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Re-allocating taxing rights and minimum tax rates in international profit taxation

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Non-technical summary

Research Question

In 2019, a group of OECD countries presented a proposal on the reform of international profit taxation. The proposal is based on two pillars: (i.) the re-allocation of taxing rights away from source countries (where goods are produced) to market countries (where goods are consumed), and (ii.) the introduction of minimum taxation. What are the macroeconomic implications of re-allocating taxing rights and introducing minimum rates in international profit taxation?

Contribution

We assess this question in a three-region dynamic macroeconomic model in which profit taxation is explicitly modelled as opposed to assuming a general income tax on the return to capital, which is generally the case in standard models. In our model, households own firms, which undertake production, employment and investment decisions with a view to maximizing profits.

Results

We find that, in low-tax economies, the average profit tax rate faced by firms will rise as a response to the introduction of minimum tax rates and the re-allocation of taxing rights. On the one hand, this reduces price competitiveness of firms located in these regions and, thereby, demand for goods produced there, and output. On the other hand, higher profit tax revenues resulting from increased rates help to reduce other taxes. Moreover, lower expected future output requires less capital in production in the long run. Firms hence invest less and (temporarily) augment dividend payments. This raises the disposable income of households, who (at least temporarily) increase consumption. The opposite holds for high-tax economies. When taxing rights are re-allocated, additional wealth transfers between regions mitigate these effects. In terms of welfare, low tax economies can benefit from an increase in profit taxation.

Nichttechnische Zusammenfassung

Fragestellung

Im Jahr 2019 hat eine Gruppe von OECD-Ländern Vorschläge erarbeitet, die Besteuerung von Unternehmensgewinnen zu reformieren. Die Vorschläge basieren auf zwei Säulen: (i.) der Neuzuordnung von Gewinnbesteuerungsrechten weg von den Quellen- und Herkunftsstaaten hin zu den Marktstaaten (Konsumort) und (ii.) der Einführung einer Mindestbesteuerung von Unternehmensgewinnen. Mit welchen makroökonomischen Konsequenzen kann bei Umsetzung dieser Vorschläge gerechnet werden?

Beitrag

Wir adressieren diese Frage im Rahmen eines drei Regionen umfassenden, dynamischen makroökonomischen Simulationsmodells, in dem Gewinnbesteuerung auf Unternehmensseite explizit modelliert ist – im Gegensatz zum Standard-Modell, wo Kapitalertragsteuern stellvertretend für Gewinnbesteuerung herangezogen werden. Haushalte besitzen Firmen, die ihre Produktions- und Investitionsentscheidungen mit dem Ziel der Gewinnmaximierung treffen.

Ergebnisse

Wir finden, dass sowohl durch die Einführung einer Mindestbesteuerung als auch durch die Neuzuordnung von Gewinnbesteuerungsrechten die durchschnittliche Gewinnbesteuerung der Unternehmen in Niedrigsteuerländern steigt. Einerseits reduziert eine höhere Gewinnbesteuerung die internationale Wettbewerbsfähigkeit der betroffenen Regionen. Dadurch sinkt die Nachfrage nach den entsprechenden Produkten und die Produktion geht zurück. Andererseits können durch höhere Gewinnsteuersätze bei Einführung der Mindestbesteuerung andere Steuern reduziert werden. Zudem wird perspektivisch weniger Kapital in der Produktion benötigt. Firmen investieren also weniger und erhöhen (zeitweise) die Dividendenzahlungen. Das erhöht das verfügbare Nettoeinkommen von Haushalten und weitet deren Konsummöglichkeiten (zumindest zeitweise) aus. Das Gegenteil passiert in Hochsteuerregionen. Bei einer Neuzuordnung von Besteuerungsrechten kommt es zusätzlich zu Vermögenstransfers zwischen den Regionen, die die oben genannten Effekte schmälern. Dennoch können die Reformen die Wohlfahrt auch in Niedrigsteuerregionen erhöhen.

Deutsche Bundesbank Discussion Paper No 03/2021

Re-Allocating Taxing Rights and Minimum Tax Rates in International Profit Taxation*

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Abstract

What are the macroeconomic implications of re-allocating taxing rights away from source countries (where goods are produced) to market countries (where goods are consumed) and introducing minimum rates in international profit taxation? We assess this question in a dynamic macroeconomic model that gives a meaningful role to profit taxation. We find that, in low tax economies, the average profit tax rate will rise. On the one hand, this reduces price competitiveness of firms located in these regions and, thereby, output. On the other hand, higher profit tax revenues help to reduce other taxes. Moreover, lower expected future output requires less capital in production in the long run. Firms hence invest less and (temporarily) augment dividend payments. This raises disposable income of households, who (at least temporarily) increase consumption. The opposite holds for high tax economies. When taxing rights are re-allocated, wealth transfers between regions mitigate these effects. In terms of welfare, low tax economies can benefit from an increase in profit taxation.

