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Abstract

This paper studies how corporate tax hikes transmit across countries through multinationals' internal networks of subsidiaries. We build a parsimonious multicountry model to underscore two opposing spillover effects: While tax competition between countries generates positive investment spillover, intra-firm production linkages predict negative spillover. Using subsidiary-level data and exogenous corporate tax hikes, we find that local business units cut investment by 0.4% for a 1% increase in foreign corporate tax. This result highlights the importance of production linkages in propagating foreign tax shocks, as the supply-chain-induced negative spillover dominates the positive spillover effect suggested by the conventional wisdom of tax competition.

Keywords: tax hike, investment, internal networks, multinationals, spillover effects.

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"In today's world, I believe that any economic agenda must consider the potential for regional and global shocks to impact our supply chains, including those shocks driven by the policies of certain foreign governments."

– Janet Yellen (December 12, 2022)[1]

1 Introduction

Multinational companies are the main drivers of economic connections between countries (Alviarez, 2019).[2] While multinationals' internal networks of subsidiaries play a crucial role in the cross-border transmission of economic shocks (Cravino and Levchenko, 2017; Bena et al., 2022), it is unclear whether and how corporate tax changes propagate through these networks. Understanding the role of multinationals' networks in transmitting foreign tax policies is of first-order importance because taxes affect not only domestic investment, but also foreign direct investment (FDI).[3] Moreover, in the aftermath of the Covid-19 crisis and the resulting fiscal deficits, tax increases have become the center of fiscal policy debate.[4] In this paper, we examine how corporate tax hikes in one country propagate through multinationals' networks of subsidiaries and affect investments in other countries. Given the level of integration of multinationals through their supply chains, it is important for both policymakers and academics to understand the potential spillover effects of tax policy.

Prior theoretical models of tax competition suggest that the investment of a multinational in one country should increase if the business unit is exposed to a foreign corporate tax hike. The rationale is that following the tax hike, the parent firm will shift resources from the

[1] See "Resilient Trade" (`https://www.project-syndicate.org/magazine/biden-trade-agenda-emphasizes-resilience-by-janet-l-yellen-2022-12?barrier=accesspaylog`).

[2] In 2014, 55% of global exports and 49% of global imports were intra-firm transactions (OECD, 2018).

[3] For the literature on taxation and domestic investment, see, e.g., Romer and Romer (2010); Mertens and Ravn (2013); Ljungqvist and Smolyansky (2018); Giroud and Rauh (2019); Jacob et al. (2019). For a survey of studies on taxation and FDIs, see Feld and Heckemeyer (2011).

[4] The OECD has conjectured that "high public social-expenditure levels may contribute to fiscal consolidation pressures" after the Covid-19 pandemic (OECD, 2020, p. 27). Several countries have pondered tax rate increases to reduce the public debt. See, for example, recent articles in the Financial Times (`https://www.ft.com/content/5e1f616e-8cc4-4678-9bc7-3a6616742b07`) and the Wall Street Journal (`https://www.wsj.com/articles/u-k-unveils-tax-increases-and-spending-cuts-to-corral-debt-11668686757`).

foreign jurisdiction with higher taxation to the other subsidiary with relatively lower taxation. This mechanism is consistent with the models of location choice driven by corporate tax rates, in which higher taxes present a negative shock to a firm's operations in that foreign country (Devereux and Griffith, 1998). In short, the tax competition view predicts a *positive* spillover effect of tax hikes on other countries as multinationals shift investment abroad.

However, we argue that a focus on tax competition is incomplete because it does not capture the full picture of multinationals' networks, which feature significant intra-firm production linkages. As a novel contribution of this paper, we first develop a model that incorporates both tax competition between jurisdictions and production linkages between up- and downstream subsidiaries within a multinational company. We show analytically that production linkages can generate *negative* spillover effects. The intuition is that a tax hike in an upstream subsidiary triggers a transfer price effect, which reduces the marginal after-tax profitability in a downstream subsidiary and, hence, its investment. Likewise, when a tax hike happens in the downstream subsidiary, the after-tax profitability in the downstream subsidiary falls, which makes investment in the intermediate input by the upstream subsidiary less attractive.[5]

Our theoretical model thus highlights a surprising negative investment spillover due to within-multinational production linkages. Ex-ante, it is unclear which of the two theoretical channels—tax competition versus production linkages—dominates. Therefore, the impact of a tax increase in one subsidiary on the investment of another subsidiary (within the multinational) remains an open empirical question. The net effect (i.e., positive or negative spillover) depends on the relative importance of tax competition versus intra-firm interdependence.

To empirically test the implications of our model, we examine investment spillovers using the subsidiary-level data of multinational companies from 20 European countries during 2004–2017. To overcome the inherent endogeneity concern that tax changes are implemented

[5]The lower return in the downstream segment may not directly translate into less profitable upstream investment if the arm's length transfer price is set above the marginal productivity of the intermediate input. Therefore, the negative spillover effect may be muted when the tax hike happens in the downstream subsidiary. We explain these forces in detail in Section 2.

in response to local economic conditions, we exploit arguably *exogenous* corporate tax hikes using a narrative approach.[6] In our setting, the tax increases are exogenous in the sense that they are passed for non-economic reasons, such as social fairness, and are therefore independent of economic conditions—especially of those in the destination country where a local subsidiary operates. This feature allows us to separate the effect of tax policy shocks from confounding economic prospects in driving local firms' investment decisions.

Our identification strategy relies on a stacked difference-in-differences (DiD) design (Cengiz et al., 2019; de Chaisemartin and D'Haultfœuille, 2020; Sun and Abraham, 2021; Baker et al., 2022). Specifically, we examine the investment response in a multinational's subsidiary that is connected to another subsidiary of the same multinational. This other subsidiary is located in a different country where an exogenous corporate tax hike is imposed. The control group comprises subsidiaries of other multinationals that have no ties to the country with the exogenous tax change. Importantly, we require the subsidiary country (where we examine the investment response) and the headquarter country of the multinational to have no tax or major fiscal policy changes. These requirements enable us to capture the treatment effect of tax hikes that stems *only* from the foreign country to which the subsidiary is connected through the multinational's network. We control for subsidiary, industry–country–year, and parent country–year fixed effects. As a result, observable and unobservable country–industry forces cannot explain the investment differences between the treated and control subsidiaries in our tests.

We find that treated subsidiaries—those exposed to a tax hike emanating from abroad—reduce investment relative to other multinationals' subsidiaries without such exposure. This finding suggests that the negative effect of intra-firm production linkages outweighs positive spillovers from tax competition. The overall effect is economically sizable: on average, a 1%

[6] See Romer and Romer (2010), Devries et al. (2011), and Alesina et al. (2015b). The narrative approach examines government documents, such as presidential speeches and congressional reports, to determine the intention behind each tax policy and to ensure that related policies are not driven by prospective economic conditions. We do not include tax cuts in our empirical analysis because exogenous tax policies aim to reduce inherited budget deficits and, therefore, cannot be tax cuts. In contrast, tax cuts are overwhelmingly passed to stimulate economic growth (Romer and Romer, 2010).

increase in the foreign corporate tax hike intensity, measured as the increased tax revenue scaled by GDP, is associated with a drop in treated subsidiary investment of 0.4%. Our estimate of elasticity (–0.4) is thus very close to the corporate tax elasticity of –0.4 to –0.5 in Giroud and Rauh (2019) using a sample of multistate firms in the US. However, the spillover effect is significantly smaller than the *direct* impact of domestic corporate tax increase on domestic investment (elasticity of –1.1 in our sample). Moreover, we find that the spillover effect on investment occurs one year after the tax hike is effective and that there is a parallel trend in pre-treatment periods, supporting our identification assumptions.

We perform several analyses to isolate the two theoretical channels for a spillover effect, namely the production linkage channel and the tax competition channel. Consistent with the key insight from our model that within-firm production interdependence generates negative spillovers, we document a significantly stronger investment cut in subsidiaries that are customers of the subsidiaries in the tax-hike country. We obtain this result using country–industry pairwise input–output data, which allow us to map out the potential supply chain connections between subsidiaries. This finding is in line with the model's implication that highly taxed upstream revenues reduce the profitability of the downstream investment (via the arm's length transfer payment). In contrast, we find little evidence that foreign tax shocks propagate upstream from customers to suppliers. This is consistent with our model showing that, if the (arm's length) transfer price is set above the marginal productivity of the intermediate input from the upstream subsidiary, then a large part of the return and downstream tax base is shifted upstream. In this case, the negative marginal return effect on the upstream subsidiary is mitigated by the transfer price effect. Noticeably, these findings are consistent with the results of Briganti et al. (2018) that tax hikes are primarily supply shocks that transmit downstream but not the other way around.

We then examine the tax competition channel in two supplemental analyses using subsidiaries operating in non-tradable sectors. A prominent feature of the non-tradable sectors is that business relies mainly on local supply and demand (think about restaurants). We show that when international production linkages are less important, subsidiaries *increase* investment when their peer foreign subsidiaries are subject to a corporate tax hike. This positive spillover effect is consistent with the tax competition channel in which parent firms reallocate investment to a (relatively) less-taxed subsidiary. To further corroborate the tax competition channel, we exploit heterogenous responses based on the economic significance of tax-hike countries. In our model, tax competition is realized through changes in the so-called world interest rate (capturing the costs of funding for investment). When tax hikes are implemented in larger capital markets, they should trigger greater tax competition effects (i.e., positive investment spillover). We find support for this notion in the data.

In the final step, we show that when a subsidiary has greater product market power and, hence, the ability to pass the tax burden to its customers, the spillover effect is attenuated. Taken together, these findings support our model prediction and underscore production linkage as a mechanism underlying the baseline findings: While tax competition is present in some situations (e.g., in non-tradable sectors), on average, the production linkage channel dominates, leading to an economically significant negative spillover across countries.

Our paper contributes to two strands of literature. First, our study adds to the literature on fiscal policy and, in particular, the role of taxes in investment decisions (Romer and Romer, 2010; Mertens and Ravn, 2013; Ljungqvist and Smolyansky, 2018; Giroud and Rauh, 2019; Jacob et al., 2019; Glaeser et al., 2022).[7] Unlike in these studies, a new key finding in our paper is the sizeable negative spillover effect on *other* countries via production linkages within multinationals' internal networks. Since this result contrasts with the canonical tax competition argument, we extend—both theoretically and empirically—the literature on cross-border investment spillover. We highlight a distinct transmission mechanism via production linkages and provide a micro-level explanation using subsidiary-level data.

Our study also contributes to the burgeoning literature on firms' internal interdependence and internal networks. For example, Giroud and Mueller (2015, 2019), Cravino and

[7] Most of this work focuses on aggregate domestic outcomes, such as the GDP. Ramey (2011), Favero and Karamysheva (2015), and Alesina et al. (2019a,b) provide excellent reviews on this topic.

Levchenko (2017), and Bena et al. (2022) use establishment or subsidiary data to investigate the transmission of economic shocks. Here, we examine foreign policy (i.e., tax) shocks. Our findings, underscoring how firms' internal networks transmit these policy shocks, provide a potential explanation for the correlation in growth rates across countries (Burstein et al., 2008; Johnson, 2014).[8] Our theoretical exercises, which feature intra-firm production interdependence and tax competition, also complement the models of intersectoral linkages between firms (Acemoglu et al., 2012, 2016) and expand the classic models on cross-border tax competition (Harberger, 1962; Devereux and Griffith, 1998, 2003).

Our work also has policy implications. Given the soaring budget deficits around the globe due to the Covid-19 crisis and the need to increase tax revenues, we provide timely evidence of spillover effects across countries. We show that aside from the impact on the domestic economy, tax hikes can reduce investment in other countries due to the interconnectedness of economies via multinationals' networks. These results echo the call by some policymakers for joint actions to minimize potential negative spillovers (see the opening quote).

2 Theory and hypotheses

To guide our empirical tests on how corporate tax hikes propagate within a multinational's internal network, we embed an international production chain into a standard model of a multinational. We then derive—given tax-efficient capital structures—predictions on the investment spillover effects of tax hikes in one subsidiary on related subsidiaries in other countries. In this section, we focus on the main aspects and key results of the model. We relegate all formal derivations to the Internet Appendix to conserve space.

[8] Recent studies on firms' supply networks include Elliott et al. (2022) and Crosignani et al. (2023). Our paper is also related to studies that examine the internal capital markets and resource allocations within conglomerates (e.g., Lamont, 1997; Khanna and Tice, 2001; Campello, 2002; Gopalan et al., 2014; Matvos and Seru, 2014; Duchin et al., 2017).

2.1 Tax competition versus international production chains

In standard tax competition models, there is a fixed stock of capital that is internationally mobile (see, e.g., Keen and Konrad, 2013, for an overview). The intuitive outcome of these models is that when one country increases its tax rate, ceteris paribus, investment incentives in this country decrease, and capital flows out of this country until the marginal after-tax productivity of capital (or firms' marginal profits) is rebalanced. Consequently, a higher tax rate in one country triggers a positive externality on other countries because capital investment flows from the tax-hike country to the other countries with lower tax rates.

If one extends the early tax competition models, which rely on purely productive capital, by incorporating a perfectly integrated world capital market, the positive spillover of a tax increase works via changes in the so-called world interest rate. Effectively, the world interest rate represents the return on portfolio investment and reflects the costs of funding physical (real) investment.[9] The after-tax profitability in each country meets the world market interest rate. When a sufficiently large country increases its tax rate, investment in this large country declines, which in turn creates excess supply on the world capital market. As a result, the market interest rate decreases because of less demand for capital investment in the high-tax country. The resulting drop in the world market interest rate leads to more capital investment in all other countries. This is the positive externality under tax competition: Higher taxes in one country should *increase* investment in other countries.[10]

However, the traditional tax competition framework neglects the emergence of vertically integrated multinationals in which subsidiaries are interlinked through production chains. Considering such production linkages is important because, for example, a tax increase in a downstream subsidiary not only makes the production of the final goods less profitable but also transmits the profitability shock along the supply chain to the upstream subsidiary, leading to less attractive investment in the intermediate goods production. As a result,

[9] Specifically, from the point of view of a firm, the world market interest rate in tax competition models is the cost of capital before taxation and a key driver of effective capital costs.

[10] See, e.g., Eggert and Kolmar (2002) for an early application of the separation between financial and physical capital investment in an analysis of information exchange agreements.

the production linkage could potentially counteract the positive externality generated by tax competition. The resulting tension between these channels—tax competition versus integrated production chains—is at the core of our theoretical model described below.

2.2 The model

We model a vertically and horizontally integrated multinational with the parent domiciled in country p. The multinational owns one upstream subsidiary and two downstream subsidiaries. The upstream subsidiary resides in country C and the two downstream subsidiaries are in countries A and B. Without loss of generality, we assume that subsidiaries A and B are homogeneous whereas subsidiary C faces a different corporate tax rate and that the parent is a pure holding company. All subsidiaries are fully owned by the parent.

