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Innovation under Nexus Requirements

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Abstract

Exploiting granular European innovation data and the introduction of nexus requirements to patent boxes, I find that tightening access to preferential tax treatment of innovation output reduces inventive activity. A stylized framework and firm-reported constraints both point to internal funding as the binding mechanism. Consistently, effects appear on both the extensive margin, lowering the number of innovating firms, and the intensive margin, reducing resources devoted to innovation. Externally organized innovation declines relative to in-house activity, and innovation quality declines modestly. Spillover analyses indicate innovation decreases reflect forgone rather than reallocated innovation. Findings inform tax policy design and corporate innovation strategies.

Keywords: *Innovation, International Taxation, Patent Box, Nexus Requirements*

1 Introduction

Incentivizing firm innovation is a central objective of economic policy. One commonly adopted instrument to advance this goal in Europe is the patent box (also referred to as an "IP box"), which grants preferential tax treatment to income derived from intellectual property (IP). However, because IP not only is a key innovation outcome but also is central to tax avoidance through profit shifting (Guvenen et al., 2022), governments have implemented restrictions to patent box regimes in a multilateral effort to counteract "harmful" tax avoidance. As patent boxes thus sit at the intersection of the policy objectives to promote innovation and curb tax avoidance, a key question emerges: how do anti–tax avoidance measures that tighten preferential tax regimes affect firms' inventive activity?

This paper contributes novel empirical, theoretical, and survey-evidence to this question by analyzing restrictions to patent box regimes introduced as substance requirements under the OECD's 2014 agreement on the *modified nexus approach*. Mandatorily adopted under BEPS Action 5 (OECD, 2015), nexus requirements are economically significant (Stantcheva, 2021) yet conceptually ambiguous in their innovation effects. Rather than mechanically operating through general changes in rates or the tax base (Mukherjee et al., 2017; Li et al., 2021), nexus requirements condition preferential tax treatment of IP income (output) on the co-location with firms' own inventive activity (input). To clarify this ambiguity, I develop a stylized framework in which nexus requirements tighten firms' internal funding constraints, reducing both their capacity to undertake innovation projects and their organizational flexibility in sourcing inventive activity.

Empirically testing this framework requires data that capture multiple dimensions of innovation behavior. A key challenge in analyzing firm innovation is *"accurately measuring and capturing innovative investment"* (Lester, 2021). To overcome this, I utilize granular Eurostat data from the Community Innovation Survey (CIS), which covers a wide range of activities that enterprises undertake to implement innovation (Eurostat, 2021). Conducted biannually across the EU with stratified samples of all enterprises with ten or more employees,

the CIS represents the largest innovation survey in the world (Arundel and Smith, 2013). In line with the OECD's Oslo Manual, it defines innovation as the introduction of new or significantly improved products, services, or processes, capturing innovation relative to the firm's existing products and processes (for discussions, see Breuer et al. (2025); Glaeser and Lang (2024)). By capturing a broad spectrum of inventive efforts—specifically including those not strategically codified into patents—the CIS data ensure that I observe the total firm-level innovation response rather than only those outcomes that patent boxes explicitly target.

The choice of CIS data is further motivated by the tension that remains under the framework. While the framework predicts that nexus requirements may dampen innovation, firms might alternatively substitute toward or increase qualifying inventive activities to retain tax benefits. The CIS data are ideally suited to distinguish between these possibilities: they provide detailed information not only on whether firms innovate, but also on the intensity of innovation expenditures, the organizational mode of inventive activity (e.g., in-house vs. outsourced activities), and turnover from new-to-market products, allowing me to test whether nexus requirements reduce innovation or simply reshape how firms organize it.

Comprehensive information on patent box regimes comes from reports by Code of Conduct Group for Business Taxation at the Council of the European Union. I use this information to establish a treatment group (countries with patent boxes that introduce nexus requirements) and a control group (countries without patent boxes). With few exceptions, the sampled treatment countries already had patent boxes in place but were required under the mandatory BEPS Action 5 to adopt nexus requirements. This context helps mitigate endogeneity concerns. Using difference-in-differences (DiD) regressions, I isolate the effect of introducing nexus requirements on innovation.

I estimate that tightening patent boxes through nexus requirements reduces the average probability that a firm innovates by about 3.5 percentage points. Consistent with the policy's phase-in and potential transitory effects (the OECD agreement in late 2014 was to

be implemented by jurisdictions by mid 2016, coinciding with the 2016 CIS wave), I find that the effect becomes more negative from the 2016 to the 2018 CIS wave. Collapsing the data at the country $\times$ industry $\times$ CIS wave (i.e., year) level and employing Poisson regression on counts of innovators confirms the negative effect on innovation outcomes: fewer firms engage in innovation overall. Exploring heterogeneity by headquarters location, I find that the decline in innovation is significantly more pronounced for firms with headquarters outside the European Union, consistent with the view that nexus requirements bind more tightly for internationally organized firms. Taken together, these results indicate that nexus requirements indeed dampen genuine firm innovation.

Building on the results for firms' innovation propensity, I turn to the intensity of inventive activities. I estimate a regression with CIS data on innovation spending (as a share of total turnover) as the outcome variable and find significant reductions in firms' innovation spending. I complement these DiD estimates with an application of a synthetic control approach, which consistently reveals a marked decline in innovation spending by the 2018 CIS wave. Because innovation spending is an outcome that closely reflects innovation *input*, these results imply that resources devoted to innovation also decrease under nexus requirements. This evidence closely aligns with the stylized framework under which tightened internal funding limits the scale of innovation inputs.

Since nexus requirements primarily link preferential tax treatment of innovation output to a firm's own inventive activities, some externally organized innovation is penalized, allowing me to examine how firms adjust their inventive organization. Distinguishing CIS items on the prevalence of external and in-house inventive activities, I find that external innovation declines relative to in-house activity, suggesting that the policy disproportionately reduces outsourced innovation.

Taken together, these results indicate that nexus requirements not only lower the likelihood and intensity of innovation but also alter how firms organize innovation, requiring managers to adapt organizational choices when tax incentives shift, patterns consistent with

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the framework's predictions. Further supporting these conclusions and the framework's assumptions, I triangulate findings with firms' responses to additional CIS items. Specifically, innovation-hampering items added to the latest available CIS wave indicate that firms report internal funding constraints as significantly more binding than lack of external credit. This "survey"-evidence suggests that firms do not seamlessly substitute to external finance and that the mechanism does not reflect general financial distress. Additionally, taxes are cited as the most frequently regulatory obstacle to innovation among respondents, underscoring the relevance of tax policy in incentivizing firm innovation.

I then examine whether nexus requirements affect the quality of innovation. While the framework does not yield a sharp prediction for innovation quality, this analysis assesses whether the observed reductions in innovation inputs and activity translate into changes in the economic success of innovation. Using CIS information on firms' turnover from products new to the market as a proxy for the novelty and economic value of innovation, I find modest but negative effects following the introduction of nexus requirements. Since the estimated effects are less conclusive in this set of tests, I cautiously conclude that nexus requirements have reduced the market success of innovation, suggesting a modest decline in innovation quality.

As noted above, cross-sectional analyses reveal stronger innovation responses for internationally organized firms (i.e., those with headquarters outside the European Union). While underscoring important heterogeneity in the effects, it is important to note that these analyses include country $\times$ year fixed effects that control for time-varying, country-specific shocks such as changes in relevant national policies or macroeconomic conditions, strengthening confidence that the baseline results are not driven by broader country-level shifts. In additional robustness checks, I estimate the innovation response in a leave-one-out design by countries and industries to ensure that findings are not dominated by individual countries or sectors.

Finally, I examine potential spillovers along trade ties to assess whether negative inno-

vation estimates in treated countries are (partially) offset by increases in control countries. Using bilateral export data, I construct a trade spillover measure capturing each control country's exposure to treated countries. The results provide little evidence of spillovers along trade ties. In particular, control countries with higher trade exposure to treated countries do not experience relatively larger post-treatment increases in innovation. When I repeat this analysis with R&D tax subsidies as a potential mechanism behind spillovers, results suggest that such incentives also do not account for innovation spillovers. Taken together, the analyses provide no evidence of innovation spillovers from treated to control countries, suggesting that the decline in innovation among treated countries reflects forgone rather than reallocated innovation.

Analyzing the introduction of the nexus requirements to patent boxes contributes to the insights on the real effects of these regimes. With some research critical of the effectiveness of patent boxes (Haufler and Schindler, 2023; Ciaramella, 2023; Gaessler et al., 2021), firms are found to acquire IP through acquisitions when patent boxes are introduced (Bradley et al., 2021), which might explain increases in regime-eligible innovation output (e.g., see Bornemann et al. (2023) who document innovation increases in Belgium). Lester (2021) asks whether *"requiring nexus in this context is "bad" (because it limits the investment response) or "good" (because it requires real activity in exchange for tax benefits)?"* and adds that *"more evidence that incorporates data from years after implementation of the new nexus requirements is necessary to better evaluate this policy design."*

Relying on novel, comprehensive, and large-scale data on firms' innovation across the European Union (as recently also brought forward by Breuer et al. (2025)), I show that tightening access to preferential tax treatment of innovation output impacts firm innovation. Beyond documenting an average decline in firms' propensity to innovate, I also demonstrate that nexus requirements reduce resources devoted to innovation, reshape inventive organization, and reduce innovation quality (with some evidence). I also show that negative effects are not offset by spillovers to control countries along trade ties or tax subsidies. These

key findings not only expand related analyses on employment effects and patent-protected knowledge (Boie-Wegener, 2024; Schwab and Todtenhaupt, 2021; Chen et al., 2023), but also answer calls for research on measures, characteristics, and value of other highly prevalent innovations (Glaeser and Lang, 2024). Overall, the evidence implies that substance requirements in tax policy can alter not just the scale, but also the organization, of inventive activities.

This study further contributes to the literature on innovation responses to tax policy by isolating a distinct mechanism through which anti-tax-avoidance rules affect firm behavior. Seminal work establishes that higher taxes negatively impact the quantity and location of innovation (Akcigit et al., 2016, 2021), with findings underscoring that taxes can reduce the net present value of projects (Li et al., 2021) or alter risk-taking incentives (Mukherjee et al., 2017; Welsch, 2023). I empirically identify—consistent with both a stylized framework and evidence from recently added CIS items on innovation hampering factors—a substance-based mechanism that primarily emphasizes internal funding constraints. As substance becomes a central element of modern tax policy, my study bridges the literature on R&D tax incentives and anti-tax avoidance rules, providing novel evidence on the consequences of tightening patent box regimes across the European Union. Stantcheva (2021) specifically highlights that *"[...] patent boxes can affect the full chain of decision-making of firms [...]"*, underscoring the importance of my analyses for managers and policymakers balancing the carrot and the stick in tax policy design.

2   Institutional Details & Data

2.1   Patent Box Regimes & Nexus Requirements

Patent boxes grant preferential treatment to income derived from intellectual property (IP), a key output of innovation. A patent box typically allocates IP income into a separate *box* and applies a tax rate much lower than the corporate income tax rate to the income in

the box.[1] These regimes (also referred to as IP boxes or IP regimes), however, raised tax avoidance concerns because they commonly lacked a substance requirement. Since patent boxes preferentially treat IP, which is highly mobile, IP could be shifted to or acquired in patent box jurisdictions (Bradley et al., 2021), even if the underlying inventive activities took place elsewhere. This ability to decouple the location of inventive activities (i.e., innovation input) from the location of taxed IP income led to significant base erosion and profit shifting (BEPS) concerns among member states of the OECD.