Keywords: Re-Allocating Profit Taxing Rights, Minimum Taxation, International Macro

JEL classification: H25, L52, E20, E62, L10

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1 Introduction

Under the OECD/G20 Inclusive Framework on BEPS (Base Erosion and Profit Tax Shifting), over 135 countries are implementing actions to tackle tax avoidance, improve the coherence of international tax rules and ensure a more transparent tax environment (see *http://www.oecd.org/tax/beps/*). In 2019, a group of these countries presented a proposal for how to reform international profit taxation. The proposal is to be finalized and decided upon by mid-2021 (see OECD, 2019, 2020a). It is based on two pillars: (i.) the re-allocation of taxing rights (Pillar 1), and (ii.) the introduction of minimum taxation (Pillar 2, also called Global Anti-Base Erosion, GLoBE).[1]

At present, firm profits are in principle taxed by the country in which a firm has a physical presence (source country).[2] However, one can also imagine taxing profits where the final goods are sold (market-based taxation). Pillar 1 of the OECD proposal suggests that some share of taxing rights should be assigned to the market countries.[3] Under Pillar 2, countries would multi-nationally agree on minimum taxation of firm profits. The main goals are avoiding profit-shifting and curbing tax competition.

In this paper, we assess the macroeconomic implications of the OECD/G20 proposals by means of a dynamic macroeconomic model that gives a meaningful role to profit taxation along the lines of Anagnostopoulos, Carceles-Poveda, and Lin (2012), Anagnostopoulos, Atesagaoglu, and Carceles-Poveda (2018), Atesagaoglu (2012), Gourio and Miao (2010), McGrattan and Prescott (2005), Santoro and Wei (2012) and Zeida (2019). The main difference between these models and standard RBC approaches is that profit taxation is explicitly modelled as opposed to assuming a general income tax on the return to capital. The international dimension is introduced by extending our model to three countries: (i.) a high, (ii.) an intermediate and (iii.) a low profit tax economy. All countries trade with each other. Each country is inhabited by a representative household and a representative corporate firm. Both take dynamic decisions in the presence of profit taxation. Households own firms which undertake production, employment and investment decisions with a view to maximizing the shareholder value.

We model the OECD/G20 reform proposal in a stylised way as we assume that, under Pillar 1, all taxing rights (not only a fraction) are re-allocated to the market countries. While this simplification is necessary to keep the model tractable, we argue that it not critical to the (qualitative) results. Also, the specific share of residual profits to be re-

[1] Initially, BEPS was meant to deal with taxation issues concerning the digital economy. However, as mentioned in OECD (2015), for example, the involved parties soon realized that it would be impossible to ring-fence the digital economy from the rest for taxing purposes (although digital goods are certainly easier to trade cross-border). It was, therefore agreed to consider economy-wide changes in profit taxation. We do the same in this paper.

[2] Multinational enterprises can assign their profits to different countries using transfer prices, license fees or debt. The countries involved monitor these instruments with the arm's length principle. This is especially difficult when intermediate goods are very specific or even unique (for example intellectual property, see Dischinger and Riedel, 2011, or Baumann, Boehm, Knoll, and Riedel, 2020). Profit shifting to tax havens is more frequent among firms in the manufacturing sector compared to the services sector. Also, profit shifting to tax havens seems more frequent among US firms compared to German firms (see Gumpert, Hines, and Schnitzer, 2016). Often, profits end up being taxed where the firm chooses to establish its head office at a rate set by the home country.

[3] More specifically, a routine profit is to be taxed by the source country (no change) while some fraction of the residual (excess) profits is to be taxed by the market countries..

allocated to the market countries is still under discussion and remains to be fixed. Indeed, if countries manage to agree implementing the OECD/G20 proposal, it seems probable that more steps in that direction would follow.