Upstream subsidiary C uses capital input K_C to produce intermediate input S with the concave production function $S = G(K_C)$. The intermediate input is firm specific in the sense that it is only used in the downstream subsidiaries and that there is no trade with third parties. All units of the intermediate input are sold to the two related downstream subsidiaries. Each downstream subsidiary produces a homogeneous good that is sold to final customers in its market (country). We assume that each subsidiary faces perfectly elastic demand so that we can normalize the price of the final goods to one.[11] Production in downstream subsidiary $i = A, B$ uses capital input K_i and S_i units of the intermediate input. The production function takes the form $y_i = F(K_i, S_i)$. We assume positive but decreasing marginal productivity for each input and that the two input factors are complements. Thus, $\frac{\partial F(K_i,S_i)}{\partial K_i} = F_K^i > 0$, $\frac{\partial^2 F(K_i,S_i)}{\partial K_i^2} = F_{KK}^i < 0$, $\frac{\partial F(K_i,S_i)}{\partial S_i} = F_S^i > 0$, $\frac{\partial^2 F(K_i,S_i)}{\partial S_i^2} = F_{SS}^i < 0$, and $\frac{\partial^2 F(K_i,S_i)}{\partial K_i \partial S_i} = F_{KS}^i > 0 \ \forall i = A, B$.

The multinational is sufficiently small relative to a perfectly integrated world capital market so that its cost of capital is exogenous. All capital (i.e., fixed assets) is financed by

[11] Relaxing this assumption would imply that subsidiaries can shift part of their tax hike burden into the price of the final goods (i.e., to consumers). Such behavior would dampen the production linkage that we attempt to identify. We come back to this point in Section 2.5 (see the discussion related to Conjecture 1).

equity E or external debt D from third parties.[12] Following previous tax literature, we assume that equity and debt carry the same cost of capital r (also referred to as the world market interest rate). While the interest rate is exogenous to the multinational, we assume that each country is sufficiently large to have some effect on the world interest rate. Specifically, we assume that a tax increase in one country reduces the world market interest rate because of lower investment in that country. Consequently, we have $r = r(t_A, t_B, t_C)$ with $\frac{\partial r}{\partial t_i} < 0 \; \forall \; i$. This provides a simple way to capture the standard tax competition effect in our model.

Following the trade-off theory, external debt brings additional benefits and costs compared to equity.[13] We label these additional benefits and costs as "agency costs" and assume that they are subsidiary specific. We denote a subsidiary's debt-to-asset ratio by $b_i = \frac{D_i}{K_i}$ and the optimal debt-to-asset ratio in the absence of taxation by b_i^*. In line with the literature, we assume that the agency costs per unit of capital are U-shaped in the debt-to-asset ratio and that they increase monotonically after the optimal debt-to-asset ratio is reached (Huizinga et al., 2008). Differing from previous literature, to simplify the mathematics to follow, we assume that total agency costs are proportional to a subsidiary's capital costs $r \cdot K_i$ (rather than proportional to capital stock K_i). Thus, we can write the agency costs as

$$C^E = C(b_i) r K_i \;\text{ with }\; C_b(b_i) > 0 \;\text{ if }\; b_i > b_i^*, \;\; C_b(b_i) < 0 \;\text{ if }\; b_i < b_i^*, \;\text{ and }\; C_{bb}(b_i) > 0. \quad (1)$$

Note that we assume that the parent does *not* guarantee for any debt at the subsidiary level. Therefore, there are no overall bankruptcy costs.

[12]We neglect aspects such as external and internal debt shifting and parental debt that are part of a tax-efficient capital structure (see Huizinga et al., 2008; Goldbach et al., 2021). As we show below, tax-induced changes in the debt-to-asset ratio do not have a first-order effect on capital investment, cf. equation (A.8). However, due to external debt shifting, an increase in the external debt-to-asset ratio in response to a foreign tax hike would have adverse effects on domestic capital costs. This could generate an additional mechanism that complements the production link that we identify.

[13]Most importantly, debt induces monitoring by the capital market. As a result, debt has a disciplining effect on managers, reduces information asymmetries, and limits agency costs (Jensen and Meckling, 1976; Jensen, 1986). However, too much external debt can trigger excessive risk-taking and induce debt overhang (Myers, 1977). Furthermore, high debt increases the likelihood of financial distress and expected bankruptcy costs (Kraus and Litzenberger, 1973). See Hovakimian et al. (2004) and Aggarwal and Kyaw (2010) for an overview of the trade-off theory and of the costs and benefits of external debt.

The multinational is centralized, and all decisions are made by the parent. Each subsidiary i faces a constant corporate tax rate t_i. For the tax system, we follow most OECD countries in that (a) revenues are taxed, (b) costs of intermediate inputs and cost of debt are deductible expenses, and (c) costs of equity are not tax-deductible. Furthermore, we assume that the exemption method applies to the foreign income of subsidiaries, as it is implemented in almost all countries worldwide, including the US.[14] This implies that all profits are taxed at source and that there is no additional tax on inter-corporate dividends. Therefore, it is also immaterial in which country the parent is residing.

We assume that the tax authorities set and enforce arm's length price q for the intermediate input. This price could be inferred from observing the average quality of the intermediate in the market or from applying some of the OECD transfer pricing methods. It might also be that the tax authority sets an arm's length price "opportunistically" and then enforces it (Mescall and Klassen, 2018).[15] Accordingly, the arm's length price q at which the intermediate input trades is exogenous to the multinational firm.

To sum up, after-tax profits π_i of a downstream subsidiary $i = A, B$ are given as

$$\pi_i = (1 - t_i)[F(K_i, S_i) - qS_i] - [1 - t_i b_i + (1 - t_i)C(b_i)]rK_i,$$

where the squared bracket in the first term represents EBIT (i.e., sales minus the transfer payment for the intermediate input) and the second term represents net capital costs. The

[14]Since the United Kingdom, Japan and the US (in its 2017 tax reform) have switched to the exemption method over the last 15 years, this method is relevant for the overwhelming majority of OECD countries (and, due to the EU Parent-Subsidiary Directive, applies to all European Union countries). The remaining exceptions in the OECD are Chile, Israel, Mexico, and South Korea.

[15]To focus on the main tension between tax competition and intra-firm production chains and to keep the model tractable, we neglect tax-motivated transfer pricing. Whether tax-motivated transfer pricing affects investment is unclear and disputed. The scarce empirical evidence is contradictory (see Buettner et al., 2018; de Mooij and Liu, 2020). In theoretical analyses, Juranek et al. (2018) show that there is no investment effect of tax-motivated transfer pricing in intangibles under the standard OECD transfer pricing methods. By contrast, Nielsen et al. (2022) show investment effects of tax-motivated transfer pricing in tangible intermediate goods under most OECD transfer pricing methods. The latter finding, however, does not apply in the case of the transactional net margin method.

upstream subsidiary earns after-tax profits

$$\pi_C = (1 - t_C)q(S_A + S_B) - [1 - t_C b_C + (1 - t_C)C(b_C)]rK_C.$$

Global after-tax profits of the multinational Π_p are consolidated profits across subsidiaries:

$$\begin{aligned}
\Pi_p &= \pi_A + \pi_B + \pi_C \\
&= (1 - t_A)F(K_A, S_A) - [1 - t_A b_A + (1 - t_A)C(b_A)]rK_A \\
&+ (1 - t_B)F(K_B, S_B) - [1 - t_B b_B + (1 - t_B)C(b_B)]rK_B \\
&+ (t_A - t_C)qS_A + (t_B - t_C)qS_B - [1 - t_C b_C + (1 - t_C)C(b_C)]rK_C,
\end{aligned} \tag{2}$$

where $S_A + S_B = S = G(K_C)$.

To maximize global profits in equation (2), the multinational chooses debt-to-asset ratio b_i and capital investment K_i in each subsidiary i and decides on the allocation of the intermediate input on the downstream subsidiaries, i.e., S_A and S_B.

2.3 Optimal behavior

For each subsidiary, the multinational chooses debt-to-asset ratio b_i such that marginal debt-tax shield $\frac{t_i r}{1-t_i}$ equals marginal agency costs $C_b(b_i)$. From equation (A.2), we have:[16]

$$\frac{t_i}{1 - t_i} = C_b(b_i), \quad \forall\ i = A, B, C. \tag{3}$$

Given tax-efficient capital structure b_i, the optimal capital investment in a downstream subsidiary is (see equation (A.4)):

$$F_K^i = \tilde{r}_i, \quad i = A, B, \tag{4}$$

[16]See the Internet Appendix for details on deriving all first-order conditions presented in this section.

where $\tilde{r}_i = [1 - t_i b_i + (1 - t_i)C(b_i)]\frac{r}{1-t_i}$ represents effective capital costs after taxation and marginal productivity of capital F^i_K meets effective capital costs. Importantly, note that a small change in the tax-efficient capital structure (i.e., b_i) does not affect a subsidiary's effective capital costs. See equation (A.8).

Similarly, the marginal net productivity of investment K_C in the upstream subsidiary must equal effective capital costs in that subsidiary, as we obtain from equation (A.5):

$$\left[\frac{1 - t_B}{1 - t_C} F^B_S + \frac{t_B - t_C}{1 - t_C} q\right] G_K = \tilde{r}_C. \tag{5}$$

The net marginal productivity of investment into the intermediate input depends on the tax-adjusted increase in sales revenues in the downstream subsidiaries, $\frac{1-t_B}{1-t_C} F^B_S G_K$, and the additional tax savings from increased transfer payments to subsidiary C, i.e., $\frac{t_B-t_C}{1-t_C} q G_K \gtrless 0$.

Finally, the multinational allocates the intermediate input to the two downstream subsidiaries such that the marginal (after-tax) productivity of the intermediate input equalizes. This requires adjustment for the differential tax gain from deducting the transfer payment from the local tax base at the local tax rate, i.e., $(t_A - t_B)q$. See equation (A.6). As the downstream subsidiaries are symmetric, the condition simplifies to balancing the before-tax marginal productivity of the intermediate input such that

$$F^A_S = F^B_S. \tag{6}$$

Using one more unit of the intermediate input S in any of the downstream subsidiaries triggers the same increase in sales revenues.

2.4 Responses to tax policy changes

The optimal investment behavior described above helps inform the investment response to changes in corporate tax. For the investment responses in the tax-hike country, our model predicts that investment decreases as long as transfer price effect and the change in the world market interest rate do not overcompensate the direct taxation effect.[17] Moreover, our model is in line with extensive empirical evidence that higher domestic corporate taxes reduce domestic investment or inbound FDI (see, e.g., de Mooij and Ederveen, 2003; Giroud and Rauh, 2019).

Our main interest, however, is to identify the within-multinational spillover effect generated by a tax hike in one of its subsidiary countries. First, we assess the investment response in the downstream subsidiaries when an increase of tax hits the upstream subsidiary. From equation (A.16), we see that

$$\frac{dK_A}{dt_C} = \frac{dK_B}{dt_C} = \overbrace{\frac{(SOC_{33} - F_{KS}^2 G_{KK} U)\, X - F_{KS} G_K (F_{KK} F_{SS} - F_{KS}^2) \frac{X_C}{1-t}}{|H|} \frac{\partial r}{\partial t_C}}^{\textit{tax competition}} + \underbrace{\frac{F_{KS} G_K (F_{KK} F_{SS} - F_{KS}^2)}{|H|} \frac{[b_c + C^C(b_C)]r}{1-t} - \frac{F_{KS} G_K^2 (F_{KK} F_{SS} - F_{KS}^2)}{|H|} \frac{q}{1-t}}_{\textit{production linkage}} \gtrless 0, \tag{7}$$

where $SOC_{33} = [2F_{SS}F_{KK} - FKS^2](G_{KK}U + F_{SS}G_K^2) - F_{KK}F_{SS}^2G_K < 0$ is the determinant of the 3×3 sub-matrix of the Hessian, which is negative by the second-order conditions. Furthermore, $|H| > 0$ is the determinant of the Hessian itself, which is positive by the second-order conditions. Finally, to save notation, $X_i = \frac{1-t_i b_i + (1-t_i)C(b_i)}{1-t_i} > 0$ from effective capital costs, and $U = F_S + \frac{t-t_C}{1-t} q > 0$ by the second-order conditions.

We highlight two key channels—the *tax competition* channel and the *production linkage* channel—as shown in equation (7). The first channel, tax competition, is shown in the first line of equation (7). A higher tax rate in country C makes investment relatively less attractive there, frees up capital for investment in other countries, and reduces the world market interest rate ($\frac{\partial r}{\partial t_C} < 0$). This leads to positive investment spillover in other countries.[18]

[17] Importantly, the interest rate effect in isolation can never overcompensate the direct effect of the tax increase. To achieve a favorable terms-of-trade effect, there needs to be some excess supply on the world market. Thus, at least one country needs to reduce its capital demand to decrease the interest rate in equilibrium.

[18] As larger countries have a stronger impact on the capital market, the tax competition effect should be stronger the larger the country with the tax hike. Note that the presence of production links weakens the tax competition effect, as shown in the positive second part ($-F_{KS}^2 G_{KK} U > 0$) of the first term.

The second channel, production linkage, shows up in the second line of equation (7). This channel comprises two related, but distinct, effects, namely a marginal return effect and a transfer price effect. The *marginal return effect* is captured by the first term in the second line of equation (7). Higher tax intensity in subsidiary C fosters leverage, which decreases after-tax capital costs due to the debt tax shield. Therefore, investment into the intermediate input becomes more attractive, which in turn makes investment into final goods production more productive. Importantly, the driving force behind this unexpectedly positive effect is the fact that the returns on the intermediate input are effectively taxed via sales revenues in the downstream subsidiaries. Accordingly, the tax increase in country C does not directly fall on the marginal productivity of the intermediate input and the standard corporate tax distortion does not apply.[19] The *transfer price effect*, which is captured by the last term in the second line, triggers a *negative* spillover in downstream investment. The more marginal revenue is passed on from a downstream subsidiary to the upstream subsidiary (via arm's length transfer payment q), the more profits get taxed at the now higher rate in country C. The larger tax burden on revenues makes investment into the intermediate input less profitable. The resulting reduction in investment into the intermediate input also decreases the productivity of capital in the downstream subsidiaries, which dampens the overall economic activity of the multinational. This explains the negative spillover effect.