In addressing "harmful tax practices more effectively", OECD BEPS Action 5 introduced a substantive activity requirement for any preferential tax regime. Countries agreed that such a requirement is essential to realign the taxation of profits with the activities generating them. Specifically, a consensus was reached on the *nexus approach*, developed in the context of patent box regimes. Under nexus requirements, preferential tax treatment of IP income in patent boxes is limited to the extent that the taxpayer has incurred qualifying innovation expenses that give rise to the IP income. Expenses thus serve as a proxy for *input* activity, ensuring that preferential regimes reward genuine inventive efforts supported by actual spending for innovation (OECD, 2015). Effectively, the eligible tax benefit is determined by multiplying the overall IP income by the *nexus ratio*, defined as the proportion of qualifying expenses relative to overall expenses incurred in the project. (Online Supplement OS1 contains additional institutional details on how nexus requirements are designed to ensure that preferential tax treatment in patent boxes is only granted to income arising from substantive inventive activities.)

I collect information on European countries with patent boxes and adjustments to these regimes under nexus requirements from reports by the code of conduct group (CCG) for business taxation at the European Union.[2] The CCG is an "[...] important instrument of the EU, which promotes fair tax competition [...]" (see Council of the EU). The group assesses

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[1] For an overview of 2025 patent box tax rates see Tax Foundation.

[2] This working group was established to identify potentially harmful tax measures. Their reports are available here.

preferential tax measures in EU member states that could establish "harmful tax competition inside the EU" (CCG, 2024). Since its assessments establish a *political commitment* for member states, relying on reports by the CCG overcomes subjective classification of patent boxes into harmful/not harmful-status with regard to nexus requirements Notably, the CCG assessed each pre-nexus existing patent box of sampled countries as non-compliant with nexus requirements - assessments that differ from classifications by research in the field. Importantly, Table A2 also shows that states indeed follow CCG assessments and adjust patent boxes accordingly.

In its assessments of patent boxes under the modified nexus approach, the CCG lays out some key criteria. First, "the very conceptual basis of the Modified Nexus Approach is intended to ensure that, in order for a significant proportion of IP income to qualify for benefits, a significant proportion of the actual R&D activities must have been undertaken by the qualifying taxpayer itself." Any non-harmful regime, for which legislative process necessary to adhere to the nexus requirements must commence in 2015, further disallows new entrants into existing regimes by 30 June 2016 and prohibits grandfathering of benefits from existing regimes beyond 30 June 2021 (CCG, 2024). With few exceptions, the vast majority of sampled treatment countries (see below 2.2) already had patent boxes in place but were required to adopt nexus requirements, helping mitigate potential endogeneity concerns of the research design (see Table A2).

2.2 Eurostat Community Innovation Survey

This study utilizes scientific usefiles of the Community Innovation Survey (CIS), provided by Eurostat. The CIS is biannually performed by the member states of the European Union, and is populated with stratified samples of all enterprises with 10 or more employees (see relevant Regulations (EU) No 995/2012 and (EU) 2019/2152).[3] Mandatory core questionnaires per

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[3]In this context, enterprise refers to "the smallest combination of legal units that is an organisational unit producing goods or services, which benefits from a certain degree of autonomy in decision making, especially for the allocation of its current resources" (e.g., see CIS metadata for 2016).

wave are rolled out across all countries, with key innovation items being traceable through various waves (e.g., see CIS Questionnaire Library). To maintain comparability across waves despite periodic questionnaire revisions, I rely on CIS waves 2010 to 2018 (the latest available set of usefiles), whereas each biannual wave typically refers to the period since the last survey as reference (i.e., CIS 2012 refers to the period from 2010 to 2012). Combining data across waves and conditional on non-missing items for identification, I construct a pooled cross sectional dataset of roughly 447,000 observations across 15 European jurisdictions.

The CIS captures corporate innovation comprehensively: innovation to the firm is the introduction of new or significantly improved products, services, or processes. (For a discussion of the advantages and disadvantages of the CIS measures see Breuer et al. (2025).) While Glaeser and Lang (2024) similarly "define an innovation as a novel idea that improves a production process, product, method, or platform", the CIS explicitly refers to innovation relative to the firm's existing products and processes. Definitions of innovation in the CIS and an in the OECD Oslo Manual are thus closely aligned (OECD, 2018).[4]

In addition to capturing innovation, the CIS collects information on innovation spending (as share of total turnover), inventive organization (e.g., external vs. internal organization), and enterprise information, such as employment/turnover growth and affiliation of the respondent to a group of enterprises.[5] (While detailed summary statistics are not tabulated here to avoid de-anonymization of observations in CIS, Table A3 provides country-level sample information.)

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[4]Chapter 3.4 in OECD (2018) highlights changes that are *not* innovation. The 2018 CIS questionnaire (3.1) explicitly instructs to exclude "the simple re-sale of new goods and changes of a solely aesthetic nature" from product and service innovations.

[5]A potential concern with survey data is that stated and revealed preferences may differ, possibly even systematically between treatment and control groups. However, the CIS is a broad, harmonized data collection instrument not designed to capture firm responses to specific policy changes such as the nexus requirements. Moreover, substantial confidentiality and data protection measures limit the scope for strategic or biased responses: commercial firms are excluded from data access, the data are provided for research and policy analysis purposes only (upon approval by all national statistical agencies), with a considerable time lag between survey execution and data availability: "According to Commission Regulation No 995/2012, national CIS statistics must be delivered to Eurostat within 18 months from the end of the reference year. Most countries conformed to the Regulation and transmitted the data by the requested time. Eurostat disseminated CIS 2018 data in January 2021." (CIS 2018 Metadata).

Combining available usefiles of survey waves with information by CCG allows me to distinguish between countries with patent boxes that require a nexus (treatment) and countries that do not have these preferential regimes in place (control). In particular, Cyprus (CY), Spain (ES), Hungary (HU), Lithuania (LT), Malta (MT), Portugal (PT), and Slovakia (SK) establish treated countries, Bulgaria (BG) and Czech Republich (CZ), Germany (DE), Estonia (EE), Croatia (HR), Latvia (LV), Romania (RO), and Slovenia (SI) establish control countries (see Table A2).

3 Theory & Identification Strategy

Although countries are often characterized as both high-tax and high-innovation, existing evidence points to a negative association between taxation and innovation (e.g., see Stantcheva (2021) for a review). This evidence can broadly be organized around two conceptual mechanisms: resource constraints and risk taking.

The resource-constraint view emphasizes that taxes induce wedges between firms' gross resources and the innovation inputs they can effectively deploy. Innovation inputs such as internal funds, skilled labor, and organizational capacity are costly to adjust and often tied to specific locations or organizational structures. These adjustment frictions imply that taxes can constrain innovation by limiting the scale at which innovative activity is undertaken, the locations in which it is performed, or the way it is organized. Empirical evidence consistent with this view shows that higher taxes reduce the quantity and geographic location of innovation and inventors (Akcigit et al., 2021, 2016). Related work further shows that tax-base-broadening policies such as state add-back statutes impede corporate innovation by reducing the projected net present value of innovation projects (Li et al., 2021).

In contrast, the risk-taking view highlights how taxes affect the distribution of payoffs from innovation by lowering the upside of successful projects while providing limited downside protection, thereby discouraging risky inventive activity (consistent with a "high cost

of growing" argument; Aghion et al., 2023). Supporting this mechanism, Mukherjee et al. (2017) document a systematic decline in the riskiness of innovation projects following tax rate hikes. However, evidence on risk taking is policy-specific: Welsch (2023) show that combined reporting, a return-based anti–tax-avoidance policy comparable to those studied in Li et al. (2021), can increase firms' appetite for risk.

In the next section, I develop a stylized framework that is rooted in the resource-constraint view and specifically illustrates how nexus requirements can influence innovation. The framework emphasizes internal funding constraints as a key mechanism.

3.1 Stylized Framework for Nexus Requirements

Consider a firm evaluating a prospective innovation project i with net present value

$$NPV_i = p_i B_i - C_i,$$

where p_i is the probability of success, B_i is the after-tax payoff (benefit) conditional on success, and C_i is the upfront innovation cost.

Internal funding constraint. Assume that a project can only be undertaken if its cost satisfies an internal funding constraint

$$C_i \leq \lambda \cdot CF,$$

where CF denotes the internal funds available to support innovation projects (e.g., see Brown et al. (2012) on European firms). $\lambda \in [0, 1]$ captures the fraction of internal funds that can be committed to innovation projects, arising from limitations due to managerial discretion, liquidity, or internal capital rationing (Seru, 2014).[6]

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[6]While firms may alternatively access external capital, such substitution is not without frictions: information asymmetries regarding inventive prospects or limited possibilities to provide collateral could induce the cost of external finance to exceed the returns required for internal funding decisions. Therefore, I assume

Pre-nexus internal funding. Before the introduction of nexus requirements, internal funds consist of after-tax profits from non-IP and IP activities:

$$CF^{pre} = (1 - \tau)\Pi^{non\text{-}IP} + (1 - \tau^{PB})\Pi^{IP},$$

where $\tau^{PB} \ll \tau$ reflects the preferential tax treatment of IP income in patent box regimes.

Post-nexus internal funding. Nexus requirements condition preferential tax treatment on qualifying inventive activity. Let $\theta \in [0, 1]$ denote the expected share of IP income that will qualify for preferential treatment given the firm's organization and sourcing of innovation. In other words, θ is a firm-wide *nexus ratio* that increases when the actual inventive activity is undertaken by the taxpayer itself (i.e., when innovation meets *substance* as described in detail in Section 2.1 and in Online Supplement OS1). Internal financing after nexus becomes

$$CF^{post} = (1 - \tau)\Pi^{non\text{-}IP} + \theta(1 - \tau^{PB})\Pi^{IP} + (1 - \theta)(1 - \tau)\Pi^{IP}.$$

Expected project payoff and feasibility. Nexus requirements affect innovation decisions through the interaction of project-level eligibility and firm-wide internal funding. Consider first a successful and patent-protected innovation project that fully satisfies the nexus criteria, i.e., $\theta_i = 1$ at the project level. For such a project, the conditional after-tax payoff $B_i = (1 - \tau^{PB})\Pi_i^{IP}$ remains unchanged. Nevertheless, because firms typically operate multiple innovation projects and can adjust the organization of inventive activity only gradually and within limits (Hall, 2002), it is reasonable to expect that the firm-wide share of qualifying inventive activity is below one in the short to medium run. As a result, even when an individual project is fully nexus-eligible, the pool of internal funds available for innovation is reduced relative to the pre-nexus regime (i.e., $CF^{post} < CF^{pre}$), tightening the internal funding constraint $C_i \leq \lambda \cdot CF^{post}$.

that internal funds remain the binding constraint on the margin. I gather support for this view in Section 6.

Now consider a project for which $\theta_i < 1$ at the project level. In this case, the expected after-tax payoff of the project itself is reduced to

$$E[B_i] = \theta_i(1 - \tau^{PB})\Pi_i^{IP} + (1 - \theta_i)(1 - \tau)\Pi_i^{IP}.$$

While the lower expected payoff makes the project less attractive ex-ante, the firm-wide pool of internal funds available for innovation is reduced relative to the pre-nexus regime. That is both because $\theta_i < 1$ for the project and because the firm's overall θ remains below one in the short to medium run. Thus, nexus requirements reduce the feasibility of undertaking innovation projects primarily through tighter internal funding constraints that affect all projects regardless of individual nexus eligibility, with projects where $\theta_i < 1$ facing the additional burden of lower expected returns.[7]

Implications. The framework implies that nexus requirements primarily affect innovation through tighter internal funding constraints rather than through a uniform reduction in the technological payoff of individual projects. This motivates tests that examine firms' innovation decisions along multiple dimensions. In particular, the model predicts that firms are generally less likely to undertake innovation. Further, the smaller pool of internally available funds constrains the scale of innovation inputs (i.e., resources devoted to innovation). Because preferential tax treatment under nexus requirements depends on substantive in-house inventive activity, firms are predicted to adjust how innovation is organized, with a relative decline in externally sourced or outsourced innovation in favor of in-house projects that increase expected nexus eligibility.