Our results show that, when implementing the OECD/G20 BEPS proposals, profit taxation of firms increases in the low tax country. This is either the case because the country has to increase regional tax rate to a minimum level, because some sales are taxed at higher foreign rates when taxing rights are re-allocated or because of both. To compensate for the loss of after-tax profits, firms in that region raise prices (relative to goods produced in other regions), which reduces demand for goods produced in the low tax region. Output falls. The opposite basically holds in the high tax region, especially if it decides to reduce its profit tax rate to the new minimum rate. For the country with intermediate profit taxation (basically at the minimum rate already), output effects are small, and, if anything, most likely negative (at least in the long run). Depending on the exact policy change, this is for one of two reasons. Either average world-wide profit taxation increases such that, due to the pricing effects just described, aggregate world demand falls (including the demand for goods produced in the intermediate tax region). Or price competitiveness of the high tax country increases disproportionately,[4] which affects demand for goods produced in the intermediate tax region negatively. In this latter case, the (long-run) output effects on the intermediate tax region are extremely small though. Aggregate world output falls in the long run if taxation is increased in the low-tax economy because overall distortions in the economic system are increased. It stays constant when also the high-tax economy reduces taxation.

The tax change-induced effects on output do not necessarily translate into changes in regional consumption, however, especially along the transition. Households in the low tax region manage to (at least temporarily) increase consumption notably, although output falls, and they have to reduce consumption in the long run only very little. The opposite holds for the high tax regions. The reason is that (expected) long-run output losses (gains) in the respective region makes firms increase (decrease) their dividend payments to households due to the lower (higher) capital stock necessary in production in the future. In the end, households start (dis-)saving. Moreover, the increase (decrease) in the profit tax rate in the low (high) tax country generates public revenue gains (losses) that the government compensates by lowering (raising) other taxes. This, in turn, increases (decreases) the disposable income that households can use for consumption. In the region with intermediate profit taxation, consumption falls whenever output in that region is affected negatively (which is the case whenever aggregate world demand falls). It increases slightly if world demand is not affected too much (which is the case when average world-wide profit taxation remains rather stable).

The resulting implications for welfare are, in principle, those that we have observed for consumption. Hence, maybe contrary to what would be expected, it is the low profit tax region that benefits from the tax reform, and it is the high tax region that loses in terms of consumer welfare. The effects on regional consumption are mitigated when taxing rights are re-allocated. The reason is that, in this case, the low tax region transfers some of wealth to the high tax region (via profit taxation).

The higher is the trade between the regions (due to openness or preferences), the

[4]This is the case whenever the high-tax region reduces its tax rate such that average profit taxation remains unchanged.

stronger will be the effects just described. If the economies are relatively closed, spillover effects are of only minor importance. In terms of country size, we find that, if the low-tax region is relatively large, it is very likely that consumers in all regions will lose from a (large) increase in profit taxation in that region due to a relatively large increase in world-wide profit taxation. The opposite holds when the high-tax country is relatively large (and potentially reduces taxation to a new minimum level). It should also be noted that gains and losses are higher if the goods produced in the different regions are (more) difficult to substituter with each other. The reason is that firms can then better pass on the "costs" of the profit tax increase to households.

The rest of the paper is organized as follows. Related literature is discussed very briefly in Section 2. In Section 3, we present the model and describe its calibration. The simulation design is laid out in Section 4. Section 5 discusses the results. Section 6 concludes.

2 Related literature

This paper relates to different strands of the literature. Effects of tax reforms are routinely analysed by calculating forward-looking effective corporate income tax rates (Devereux and Griffith, 2003, and Spengel, Schmidt, Heckemeyer, and Nicolay, 2019). Under this approach, one or various typical investment projects are defined. Effective (average and marginal) tax rates before and after the reform are calculated. OECD (2020b), OECD (2020c) as well as Hanappi and Cabral (2020) simulate the reform effects on such effective tax rates. They find that the OECD/G20 reform proposal would increase the effective average tax rate on an investment project conducted by a multinational enterprise by 0.3 percentage points. The effective marginal tax rate would be increased by 1.3 percentage points on average. The main increase results from the Pillar 2 reform. These studies argue that the additional tax burden would predominantly fall on highly profitable multinational enterprises which are expected to have a low sensitivity to higher corporate taxes. As a result, they find that the medium to long-term effects on GDP would be moderate (0.1% of GDP). According to these estimates, the tax rate hike induced by the reform is almost uniform across high- and low-to-middle income countries. Investment hub countries experience a larger increase in the effective average tax rate. OECD (2020d) and Saint-Amans (2020) argue that a possible negative effect of this tax rate increase on investment may well be offset by legal certainty. Related papers explore more specific aspects of the OECD reform proposal using data on multinational enterprise groups. For example, Beer, de Mooij, Hebous, Keen, and Liu (2020) analyse the implications of residual profit allocation used in Pillar 1 of the proposal. de Mooij, Liu, and Prihardini (2019) analyse the effects of formula apportionment within international tax reform. Other papers review the effectiveness of unilateral anti-avoidance measures (see, for example, Collier and Riedel, 2018).