Next, we examine how a tax hike faced by the downstream subsidiaries affects investment in the upstream subsidiary. From equation (A.17), we obtain

$$\frac{dK_C}{dt_A} = \frac{dK_C}{dt_B} = \overbrace{-\frac{2[F_{KK}F_{SS} - F_{KS}^2]F_{KS}G_K X - 2F_{KK}[F_{KK}F_{SS} - F_{KS}^2]X_C}{|H|}\frac{\partial r}{\partial t_A}}^{\textit{tax competition}} \tag{8}$$

$$\underbrace{-\frac{F_{KS}G_K[F_{KK}F_{SS} - F_{KS}^2]}{|H|}\frac{(1-b)r}{(1-t)^2} + \frac{F_{KK}[F_{KK}F_{SS} - F_{KS}^2]G_K}{|H|}\frac{F_S - q}{1-t}}_{\textit{production linkage}} \gtrless 0.$$

[19]This is the main difference from tax increases in downstream subsidiaries where the standard corporate tax distortion overcompensates the leverage effect and turns the marginal return effect into a negative spillover.

Again, two competing channels emerge. First, the standard tax competition channel ($\frac{\partial r}{\partial t_A} < 0$) generates a positive investment spillover (see the first line in equation (8)).

Second, the production linkage channel (the second line in (8)) comprises two effects: The marginal return effect generates *negative* spillover on the upstream subsidiary. This is shown in the first term in the second line of (8). The more that the tax burden falls on the normal rate of return in the downstream subsidiary, i.e., the larger $(1-b)r$ is, the more the tax hike reduces the downstream investment. Lower downstream investment makes the intermediate input less productive and, hence, disincentivizes investment in the upstream subsidiary.[20]

The last term in equation (8) represents a transfer price effect, which is ambiguous and may offset the marginal return effect. Here, the intuition is that if arm's length price q is below (above) the marginal productivity of the intermediate input, a downstream tax hike causes a negative (positive) investment effect in the upstream subsidiary. If the arm's length price is insufficient to cover the marginal value of the intermediate input ($F_S > q$), a part of its marginal return is taxed in the downstream subsidiary. Thus, a downstream tax hike increases the tax burden on the marginal intermediate input and causes a negative spillover. The opposite applies for $F_S < q$, where part of the marginal return on capital in the downstream subsidiary becomes effectively taxed in the upstream subsidiary.

Finally, we discuss the effect of a tax hike in country B on the investment in country A. That is, we explore the cross-country effect of a tax increase between subsidiaries without direct trades, such as subsidiaries in non-tradable sectors. Following equation (A.18),

$$\begin{aligned}\frac{dK_A}{dt_B} &= \frac{(SOC_{33} - F_{KS}^2 G_{KK} U)\, X - F_{KS} G_K (F_{KK} F_{SS} - F_{KS}^2) \frac{X_C}{1-t}}{|H|} \frac{\partial r}{\partial t_B} \\ &- \frac{F_{KS}^2 G_{KK} U}{|H|} \frac{(1-b)r}{(1-t)^2} + \frac{F_{KS} F_{KK} G_{KK} U}{|H|} \frac{F_S - q}{1-t} \gtrless 0. \end{aligned} \tag{9}$$

[20] An implication of our analytical results is that this effect matters less if a smaller proportion of the cost of equity is non-deductible, i.e., the more levered the subsidiary is. A tax on pure rents in the downstream subsidiary would not cause this effect via distorting marginal returns.

Three effects are relevant. First, the standard tax competition effect via $\frac{\partial r}{\partial t_B} < 0$ is similar to the previous cases in equations (7) and (8) and triggers positive investment spillover (see the first line in equation (9)). Second, the marginal return effect turns into a substitution effect as shown in the first term of the second line. As soon as the tax burden falls on the normal rate of return $(1 - b > 0)$, a tax increase in country B makes it more attractive to invest in the final output in the other downstream subsidiary A. The reason is that economic activity in A is taxed at a lower rate $(t_a < t_b)$. Third, an ambiguous transfer price effect applies. If the arm's length price is below the marginal productivity of the intermediate input $(F_S > q)$, part of the return becomes taxed downstream, and it is preferable to relocate investment to the relatively less-taxed downstream subsidiary. Therefore, the effect triggers a positive spillover. In the opposite case $(F_S < q)$, part of the return on downstream investment effectively gets taxed in the upstream subsidiary. To benefit from higher tax deductibility, it is then profitable to shift investment from the relatively less-taxed downstream subsidiary to the tax-hike downstream subsidiary. This translates into a negative spillover effect.

2.5 Empirical predictions and discussion

Given the tension between intra-firm production chains and tax competition as embedded in the above framework, we propose the following hypothesis:

Hypothesis *A tax hike in a multinational's subsidiary triggers a negative (positive) investment spillover on other related subsidiaries if the production linkage channel is relatively strong (weak) compared to the tax competition effect.*

Several observations related to our hypothesis are noteworthy. First, a potential negative investment spillover may transpire in cases of tax hikes in both upstream and downstream segments, as encapsulated in equations (7) and (8). The strength of the spillover crucially depends on the volume of the (marginal) intra-firm payments and the value of the intermediate goods (q). When a tax hike happens in the downstream subsidiary, the negative spillover generated by the marginal return effect could be offset by the transfer price when such a price is set to cover (or exceed) the marginal value of the intermediate input ($F_S < q$). Additionally, when one extends our model to several downstream subsidiaries, the relative weight of one downstream subsidiary decreases. Thus, if a tax hike happens in one (small) affiliate of many downstream subsidiaries, the production linkage to the upstream subsidiary will be muted. Consequently, it is reasonable to hypothesize that a tax hike in an upstream subsidiary triggers greater negative spillover than a tax hike in a downstream subsidiary.

Second, and as a natural proposition of our model, sectors with limited supply chain linkages (e.g., non-tradable industries) are mainly subject to a tax competition effect, namely a positive investment spillover. This is because, in these sectors, intra-firm trade and transfer payments are not material so that the transfer price effect is muted.

Third, the effect of tax competition should be larger if the tax hike happens in an economically significant larger country because such an economy has a stronger impact on the capital market equilibrium and the world interest rate. Here, an implication is that tax hikes in economically larger countries enhance the tax competition effect and reduce the overall (potentially) negative spillover. We test these predictions in the following sections.

We end our discussion with an extension of the model that captures firms' market power. In Section 2.2, we focus on price-taking multinationals that cannot shift their tax burden onto consumers. We do so to keep the comparative-static analysis tractable. To the extent that some multinationals have market power, they can pass part of the tax burden onto consumers via higher sales prices of the final output goods. Looking at the first-order conditions in equations (4) and (5), we easily see that increasing the sales price, and with it the marginal revenue on the LHS, is an alternative to reallocating capital investment to rebalance marginal benefits and capital costs following a tax hike. Loosely speaking, the price increase will offset the tax increase. Accordingly, when going beyond our model, we suggest the following:

Conjecture *The spillover effect is muted when the market power of multinationals increases because passing the tax burden onto consumer prices mitigates the marginal return effect.*

3 Estimation approach and data

In this section, we discuss our empirical approach to testing the theoretical hypothesis. Our empirical exercise proceeds in two steps. First, we explore the *average* spillover effect to understand whether it is positive (i.e., the tax competition channel dominates) or negative (i.e., the production linkage channel dominates). This analysis thus gives us a sense of the overall importance of the spillover. Second (see Section 5), we attempt to tease out the specific channels—production linkages versus tax competition—guided by the theoretical predictions outlined in Section 2.

3.1 Exogenous corporate tax hikes

Our empirical approach explores corporate tax changes. However, corporate tax laws change for various reasons. Some changes are adopted in response to factors likely to affect output growth. Others are implemented independent of prospective economic conditions. This latter category of policy shifts is our subject of interest because these tax hikes are typically passed for philosophical reasons (e.g., social fairness) or result from complex political processes, making the prediction of their adoption difficult (Romer and Romer, 2010; Alesina et al., 2015b). Crucial to our identification, we require the tax policies in one country to be exogenous to the economic conditions in the destination country where we examine the investment activities of subsidiaries.

We obtain data on corporate tax hikes from Devries et al. (2011) and Alesina et al. (2015b). The data identify exogenous fiscal plans based on a narrative approach, which examines government policy documents to identify the intentions behind each policy shift. To ensure exogeneity, we exclude tax hikes passed in response to prospective economic conditions (i.e., endogenous policies). In most cases, exogenous shocks are purely motivated by a desire to reduce inherited government deficits.[21] As Romer and Romer (2010, p. 770) write,

[21]For this reason, we do not and cannot explore tax cuts because they do not satisfy the exogeneity criteria by Romer and Romer (2010).

"[a]n inherited deficit reflects past economic conditions and budgetary decisions, not current conditions or spending changes. If policymakers raise taxes to reduce such a deficit, this is not a change motivated by a desire to return growth to normal or to prevent abnormal growth. So it is exogenous." Since Romer and Romer (2010), exogenous tax hikes have been widely used in the related literature (e.g., Mertens and Ravn, 2014; Guajardo et al., 2014; Giroud and Rauh, 2019).

In Table 1, we report the eight exogenous corporate tax hikes in our sample of European countries from 2004 to 2017. These tax hikes comprise both tax rate increases and tax base broadening (e.g., cutting allowances and deductions).[22] Two observations are noteworthy: First, because we focus on exogenous corporate tax increases introduced to reduce inherited deficits, these tax changes are often implemented following episodes of high sovereign debt. In contrast, endogenous policies adopted following crises to boost investments would require a *decrease* of taxes. Second, tax hikes are often amended on the run, making it difficult for economic agents to formulate expectations about the future (Alesina et al., 2015b).[23]

3.2 Empirical specification

Our empirical setting focuses on subsidiaries located in a non-tax-hike country. The appeal of studying firms in non-tax-hike countries is that the direct impact of tax hikes cannot explain any investment response by local firms. Our goal is to compare the investment of a business

[22]For example, in 2012, Spain significantly decreased the allowance for accelerated depreciation on long-term assets. In 2010, Portugal increased the corporate income tax rate (up to 9%) for larger firms with taxable profits exceeding a given threshold. Therefore, we report the tax hike intensity using the increased tax revenue scaled by the tax-hike country's GDP (in $t-1$) in Table 1.

[23]Some work (de Cos and Moral-Benito, 2016; Jorda and Taylor, 2016) reveals that some macroeconomic fluctuations in the source country can predict fiscal adjustments. However, these findings do not jeopardize our identification strategy because we only require the shocks to be independent of the economic conditions in the foreign country of subsidiaries. We confirm this assumption by investigating whether the tax hikes in our sample are systematically correlated with economic conditions in a different country where we compare subsidiary investments. We apply a pooled probit estimator. The dependent variable equals one if country i passes a tax hike in year t and zero otherwise. The independent variables are economic fluctuations (e.g., de Cos and Moral-Benito, 2016) in country j measured at $t-1$. Table A1 of the Internet Appendix shows that among a large set of economic determinants, none correlates with our tax hikes, confirming our underlying assumption that shocks in a *source* country (which we exploit) are exogenous to economic conditions in other *foreign* countries (where we run our subsidiary-level analyses).

subsidiary with exposure to tax hikes through a foreign entity in the same multinational group ("treated unit") to the investment of other firms without such exposure ("control units"). Connecting this empirical design to our model and assuming a tax hike in country C, we effectively compare investment differences in country A between treated subsidiaries with a connection to C and control subsidiaries whose multinational group is not present in C. We choose other multinationals' subsidiaries as the control group to account for differences between a multinational's subsidiary and standalone domestic firms. This way, both the treated and control subsidiaries are part of an internal international network. We also require that the parent countries of both the treated and the control multinationals not be subject to a tax policy change because shocks from the parent country could directly influence the subsidiary investment (Cravino and Levchenko, 2017). Returning to the example above, we exclude all multinationals headquartered in country C. Therefore, in our setting, the tax shock comes directly and solely from a foreign subsidiary country within the multinational's network. The tax shock can occur in either a downstream or an upstream subsidiary.

We use a stacked DiD method to estimate the average treatment effect (ATE) on changes in investment. As the corporate tax changes are implemented in a staggered manner, later-treated groups could act as controls before their treatment, while earlier-treated groups could serve as controls after treatment. This feature could lead to biased estimates of treatment effects in staggered DiD designs with two-way fixed effect regressions (see, e.g., Cengiz et al., 2019; de Chaisemartin and D'Haultfœuille, 2020; Barrios, 2021; Callaway and Sant'Anna, 2021; Sun and Abraham, 2021). Baker et al. (2022) propose stacked DiD estimation to overcome the above issues. Specifically, we apply stacked DiD estimation in two steps. To start, for each corporate tax hike, we create an event-specific cohort that includes subsidiaries with tax-hike exposure (treated subsidiaries) and subsidiaries that have no ties to the tax hike within –3 and +3 years around the tax-hike year ("clean" controls). Therefore, in our event-specific panel—each consisting of seven years centered around the tax hike—already-treated units never serve as controls so that the heterogeneous treatment problem described in Baker et al. (2022) does not occur. We then stack all the event-specific datasets in relative time and perform the DiD estimation on the stacked data. Our estimation equation is

$$Investment_{i,t,e} = \alpha + \beta \cdot Tax\ hike_i \times Post_{t,e} + \gamma \cdot Controls_{i,t-1,e} + \lambda_{i,e} + \delta_{p,t,e} + \mu_{s,t,e} + \epsilon_{i,t,e} \quad (10)$$

where the dependent variable is the investment of subsidiary i in year t of event e. The key variable of interest is the interaction term of *Tax hike*×*Post*. The variable *Tax hike* equals one for the treated subsidiary and zero otherwise. The indicator variable *Post* equals one after the tax-hike year and zero otherwise. In all regressions, we include event-specific subsidiary fixed effects, $\lambda_{i,e}$, parent country–year fixed effects, $\delta_{p,t,e}$, and subsidiary country–year fixed effects, $\mu_{s,t,e}$.[24] With these fixed effects, we control for determinants of investment that persist within subsidiaries and time-varying shocks that come from the parent and subsidiary countries (such as local demand shocks or economic prospects). In some specifications, we also control for more granular subsidiary country–year–industry fixed effects to account for industry factors driving local investment in a given year. These fixed effects fully subsume the standalone estimates of *Tax hike* and *Post*, so we only keep their interaction term (i.e., *Tax hike*×*Post*) in the regression. The control variables include subsidiary-level cash holdings, profitability, logarithm of asset size, and sales growth.[25] Following the suggestion in Petersen (2008), we double cluster standard errors at the subsidiary–event and parent–event levels.

We are mainly interested in coefficient β. A negative estimate of β would support negative spillover from foreign tax hikes due to production linkages. In contrast, the tax competition hypothesis would predict a positive β. In some tests, we replace the *Tax hike* indicator and use a continuous measure of the tax hike intensity (percentage of the GDP) following Romer and Romer (2010) to estimate the elasticity, which allows us to compare the effects to prior literature.