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[7]Notably, the internal funding constraint here differs from financial distress measures (high leverage, limited debt access). Allocation of internal funds to innovation, instead, is a strategic decision with high adjustment costs. Consequently, a firm may experience internal funding constraints under nexus requirements even if the firm is financially healthy with strong credit ratings and ample liquidity. Again, I refer to Section 6 for support.

3.2 Regression Design

To empirically identify the effects of nexus requirements for patent boxes on firm innovation, I estimate a difference-in-differences regression using OLS:

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\begin{aligned}
Innovating\ Firm_{i,t} = \alpha\ &+\ \beta_1 Nexus_c \times Post_t \\
&+\ \Sigma_n\ \beta_n\ Controls_{i,t}^n +\ \delta_c\ +\ \tau_t\ +\omega_{ind} +\ \varepsilon_{i,t}
\end{aligned}
\tag{1}
$$

I start by analyzing *Innovating Firm* as dependent variable, an indicator equal to one when a firm introduces new or significantly improved products, services, or processes. Guided by the conceptual framework, this measure captures the extent to which nexus requirements can prevent firms from undertaking innovation projects altogether.[8] On average, 27% of the sampled respondents report innovation across the CIS waves (SD 0.44), with firms from patent box regimes reporting slightly higher levels of innovation (see Table A3). Following the OECD's implementation deadline for nexus requirements, $Post_t$ equals one for CIS waves from 2016 on.[9] The indicator $Nexus_c$ equals one for countries with a patent box regime. The interaction $Nexus \times Post$ captures the average treatment effect on the treated (ATT) so that β_1 is the coefficient of interest in equation (1). Baselines of $Post_t$ and $Nexus_c$ are subsumed by CIS wave (i.e., year), τ_t, and country, δ_c, fixed effects (stratified sampling and anoymization of the usefiles prohibit the use of firm fixed effects). Further, industry fixed

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[8]Under the CIS/OECD definition of innovation certain innovations will not qualify for preferential tax treatment under patent box regimes. Their inclusion, however, is central to the study's objective. Rather than measuring narrow responses to patent box claims, this paper examines the systemic effect of nexus requirements on firms' aggregate innovation activity. The framework predicts that nexus requirements operate through firm-wide funding constraints rather than by reducing the payoff of specific box-eligible projects, implying effects that extend beyond the subset of innovations directly qualifying for tax benefits. The CIS measures thus reveal broader economic consequences that would be obscured by a focus on patent counts alone.

[9]With the vast majority of sampled treatment countries already having patent boxes in place when nexus requirements were agreed upon (see Table A2), the canonical DiD design captures treatment effects but introduces potential ambiguity regarding the two sampled countries (LT, SK) that implemented patent box regimes after 2016. Therefore, I also consider a staggered DiD design solely among treated countries and estimate the 2016 treatment effect of already treated countries against the later treated countries. The results indicate a negative differential effect for early treatment relative to late treatment in the 2016 CIS wave. The canonical DiD estimate for 2016 (see equation (2)) thus is conservative with respect to finding a negative effect.

effects, ω_{ind}, control for systematic variation across industries. A vector of control variables, $\Sigma_n\ \beta_n$, including a firm's *employment growth* (p50 0), *turnover growth* (p50 0), *turnover level*, and affiliation to a *group* of companies (avg. 0.29, SD 0.45), control for other confounding factors. Given the limited numbers of sampled countries, standard errors are clustered at the country $\times$ industry level.[10]

4   Results

4.1   Innovation

[Table 1 about here.]

The ATTs displayed in Table 1 suggest that tightening access to preferential tax treatment of innovation output is estimated to reduce the probability that a firm innovates by about 3.5 percentage points, and the effect is statistically strong.[11] Control variables, which are included in column (2) of Table 1, behave as expected. Reporting employment growth, turnover growth, higher levels of turnover, and enterprise group affiliation are positively associated with firm innovation, with the effects being statistically significant at conventional levels for all but the employment growth measure.

I interpret these findings as initial evidence that tightening access to preferential tax treatment of innovation output dampens genuine firm innovation. While quantifying the macroeconomic effects from these innovation responses to nexus requirements lies beyond the scope of this study, existing research shows that changes innovation policy can have substantial macro-effects. For instance, Atkeson and Burstein (2019) find that changes in innovation subsidies can generate sizable impact on welfare.

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[10]With only 15 sampled countries, country-level clustering of standard errors (treatment level assignment) could yield unreliable inferences. In the Online Supplement, I present event study estimates (Figure OS2a) with standard errors clustered at the country-level.

[11]I identify a consistent nexus $\times$ post estimate when additionally interacting the post indicator with the control variables (untabulated). When employing a logit model as alternative, marginal effects are consistent with the tabulated OLS estimates (untabulated).

Dynamic Effects

Since the OECD agreement on nexus requirements was reached in late 2014 and to be implemented by jurisdictions by 2016 (coinciding with the reference period of the 2016 CIS wave), I am interested in the transitory effects of the policy's impact. I analyze dynamic effects by splitting *Post* from equation (1) into $Post_{2016}$ and $Post_{2018}$:

$$Innovating\ Firm_{i,t} = \alpha\ +\ \beta_1 Nexus_c \times Post_{2016} + \beta_2 Nexus_c \times Post_{2018}$$
$$+\ \Sigma_n\ \beta_n\ Controls_{i,t}^n\ +\ \delta_c\ +\ \tau_t\ + \omega_{ind} +\ \varepsilon_{i,t} \tag{2}$$

Principally, some effects may occur already during the implementation-period of nexus requirements to patent boxes (i.e., incorporating *expected* changes in tax incentives), such that β_1 would capture these responses. In contrast, I expect the full innovation response to nexus requirements to materialize by 2018, which is captured by the β_2 estimate in equation (2). The results in column (3) of Table 1 show that nexus requirements are not associated with a statistically significant decline innovation in the 2016 CIS wave. However, for the next CIS wave (i.e., β_2), the policy is linked to a meaningful 5.9 percentage point decrease in innovation that is statistically significant. The delayed decline is consistent with a transitory impact of nexus requirements, where innovation responses are more pronounced once the nexus requirements are fully in place. Thus, the findings are consistent with *"[innovation] at the firm level typically behaves as though it has high adjustment costs"* (Hall, 2002).

[Figure 1 about here.]

To corroborate these findings, I apply the technique by Callaway and Sant'Anna (2020) (CS) for DiD to this multi-period setting and depict three takeaways in Figure 1.[12] Firstly, the aggregated ATT using this technique also suggests a negative impact of nexus requirements on innovation (horizontal dotted line). Secondly, I find no evidence of a violated

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[12]The method accommodates settings with a single treatment cohort as a minimal case of the multi-period framework. Figure OS2 shows (i) results for a event study alternative to the analysis presented here (the effect of nexus requirements on firm innovation is allowed to vary across CIS survey waves, with 2014 as the reference year), and (ii) effect-estimates using the CS DiD technique for other outcome variables.

parallel-trend assumption in the pre-period, with treatment effects under CS DiD constructed using all available pre-treatment comparisons rather than an arbitrary baseline. If anything, I observe a slight increase in innovation across patent box countries relative to control countries that could be consistent with stimulated innovation through patent boxes per se. (See Online Supplement OS3 for an application of synthetic DiD, where pre-treatment trends are strictly parallelized by construction.) The treatment effect also becomes more negative and significant from 2016 to 2018 under this estimation technique, although the 2016-estimate is already larger (yet also insignificant). Generally consistent with the estimates of equation (2), these results suggest transitory effects in the policy's impact.

Aggregated Data

[Table 2 about here.]

To complement the firm-level "micro" analysis (and facilitate additional tests), I collapse the CIS data to the Country × NACE × CIS level, following Breuer et al. (2025). In column (1) of Table 2, I first re-estimate equation (1), using the simple average of *Innovating Firm* per cell as the outcome (i.e. *Inn. Firm Avg*), and find results consistent with those in Table 1. Specifically, the data aggregation allows me to consider *counts* of innovators at the country–industry–year level. I observe that there are on average (median) 102 (51) innovating firms per cell (variable *Inn. Firm Tot.*). When estimating a Poisson model (column (2) of Table 2), I identify a negative and significant coefficient that complements the OLS estimates. Controls and fixed effects are identical to those in micro data tests above but controls are averaged across cells and then standardized at mean zero and SD one. In comparison to Table 1, aggregation slightly attenuates effects, but the direction and significance remain consistent.[13] The identified patterns are thus consistent with the policy reducing innovation on the extensive margin, i.e., decreasing the number of firms that engage in innovation at all.

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[13]When utilizing sampling weights in the micro and aggregated data analyses (see Online Supplement OS4 and Table OS1), I identify estimates that are near-identical in magnitude.

Taken together, findings in Section 4.1 indicate that tightening access to preferential tax treatment of innovation output (unintentionally) dampens genuine firm innovation. Therefore, I next analyze whether resources devoted to and the organization of inventive activities also changed in response to nexus requirements for patent boxes.

4.2 Innovation Spending

[Table 3 about here.]

The framework in Section 3.1 implies that nexus requirements operate by tightening internal funding and allocation constraints, thereby limiting the scale of innovation inputs. To test this prediction, I next analyze the effect of nexus requirements on firms' innovation spending, measured as the share of total turnover devoted to innovation activities (i.e., *Innovation Spending*).

Having shown that the main effects replicate in data aggregated at the Country × NACE × CIS level (subsequently also referred to as country-industry-year data), I also analyze the effects on innovation spending in the aggregated data. This aggregation is particularly relevant for innovation spending, as the CIS item exhibits substantial item nonresponse and there is no credible strategy to impute missing values (unlike, for example, setting turnover from innovation to zero when a firm introduces no innovation (Section 4.4)). Thus, aggregating the data mitigates the influence of outliers in this continuous outcome and accommodates missing responses by averaging over available observations, while preserving the policy assignment and maintaining sufficient variation across treatment and control groups.

I then estimate a DiD regression using OLS with the cell-level average *Inn. Spend Avg.* (avg. 8%, SD 0.15) as the outcome and present results in Table 3. In column (1), I find significant reductions in firms' innovation spending, an outcome that closely reflects innovation input, implying that resources devoted to innovation decrease under nexus requirements. Splitting $Nexus_c \times Post_t$ into $Nexus_c \times Post_{2016}$ and $Nexus_c \times Post_{2018}$ suggests that the

spending response is immediate and persistent. Both DiD estimates (depicted in column (2) of Table 3) are negative, statistically significant, and essentially identical in magnitude.

However, untabulated event-study estimates reveal substantial variation in pre-treatment coefficients, raising concerns about the validity of the parallel-trends assumption and thus about the interpretation of the DiD estimates in Table 3. To address this issue, I complement the DiD analysis with a synthetic control approach. Specifically, the procedure, described in detail in Online Supplement OS3, constructs synthetic counterfactuals by using pre-treatment outcomes to arrive at the weights. When applying synthetic control with *Innovation Spending* as the outcome, the pre-treatment trajectories of treated and synthetic units align closely, indicating successfully flattened pre-trends (Figure OS3d). Consistent with the DiD results, the synthetic control analysis reveals a marked decline in innovation spending by the 2018 CIS wave, reinforcing the conclusion that nexus requirements led to persistent reductions in innovation input.

Taken together, I find not only effects on the extensive margin but also on the intensive margin, as results suggest a reduction in the resources devoted to innovation. In other words, I find that innovation spending declines under nexus requirements.

4.3 Inventive Organization

[Table 4 about here.]

Under nexus requirements, preferential tax treatment of income in patent boxes is generally limited to the extent that the taxpayer has incurred qualifying innovation expenditures giving rise to the income (see Online Supplement OS1 for additional details beyond those in Section 2.1). As a result, nexus requirements penalize innovation expenses that are outsourced, particularly when undertaken with related parties.[14] This institutional feature maps directly

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[14]Expenses for related-party outsourcing reduce the fraction of IP income that is eligible for preferential tax treatment, while expenses for unrelated-party outsourcing (e.g., to universities) are not penalized under nexus requirements (see Online Supplement OS1). Relevant CIS items do not distinguish between unrelated- and related-party outsourcing.

into the framework's prediction that firms are incentivized to adjust the organization of inventive activity to preserve expected nexus eligibility, implying a relative shift away from externally sourced innovation toward in-house inventive activity. Accordingly, I examine whether nexus requirements disproportionately reduce external inventive activities relative to in-house innovation.

