964	0.954	0.968	0.964	0.954

Notes: See notes to Table 2. Dependent variables are defined as in Section IV.B as *Log_Own*, *Log_NoReattribute*, and *Log_Own_Reattribute*.