[24]Following Baker et al. (2022), we interact all fixed effects with stack-specific indicators to explore *within-event* variation.

[25]We do not control for leverage because leverage can be directly affected by tax hikes. Our results are unchanged if we control for subsidiary leverage.

3.3 Data and summary statistics

We begin by collecting disaggregated subsidiary-level data over the period from 2004 to 2017. Our sample period thus begins three years before the first corporate tax shock and ends three years following the last tax hike. Subsidiary data come from the Amadeus database published by Bureau van Dijk. Amadeus contains detailed financial and ownership data for a comprehensive sample of both public and private firms. A key advantage of using Amadeus is that we are able to accurately track the ownership structure between subsidiaries and their parent firms over time.[26] Each subsidiary s is classified as part of multinational group p if p is a foreign ultimate owner that owns more than 50% of s. Focusing on the majority ownership, we ensure that the parent firm has sufficient voting rights to control the subsidiary.[27] Following Bena et al. (2022), we exclude firms in the financial industry as well as in public administration, defense, education, health and social work, and other community, social, and personal service activities (two-digit NACE Rev 1.1 codes 65–67, 75, 80, 85, and 90–99). Sales, total assets, and cash holdings must be positive for each subsidiary–year.

We require both subsidiaries and parent firms to be incorporated and located in the European Union (EU) because these firms are subject to a similar regulatory environment. Our stacked DiD approach additionally requires "clean" control firms to be located in countries where no major fiscal plans are implemented around the tax-hike years. As a result, we exclude country–years where a fiscal policy, such as public spending cuts and other tax episodes, is in place. These stringent sampling criteria lead us to drop eight EU countries with frequent fiscal plan changes.[28]

The final sample consists of 3,415 unique subsidiaries owned by 3,039 unique parent (multinational) companies from 20 EU countries. Panel A of Table 2 gives an overview of the

[26]All firms that file financial statements are covered by Amadeus. However, firm observations are periodically deleted (typically every four years), and the ownership information is available only for the last reported date (Budd et al., 2005). We thus combine the yearly tapes of the datasets.

[27]Our empirical analysis is not sensitive to this threshold. When examining parent ownership of at least 90% of the subsidiary shares, we find very similar results (see the Internet Appendix). Note that our identification is consistent with our model in Section 2 that the parent company is the majority owner of the subsidiaries.

[28]These countries are Croatia, Denmark, Germany, Greece, Ireland, Italy, Lithuania, and Portugal.

geographical distribution of the firms in our sample.[29] Panel B of Table 2 presents descriptive statistics for the key subsidiary characteristics. Our main dependent variable, *Investment*, is defined as the change in fixed assets before depreciation, scaled by the previous year's total assets (e.g., Asker et al., 2015; Jacob et al., 2019).[30] To conserve space, the definitions for all the other variables are reported in the Appendix. Panel B shows that our sample characteristics are similar in the most important respects to those of the samples used in the literature. For example, investment has a mean of 0.068. Given an average subsidiary asset size of EUR 12.9 million, a typical subsidiary invests approximately EUR 0.88 million per year. A subsidiary's cash holdings represent about 15% of its total assets. Average profitability and sales growth are 0.08 and 0.02, respectively.

4 Spillover effect of tax hikes

4.1 Results

Table 3 presents the regression results from equation (10). We start with a model without control variables to avoid the issue of potentially endogenous control variables (e.g., Lechner, 2008). The first column in Table 3 shows a negative point estimate of foreign tax hikes, which is statistically significant (p-value = 0.046). This finding is consistent with a negative spillover effect. In column 2, we add subsidiary country–year–industry fixed effects. With these fixed effects, the estimate on *Tax hike*×*Post* can be interpreted as capturing the difference in investment between the treated firms and control firms in the same subsidiary country and industry in a given year. We see that the results barely change. Columns 3 and 4 report the full model that also includes subsidiary-level control variables. We find an estimate of

[29]Note that the number of firm–year observations in each country does not reflect the economic size of that country. This is because the number of firm–year observations is mainly driven by the treated and "clean control" firm matches as described in the stacked data construction (Section 3.2).

[30]We note that the Amadeus data do not include capital expenditures. Our proxy for investment uses pre-depreciation items to ensure that accounting write-downs are not responsible for our findings. To reduce the influence of outliers, all continuous variables are winsorized at the 1st and 99th percentiles. All values are converted into euros when applicable.

$\beta = -0.064$ in column 3, statistically significant at the 1% level. This means that exposure to foreign tax hikes leads to an investment cut of 6.4 percentage points relative to the control subsidiaries. These findings are consistent with an average negative spillover effect due to within-firm production linkages (in contrast to the tax competition prediction).

Because regressions 1 to 4 are estimated with a treatment indicator that is independent of treatment intensity, we cannot determine the precise magnitude of tax elasticity. To obtain a readily interpretable economic effect, we run an estimation using the intensity of the tax hike instead of the indicator variable. We measure the intensity by calculating the increased tax revenue scaled by the (tax-hike) country's GDP in the previous year. This measure is commonly used in public finance literature (e.g., Romer and Romer, 2010; Devries et al., 2011; Alesina et al., 2015a,b) and allows us to quantify the impact of tax hikes in two forms: increased *tax rates* and widened *tax bases* to which the tax rates are applied.

Columns 5 and 6 report the results. In the full model with subsidiary country–year–industry fixed effects (column 6), the point estimate is $\beta = -0.223$, significant at the 1% level. This estimate translates into an elasticity of of –0.4, which implies that a 1% change in the tax-hike intensity would lead to a drop of 0.4% in investment.[31] Using a multistate firm setup, Giroud and Rauh (2019) find that US state-level corporate taxes have short-run elasticities of –0.4 to –0.5. Therefore, in terms of magnitude, our results on capital investment compare favorably to those in Giroud and Rauh (2019). Alternatively, we can compare the elasticity (of foreign tax hike spillover) to a direct impact of domestic tax hike on local investment. In Table A2 (of the Internet Appendix), we estimate a model that regresses subsidiary investment on a domestic tax hike intensity.[32] Unsurprisingly, we find that domestic corporate tax hikes significantly reduce domestic investment. The direct tax

[31] Elasticity is defined as $(dy/dx) \times (x/y)$ following the standard in the tax literature (e.g., Faccio and Xu, 2015; De Vito and Jacob, 2022). We calculate the elasticity as follows: We multiply the marginal effect of the tax hike in column 6 by the mean of tax-hike intensity to obtain 0.029. We then divide this magnitude by the average investment level of 0.068 to obtain the elasticity of 0.4.

[32] In these regressions, we use a stacked event sample constructed following the same procedure as described in Section 3.2. The model is specified based on equation (10), with the key independent variable, *Tax hike*$\times$*Post*, replaced by subsidiary country (i.e., domestic) tax hike intensity.

elasticity is –1.1 based on our estimate.[33] Thus, consistent with the notion that spillover effects tend to be smaller than direct effects, the impact of a foreign tax hike is substantially weaker than that of a domestic tax change. Nevertheless, the spillover is still economically meaningful with an elasticity of –0.4.

Before exploring the robustness of our main findings, we note that the coefficients on the control variables yield results that are in line with the results from previous literature. For instance, as in Becker et al. (2013), sales growth is positively related to investment. As in Malmendier and Tate (2005), investment is higher for cash-rich firms.

4.2 Parallel trends and dynamic investment responses

One implicit assumption of the stacked DiD design is that pre-shock parallel trends hold. In other words, in the absence of treatment, the difference in investment between the treated and control groups is constant over time (Bertrand et al., 2004). While testing for ex post counterfactual parallel trends is inheritably infeasible, we assess the dynamics of the spillover effect. By doing so, we evaluate whether contemporaneous unobserved trends other than the tax hikes confound the treatment effect of interest. Moreover, we also test for the investment dynamics after the respective tax hike. To examine parallel pre-trends and the post-shock investment dynamics, we augment equation (10) with a set of time indicators interacted with the treated dummy variable. We denote these interactions $\textit{Tax hike} \times \textit{Post}_{t+n}$, where $n \in [-3, +3]$. We then plot the cumulative investment response (i.e., estimate of $\textit{Tax hike} \times \textit{Post}_{t+n}$) in each year around the tax hike, where the year before the tax hike $(t-1)$ is the benchmark year. Figure 1 plots the respective coefficient estimates.

A few observations are noteworthy. First, we observe a relatively stable investment trend between the treated and control subsidiaries. Put differently, the treated and control groups follow a similar trend prior to the introduction of the tax hike. Second, we find a decrease

[33] The negative impact of tax hikes or fiscal consolidation on domestic investment is consistent with the results found in Alesina et al. (2002), Guajardo et al. (2014), and Jorda and Taylor (2016). It is also in line with our theoretical model (see the discussion at the beginning of Section 2.4). Our estimate for the domestic elasticity (–1.1) is largely in line with prior studies (see Hassett and Glenn Hubbard (2002) for a survey).

in investment in treated (relative to control) firms around $t+1$. This pattern suggests that the investment cut becomes significant one year *after* the policy is in effect and remains significant until at least year $t+2$.

4.3 Robustness tests

In this section, we discuss several robustness and sensitivity checks of our main analyses. These checks cover tests of the stable unit treatment value assumption (SUTVA), alternative dependent variables, the role of economic downturns, the relevance of foreign subsidiaries for a multinational, and a series of supplemental tests.

4.3.1 Stable unit treatment value assumption

Our DiD estimation relies on the SUTVA. That is, we require the control group to be unaffected by the foreign tax shock. The SUTVA might be violated if, for example, control firms take on the opportunity to raise investment vis-à-vis the treated group. If this occurs, the estimate of β in equation (10) will be biased upward, leading us to overstate the true spillover effect. To address this concern, we follow the approach proposed by Berg et al. (2021). These authors suggest a spillover model in which econometricians control for potential interactions between the treated and control groups in DiD regressions. Following Berg et al. (2021), we augment the baseline regression and estimate the following equation:

$$\begin{aligned} Investment_{i,t,e} = \alpha &+ \beta \cdot Tax\ hike_i \times Post_{t,e} + \eta \cdot \overline{D}_{tax\text{-}hike} \times Tax\ hike_i \times Post_{t,e} \\ &+ \theta \cdot \overline{D}_{tax\text{-}hike} \times (1 - Tax\ hike_i \times Post_{t,e}) \\ &+ \gamma \cdot Controls_{i,t-1,e} + \lambda_{i,e} + \delta_{p,t,e} + \mu_{s,t,e} + \epsilon_{i,t,e} \end{aligned} \tag{11}$$

Equation (11) controls for the fraction of treated firms (i.e., firms subject to a foreign tax hike) in the subsidiary country–industry, $\overline{D}_{tax\text{-}hike}$.[34] The interaction terms of $\overline{D}$ with *Tax*

[34] $\overline{D}_{tax\text{-}hike}$ is defined in the year before the treatment and based on the subsidiary's one-digit SIC industry. We use an equal-weighted average indicator. Our results are robust to value-weighted average using the share

hike×*Post* and with (1−*Tax hike*×*Post*) test the potential spillover of treatment effects on the control units. We estimate equation (11) with the same stacked datasets as before to check whether violation of SUTVA poses a potential threat to our baseline estimation.

The results in Panel A of Table 4 show that our conclusion about negative intra-firm investment spillover is robust to Berg et al. (2021)'s correction procedure. The interaction terms between $\overline{D}$ and treated (or control) dummies are statistically insignificant, indicating that the SUTVA likely holds in our empirical setting. Importantly, our DiD coefficient on *Tax hike*×*Post* remains statistically significant, although with slightly reduced magnitudes.

4.3.2 Alternative measures of investment

Another concern is that investment (of private subsidiaries) is measured with noise because Amadeus does not provide data on actual capital expenditures. In Panel B of Table 4, we assess the robustness of our results by replacing the dependent variable with alternative definitions of investment. In the first two columns, we examine *capital intensity*, defined as the ratio of fixed assets to (lagged) total assets. In columns 3 and 4, we focus on *net investment*, defined as the change in fixed assets from $t-1$ to t scaled by total assets in $t-1$. The results show that the effects of foreign tax hikes are robust to these alternative investment measures.

4.3.3 Economic crisis and contemporaneous non-tax policy changes

Next, we address the concern that our results might be driven by confounding events, such as contemporaneous economic shocks in the foreign countries. To capture the potential transmissions of economic or banking crises, we estimate equation (10) by including an indicator (0/1) for economic or banking crises in the foreign country to which a subsidiary is connected. We define a country as being in crisis if its real GDP growth rate is more than two standard deviations below its long-run average (Bena et al., 2022). The first two columns of Panel

of subsidiary investment as weight. We exclude firm i itself in constructing $\overline{D}$, as in Berg et al. (2021). As Berg et al. (2021) suggest, we do not include subsidiary country–industry–year dummies in the model.

C show that controlling for foreign economic crisis has little impact on the magnitude or statistical significance of the coefficient on *Tax hike*$\times$*Post*. Similarly, controlling for banking crisis (as in Laeven and Valencia, 2018) gives similar results (columns 3 and 4).

We also consider other confounding policy changes, such as concurrent product market liberalizations or labor law reforms. Following Duval et al. (2018), we control for major labor and product market reforms. The results (shown in Panel D of Table 4) suggest that our baseline findings are robust to controlling for these contemporaneous events. To conserve space, we do not tabulate the coefficient estimates on the confounding events (dummies), which are all statistically insignificant. In an untabulated test, we control for all confounding events and crises in the same regression. The result corroborates the previous findings.

4.3.4 Importance of foreign subsidiaries

We consider differences in exposure to foreign tax hikes across firms. As implied by our model in Section 2, the importance of the subsidiary located in the tax-hike country impacts the strength of spillover. For example, when a subsidiary in the foreign country generates negligible revenues for the multinational, its ability to propagate a corporate tax hike is limited. To investigate whether our results are driven by important subsidiaries, in Panel E of Table 4, we exclude observations where the tax hike stems from a less important subsidiary country. We define unimportant subsidiaries as those whose assets (columns 1 and 2) or sales (columns 3 and 4) are below the median within the multinational. Reassuringly, we observe that the estimated magnitude of the spillover effect is greater in Panel E than in Table 3.

4.3.5 Matching

We use stacked DiD methods to estimate the spillover effect on changes in investment after a foreign corporate tax hike hits a domestic subsidiary (the treated unit) against similar investment changes for subsidiaries without foreign tax hike exposure (the control unit). To strengthen the internal validity of the DiD estimates, we perform additional analyses based on matched treated–control pairs. Specifically, for each tax hike, we apply entropy balancing matching to find similar peer subsidiaries based on size (i.e., total assets measured in the year before the shock) and industry.[35]

We start by matching treated–control pairs in the subsidiary (one-digit SIC) industry. The results of the DiD regression using the matched sample are reported in the first two columns of Panel F in Table 4. The results only strengthen our previous conclusion. In the next columns, we apply more stringent requirements by matching pairs in the subsidiary industry and country (columns 3 and 4) and in the subsidiary industry–country as well as in the parent country (columns 5 and 6). These strict matching requirements significantly reduce the sample size. However, the estimates of *Tax hike*×*Post* remain statistically significant in all of the tests. Importantly, they are also close in magnitude to those reported in Table 3. These findings corroborate the inferences drawn from the baseline specification.