For this analysis, I employ CIS items on in-house research and development activities and on contracted-out inventive activities. Again, I employ the Country $\times$ NACE $\times$ CIS aggregated data because these data allow me to directly relate external to internal inventive activities. I construct the ratio *Ext/(Ext+InH)*, defined as the number of firms in a cell reporting external inventive activities divided by the total number of firms reporting either external or in-house inventive activities. This measure allows me to test whether external activities are reduced more strongly than in-house activities (since the latter may also be affected, as discussed above). Additionally, I construct the ratios *Ext/N* and *Ext/Inn*, defined as (i) the number of firms in a cell reporting external inventive activities divided by the total number of observations per cell, and (ii) the number of firms in a cell reporting external inventive activities divided by the number of firms that report innovation (i.e., *Inn. Firm Tot.*).

The estimates in Table 4 show a reduction in the share of external inventive activities across all three measures. The ratio *Ext/(Ext+InH)* (column (1)) declines by about 4 percentage points, indicating that external activities are reduced more strongly than in-house activities. This pattern is reinforced by the results for *Ext/Inn* (column (3)), which suggest that even among innovating firms, inventive activities shift away from external collaboration. Finally, results for *Ext/N* in column (2) of Table 4 show that external inventive activities decrease in the firm population as a whole, not only relative to in-house activity. These results indicate that nexus requirements disproportionately reduce external collaboration, consistent with the polciy's design to tie tax benefits stronger to in-house inventive activities.

4.4 Innovation Quality

Having shown that nexus requirements lower the likelihood and intensity of innovation and reshape how firms organize inventive activity, I next examine potential effects on the quality of innovation. I proxy for innovation quality using firms' *turnover from products new to the market* (as a share of total turnover), which captures the novelty and economic value of innovation outcomes and reflects the extent to which inventive activity translates into commercially successful products (the 2018 CIS questionnaire instructs to read new-to-market as *not previously offered by any of your competitors*). I assign this variable a value of zero when the *Innovating Firm* indicator equals zero, under the assumption that firms do not generate turnover from new-to-market products in the absence of reported innovation. The resulting *Innovation Turnover* measure has a mean of 3% (SD 0.13).

While the framework does not yield a sharp prediction for innovation quality—since nexus requirements primarily operate through firms' ability to undertake and scale innovation rather than directly altering technological payoffs—this analysis assesses whether the observed reductions in innovation inputs and activity translate into changes in the economic success of innovation.

Table 5 presents estimates of the effect of nexus requirements on the share of firms' turnover generated from products new to the market. Across specifications, the coefficients indicate a modest (i.e., at most about a half SD) decline in innovation turnover following the introduction of nexus requirements. The negative and statistically significant estimates in columns (1) and (2) suggest that tightening patent box regimes is associated with a reduction in the share of revenue attributable to novel products. Consistent with the transitory effects identified for innovation outcomes, the decline becomes stronger for the 2018 survey wave. To assess whether the results reflect changes in innovation quality rather than solely selection into innovation, I additionally restrict the sample to firms with positive innovation spending. The estimated effect remains negative, indicating that the observed decline in

innovation turnover is not entirely explained by fewer firms undertaking innovative activity (untabulated). However, when aggregating the data at the Country $\times$ NACE $\times$ CIS level, the estimated effect becomes statistically insignificant (untabulated). I conclude that these results provide some indication that nexus requirements may dampen the commercial success of innovative activity, although the evidence is less conclusive than for firms' overall innovation propensity and organization.

5 Cross-Sectional Analyses

5.1 Multinationals

[Table 6 about here.]

To explore heterogeneity in innovation responses to nexus requirements, I next examine whether effects differ by the location of firms' headquarters. I construct an indicator variable, which equals one if a firm reports that its headquarter is located in the *rest of the world* (i.e., HQ_{ROW}) and zero if the headquarter is located within the European Union or domestically. (Missings are not recoded.)

Consistent with the framework's emphasis on internal funding constraints, internationally organized firms (MNEs) are expected to be particularly sensitive to nexus requirements. Egger et al. (2014) demonstrate that MNEs actively use internal capital markets to respond to tax differentials, suggesting that such firms have greater capacity and incentive to structure their operations around tax incentives. For these firms, the introduction of nexus requirements represents a structural tightening of the internal funding constraint. Because MNEs often operate at the frontier of tax optimization, the gap between their actual nexus-eligible activity and the IP previously qualifying for preferential treatment is potentially wider.

Table 6 reports results. Columns (1) and (2) present separate estimates of equation (2) for firms headquartered within the country or the European Union ($HQ_{Country\&EU}$) and for firms with headquarters located in the rest of the world (HQ_{ROW}). In both groups, innovation

declines following the introduction of nexus requirements, with the strongest effects observed after 2018. The coefficients in columns (1) and (2) suggest that the reduction in firms' innovation propensity is more pronounced among internationally headquartered firms.

Column (3) of Table 6 presents results from a triple-difference specification of equation (2), which includes $Country \times Year$, $Country \times HQ$, and $Year \times HQ$ fixed effects to absorb all baseline differences and two-way interactions, thereby isolating the differential treatment effect captured by $Nexus \times Post_{Year} \times HQ_{ROW}$. This approach controls for all time-varying country-specific shocks, such as changes in national R&D policies or macroeconomic conditions (common concerns in multi-country studies), as well as any systematic differences in innovation trends between ROW-headquartered and EU-based firms unrelated to nexus requirements.

The interaction term $Nexus \times Post_{2018} \times HQ_{ROW}$ is negative and significant, indicating that the decline in innovation is significantly stronger for firms with headquarters outside the European Union. This pattern is consistent with the framework's prediction that nexus requirements bind more tightly for internationally organized firms, resulting in more substantial adjustments to their innovation strategies. Although the number of foreign-headquartered firms is limited, these findings offer meaningful evidence of heterogeneity in innovation responses to nexus requirements.

5.2   Is Innovation Lost?

Trade Ties & Spillovers

[Table 7 about here.]

The DiD estimates in Section 4.1 capture the average treatment effect on the treated, conditional on fixed effects that absorb developments within the control group. This standard design implies that even if innovation activity among treated firms remains stable or increases slightly, the estimated effect is negative when the control group experiences a stronger post-

period increase. The data suggest such a pattern: innovation appears to rise among control firms in the post-treatment period. The unconditional and synthetic control trends in Figures OS1 and OS3a illustrate this development descriptively, and column (1) of Table 7 provides consistent empirical evidence. This finding in itself indicates that the negative effects observed for treated countries are relative rather than absolute. It, however, also raises the important question of whether these relative effects reflect a spillover of innovation from treated to control countries. Put differently, I next examine whether innovation is actually lost.

To explore this possibility, I estimate a model that generalizes the idea of Berg et al. (2021). Specifically, I exploit cross-country variation of control countries in exposure to treated economies through trade linkages. Using bilateral export data from the IMF, I construct the variable *Trade Spillover*, which is defined as a control country's exports to treated countries divided by the country's total exports to all countries in the sample (standardized at mean zero and SD one). *Trade Spillover* is time-invariant and set to zero for treated countries. I then add the interaction of *Post* × *Trade Spillover* to equation (2):

$$
\begin{aligned}
Innovating\ Firm_{i,t} = \alpha\ +\ &\beta_1 Nexus_c \times Post_{2016} + \beta_2 Nexus_c \times Post_{2018} \\
&+ \beta_3 Post_t \times Trade\ Spillover_c \\
&+\ \delta_c\ +\ \tau_t\ + \omega_{ind} +\ \varepsilon_{i,t}
\end{aligned}
\tag{3}
$$

In equation (3), the coefficient on the interaction term, β_3, captures the extent to which innovation in control countries responds to their exposure to treated countries through trade ties. If control countries with higher *Trade Spillover* values experience relatively larger post-treatment increases in innovation, a positive and significant β_3 provides evidence of such spillovers. In contrast, a zero or negative β_3 suggests limited or absent spillovers along trade ties.

The spillover estimate (β_3) in column (2) of Table 7 is negative, suggesting that, if anything, innovation in control countries does not increase with higher trade exposure to

treated countries. However, when Germany is excluded from the sample (column (3)), β_3 shrinks in magnitude and becomes statistically insignificant, indicating that the negative effect is largely driven by Germany. Nevertheless, even this specification does not hint at a positive spillover effect to control countries through trade exposure.

Taken together, although innovation trajectories in control countries indicate a positive trend after the introduction of nexus requirements, I find little evidence that this pattern is driven by spillovers from treated to control countries along trade ties. I corroborate these findings by analyzing R&D tax subsidies as potential spillover mechanism.

R&D Tax Subsidies & Spillovers

[Table 8 about here.]

I use this section to explore whether R&D tax subsidies are an alternative spillover mechanism. Data for this analysis are drawn from the OECD R&D Tax Incentives Database, which provides harmonized time-series indicators of implied R&D tax subsidy rates across a wide set of countries. The database builds on the B-Index, a measure of the before-tax income a representative firm requires to break even on one additional unit of R&D spending. The implied $RnD\ Tax\ Subsidy$ rate then is computed as one minus the B-Index, capturing the effective tax support granted to marginal R&D investments. I estimate a specification of equation (3) that includes $\beta_3\ Post_t \times RnD\ Tax\ Subsidy\ Spillover$, with the latter constructed as the pre-2016 average tax subsidy rate per country (to avoid influence of concurrent changes in RnD tax subsidies). Again, I set non-missing observations among the treatment group to zero so that the remaining variation in $RnD\ Tax\ Subsidy\ Spillover$ only exists among control countries.

Results are presented in Table 8. In column (1), the spillover estimate (β_3) is small and statistically insignificant, indicating no detectable incremental increase in innovation among control observations with higher R&D tax subsidies. When Germany is excluded from the sample (column (2)), the coefficient turns negative and statistically significant.

Taken together, these results suggest that R&D tax subsidies do not account for innovation spillovers.[15]

Overall, neither trade ties nor R&D tax subsidies provide evidence of innovation spillovers from treated to sampled control countries. This evidence thus suggests that the decline in innovation among treated countries reflects forgone rather than reallocated innovation, though it does not preclude the relocation of innovation to other destinations (e.g., countries not included in the sample).

6 Triangulation with Additional CIS Items

In the final section of the paper, I triangulate the empirical evidence by exploiting a set of *innovation-hampering* items that were added to the 2018 CIS wave. I focus on two groups of variables: (i) factors constraining innovation (e.g., *internal funding* and *external credit*), and (ii) regulation-related items that indicate whether specific legislative areas prevented, hampered or increased innovation costs (e.g., *tax* and *product safety*). Table A1 contains the exact terminology used in the survey.

The regulatory items address a foundational question: are taxes seen to meaningfully affect firms' innovation decisions, or are they merely higher-order considerations? Interestingly, taxes are cited as the most frequently reported hampering category among respondents. In the context of this study, these statements not only are consistent with Stantcheva (2021)'s assessment that *"[...] patent boxes can affect the full chain of decision-making of firms,"* but also underscore the relevance of my analyses.

The hampering factors further address a key framework assumption: that internal funds are a binding constraint for innovation. Lack of *internal funding* is reported significantly more often than lack of *external credit* (1.08 vs. 0.90 on a 0–3 scale, $p < 0.001$). This gap persists across both treated and control countries and across both innovators and non-

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[15]Conclusions on spillovers to control countries (for both mechanisms trade ties and tax subsidies) do not change when estimating triple-DiD specifications that also employ variation in the cross-sectional variables for the treated group (untabulated).

innovators. These patterns support two critical assumptions. First, internal funding is indeed a key binding constraint for innovation, validating that firms do not seamlessly substitute to external finance. Second, the mechanism does not reflect general financial distress: if firms faced broad capital market constraints, external credit would be equally or more constrained. Instead, the internal funding gap indicates that innovation hinges on internal resource allocation, consistent with the framework's set up.