4.3.6 Other robustness tests

We report untabulated robustness tests in the Internet Appendix. These tests (a) rule out the possibility that any single tax reform drives the main findings,[36] (b) consider time series autocorrelation in investment by controlling for lagged investment (e.g., Bloom et al., 2007), and (c) use an alternative ownership threshold in the subsidiary firm.[37] Our main conclusion remains unaffected.

5 Mechanisms: production linkage vs. tax competition

The preceding empirical results support the notion of significantly negative spillover effects on domestic investment due to exposure to foreign tax hikes. Interpreting these results

[35]Entropy balancing matching has been increasingly applied in recent work (e.g., Hainmueller, 2012; Wilde, 2017; Chapman et al., 2019; Jacob et al., 2019). The summary statistics of the matched covariate (before and after matching) are presented in Table A3 in the Internet Appendix.

[36]Specifically, we estimate equation (10) but exclude one event (tax hike) at a time. In other words, we do not allow a specific event to influence the overall effect. Figure A1 in the Internet Appendix plots the coefficient estimates of *Tax hike*×*Post* following this exercise.

[37]The results appear in Table A4 of the Internet Appendix.

through the lens of the model in Section 2, one implication is that the production linkage channel outweighs the tax competition effect. In this section, we circle back to the theoretical predictions and link our findings in Section 4 to the mechanisms of production linkages and tax competition. We test the importance of the former by examining cases where the tax hike occurs either in downstream or in upstream subsidiaries. We evaluate the tax competition channel by examining heterogenous investment responses across tradable and non-tradable industries. In a supplemental test, we also test the conjecture from our model that the strength of the spillover depends on a firm's ability to pass the tax burden onto customers.

5.1 The role of production linkages

Our model in Section 2 can be given a reduced-form presentation and used to estimate the role of intra-firm production linkage. Econometrically, we estimate the following equations, which are based on equation (7) and (8):

$$\begin{aligned} \mathit{Investment}_{i,t,e} = {} & \alpha + \beta^{U\to D} \cdot \mathit{Tax\ hike}_i \times \mathit{Post}_{t,e} \times \mathit{Link}^{U\to D}_{i,t,e} + \eta \cdot \mathit{Tax\ hike}_i \times \mathit{Post}_{t,e} \\ & + \theta \cdot \mathit{Link}^{U\to D}_{i,t,e} + \xi \cdot \mathit{Tax\ hike}_i \times \mathit{Link}^{U\to D}_{i,t,e} + \pi \cdot \mathit{Post}_{t,e} \times \mathit{Link}^{U\to D}_{i,t,e} \\ & + \gamma \cdot \mathit{Controls}_{i,t-1,e} + \lambda_{i,e} + \delta_{p,t,e} + \mu_{s,t,e} + \epsilon_{i,t,e} \end{aligned} \tag{12}$$

$$\begin{aligned} \mathit{Investment}_{i,t,e} = {} & \alpha + \beta^{D\to U} \cdot \mathit{Tax\ hike}_i \times \mathit{Post}_{t,e} \times \mathit{Link}^{D\to U}_{i,t,e} + \eta \cdot \mathit{Tax\ hike}_i \times \mathit{Post}_{t,e} \\ & + \theta \cdot \mathit{Link}^{D\to U}_{i,t,e} + \xi \cdot \mathit{Tax\ hike}_i \times \mathit{Link}^{D\to U}_{i,t,e} + \pi \cdot \mathit{Post}_{t,e} \times \mathit{Link}^{D\to U}_{i,t,e} \\ & + \gamma \cdot \mathit{Controls}_{i,t-1,e} + \lambda_{i,e} + \delta_{p,t,e} + \mu_{s,t,e} + \epsilon_{i,t,e} \end{aligned} \tag{13}$$

where *Link* flags the production linkage of subsidiary i to another subsidiary located in a foreign tax-hike country (in t). We differentiate two cases: The variable $\mathit{Link}^{U\to D}$ captures the case where a tax hike occurs upstream (U) while the investment is measured downstream (D). Likewise, $\mathit{Link}^{D\to U}$ captures the case where a tax hike occurs downstream (D) while the investment is measured upstream (U). The specifications are otherwise similar to those in equation (10).

We are mainly interested in $\beta^{U \to D}$ and $\beta^{D \to U}$. Negative estimates of β would support the production linkage channel, which predicts a greater investment cut when a subsidiary's supplier (or customer) is subject to a tax hike. In the case of a downstream tax hike, the magnitude of $\beta^{D \to U}$ depends on whether the transfer pricing effect overcompensates the lower marginal return in the upstream. Following this reasoning, the production link channel suggests that it is theoretically plausible that $\beta^{U \to D} < \beta^{D \to U}$.

A challenge that we face is that Amadeus data do not provide information on inter-subsidiary shipments. Thus, we must proxy for such relations using the input–output matrix at the country–industry level (e.g., Lemelin, 1982; Matsusaka, 1996; Fan and Goyal, 2006; Bena and Ortiz-Molina, 2013; Bena et al., 2022). For example, consider the shipment of chemical products from Finland to Austria. Suppose that in the aggregate, these chemical products are imported as the main inputs for downstream Austrian agricultural production. Thus, in our sample, if we observe a Finnish subsidiary in the chemical production industry and an Austrian subsidiary in the agricultural sector, we assume that the Austrian subsidiary is a downstream customer of the Finnish supplier.

We collect country–industry pairwise input–output tables from the OECD.[38] These tables allow us to identify, for example, the dollar amount of inputs required from industry u (e.g., chemical products) in country C (e.g., Finland) for each dollar of output produced in industry d of country A (e.g., agricultural goods in Austria). To account for indirect supply chain effects, we follow the literature (e.g., Miller and Blair, 2009, Ch.2) and use the Leontief inverse matrix, which gives the total required inputs for \$1 of output for each country–industry pair. Finally, we define a subsidiary in industry d of country A as a *downstream customer* (*upstream supplier*) of a peer subsidiary in industry u of country C if the required supply (purchase) from country–industry $\{C, u\}$ to $\{A, d\}$ is in the top decile in the annual input–output distribution (as in Bena et al., 2022).

[38] These tables are available on an annual basis at `https://www.oecd.org/sti/ind/inter-country-input-output-tables.htm`.

Table 5 reports the results for the production linkages. We begin with downstream propagation: In columns 1 and 2, the variable $Link^{U \to D}$ indicates that the subsidiary is a downstream customer of the subsidiary located in a tax-hike country. We see that the coefficient estimate on the triple interaction term, $\beta^{U \to D}$, is negative and significant, suggesting a greater downstream transmission of tax hikes from the supplier country to the customer subsidiary. This result is consistent with the production linkage channel outlined in equation (7): Heavily taxed upstream profits reduce the marginal profitability in the downstream subsidiaries, dominating any potential positive spillover effects generated by tax competition.

In columns 3 and 4, we examine potential upstream propagation. The variable $Link^{D \to U}$ in these models flags cases in which the local subsidiary is a supplier that is exposed to a foreign tax hike in a downstream customer. In contrast to the preceding case, the interaction term is insignificant. These findings suggest that spillover driven by corporate tax hikes represents a harder hit for downstream investment than for upstream investment. The insignificant upstream tax hike propagation implies a substantial transfer pricing effect that mitigates the lower return in the upstream subsidiary, according to equation (8) of our model. Intuitively, when the intra-firm transfer price (which we do not directly observe) is set sufficiently high, the return on investment in the downstream subsidiary is shifted to and taxed in the upstream subsidiary. Consequently, the downstream subsidiary is effectively less exposed to the tax hike, muting the production linkage channel. It is worth mentioning that these findings echo the argument of Briganti et al. (2018) that tax hikes are primarily supply shocks that transmit downstream.

The last two columns of Table 5 include both sets of linkage variables in the same regression. The estimates of β, $\beta^{U \to D}$, and $\beta^{D \to U}$ mirror the preceding findings. Overall, these results corroborate the role of within-firm production networks as a channel for transmitting foreign tax hikes. Importantly, when we interpret the results in Table 5 along the lines of our theoretical predictions in equations (7) to (9), all coefficients consistently imply a substantial (arm's length) transfer price that is set higher than the marginal productivity of the intermediate input. Accordingly, our results also suggest that arm's length prices are too generous on average, allowing for income shifting from downstream to upstream subsidiaries.

5.2 Assessing the tax competition channel: evidence from tradable versus non-tradable sectors

In the next step, we assess the role of the tax competition channel. While the heterogeneous spillover effects generated by upstream versus downstream tax hikes are informative about the production linkage channel, they do not isolate the tax competition channel. To the extent that some industries have limited production linkages, we expect that the tax competition channel should dominate in these industries, resulting in positive spillover. To isolate the tax competition channel, we thus consider non-tradable sectors. A prominent feature of these sectors is that their investment opportunities are confined to a local geographical area, as firms in these sectors rely mostly on local supplies and consumer demand (e.g., restaurants or grocery stores). Given that production linkages are immaterial, tax competition is likely to prevail and outweigh the production linkage channel. Thus, domestic investment is expected to *increase* in response to a foreign tax hike because higher foreign taxes make the local investment more attractive.

To test these predictions, we split our sample of subsidiaries into tradable and non-tradable sectors, following Bernstein et al. (2019). A non-tradable business is defined as one that operates in the construction, retail trade, hotel, or restaurant industry. Our empirical specification is based on equation (10). In the first two columns of Panel A of Table 6, we find that subsidiaries in a non-tradable sector increase capital investment when their peer foreign subsidiaries are subject to a corporate tax hike. This shift in investment is consistent with the tax competition channel where the parent group reallocates capitals to a subsidiary facing relatively lower taxation.

In contrast, and consistent with our previous findings in Section 4, columns 3 and 4 show negative tax hike spillovers to tradable peer subsidiaries. In this subsample, the regression estimates mirror those in Table 3, suggesting that tradable sectors are driving the main results in our baseline specification. Overall, the results confirm our theoretical predictions and reinforce the production linkage (tax competition) channel as the key mechanism underlying the negative (positive) investment spillover. These results suggest that, on average, the production linkage channel outweighs the tax competition channel; however, there are cases in which the tax competition channel dominates.

5.3 Assessing the tax competition channel: large versus small countries

Next, we take another approach to testing for the tax competition channel. Based on our theoretical framework, the strength of the tax competition depends on the influence of the tax-hike country on the world interest rate. As larger markets have stronger impacts on the capital market equilibrium, we examine whether tax hikes in a larger country enhance the tax competition channel. We use stock market capitalization (in US dollars) as a proxy for overall market significance. We augment equation (10) by regressing subsidiary investment on a term that interacts the treatment status (*Tax hike* × *Post*) with *Market size*, a variable that measures the average difference in market capitalization between the tax-hike country and the destination country. We calculate the difference in market capitalization to capture the relative strength of the tax-hike country in transmitting the world interest rate to the destination (subsidiary) country. The results appear in Panel B of Table 6. To conserve space, we do not tabulate all pairwise interaction terms included in the regressions.

Some interesting patterns emerge. We see that *Tax hike* × *Post* is negative and significant, echoing the baseline results that foreign tax hikes generate an overall negative spillover. However, when the tax hike emanates from a relatively larger capital market, the overall negative investment spillover is attenuated, as indicated by the positive and significant *Tax hike* × *Post* × *Market size* coefficient. This finding is consistent with the idea that tax hikes in larger capital markets enhance tax competition, which predicts positive spillover and reduces the overall negative externality. Overall, these results indicate heterogeneous effects of tax competition due to the influence of tax-hike countries on the world interest rate, as suggested in our theoretical model (and prior models).

5.4 Supplemental test: product market power and heterogeneous response

Finally, we evaluate the conjecture of the model, namely that a firm's investment response to foreign corporate tax hikes is a function of its ability to pass the tax burden to its customers. We proxy for a firm's ability to shift the tax burden using a measure of market concentration. We define market concentration as the firm's Herfindahl–Hirschman Index (HHI) in the two-digit SIC wherein the firm operates. We then augment equation (10) by interacting *High HHI*, an indicator variable that equals one if the subsidiary's HHI is in the top quartile of its given country distribution, with *Tax hike* × *Post*, *Tax hike*, and *Post*.

The results, shown in Table 7, suggest that high HHI subsidiaries are significantly *less* sensitive to the foreign tax hike (i.e., the interaction term is significantly positive). This evidence supports our conjecture that tax-shifting ability attenuates the effect of corporate tax hike spillover. This result also parallels that in extant studies on tax incidence (e.g., Feldstein, 1974; Fuest et al., 2018; Dyreng et al., 2022). The joint effect of *Tax hike* × *Post* becomes nonsignificant for the *High HHI* firms (untabulated). This suggests that although an average negative spillover effect exists, it disappears when firms operate in concentrated industries due to their ability to pass on the tax burden to other stakeholders.

6 Conclusion

While previous literature has extensively studied how taxes affect domestic investment (e.g., Romer and Romer, 2010; Mertens and Ravn, 2013; Ljungqvist and Smolyansky, 2018; Giroud and Rauh, 2019; Jacob et al., 2019), we examine the spillover effect that tax hikes create via multinationals' internal networks. Our empirical approach focuses on exogenous corporate tax hikes identified based on the narrative approach of Romer and Romer (2010). We use detailed subsidiary data on 3,039 multinational firms across 20 European countries to study their investment reactions to the exogenous implementation of foreign tax hikes. We find that in response to a foreign corporate tax hike, domestic subsidiaries cut investment relative to a group of unaffected subsidiaries of other multinationals. These results stand in stark contrast to the standard tax competition arguments.

To embed our findings in theory, we provide a multicountry model that incorporates both cross-country tax competition and intra-firm production interdependence. We show that production linkages explain the large negative investment spillover. Consistent with our model, empirical exercises suggest a larger spillover effect in downstream subsidiaries when the tax hike hits the related upstream suppliers. Moreover, negative spillover is most pronounced in tradable sectors whereas positive spillover occurs in non-tradable sectors, particularly when the tax hike is implemented in a larger capital market.