7 Conclusion

Intellectual property, a key innovation outcome, is central to both economic growth and tax avoidance through profit shifting. While incentivizing firm innovation motivates economic and tax policy, governments also implement measures to counteract tax avoidance. Patent boxes sit directly at the intersection of these objectives: they are designed to stimulate innovation and the exploitation of intellectual property, yet were fundamentally reshaped through the introduction of nexus requirements as part of multilateral efforts to curb tax avoidance. This tension raises a fundamental question: does tightening access to preferential tax regimes through anti–tax avoidance rules affect firms' innovation? The evidence in this paper shows that curbing preferential tax treatment of innovation output can indeed reduce firms' inventive activities. These effects materialize both on the extensive margin, lowering the propensity (number) of firms to (that) innovate, and on the intensive margin, reducing the resources devoted to innovation. Moreover, nexus requirements alter the organization of innovation by disproportionately discouraging external collaboration relative to in-house activities. Further, neither trade ties nor tax subsidies provide evidence of innovation spillovers from treated to sampled control countries, suggesting that the decline in innovation among treated countries reflects forgone rather than reallocated innovation.

The findings have several implications. For policymakers, they highlight a trade-off inherent in anti–tax avoidance rules: tightening access to preferential regimes through nexus

requirements might curb profit shifting but also reduces innovation, particularly by discouraging collaborative external activities. For firms, the results, for instance, imply that strategies relying heavily on collaborations become relatively less attractive under nexus requirements, requiring managers to adapt organizational choices when incentives shift. For researchers, the results underscore the importance of studying how tax policy shapes inventive activity (beyond patents), considering effects on innovation outcomes, resources devoted to innovation, and organization of innovation.

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Appendix

Table A1: Variable Definitions

Variable	Definition [Data Source]
Key Variables	
Innovating Firm	Indicator variable equal to one for firms that introduce new or significantly improved products, services, or processes; also referred to as _Inn. Firm_ and _Inn._ [CIS]
Innovation Spending	Ratio of expenses for innovation to a firm's total turnover (turnover in CIS is defined as the market sales of goods and services); also referred to as _Inn. Spend_; winsorized at p99. [CIS]
Innovation Turnover	Share of turnover from innovations not previously offered by competitors (i.e., new to the market); set to zero when _Innovating Firm_ $= 0$. [CIS]
Inventive Organization	Number of firms (at _country_ $\times$ _CIS_ $\times$ _industry_ level) reporting external inventive activities (numerator) divided by the total number of firms reporting either external or in-house inventive activities: $\frac{Ext}{Ext+InH}$; or numerator divided by the total number of observations per cell: $\frac{Ext}{N}$; or numerator divided by the number of firms that report innovation $\frac{Ext}{Inn}$. [CIS]
Nexus	Indicator variable that equals one for countries with a nexus-conform patent box (conditional on CIS availability): Cyprus (CY), Spain (ES), Hungary (HU), Lithuania (LT), Malta (MT), Portugal (PT), and Slovakia (SK); equals zero for control countries: Bulgaria (BG) and Czech Republich (CZ), Germany (DE), Estonia (EE), Croatia (HR), Latvia (LV), Romania (RO), and Slovenia (SI). [CIS and CCG]
Post	Equals one for CIS waves 2016 and 2018, equals zero for CIS waves 2010, 2012, and 2014. CIS information are extracted from scientific usefiles of Eurostat's Community Innovation Survey. [CIS]
. . . Avg	Data collapsed at the Country $\times$ NACE $\times$ CIS level; item average per cell. [CIS]
. . . Total	Data collapsed at the Country $\times$ NACE $\times$ CIS level; item count per cell. [CIS]

Variable	Definition [Data Source]
Other Variables	
CIS (Year)	The Community Innovation Survey (CIS) is conducted biannually (e.g., over a 2008-2010 reference period in CIS 2010) across the European Union with stratified samples of all enterprises with ten or more employees. The CIS is considered the largest innovation survey in the world and covers a wide range of activities that enterprises undertake in order to implement innovation. CIS waves (read "years") are used to construct the key variable of interest. [CIS]
Employment Growth	Employment growth between the first year of a CIS wave reference period and the last year of a reference period: $(emp_{end} - emp_{start})/emp_{start}$; range [-1;20] (upper end capped by CIS); set to zero when missing. [CIS]
Group	Indicator that equals one when an enterprise is part of an enterprise group; missings are set to zero. [CIS]
HQ	Captures headquarters: (i) an enterprise's head office country and country of operation are the same (national), (ii) HO is located in another EU, EFTA or candidate country (EU), (iii) HO is located in the rest of the world (ROW); the indicator variable HQ_{ROW} equals one when a firm reports that its headquarter is located in "ROW", zero when "EU" or "national". [CIS]
Industry (NACE)	NACE Rev. 2 industry classifications. Where possible, provided at the two-digit level in a CIS wave but when there is a small number of responses within size/NACE categories within a country, a less detailed NACE category is provided for that country (e.g., NACE categories, 49, 50, and 51 are collapsed to "49-51" in this case); all industry classifications are crosswalked into such sparser categories for consistency; the entire set of included industry-classifications are depicted in Figure OS4b. [CIS]
Hampering Factors	Ordinal variables (0-3 scale from "not a constraint" to "high") measuring the degree to which various factors hamper innovation: "Lack of internal finance for innovation" (variable *internal funding*), "Lack of credit or private equity" (variable *external credit*), "Difficulties in obtaining public grants or subsidies", "Costs too high", "Lack of skilled employees within your enterprise", "Lack of access to external knowledge", "Lack of collaboration partners", "Uncertain market demand for your ideas", "Too much competition in your market", "Different priorities within your enterprise." [CIS 2018]

Variable	Definition [Data Source]
Hampering Regulation	Indicator variables equal to one if regulations prevented, hampered or increased costs of innovation activities, covering "product safety and consumer protection", "environmental", "intellectual property", "tax", and "employment, worker safety or social affairs." [CIS 2018]
RnD Tax Subsidy	Computed as one minus the B-Index (a measure of the before-tax income a representative firm requires to break even on one additional unit of R&D spending), capturing the effective tax support granted to marginal R&D investments ("Implied Tax Subsidy Rate on R&D Expenditures for SMEs under a Profitable Scenario"); *RnD Tax Subsidy Spillover* builds on this variable: I employ the pre-2016 average per country and set the constructed measure to zero for treated countries so that the remaining variation only exists among control countries. [OECD]
Turnover (Growth)	Turnover *growth* between the first year of a CIS wave reference period and the last year of a reference period: $(turn_{end} - turn_{start})/turn_{start}$; range [-1;20] (upper end imposed as in employment growth: larger values are set to missing, missings subsequently dropped); turnover *level* is microaggregated/pertubated turnover (to avoid de-anonymization); winsorized at p99 per country. [CIS]
Trade Ties	*Trade Share to Regime* is a country's exports to treated countries divided by the country's total exports to all countries in the sample (time-invariant average across sample period); *Trade Spillover* builds on this variable: I set the constructed measure to zero for treated countries so that the remaining variation only exists among control countries. [IMF]

Table A2: CCG Assessments of Patent Boxes (CIS-CCG Sample)

| Country	Code	Ass. Year	Treated	Assessment CCG	Ass. Report CCG	Add. CCG	Add. Assessment
Bulgaria	BG		0				
Cyprus	CY	2013	1	harmful	16553/1/14		PWC Worldwide Tax Sum. 2017/2018 p. 110
Cyprus	CY	2017	1	not harmful	10047/17		PWC Worldwide Tax Sum. 2017/2018 p. 110
Czech Rep.	CZ		0				
Germany	DE		0				
Estonia	EE		0				
Spain	ES	2008	1	harmful	16553/1/14		
Spain	ES	2014	1	harmful	16553/1/14		
Spain	ES	2016	1	not harmful*	14784/17	14364/18 ADD 11 (*initially harmful but corrected)	EY Tax Guide 2017 p. 1446
Croatia	HR		0				
Hungary	HU	2014	1	harmful	16553/1/14		
Hungary	HU	2017	1	not harmful	10047/17		EY Tax Guide 2017 p. 628
Lithuania	LT	2018	1	not harmful	9652/19	9652/19 ADD 3	EY Tax Guide 2018 p. 917
Latvia	LV		0				
Malta	MT	2014	1	harmful	16553/1/14		
Malta	MT	2019	1	not harmful	14114/19	14114/19 ADD 1	EY Tax Guide 2020 p. 1050
Portugal	PT	2014	1	harmful	16553/1/14		
Portugal	PT	2017	1	not harmful	10047/17		EY Tax Guide 2017 p. 1244
Romania	RO	2018	0	review on hold	9652/19		not implemented
Slovenia	SI		0				
Slovakia	SK	2018	1	not harmful	14364/18	14364/18 ADD 9	EY Tax Guide 2018 p. 1433

This table reports sampled countries and assessments by CCG on the countries' patent boxes. Treated is the country-level *Nexus* indicator that equals one for sampled countries with a nexus-conform patent box. The year of the CCG assessment is provided by *Ass. Year*

Table A3: CIS-CCG Sample Composition

Code	Treated	CIS 2010	CIS 2012	CIS 2014	CIS 2016	CIS 2018	Avg. Inn. Firm	SD Inn. Firm
BG	0	14,440	14,144	14,097	14,483	14,688	0.156	0.362
CY	1	1,059	1,200	1,344	0	0	0.284	0.451
CZ	0	5,132	5,334	5,116	5,510	5,642	0.384	0.486
DE	0	5,209	5,065	4,908	4,958	4,924	0.491	0.500
EE	0	1,726	1,712	1,655	1,475	937	0.395	0.489
ES	1	34,423	31,996	30,228	31,667	30,890	0.280	0.449
HR	0	3,378	3,173	3,234	3,267	2,621	0.290	0.454
HU	1	4,635	5,032	6,780	7,001	7,281	0.202	0.402
LT	1	2,006	2,090	2,395	2,357	2,356	0.361	0.480
LV	0	0	0	1,369	2,824	2,647	0.244	0.429
MT	1	0	0	0	1,886	2,302	0.213	0.409
PT	1	6,158	6,831	7,070	6,754	8,176	0.421	0.494
RO	0	8,299	7,378	7,980	0	7,528	0.114	0.318
SI	0	2,290	1,807	0	0	0	0.339	0.473
SK	1	2,304	2,849	2,783	3,210	3,200	0.182	0.386
Total		91,059	88,611	88,959	85,392	93,192	0.273	0.445

This table reports country-level counts of observations by CIS wave (2010–2018). Treated is the country-level *Nexus* indicator that equals one for sampled countries with a nexus-conform patent box. Variables *Avg. Inn. Firm* and *SD Inn. Firm* are the country-level mean and standard deviation of *Innovating Firm*, which is an indicator variable equal to one for firms that introduce new or significantly improved products, services, or processes. The *Total* row aggregates across all countries and reports overall counts by wave and overall innovation statistics. All statistics use available observations only, with the sample information drawn from the test-ready CIS dataset for 2010–2018.

Figure 1: Dynamic Effects
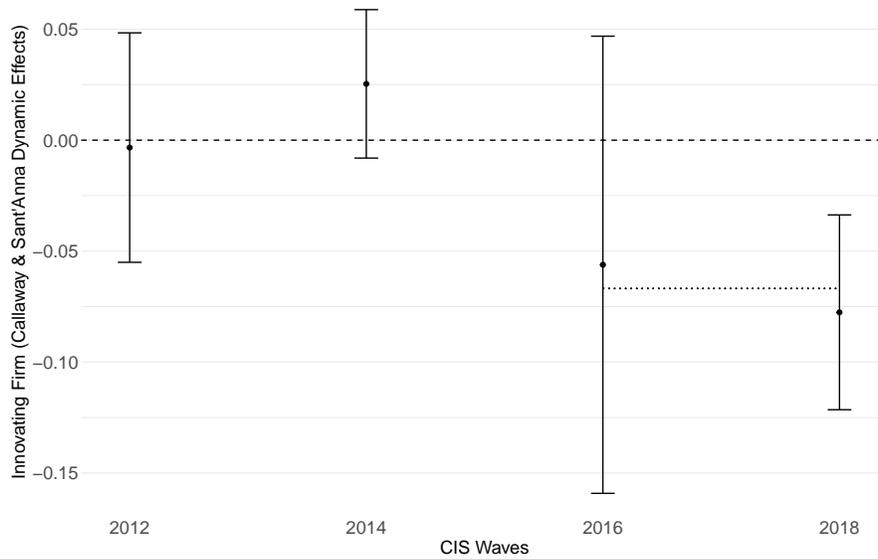
This figure depicts results from an event study applying the technique by Callaway and Sant'Anna (2020) for DiD. The dependent variable is *Innovating Firm*, which is an indicator variable equal to one for firms that introduce new or significantly improved products, services, or processes. Points mark the estimates, the error bars cover the 95% confidence intervals, and the horizontal dotted line marks the aggregated ATT estimate.

Table 1: Innovation under Nexus Requirements

| | **Innovating Firm** | | |
	(1)	(2)	(3)
Nexus × Post	-0.0357***	-0.0345***	
	(0.0089)	(0.0088)	
Nexus × Post$_{2016}$			-0.0057
			(0.0087)
Nexus × Post$_{2018}$			-0.0593***
			(0.0111)
Employment Growth (z)		0.0014	0.0014
		(0.0009)	(0.0009)
Turnover (z)		0.0273***	0.0274***
		(0.0100)	(0.0100)
Turnover Growth (z)		0.0049***	0.0048***
		(0.0010)	(0.0010)
Group		0.1199***	0.1199***
		(0.0082)	(0.0082)
Country fixed effects	✓	✓	✓
CIS fixed effects	✓	✓	✓
NACE fixed effects	✓	✓	✓
Observations	447,213	447,213	447,213
Adjusted R^2	0.13291	0.14934	0.14968

This table reports OLS estimates from regressions with *Innovating Firm* as dependent variable, which is an indicator variable equal to one for firms that introduce new or significantly improved products, services, or processes. Nexus is an indicator variable for countries with a nexus conform patent box. Post equals one for CIS waves from 2016 on. Standard errors in parentheses are clustered at the Country × NACE level. Stars denote significance at the *** 1%, ** 5%, * 10% levels; (z) denotes standardization at mean zero and standard deviation one.

Table 2: Aggregated Data

	Inn. Firm Avg.	**Inn. Firm Tot.**
	(1)	(2)
	OLS	Poisson
Nexus × Post	-0.0250**	-0.1298***
	(0.0120)	(0.0386)
Controls	✓	✓
Country fixed effects	✓	✓
CIS fixed effects	✓	✓
NACE fixed effects	✓	✓
Observations	1,199	1,199
Adjusted R^2	0.77379	

This table reports regression estimates using CIS data that are collapsed at the Country × NACE × CIS level. I drop cells with fewer than five observations. In (1), the dependent variable is the average of *Innovating Firm* per Country × NACE × CIS. In (2), the dependent variable is the total number of *Innovating Firm* = 1 observations per Country × NACE × CIS (i.e., *Innovating Firm Tot.* is the innovator cell count). Estimates in this column rely on Poisson regression that includes $ln(cell\ count)$ as offset. Standard errors in parentheses are clustered at the Country × NACE level. Stars denote significance at the *** 1%, ** 5%, * 10% levels; (z) denotes standardization at mean zero and standard deviation one.

Table 3: Innovation Spending

	Inn. Spend Avg.	
	(1)	(2)
Nexus $\times$ Post	-0.0266*	
	(0.0137)	
Nexus $\times$ Post$_{2016}$		-0.0266*
		(0.0140)
Nexus $\times$ Post$_{2018}$		-0.0265*
		(0.0154)
Controls	✓	✓
Country fixed effects	✓	✓
CIS fixed effects	✓	✓
NACE fixed effects	✓	✓
Observations	1,166	1,166
Adjusted R^2	0.45571	0.45522

This table reports OLS estimates from regressions using CIS data that are collapsed at the Country $\times$ NACE $\times$ CIS level. I drop cells with fewer than five observations. The dependent variable is the average of the ratio of innovation expenses to a firm's total turnover per Country $\times$ NACE $\times$ CIS. Standard errors in parentheses are clustered at the Country $\times$ NACE level. Stars denote significance at the *** 1%, ** 5%, * 10% levels; (z) denotes standardization at mean zero and standard deviation one.

Table 4: Inventive Organization

	Ext/(Ext+InH) (1)	*Ext/N* (2)	*Ext/Inn.* (3)
Nexus × Post	-0.0423***	-0.0154***	-0.0496***
	(0.0122)	(0.0056)	(0.0186)
Controls	✓	✓	✓
Country fixed effects	✓	✓	✓
CIS fixed effects	✓	✓	✓
NACE fixed effects	✓	✓	✓
Observations	1,152	1,162	1,162
Adjusted R^2	0.43342	0.71422	0.51791

This table reports OLS estimates. Data for these analyses are collapsed at the Country × NACE × CIS level. I drop cells with fewer than five observations. In (1), the dependent variable is defined as the number of firms in a cell reporting external inventive activities divided by the total number of firms reporting either external or in-house inventive activities. In (2), the dependent variable is defined as the number of firms in a cell reporting external inventive activities divided by the total number of observations per cell. In (3), the dependent variable is defined as the number of firms in a cell reporting external inventive activities divided by the number of firms that report innovation (i.e., *Inn. Firm Tot.*). Standard errors in parentheses are clustered at the Country × NACE level. Stars denote significance at the *** 1%, ** 5%, * 10% levels; (z) denotes standardization at mean zero and standard deviation one.

Table 5: Innovation Quality

	Innovation Turnover	
	(1)	(2)
Nexus × Post	-0.0046**	
	(0.0020)	
Nexus × Post$_{2016}$		-0.0017
		(0.0018)
Nexus × Post$_{2018}$		-0.0070***
		(0.0024)
Controls	✓	✓
Country fixed effects	✓	✓
CIS fixed effects	✓	✓
NACE fixed effects	✓	✓
Observations	424,407	424,407
Adjusted R^2	0.04983	0.04987

This table reports OLS estimates. The dependent variables is firms' *turnover from products new to the market* (as a share of total turnover) which proxies for the novelty and economic value of innovation. I assign this variable a value of zero for firms without reported innovation activity, assuming that firms do not generate turnover from new-to-market products when the *Innovating Firm* indicator equals zero. Standard errors in parentheses are clustered at the Country × NACE level. Stars denote significance at the *** 1%, ** 5%, * 10% levels; (z) denotes standardization at mean zero and standard deviation one.

Table 6: Multinationals

| | **Innovating Firm** | | |
| | $\text{HQ}_{Country\&EU}$ | HQ_{ROW} | |
	(1)	(2)	(3)
Nexus × Post$_{2016}$	-0.0031	-0.0008	
	(0.0100)	(0.0248)	
Nexus × Post$_{2018}$	-0.0489***	-0.0811**	
	(0.0156)	(0.0320)	
Nexus × Post$_{2016}$ × HQ_{ROW}			-0.0138
			(0.0263)
Nexus × Post$_{2018}$ × HQ_{ROW}			-0.0509*
			(0.0294)
Country fixed effects	✓	✓	
CIS fixed effects	✓	✓	
NACE fixed effects	✓	✓	
Country-CIS fixed effects			✓
HQ_{ROW}-CIS fixed effects			✓
Country-HQ_{ROW} fixed effects			✓
Observations	117,401	10,536	127,937
Adjusted R^2	0.13448	0.14841	0.05287

This table reports OLS estimates from regressions with *Innovating Firm* as dependent variable, which is an indicator variable equal to one for firms that introduce new or significantly improved products, services, or processes. Nexus is an indicator variable for countries with a nexus conform patent box. Post equals one for CIS waves from 2016 on. The indicator variable *HQ_{ROW}* equals one when a firm reports that its headquarter is located in the "rest of the world", zero when "EU" or "national". Standard errors in parentheses are clustered at the Country × NACE level. Stars denote significance at the *** 1%, ** 5%, * 10% levels; (z) denotes standardization at mean zero and standard deviation one.

Table 7: Trade Ties & Spillovers

| | **Innovating Firm** | | |
| | Control Only | Full Sample | Remove DE |
	(1)	(2)	(3)
Post	0.0394***		
	(0.0067)		
Nexus × Post$_{2016}$		-0.0816***	-0.0468*
		(0.0173)	(0.0267)
Nexus × Post$_{2018}$		-0.1347***	-0.1004***
		(0.0183)	(0.0283)
Post × Trade Spillover (z)		-0.0424***	-0.0179
		(0.0070)	(0.0152)
Country fixed effects	✓	✓	✓
NACE fixed effects	✓	✓	✓
CIS fixed effects		✓	✓
Observations	188,950	447,213	422,149
Adjusted R^2	0.15826	0.13375	0.12219

This table reports OLS estimates with *Innovating Firm* as the dependent variable, which is an indicator variable equal to one for firms that introduce new or significantly improved products, services, or processes. In (1), data are subset to control observations, CIS fixed effects are removed and *Innovating Firm* is regressed on Post. Post equals one for CIS waves from 2016 on. In columns (2) and (3), Nexus is an indicator variable for countries that introduce a nexus conform patent box. Trade Spillover is defined as a control country's exports to treated countries divided by the country's total exports to all countries in the sample (i.e., time-invariant and set to zero for treated countries). In (3), Germany is removed from the sample. Stars denote significance at the *** 1%, ** 5%, * 10% levels; (z) denotes standardization at mean zero and standard deviation one.

Table 8: R&D Tax Subsidies & Spillovers

| | **Innovating Firm** | |
| | Full Sample | Remove DE |
	(1)	(2)
Nexus $\times$ Post$_{2016}$	0.0142	-0.0506***
	(0.0131)	(0.0116)
Nexus $\times$ Post$_{2018}$	-0.0320**	-0.0855***
	(0.0154)	(0.0144)
Post $\times$ RnD Tax Subsidy Spillover (z)	0.0039	-0.0176***
	(0.0045)	(0.0038)
Country fixed effects	✓	✓
CIS fixed effects	✓	✓
NACE fixed effects	✓	✓
Observations	367,856	342,792
Adjusted R^2	0.12829	0.11726

This table reports OLS estimates with *Innovating Firm* as the dependent variable, which is an indicator variable equal to one for firms that introduce new or significantly improved products, services, or processes. Nexus is an indicator variable for countries that introduce a nexus conform patent box. R&D Tax Subsidy Spillover is defined as a control country's pre-2016 average implied R&D tax subsidy rate, constructed from the OECD R&D Tax Incentives Database (i.e., time-invariant and replaced with zero for treated countries). In (2), Germany is removed from the sample. Stars denote significance at the *** 1%, ** 5%, * 10% levels; (z) denotes standardization at mean zero and standard deviation one.