Our results are important for policymakers given the increasing budget deficits around the globe following the Covid-19 crisis and the call for raising (corporate) taxes. Our findings highlight the importance of internal firm networks in transmitting tax shocks emanating from foreign countries, as the spillover could potentially affect aggregate economic activities and growth in the destination nations. Although our focus is on within-firm networks, it is reasonable to believe that the effect we document also arises in cross-firm networks. That is, even among standalone firms, tax hike policies could spill over if standalone firms are connected via cross-border trade networks. With data on cross-firm supply chains, future research could address this related question.

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Appendix. Variable Definition

Variable	**Definition**
Investment	Change in fixed assets ($fias$) before depreciation ($depr$) relative to the prior year's total assets ($toas$). (Source: Amadeus)
Capital intensity	Fixed assets ($fias$) relative to the prior year's total assets ($toas$). (Source: Amadeus)
Net investment	Change in fixed assets from year $t-1$ to t scaled by the total assets in year $t-1$. (Source: Amadeus)
Tax hike	Dummy variable that equals one if the subsidiary's multinational group has a subsidiary in a country experiencing tax increases that year, and zero otherwise.
Tax hike intensity	The amount of the increased tax revenue relative to the country's GDP at $t-1$.
Sales growth	Percentage change in sales ($turn$) from $t-1$ to t. (Source: Amadeus)
Profitability	Earnings before interest and taxes ($ebit$) relative to the prior year's total assets ($toas$). (Source: Amadeus)
Size	Natural logarithm of total assets ($toas$). (Source: Amadeus)
Cash holdings	Cash ($cash$) relative to the prior year's total assets ($toas$). (Source: Amadeus)
Link ($U \rightarrow D$)	Dummy variable that takes the value of one if the input requirement from the country–industry of the tax-hike subsidiary to the subsidiary's country–industry is in the top decile of the subsidiary country–year distribution, and zero otherwise. (Source: OECD)
Link ($D \rightarrow U$)	Dummy variable that takes the value of one if the input requirement from the country–industry of the subsidiary to the tax-hike country–industry is in the top decile of the tax-hike country–year distribution, and zero otherwise. (Source: OECD)
High market power	Dummy variable that equals one if the subsidiary's Herfindahl–Hirschman Index is in the top quartile of the country distribution, and zero otherwise. (Source: Amadeus)
Market size	The stock market capitalization (in US dollars) of the tax-hike country minus the market capitalization of the subsidiary country. (Source: World Bank)

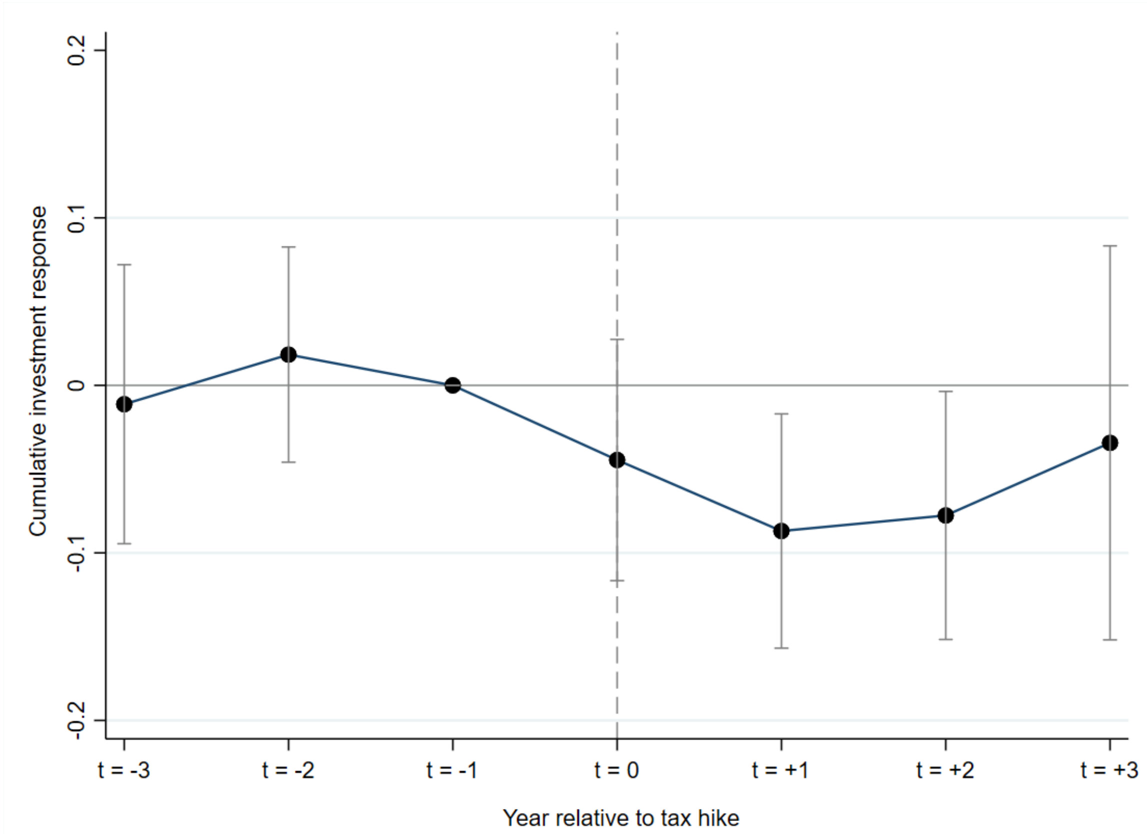

Figure 1: Cumulative changes in investment

This figure plots the cumulative difference in investment between the treated subsidiaries and control subsidiaries from year $t-3$ to $t+3$. Treated subsidiaries are those whose multinational group has a subsidiary in a country experiencing a corporate tax hike that year. Control subsidiaries are those whose multinational group does not have a subsidiary in a country experiencing tax hikes that year. We estimate the cumulative treatment effects using the regression specified in equation (10) with firm controls. The connected line indicates the 95% confidence interval.

Table 1: Corporate Tax Hikes

This table reports the exogenous corporate tax hikes in Europe over 2004–2017.

Country	Years of tax hikes	Tax hike intensity (% of GDP)
Austria	2011	0.19%
Denmark	2009	0.34%
Finland	2013	0.24%
Ireland	2009	0.18%
Italy	2007	0.12%
Italy	2014	0.26%
Portugal	2010	0.22%
Spain	2012	0.38%

Table 2: Descriptive Statistics

This table describes the sample and provides summary statistics for the main variables used in the empirical tests. Panel A reports the geographical distribution of the sample subsidiary–years and parent–years in the stacked dataset. Panel B reports key subsidiary characteristics. The definitions of all the variables are in the Appendix.

Panel A. Country distribution

Parent countries (firm–year obs.)		*Subsidiary Countries (firm–year obs.)*	
Austria	486	Austria	16
Belgium	1,038	Belgium	429
Bulgaria	290	Bulgaria	99
Cyprus	4,916	Cyprus	0
Czech	9,522	Czech	14,177
Estonia	119	Estonia	3,736
Finland	1,229	Finland	1,713
France	509	France	2,597
Hungary	1,989	Hungary	742
Latvia	691	Latvia	0
Luxembourg	3,966	Luxembourg	0
Malta	555	Malta	0
Netherlands	10,654	Netherlands	17
Poland	2,651	Poland	9,803
Romania	106	Romania	699
Slovakia	3,682	Slovakia	14,631
Slovenia	364	Slovenia	838
Spain	229	Spain	278
Sweden	6,748	Sweden	539
U.K.	4,452	U.K.	3,882
Total	54,196		54,196

Panel B. Summary statistics

	N	Mean	Std. Dev.	25th	Median	75th
Subsidiary-level variables:						
Investment	54,196	0.0683	0.1959	0.0010	0.0203	0.0710
Net investment	54,196	0.0239	0.1798	-0.0281	-0.0030	0.0262
Capital intensity	54,196	0.3141	0.3172	0.0582	0.2157	0.4928
Size	54,196	14.8579	1.5612	13.7851	14.7182	15.8189
Cash	54,196	0.1514	0.2067	0.0195	0.0733	0.1992
Sales growth	54,196	0.0173	0.6107	-0.1068	0.0418	0.1921
Profitability	54,196	0.0840	0.2130	0.0044	0.0587	0.1536

Table 3: Tax-Hike Spillover

This table reports results from OLS regressions of subsidiary investment, using the sample described in Section 3. The dependent variable is subsidiary *investment*. Columns 1 through 4 use a dummy variable, *Tax hike*, to indicate subsidiaries that are linked to a foreign tax-hike country. In columns 5 and 6, we measure the intensity of corporate tax hikes as the increase of tax revenue relative to the country's lagged GDP. The definitions for all the variables are in the Appendix. Standard errors are double clustered by parent–event and by subsidiary–event, and are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	Investment					
	1	2	3	4	5	6
Tax hike × Post	-0.046**	-0.050**	-0.064***	-0.059**		
	(0.023)	(0.024)	(0.024)	(0.024)		
Tax-hike intensity × Post					-0.178**	-0.223***
					(0.078)	(0.083)
Profitability			0.063***	0.065***		0.065***
			(0.007)	(0.008)		(0.008)
Cash			0.105***	0.104***		0.104***
			(0.008)	(0.008)		(0.008)
Size			-0.154***	-0.153***		-0.153***
			(0.005)	(0.005)		(0.005)
Sales growth			0.006**	0.006**		0.006**
			(0.003)	(0.003)		(0.003)
N	54,196	54,196	54,196	54,196	54,196	54,196
Subsidiary FE	Yes	Yes	Yes	Yes	Yes	Yes
Parent country-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Sub. country-Year FE	Yes	–	Yes	–	–	–
Sub. country-Ind.-Year FE	–	Yes	–	Yes	Yes	Yes
Adjusted R^2	0.126	0.130	0.205	0.209	0.130	0.209

Table 4: Robustness Tests

This table reports robustness tests of the results reported in Table 3. Panel A examines the stable unit treatment value assumption (SUTVA) using Berg et al. (2021) procedure. Panel B uses alternative measures of investment, including *capital intensity* (columns 1 and 2) and *net investment* (columns 3 and 4). In Panel C, we control for economic crises and banking crises. Panel D controls for product market reforms and labor reforms. In Panel E, we exclude tax-hike subsidiaries with below-median sales or assets within the multinational. Panel F explores different matching methods combined with stacked DiD estimation. Control variables are the same as those in Table 3. Standard errors are double clustered by parent–event and by subsidiary–event, and are reported in parentheses. ***, **, and * to denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Panel A. SUTVA (spillover models as in Berg et al. (2021))

	1	2
Tax hike × Post	-0.046*	-0.045*
	(0.024)	(0.024)
$\overline{D}_{tax\text{-}hike}\times$ Tax hike × Post	-0.303	-0.248
	(0.301)	(0.311)
$\overline{D}_{tax\text{-}hike}\times$ (1−Tax hike×Post)		0.107
		(0.194)
N	54,196	54,196
Controls as in Table 3	Yes	Yes
Subsidiary FE	Yes	Yes
Sub. country–Year FE	Yes	Yes
Parent country–Year FE	Yes	Yes
Adjusted R^2	0.205	0.205

Panel B. Alternative measures of investment

	Capital Intensity		Net Investment	
	1	2	3	4
Tax hike × Post	-0.073***	-0.078***	-0.040*	-0.048**
	(0.028)	(0.028)	(0.022)	(0.022)
N	54,196	54,196	54,196	54,196
Controls as in Table 3	No	Yes	No	Yes
Subsidiary FE	Yes	Yes	Yes	Yes
Sub. country–Ind.–Year FE	Yes	Yes	Yes	Yes
Parent country–Year FE	Yes	Yes	Yes	Yes
Adjusted R^2	0.710	0.725	0.071	0.146

Panel C. Controlling for economic and banking crises

	Control for economic crisis		Control for banking crisis	
	1	2	3	4
Tax hike × Post	-0.050**	-0.059**	-0.050**	-0.059**
	(0.024)	(0.024)	(0.024)	(0.024)
N	54,196	54,196	54,196	54,196
Controls as in Table 3	No	Yes	No	Yes
Subsidiary FE	Yes	Yes	Yes	Yes
Sub. country–Ind.–Year FE	Yes	Yes	Yes	Yes
Parent country–Year FE	Yes	Yes	Yes	Yes
Adjusted R^2	0.130	0.209	0.130	0.209

Table 4: Robustness Tests (continued)

Panel D. Controlling for other confounding events

	Control for product market reforms		Control for labor market reforms	
	1	2	3	4
Tax hike × Post	-0.050**	-0.059**	-0.050**	-0.059**
	(0.024)	(0.024)	(0.024)	(0.024)
N	54,196	54,196	54,196	54,196
Controls as in Table 3	No	Yes	No	Yes
Subsidiary FE	Yes	Yes	Yes	Yes
Sub. country–Ind.–Year FE	Yes	Yes	Yes	Yes
Parent country–Year FE	Yes	Yes	Yes	Yes
Adjusted R^2	0.130	0.209	0.130	0.209

Panel E. Excluding unimportant tax-hike subsidiaries

	Excluding subsidiaries with below-median assets		Excluding subsidiaries with below-median sales	
	1	2	3	4
Tax hike × Post	-0.073**	-0.074**	-0.065*	-0.063*
	(0.033)	(0.035)	(0.039)	(0.037)
N	36,330	36,330	37,735	37,735
Controls as in Table 3	No	Yes	No	Yes
Subsidiary FE	Yes	Yes	Yes	Yes
Sub. country–Ind.–Year FE	Yes	Yes	Yes	Yes
Parent country–Year FE	Yes	Yes	Yes	Yes
Adjusted R^2	0.147	0.231	0.144	0.221

Panel F. Matching estimation

	Match on size and subsidiary industry		Match on size, sub. industry and country		Match on size, sub. industry, sub. country and parent country	
	1	2	3	4	5	6
Tax hike × Post	-0.069**	-0.076**	-0.055*	-0.049*	-0.082**	-0.073**
	(0.031)	(0.031)	(0.030)	(0.029)	(0.035)	(0.033)
N	35,077	35,077	13,740	13,740	4,568	4,568
Controls as in Table 3	No	Yes	No	Yes	No	Yes
Subsidiary FE	Yes	Yes	Yes	Yes	Yes	Yes
Sub. country–Ind.–Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Parent country–Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.256	0.355	0.273	0.367	0.223	0.358