Online Supplement

Innovation under Nexus Requirements

OS1 BEPS Action 5 - Nexus Requirements

This section closely follows OECD (2015, p. 24-40)

The purpose of the nexus approach is to grant tax benefits in patent boxes only to income that arises from IP where the actual inventive activity was undertaken by the taxpayer itself (i.e., substance). To achieve this goal, *expenditures* act as proxy for substantive activities. However, it is not the amount of expenditures that acts as a direct proxy for the amount of activities. It is instead the proportion of *expenditures directly related to development activities* that demonstrates "real value added by the taxpayer" (p. 25) and acts as a proxy for how much inventive activity the taxpayer undertook. Specifically, the nexus requirement allows a patent box to provide for a preferential rate on IP-related income to the extent it was generated by qualifying expenditures. The nexus approach thus determines what IP income may receivve tax benefits by applying the following calculation:

$$
\frac{Qualifying\ IP\ Expenses}{Overall\ IP\ Expenses} \times Overall\ IP\ Income
$$
$$
= Income\ Receiving\ Tax\ Benefits\ in\ Patent\ Box
$$

(OS1)

The ratio in equation (OS1) is the *nexus ratio*. It includes *qualifying expenses* and *overall expenses* incurred in inventive activities (for a discussion of qualifying taxpayers, IP assets, and further details, see OECD (2015)). Qualifying expenses must have been incurred by the taxpayer, and they must be directly connected to the exploited IP. For instance, these are expenses that qualify for R&D tax credits under the tax laws of multiple jurisdictions. (Specifically, the numerator contains such expenses (a) and expenses for unrelated-party outsourcing (b); an uplift of 30% is possible.) The nexus ratio thus would equal 100% if the taxpayer incurred all relevant IP expenses itself. The ratio, however, penalizes acquisition costs (c) and expenses for related-party outsourcing (d) by including them in the overall IP expenses but not in the qualifying expenses. The nexus ratio thus equals $(a+b)/(a+b+c+d)$, with the numerator allowing for an uplift. When the ratio decreases (i.e., when expenses that are not classified as substantive own inventive activity increase), IP income that eligible

to receive preferential tax treatment in the patent box decreases, diminishing the tax benefit.

OS2 Trends

OS2.1 Unconditional Trends

[Figure OS1 about here.]

Figure 1 shows dynamic effects that underscore the key takeaways from the specifications in the main tables, including support for the parallel trend assumption. While these estimates are conditional on fixed effects, I show unconditional, descriptive trends in Figure OS1. The figure illustrates country-trends in the average share of innovating firms (*Innovating Firm*) across CIS waves, disaggregated by regime status (green markers are regime/nexus countries). Point markers represent the average values for each country, with 95% confidence intervals shown as error bars (for the sake of readability, individual countries are not identifiable in this figure). The solid lines represent fitted quadratic trends, allowing for potentially different pre-post trends and the dashed vertical line at 2016 indicates the introduction of the treatment.

Overall, Figure OS1 confirms prior evidence. The parallel-trend assumption is not violated in the pre-period. If anything, I observe a slightly better innovation-trajectory across patent box countries relative to control countries in the pre-period. (I additionally employ a synthetic control approach in Online Supplement OS3 that constructs identical trends in the pre-treatment period through weights.) Post-treatment trends in innovation, however, differ systematically between treated and control groups. While the average share of innovating firms improves among the control countries over time, treated countries substantially lag behind in this development (rendering the negative DiD estimates in the regressions).

OS2.2 Dynamic Effects

[Figure OS2 about here.]

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Figure 1 in Section 4.1 shows dynamic effect estimates using the technique by Callaway and Sant'Anna (2020) for DiD. Figure OS2a depicts results for an event study alternative to the analyses presented in the main body: the effect of nexus requirements on firm innovation (*Innovating Firm*) is allowed to vary across CIS survey waves, with 2014 as the reference year. The specification controls for firm-level characteristics and includes fixed effects for country, industry, and survey wave (all as described for equation (1)). Robust standard errors are clustered at the *country* level in this analysis. The other panels of Figure OS2 employ the CS DiD technique to show dynamic effects for other outcome variables. The dependent variables are *Inn. Firm Avg.* (Figure OS2b), *Ext/N* (Figure OS2c), and *Innovation Turnover* (Figure OS2d). In all panels, points mark the estimates, the error bars cover the 95% confidence intervals, and the horizontal dotted line marks the aggregated ATT estimate. With respect to these outcome variables, the visualizations generally provide support for both parallel-trends and the estimates presented in Section 4.

OS3   Synthetic Control

[Figure OS3 about here.]

As a complementary approach to the baseline difference-in-differences estimates, I implement a synthetic control (SC) method to assess the impact of nexus requirements on innovation. The SC analysis constructs a weighted combination of control "donor" units that closely replicates the pre-reform trajectory of the treated observations, thereby providing a data-driven counterfactual.[OS1] For this analysis, I aggregate control observations at the country × industry × year level to ensure a sufficiently large and uniquely identifiable donor pool in a balanced panel. Treated observations are collapsed annually to maintain unique identification (a requirement of the employed software). Further, weights for the SC analysis are generated exclusively from pre-treatment observations of the outcome variable (*Innovating Firm*).

[OS1]The SC method is implemented using the `tidysynth` package for R.

Figure OS3 illustrates the results. Panel OS3a depicts the evolution of the treated observations and their synthetic counterparts over time. The close alignment in the pre-treatment period suggests that the constructed synthetic control provides a credible counterfactual for the post-reform periods. Panel OS3b plots the difference between the observed and synthetic control outcomes. This gap is consistent with the estimated treatment effects from the main analyes. Panel OS3c presents placebo tests, helping to evaluate the post-reform divergence for the treated observations relative to placebo cases. Overall, the SC results shown in Figure OS3 point to a negative innovation response to nexus requirements, consistent with and complementary to the baseline difference-in-differences estimates. (Figure OS3d presents placebo trends for *Innovation Spending*, which I describe in more detail in Section 4.2.)

OS4   Sampling Weights

[Table OS1 about here.]

While estimates in the main body are presented as unweighted regressions, CIS information also contains weights, which allow to adjust for sampling design and non-response bias. The weights in the CIS waves are post-response weights where possible; otherwise sampling weights are supplied. However, there is no documentation on which type of weight applies to a given country-wave, and some countries do not provide weights at all, requiring missing values to be replaced with one. In addition, inspection of the raw weights reveals extreme outliers with country-specific patterns. For these reasons, I treat weighted regressions as a robustness check.

Specifically, I re-estimate the main regressions using sampling weights under three alternative adjustments: (i) winsorizing weights at the 75th percentile, which broadly coincides with the common rule of trimming at 3.5 times the median (θ); (ii) scaling weights by the country-average weight across CIS waves (λ); and (iii) combining (ii) with winsorization at $3.5 \times$ the median (μ). I either estimate weighted regressions in the micro data with *Innovating Firm* as outcome variable or collapse data at the Country $\times$ NACE $\times$ CIS level:

the weights are then used to construct weighted averages of *Innovating Firm* per cell when collapsing (i.e., *Inn. Firm Avg* $_{weighted\ by\ \theta|\lambda|\mu}$).

Results are depicted in Table OS1. Across all approaches, I continue to find negative and statistically significant treatment estimates that are nearly identical in size, supporting the robustness of the unweighted baseline findings.

OS5   Leave One Out

[Figure OS4 about here.]

To ensure that results are not driven by any single country (industry), I re-estimate equation (2) in a leave-one-out design, sequentially excluding each country (industry). The estimated coefficient on $Nexus_c \times Post_{2018}$ remains negative and statistically significant in all iterations (Figure OS4a), with moderate variation in magnitude, confirming that the main findings are generally not dominated by individual countries. I neither observe that sequentially excluding an industry (Figure OS4b) allows for different conclusions.

Figure OS1: Unconditional Trends
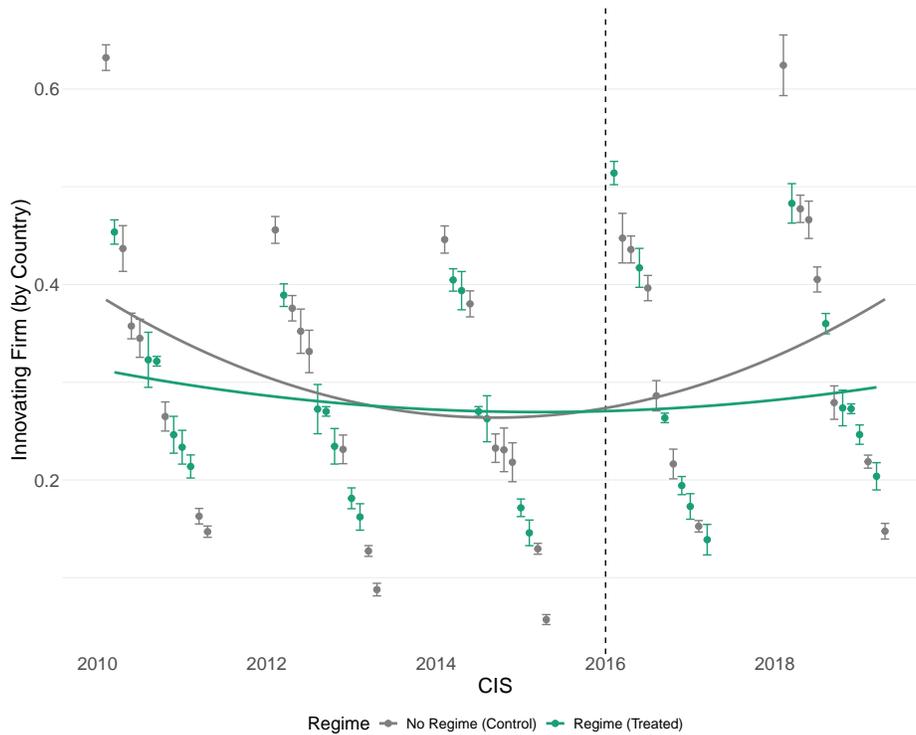
The figure illustrates country-trends in the average share of innovating firms (*Innovating Firm*) across CIS waves, disaggregated by regime status (green markers are regime/nexus countries). Point markers represent the average values for each country, with 95% confidence intervals shown as error bars (for the sake of readability, individual countries are not identifiable in this figure). A small offset is added so that observations per CIS do not overlap. The solid lines represent fitted quadratic trends, allowing for potentially different pre-post trends and the dashed vertical line at 2016 indicates the introduction of the treatment. The data is sorted by CIS wave and descending average innovating firm share within each wave.

Figure OS2: Dynamic Effects
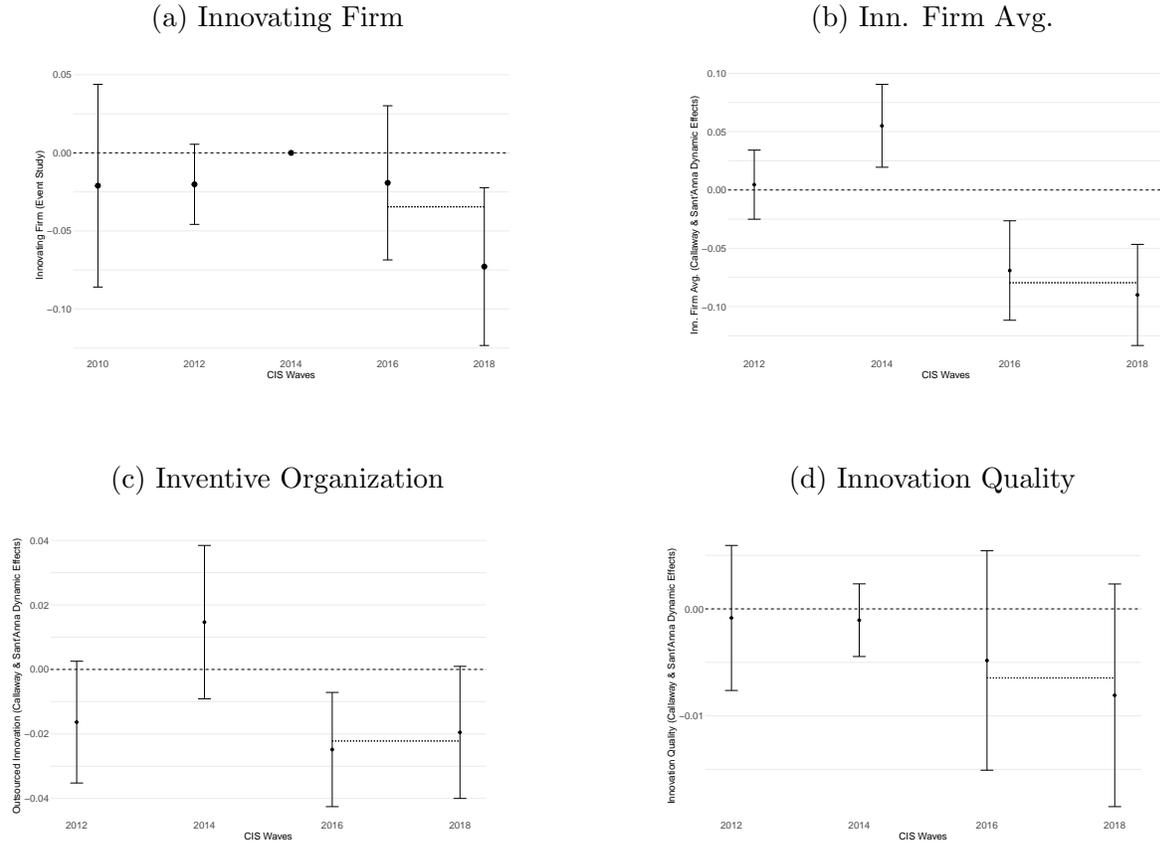
(a) Innovating Firm

(b) Inn. Firm Avg.