Table 5: Production Linkage and Tax Hike Spillover

This table tests production linkage among subsidiaries as a channel of investment spillover. The dependent variable is subsidiary *investment*. Columns 1 and 2 examine downstream linkage, where the variable *link* indicates whether the subsidiary is a downstream customer of the tax-hike country. Columns 3 and 4 examine upstream linkage, where the variable *link* indicates whether the subsidiary is an upstream supplier of the tax-hike country. Columns 5 and 6 include both sets of production linkages in the same regression. The variable definitions appear in the Appendix. Standard errors are double clustered by parent–event and by subsidiary–event, and are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	Investment					
Tax hike in ...	Upstream supplier		Downstream customer		Both	
	1	2	3	4	5	6
$\beta^{U\rightarrow D}$: Tax hike × Post × Link$^{U\rightarrow D}$	-0.332***	-0.171**			-0.407***	-0.257***
	(0.083)	(0.076)			(0.089)	(0.088)
$\beta^{D\rightarrow U}$: Tax hike × Post × Link$^{D\rightarrow U}$			0.003	0.038	0.072	0.083
			(0.068)	(0.066)	(0.058)	(0.067)
Tax hike × Post	-0.044*	-0.055**	-0.051**	-0.063***	-0.049**	-0.061**
	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)
N	54,196	54,196	54,196	54,196	54,196	54,196
Controls as in Table 3	No	Yes	No	Yes	No	Yes
Pairwise interaction terms	Yes	Yes	Yes	Yes	Yes	Yes
Subsidiary FE	Yes	Yes	Yes	Yes	Yes	Yes
Sub. country–Ind.–Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Parent country–Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.130	0.209	0.130	0.209	0.130	0.209

Table 6: Tradable versus Non-Tradable Sectors

Panel A tests investment spillover for tradable and non-tradable sectors separately. The dependent variable is subsidiary *investment*. A non-tradable business (subsidiary) is defined as one that operates in the construction, retail trade, hotel, or restaurant industry. Columns 1 and 2 examine non-tradable sectors. Columns 3 and 4 examine tradable sectors. Panel B tests heterogeneous spillover effect generated by tax hikes implemented in larger versus smaller economies. *Market size* is measured as market capitalization (in US dollars) of the tax-hike country minus market capitalization of the subsidiary country. Standard errors are double clustered by parent–event and by subsidiary–event, and are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Panel A. Spillover in non-tradable vs. tradable sectors

	Investment			
	Non-tradable		Tradable	
	1	2	3	4
Tax hike × Post	0.109**	0.107**	-0.046**	-0.053**
	(0.047)	(0.046)	(0.023)	(0.024)
N	4,386	4,386	47,013	47,013
Controls as in Table 3	No	Yes	No	Yes
Subsidiary FE	Yes	Yes	Yes	Yes
Sub. country–Ind.–Year FE	Yes	Yes	Yes	Yes
Parent country–Year FE	Yes	Yes	Yes	Yes
Adjusted R^2	0.259	0.268	0.133	0.206

Panel B. Tax hike in large vs. small markets (all sectors)

	Investment	
	1	2
Tax hike × Post × Market size	0.027**	0.028**
	(0.013)	(0.014)
Tax hike × Post	-0.052**	-0.056**
	(0.024)	(0.023)
Market size	-0.023***	-0.028***
	(0.009)	(0.010)
N	54,196	54,196
Controls as in Table 3	No	Yes
Pairwise interaction terms	Yes	Yes
Subsidiary FE	Yes	Yes
Sub. country–Ind.–Year FE	Yes	Yes
Parent country–Year FE	Yes	Yes
Adjusted R^2	0.134	0.211

Table 7: Market Power and Tax Hike Spillover

This table tests whether subsidiary's ability to shift tax burden alleviates investment spillover. The dependent variable is subsidiary *investment*. We use *High market power* as a proxy for firm ability to shift tax burden to its customers. *High market power* is a dummy variable that equals one if the subsidiary's Herfindal–Hirschman Index is in the top quartile of the country distribution, and zero otherwise. Standard errors are double clustered by parent–event and by subsidiary–event, and are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	Investment	
	1	2
Tax hike × Post × High market power	0.111***	0.094**
	(0.041)	(0.047)
Tax hike × Post	-0.082***	-0.086***
	(0.028)	(0.029)
High market power	0.008	0.005
	(0.007)	(0.007)
N	54,196	54,196
Controls as in Table 3	No	Yes
Pairwise interaction terms	Yes	Yes
Subsidiary FE	Yes	Yes
Sub. country–Ind.–Year FE	Yes	Yes
Parent country–Year FE	Yes	Yes
Adjusted R^2	0.130	0.209

Internet Appendix for

How do corporate tax hikes affect investment allocation within multinationals?

Antonio De Vito, Martin Jacob, Dirk Schindler, Guosong Xu

Internet Appendix 1 Optimal investment and comparative statics

Rearranging the production constraint in the upstream subsidiary to $S_B = S - S_A = G(K_C) - S_A$ and inserting it directly into global after-tax profits, the maximization problem of the multinational becomes

$$\begin{aligned} \max_{K_i, b_i, S_A} \Pi_p &= \pi_A + \pi_B + \pi_C \\ &= (1-t_A)F(K_A, S_A) - [1 - t_A b_A + (1-t_A)C(b_A)]rK_A \\ &+ (1-t_B)F(K_B, G(K_C) - S_A) - [1 - t_B b_B + (1-t_B)C(b_B)]rK_B \\ &+ (t_A - t_C)qS_A + (t_B - t_C)q[G(K_C) - S_A] - [1 - t_C b_C + (1-t_C)C(b_C)]rK_C, \end{aligned} \tag{A.1}$$

The first-order condition for the optimal debt-to-asset ratio in subsidiary i follows as

$$\frac{\partial \Pi_p}{\partial b_i} = [t_i - (1-t_i)C_b(b_i)]rK_i = 0 \quad \Rightarrow \quad \frac{t_i}{1-t_i} = C_b(b_i) \quad \forall\ i = A, B, C. \tag{A.2}$$

The first-order condition for each debt-to-asset ratio is fully separable from all other first-order conditions, and comparative statics follow as

$$\frac{\partial b_i}{\partial t_i} = \frac{1}{(1-t_i)^2 C_{bb}} > 0 \quad \text{and} \quad \frac{\partial b_i}{\partial t_j} = 0 \quad \forall\ i \neq j. \tag{A.3}$$

The other first-order conditions read

$$\begin{aligned} \frac{\partial \Pi_p}{\partial K_i} &= (1-t_i)F_K^i - [1 - t_i b_i + (1-t_i)C(b_i)]r = 0 \quad i = A, B, \\ \frac{\partial \Pi_p}{\partial K_C} &= (1-t_B)F_S^B G_K + (t_B - t_C)qG_K - [1 - t_C b_C + (1-t_C)C(b_C)]r = 0, \\ \frac{\partial \Pi_p}{\partial S_A} &= (1-t_A)F_S^A - (1-t_B)F_S^B + (t_A - t_B)q = 0. \end{aligned}$$

The first-order conditions can be rearranged to

$$\begin{aligned} F_K^i - \tilde{r}_i &= 0 \quad i = A, B, && \text{(A.4)} \\ \left[\frac{1-t_B}{1-t_C} F_S^B + \frac{t_B - t_C}{1-t_C} q\right] G_K - \tilde{r}_C &= 0, && \text{(A.5)} \\ (1-t_A) F_S^A - (1-t_B) F_S^B + (t_A - t_B) q &= 0, && \text{(A.6)} \end{aligned}$$

where

$$\tilde{r}_i = [1 - t_i b_i + (1-t_i) C(b_i)] \frac{r}{1-t_i} = X_i r \tag{A.7}$$

represents effective capital costs after taxation. Effective capital costs are independent of the level of capital investment, but they depend on the debt-to-asset ratio. Differentiating effective capital costs for a change in the debt-to-asset ratio and imposing the first-order condition (A.2), however, shows that

$$\frac{\partial \tilde{r}_i}{\partial b_i} = [-t_i + (1-t_i) C_b] \frac{r}{1-t_i} = 0 \quad \forall\ i. \tag{A.8}$$

Thus, a small change in the tax-efficient capital structure of a subsidiary does not affect its effective capital costs.

Respecting that the world market interest rate is a function of the three tax rates, that is, $r = r(t_A, t_B, t_C)$, effective capital costs, however, respond to changes in tax policy. We have

$$\frac{\partial \tilde{r}_i}{\partial t_i} = \frac{\partial X_i}{\partial t_i} r + X_i \frac{r}{\partial t_i} = \frac{1-b_i}{(1-t_i)^2} r + X_i \frac{\partial r}{\partial t_i} > 0 \quad \forall\ i. \tag{A.9}$$

The first term, $\frac{1-b_i}{(1-t_i)^2} r > 0$, represents the standard corporate tax distortion that arises because the equity-funded part of capital costs is not tax deductible. The second term, $X_i \frac{\partial r}{\partial t_i} < 0$, captures the fact that a higher tax rate in country i increases capital supply on the world market and reduces the market interest rate (as long as country i is not too small relative to the world market). We assume that the reduction in the interest rate is insufficient to overcompensate the corporate tax distortion so that a tax increase will always increase effective capital costs in that country.

Moreover, there is the standard capital export externality of a tax rate change in another country that plays a crucial role in the traditional tax competition literature. A tax increase in country i reduces the world market interest rate via increased capital supply and, therewith, reduces effective capital costs in all countries $j \neq i$:

$$\frac{\partial \tilde{r}_i}{\partial t_j} = X_j \frac{r}{\partial t_j} < 0 \quad \forall\, i \neq j. \tag{A.10}$$

Totally differentiating the first-order conditions (A.4) to (A.5) delivers

$$\begin{aligned}
F^A_{KK} dK_A + F^A_{KS} dS_A + [t_A - (1-t_A)C^A_b]\frac{r}{1-t_A} db_A & & \quad \text{(A.11)}\\
-\frac{\partial \tilde{r}_A}{\partial t_A} dt_A - \frac{\partial \tilde{r}_A}{\partial t_B} dt_B - \frac{\partial \tilde{r}_A}{\partial t_C} dt_C &= 0, \\
F^B_{KK} dK_B + F^B_{KS} G_K dK_C - F^B_{KS} dS_A + [t_B - (1-t_B)C^B_b]\frac{r}{1-t_B} db_B & & \quad \text{(A.12)}\\
-\frac{\partial \tilde{r}_B}{\partial t_A} dt_A - \frac{\partial \tilde{r}_B}{\partial t_B} dt_B - \frac{\partial \tilde{r}_B}{\partial t_C} dt_C &= 0, \\
\frac{1-t_B}{1-t_C} F^B_{KS} G_K dK_B + \left[\frac{1-t_B}{1-t_C}\left(F^B_{SS} G^2_K + F^B_S G_{KK}\right) + \frac{t_C - t_B}{1-t_C} q G_{KK}\right] dK_C & & \quad \text{(A.13)}\\
-\frac{1-t_B}{1-t_C} F^B_{SS} G_K dS_A - \frac{\partial \tilde{r}_C}{\partial t_A} dt_A - \left[\frac{F^B_S - q}{1-t_C} G_K + \frac{\partial \tilde{r}_C}{\partial t_B}\right] dt_B - \left[\frac{q G_K}{1-t_C} - \frac{\tilde{r}_C}{1-t_C} + \frac{\partial \tilde{r}_C}{\partial t_C}\right] dt_C &= 0 \\
(1-t_A) F^A_{KS} dK_A - (1-t_B) F^B_{KS} dK_B - (1-t_B) F^B_{SS} G_K dK_C & & \quad \text{(A.14)}\\
+ \left[(1-t_A) F^A_{SS} + (1-t-B) F^B_{SS}\right] dS_A - (F^A_S - q) dt_A + (F^B_S - q) dt_B = 0.
\end{aligned}$$

Applying the first-order condition (A.2) for the optimal debt-to-asset ratios eliminates the effects via changes in db_i from the system. When we additionally impose symmetry between countries (and subsidiaries) A and B, multiply equation (A.13) by $\frac{1-t_C}{1-t_B}$, collect terms, and slightly reorder the sequence of equations, we can summarize the system as

$$H \cdot \begin{pmatrix} dK_A \\ dS_A \\ dK_C \\ dK_B \end{pmatrix} = \begin{pmatrix} F_{KK} & F_{KS} & 0 & 0 \\ F_{KS} & 2F_{SS} & -F_{SS}G_K & -F_{KS} \\ 0 & -F_{SS}G_K & F_{SS}G_K^2 + G_{KK}\left[F_S + \frac{t-t_C}{1-t}q\right] & F_{KS}G_K \\ 0 & -F_{KS} & F_{KS}G_K & F_{KK} \end{pmatrix} \cdot \begin{pmatrix} dK_A \\ dS_A \\ dK_C \\ dK_B \end{pmatrix}$$

$$= \begin{pmatrix} \frac{(1-b)r}{(1-t)^2} + X\frac{\partial r}{\partial t_A} \\ \frac{F_S-q}{1-t} \\ X_C\frac{\partial r}{\partial t_A} \\ X\frac{\partial r}{\partial t_A} \end{pmatrix} dt_A + \begin{pmatrix} X\frac{\partial r}{\partial t_B} \\ -\frac{F_S-q}{1-t} \\ \frac{F_S-q}{1-t}G_K + X_C\frac{\partial r}{\partial t_B} \\ \frac{(1-b)r}{(1-t)^2} + X\frac{\partial r}{\partial t_B} \end{pmatrix} dt_B + \begin{pmatrix} X\frac{\partial r}{\partial t_C} \\ 0 \\ \frac{qG_K}{1-t} - \frac{[b_C + C^C(b_C)]r}{1-t} + \frac{X_C}{1-t}\frac{\partial r}{\partial t_C} \\ X\frac{\partial r}{\partial t_C} \end{pmatrix} dt_C. \tag{A.15}$$

The matrix H is the Hessian matrix of the maximization problem. The second-order conditions imply that the determinant of that matrix needs to be positive, that is $|H| > 0$. Furthermore, the second-order conditions require all entries in the main diagonal to be negative. A sufficient condition for $F_{SS}G_K^2 + G_{KK}\left[F_S + \frac{t-t_C}{1-t}q\right] < 0$ then is $F_S + \frac{t-t_C}{1-t}q = U > 0$. Throughout the paper, we assume that $U > 0$ holds.[39] Finally, the second-order conditions imply that the determinant of the 2×2 sub-matrix needs to be positive so that $2F_{KK}F_{SS} - F_{KS}^2 > 0$. A sufficient condition for this relationship is that $F_{KK}F_{SS} - F_{KS}^2 > 0$ which is a standard condition in production theory. We assume that $F_{KK}F_{SS} - F_{KS}^2 > 0$ always holds in our setting.

[39] Note that $U > 0$ always holds for any $F_S > q$ given that $t_i \in [0, 1]\, \forall\, i$.

Now, Cramer's Rule allows for deriving the comparative static effects of tax rate changes in one country on capital investment in the other countries. We find

$$
\begin{aligned}
\frac{dK_A}{dt_C} &= \frac{\begin{vmatrix} X\frac{\partial r}{\partial t_C} & F_{KS} & 0 & 0 \\ 0 & 2F_{SS} & -F_{SS}G_K & -F_{KS} \\ \frac{qG_K}{1-t} - \frac{[b_C+C^C(b_C)]r}{1-t} + \frac{X_C}{1-t}\frac{\partial r}{\partial t_C} & -F_{SS}G_K & F_{SS}G_K^2 + G_{KK}U & F_{KS}G_K \\ X\frac{\partial r}{\partial t_C} & -F_{KS} & F_{KS}G_K & F_{KK} \end{vmatrix}}{|H|} \\
&= \frac{X\frac{\partial r}{\partial t_C}\begin{vmatrix} 2F_{SS} & -F_{SS}G_K & -F_{KS} \\ -F_{SS}G_K & F_{SS}G_K^2 + G_{KK}U & F_{KS}G_K \\ -F_{KS} & F_{KS}G_K & F_{KK} \end{vmatrix}}{|H|} \\
&- \frac{F_{KS}\begin{vmatrix} 0 & -F_{SS}G_K & -F_{KS} \\ \frac{qG_K}{1-t} - \frac{[b_C+C^C(b_C)]r}{1-t} + \frac{X_C}{1-t}\frac{\partial r}{\partial t_C} & F_{SS}G_K^2 + G_{KK}U & F_{KS}G_K \\ X\frac{\partial r}{\partial t_C} & F_{KS}G_K & F_{KK} \end{vmatrix}}{|H|} \\
&= \frac{\left[\left(SOC_{33} - F_{KS}^2 G_{KK}U\right)X - F_{KS}G_K(F_{KK}F_{SS} - F_{KS}^2)\frac{X_C}{1-t}\right]\frac{\partial r}{\partial t_C}}{|H|} \\
&+ \frac{F_{KS}G_K(F_{KK}F_{SS} - F_{KS}^2)\frac{[b_c+C^C(b_C)]r}{1-t} - F_{KS}G_K^2(F_{KK}F_{SS} - F_{KS}^2)\frac{q}{1-t}}{|H|} \\
&= \frac{dK_B}{dt_C} \gtreqless 0, \qquad \text{(A.16)}
\end{aligned}
$$

where $SOC_{33} = [2F_{SS}F_{KK} - FKS^2](G_{KK}U + F_{SS}G_K^2) - F_{KK}F_{SS}^2G_K < 0$ is the determinant of the 3×3 sub-matrix of the Hessian which is negative by the second-order conditions.

Furthermore,

$$
\begin{aligned}
\frac{dK_C}{dt_A} &= \frac{\begin{vmatrix} F_{KK} & F_{KS} & \frac{(1-b)r}{(1-t)^2} + X\frac{\partial r}{\partial t_A} & 0 \\ F_{KS} & 2F_{SS} & \frac{F_S - q}{1-t} & -F_{KS} \\ 0 & -F_{SS}G_K & X_C\frac{\partial r}{\partial t_A} & F_{KS}G_K \\ 0 & -F_{KS} & X\frac{\partial r}{\partial t_A} & F_{KK} \end{vmatrix}}{|H|} \\
&= \frac{F_{KK}\begin{vmatrix} 2F_{SS} & \frac{F_S - q}{1-t} & -F_{KS} \\ -F_{SS}G_K & X_C\frac{\partial r}{\partial t_A} & F_{KS}G_K \\ -F_{KS} & X\frac{\partial r}{\partial t_A} & F_{KK} \end{vmatrix}}{|H|} - \frac{F_{KS}\begin{vmatrix} F_{KS} & \frac{(1-b)r}{(1-t)^2} + X\frac{\partial r}{\partial t_A} & 0 \\ -F_{SS}G_K & X_C\frac{\partial r}{\partial t_A} & F_{KS}G_K \\ -F_{KS} & X\frac{\partial r}{\partial t_A} & F_{KK} \end{vmatrix}}{|H|} \\
&= \frac{\left(-2[F_{KK}F_{SS} - F_{KS}^2]F_{KS}G_KX + 2F_{KK}[F_{KK}F_{SS} - F_{KS}^2]X_C\right)\frac{\partial r}{\partial t_A}}{|H|} \\
&- \frac{[F_{KK}F_{SS} - F_{KS}^2]F_{KS}G_K\frac{(1-b)r}{(1-t)^2} - F_{KK}[F_{KK}F_{SS} - F_{KS}^2]G_K\frac{F_S - q}{1-t}}{|H|} = \frac{dK_C}{dt_B} \gtrless 0. \quad \text{(A.17)}
\end{aligned}
$$

Finally,

$$
\begin{aligned}
\frac{dK_A}{dt_B} &= \frac{\begin{vmatrix} X\frac{\partial r}{\partial t_B} & F_{KS} & 0 & 0 \\ -\frac{F_S-q}{1-t} & 2F_{SS} & -F_{SS}G_K & -F_{KS} \\ \frac{F_S-q}{1-t}G_K + X_C\frac{\partial r}{\partial t_B} & -F_{SS}G_K & F_{SS}G_K^2 + G_{KK}U & F_{KS}G_K \\ \frac{(1-b)r}{(1-t)^2} + X\frac{\partial r}{\partial t_B} & -F_{KS} & F_{KS}G_K & F_{KK} \end{vmatrix}}{|H|} \\
&= \frac{X\frac{\partial r}{\partial t_B}\begin{vmatrix} 2F_{SS} & -F_{SS}G_K & -F_{KS} \\ -F_{SS}G_K & F_{SS}G_K^2 + G_{KK}U & F_{KS}G_K \\ -F_{KS} & F_{KS}G_K & F_{KK} \end{vmatrix}}{|H|} \\
&- \frac{F_{KS}\begin{vmatrix} -\frac{F_S-q}{1-t} & -F_{SS}G_K & -F_{KS} \\ \frac{F_S-q}{1-t}G_K + X_C\frac{\partial r}{\partial t_B} & F_{SS}G_K^2 + G_{KK}U & F_{KS}G_K \\ \frac{(1-b)r}{(1-t)^2} + X\frac{\partial r}{\partial t_B} & F_{KS}G_K & F_{KK} \end{vmatrix}}{|H|} \\
&= \frac{\left[\left(SOC_{33} - F_{KS}^2 G_{KK}U\right) X - F_{KS}G_K(F_{KK}F_{SS} - F_{KS}^2)\frac{X_C}{1-t}\right]\frac{\partial r}{\partial t_B}}{|H|} \\
&- \frac{F_{KS}^2 G_{KK}U\frac{(1-b)r}{(1-t)^2} - F_{KS}F_{KK}G_{KK}U\frac{F_S-q}{1-t}}{|H|} \gtrless 0. \qquad \text{(A.18)}
\end{aligned}
$$

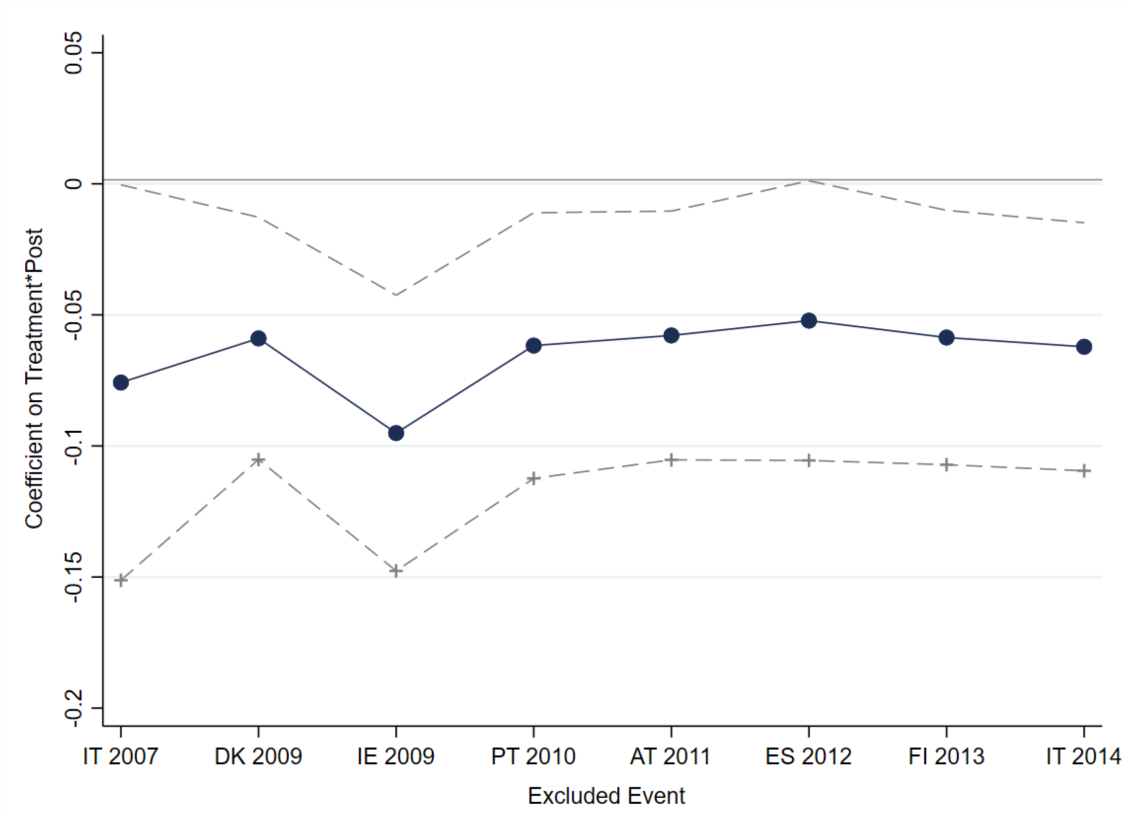

Figure A1: Tax-hike spillover: excluding one event at a time

This figure shows the coefficients on *Tax hike*×*Post* from the regression in equation (10), excluding one event (i.e., tax hike) at a time. We include firm controls in all regressions. The gray line represents the 95% confidence interval.

Table A1. Are Foreign Tax Hikes Exogenous to Domestic Economic Conditions?

This table examines the correlations between foreign tax hikes and domestic economic conditions. We use probit models and report the marginal effects at the variable means. The dependent variable is an indicator variable that equals one if a tax hike (listed in Table 1) is implemented in year t for country i, and zero otherwise. The explanatory variables include macroeconomic variables (e.g., de Cos and Moral-Benito (2016)) of country j ($j \neq i$) in year $t-1$. These variables are the interest rate (change in the three-month T-Bill rate from the IMF), the business confidence indicator (from the OECD), the Consumer Confidence Index (from the OECD), the GDP growth (from the World Bank), consumption growth (from the World Bank), investment per capita growth (from the World Bank), the GDP deflator (from the World Bank), and the debt-to-GDP ratio (from the IMF). All regressions include year and country pair fixed effects, as well as the macroeconomic variables of the source country i at $t-1$. Standard errors are clustered by country pair–event and reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	Tax Hike$_{it}$								
	1	2	3	4	5	6	7	8	9
Interest rate$_{j,t-1}$	0.519								-0.137
	(1.173)								(1.855)
Business confidence$_{j,t-1}$		0.0000							0.005
		(0.012)							(0.021)
Consumer confidence$_{j,t-1}$			-0.002						0.006
			(0.010)						(0.016)
GDP growth$_{j,t-1}$				-0.204					-0.348
				(0.530)					(1.425)
Consumption growth$_{j,t-1}$					-0.246				-0.219
					(0.470)				(1.168)
Investment growth$_{j,t-1}$						-0.061			-0.098
						(0.167)			(0.366)
GDP deflator$_{j,t-1}$							-0.244		0.488
							(0.585)		(1.378)
Debt-to-GDP$_{j,t-1}$								-0.001	-0.000
								(0.001)	(0.002)
Controls of country i	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country pair FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	595	595	595	595	595	595	595	595	595
Pseudo-R^2	0.001	0.087	0.000	0.038	0.060	0.018	0.008	0.000	0.245

Table A2. Domestic Corporate Tax Hike and Domestic Investment

This table reports OLS regressions of investment. The dependent variable is domestic investment. The independent variable is domestic corporate tax hike intensity (the increase of corporate tax revenue relative to the country's lagged GDP). The control variables are the same as in Table 3. Standard errors are double clustered by parent–event and by subsidiary–event, and are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	Domestic investment	
Domestic tax hike intensity (% GDP)	-0.381***	-0.382***
	(0.137)	(0.115)
N	189,888	189,888
Controls as in Table 3	No	Yes
Subsidiary FE	Yes	Yes
Sub. ind.–Year FE	Yes	Yes
Parent country–Year FE	Yes	Yes
Adjusted R^2	0.170	0.171

Table A3. Covariate Balance—Before and After Matching

This table presents the covariate balance before and after matching that is presented in Panel F of Table 4.

Panel A. Match on subsidiary size and industry

	N	Treatment	Control	Standardized Diff.	Variance Ratio
	1	2	3	4	5
Before matching:					
Size	35,077	15.8419	14.8272	0.6235	1.2726
After matching:					
Size		15.8419	15.8513	-0.0053	0.8836

Panel B. Match on subsidiary size, industry, and country

	N	Treatment	Control	Standardized Diff.	Variance Ratio
	1	2	3	4	5
Before matching:					
Size	13,740	15.7800	14.9441	0.5148	1.2175
After matching:					
Size		15.7800	15.8138	-0.0196	0.9479

Panel C. Match on subsidiary size, industry, country, and parent country

	N	Treatment	Control	Standardized Diff.	Variance Ratio
	1	2	3	4	5
Before matching:					
Size	4,568	15.8649	15.2028	0.4056	1.0808
After matching:					
Size		15.8649	15.7542	0.0644	0.8813

Table A4. Additional Robustness Tests

This table reports additional robustness tests of the results in Table 3. Panel A controls for lagged investment. Panel B examines the sample of subsidiaries that are at least 90% owned by the parent group. The specification is the same as in equation (1). The control variables are the same as in Table 3. All variable definitions are presented in the Appendix. Standard errors are double clustered by parent–event and by subsidiary–event, and are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Panel A. Controlling for lagged investment

	1	2
Tax hike	-0.061**	-0.057**
	(0.024)	(0.023)
N	54,196	54,196
Controls as in Table 3	Yes	Yes
Lagged investment	Yes	Yes
Subsidiary FE	Yes	Yes
Parent country–Year FE	Yes	Yes
Sub. country–Year FE	Yes	–
Sub. country–Ind.–Year FE	–	Yes
Adjusted R^2	0.209	0.212

Panel B. Ownership in subsidiary ≥90%

	1	2
Tax hike	-0.045*	-0.052**
	(0.025)	(0.025)
N	44,491	44,491
Controls as in Table 3	No	Yes
Subsidiary FE	Yes	Yes
Sub. country–Ind.–Year FE	Yes	Yes
Parent country–Year FE	Yes	Yes
Adjusted R^2	0.131	0.210