(c) Inventive Organization

(d) Innovation Quality

Figure OS2a depicts results for an event study alternative to the analyses presented in the main body: the effect of nexus requirements on firm innovation (*Innovating Firm*) is allowed to vary across CIS survey waves, with 2014 as the reference year. The specification controls for firm-level characteristics and includes fixed effects for country, industry, and survey wave (all as described for equation (1)). Robust standard errors are clustered at the *country* level in this analysis. The other panels depict results from an event study applying the technique by Callaway and Sant'Anna (2020) for DiD. The dependent variables are *Inn. Firm Avg.* (Figure OS2b), *Ext/N* (Figure OS2c), and *Innovation Turnover* (Figure OS2d). The technique is described in detail in the main body (Section 4.1). Samples are constructed as in the main body (Sections 4.1, 4.3, and 4.4). In all panels, points mark the estimates, the error bars cover the 95% confidence intervals, and the horizontal dotted line marks the aggregated ATT estimate.

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Figure OS3: Synthetic Control

(a) Trends

(b) Differences

(c) Placebos



(d) Placebos - Innovation Spending
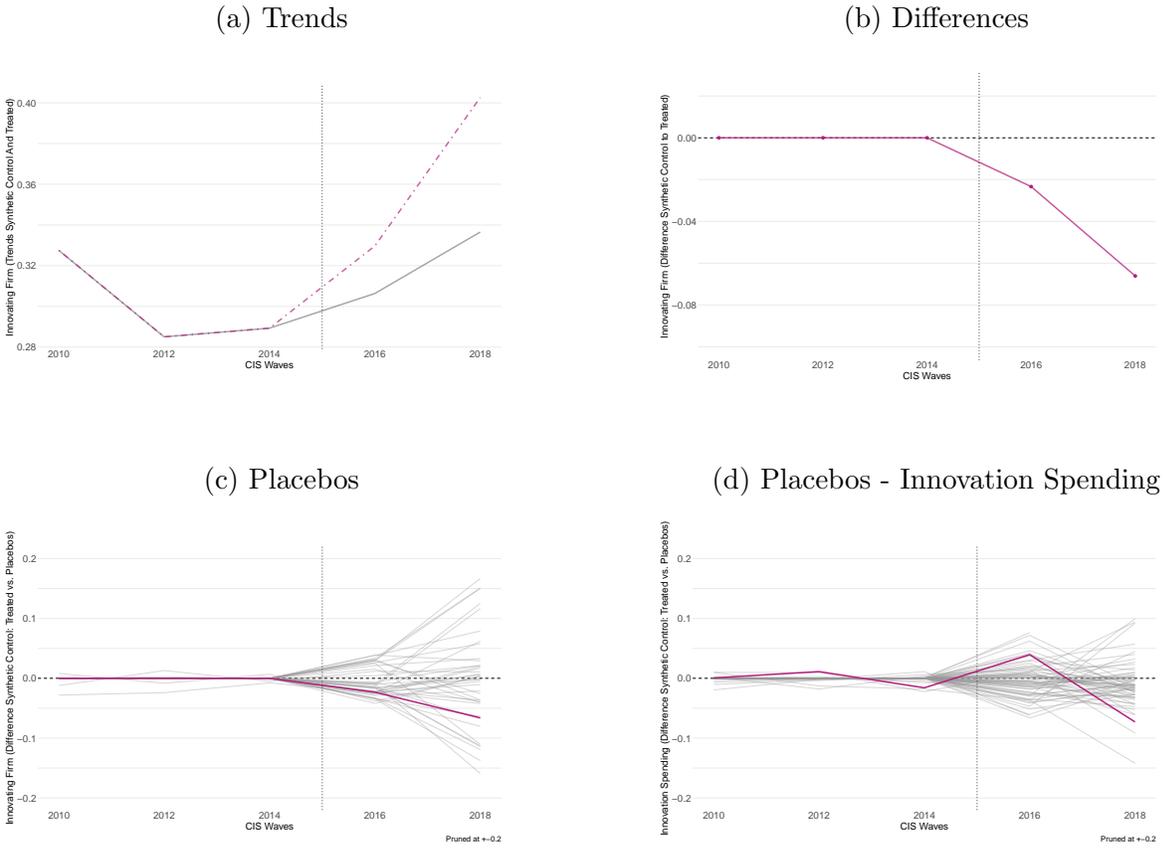
The synthetic control analysis constructs a weighted combination of control "donor" units that replicates the pre-reform trajectory of the treated observations based on pre-treatment values of *Innovating Firm*, with control observations aggregated at the country × industry × year level and treated observations collapsed annually to ensure a uniquely identifiable panel as required by the software. Figure OS3a depicts the evolution of the treated observations and their synthetic counterparts over time (the dot-dashed, colored line marks controls). Figure OS3b plots the difference between treated and synthetic outcomes. Figure OS3c presents placebo tests using donor units, showing post-reform divergence for the treated observations relative to placebo cases (the colored, bold line marks the treatment-trajectory). Figure OS3d presents placebo tests for *Innovation Spending* as outcome (with the synthetic control approach identically implemented as described for *Innovating Firm*).

Figure OS4: Leave One Out

(a) Country by Country
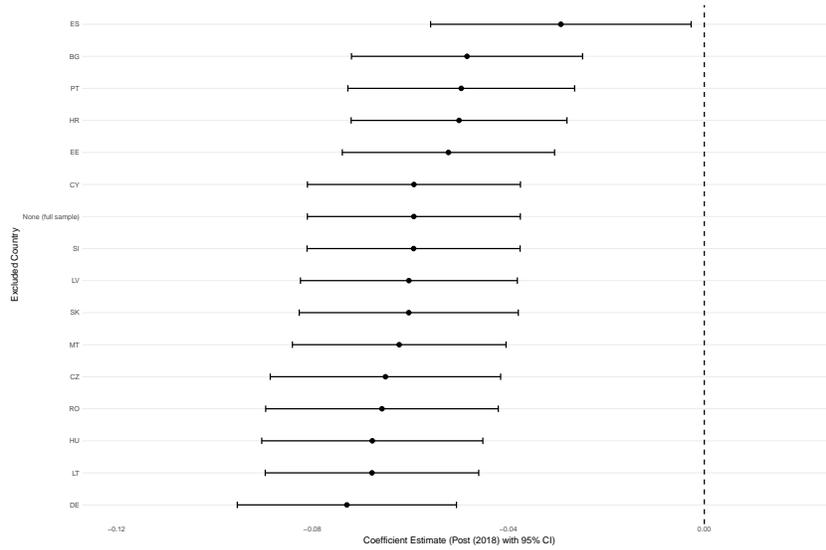
(b) Industry by Industry
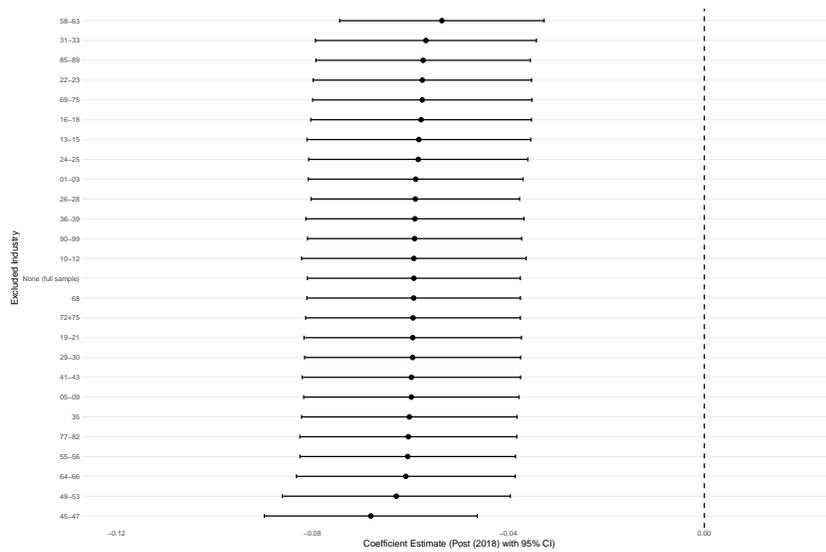
This figure depicts results from estimating equation (2) in a leave-one-out design, sequentially excluding each country (industry) from the sample in Figure OS4a (Figure OS4b). Dots depict the coefficient estimate for $Nexus_c \times Post_{2018}$, error-bars contain the 95% confidence bands.

Table OS1: Sampling Weights

	Micro θ (1)	Micro λ (2)	Micro μ (3)	Agg. θ (4)	Agg. λ (5)	Agg. μ (6)
	Innovating Firm					
Nexus $\times$ Post$_{2016}$	0.0113	0.0136	0.0089	-0.0013	0.0048	0.0046
	(0.0096)	(0.0107)	(0.0098)	(0.0117)	(0.0132)	(0.0126)
Nexus $\times$ Post$_{2018}$	-0.0350***	-0.0407***	-0.0445***	-0.0463***	-0.0482***	-0.0474***
	(0.0106)	(0.0097)	(0.0103)	(0.0156)	(0.0158)	(0.0157)
Controls	✓	✓	✓	✓	✓	✓
Country FEs	✓	✓	✓	✓	✓	✓
CIS FEs	✓	✓	✓	✓	✓	✓
NACE FEs	✓	✓	✓	✓	✓	✓
Observations	447,213	447,213	447,213	1,199	1,199	1,199
Adjusted R^2	0.14997	0.13858	0.13688	0.77382	0.76274	0.76656

This table reports weighted regression estimates of equatioin (2) using OLS. Sampling weights in the displayed set of regressions are derived from CIS sampling weights (missings are set to one) with the following adjustments: (θ) winsorizing weights at the 75th percentile, which broadly coincides with the common rule of trimming at 3.5 times the median; (λ) scaling weights by the country-average weight across CIS waves; and (μ) combining λ with winsorization at 3.5 $\times$ the median. Columns (1) to (3) show weighted regressions in the micro data with *Innovating Firm* as outcome variable. Data for the analyses in columns (4) to (6) are collapsed at the Country $\times$ NACE $\times$ CIS level: weights are used to construct weighted averages of *Innovating Firm* per cell when collapsing (i.e., *Inn. Firm Avg $_{weighted\ by\ \theta|\lambda|\mu}$*). Standard errors in parentheses are clustered at the Country $\times$ NACE level. Stars denote significance at the *** 1%, ** 5%, * 10% levels; (z) denotes standardization at mean zero and standard deviation one.