While the approach by Devereux and Griffith allows understanding the reform effects on profit-shifting and locational choice, they cannot account for general equilibrium effects. The introduction of a world-wide re-allocation of taxing rights, in particular, as well as the introduction of minimum taxation are likely to have significant implications for macroeconomic variables such as firm allocation and shareholder value, (domestic) output, consumption, investment, employment and wages, as well as international competitive-

ness and trade. These effects are analysed by the literature exploring the macroeconomic effects of tax reforms. Recently, for example, the macroeconomic effects of the 2017 US corporate income tax reform have been analysed. To mention but a few, Barro and Furman (2018) estimate the output effects of the 2017 US corporate income tax reform. They focus on comparing long-run steady state outcomes within a Ramsey type growth model. More related to our model is Lieberknecht and Wieland (2019). They use a two-country New Keynesian DSGE model to simulate the dynamic effects of the US reform on domestic investment, consumption, production and debt but also its international spillovers. To our knowledge, no macroeconomic model has yet been presented to analyse the effects of the proposed OECD/G20 international tax reforms.

In addition to the findings described so far, our paper also shows that using capital interest taxation as a proxy for a corporate taxation, which is typically done in many RBC models, may be a critical assumption. As discussed in Kempkes and Stähler (2016), Attinasi, Prammer, Stähler, Tasso, and van Parys (2019) and the literature mentioned therein, taxing capital in a conventional RBC model generates the largest negative effects on output, consumption, employment and investment relative to taxing anything else. The main reason is that capital taxes directly and persistently affect the wedge between the net interest households demand for investing in capital (which is a result of the consumption-Euler equation) and what firms have to pay such that the household receives the desired net interest. With higher tax rates on capital interest, firms reduce capital input to increase the marginal productivity of capital and, thus, gross interest paid to households. This reduces output and, in the end, consumption. In our model, we show that a "true" corporate profit taxation generates lower distortions such that it can pay off for the social planner to increase profit taxation.

3 The model

In this section, we present our three-region RBC model with profit taxation. Regions are indexed by $i = a, b, c$. In each region i, a representative firm produces a differentiated good that is tradeable across countries. Goods are purchased by households and firms in each region according to the country-specific consumption and investment baskets. Households further choose their mutual fund share and the amount of an internationally traded asset. They supply labor to the representative firm of the region they live in. Labor is immobile across countries. The representative firm in region i produces the country-specific good using labor and capital. It owns the latter. The firm pays out dividends to the household due to the presence of positive profits. Government consumption is financed by taxing profits as well as labor and capital income. As there will be no shocks in the model except for the one-time change in taxation policy (MIT shock), relative prices will be deterministic. Time is discrete. Unless otherwise indicated, quantity variables will be expressed in per capita terms throughout the paper.

3.1 Households

The representative household of region i finances real consumption expenditures including taxes at rate $\tau^{c,i}$, $(1 + \tau_t^{c,i}) \cdot c_t^i$, purchases of stocks $P_t^{S,i} \cdot S_t^i$ and purchases of real CPI-deflated net foreign assets nfa_t^i by net labor income $(1 - \tau_t^{n,i}) \cdot w_t^i$, net dividend payments

on last period's mutual fund holdings $(1-\tau_t^{d,i}) \cdot D_t^i \cdot S_{t-1}^i$, net capital gains from mutual fund holdings $\left(P_t^{S,i} - \tau_t^{g,i} \cdot (P_t^{S,i} - P_{t-1}^{S,i})\right) \cdot S_{t-1}^i$ and gross interest payments on net foreign assets $R_{t-1}^{nfa,i} \cdot nfa_{t-1}^i$. $P_t^{S,i}$ is the CPI-deflated price of stocks of region-i firms, w_t^i denotes the CPI-deflated real wage of region i and D_t^i are real dividend payments per mutual fund unit S_t^i. $\tau_t^{n,i}$ is the labor income tax rate, $\tau_t^{d,i}$ the dividend tax rate and $\tau_t^{g,i}$ the capital gains tax rate.[5] Hence, the household in region i seeks to maximize utility

$$\sum_{t=0}^{\infty} \beta^t \cdot \left(\frac{{c_t^i}^{1-\sigma^c}}{1-\sigma^c} - \kappa^{n,i} \cdot \frac{{n_t^i}^{1+\Psi}}{1+\Psi} \right), \tag{1}$$

where $\beta \in (0,1)$ is the discount factor, σ^c depicts the curvature of the utility function (as $\sigma^c \to 1$, the utility function becomes log), $\Psi \geq 0$ denotes the inverse of the Frisch elasticity of labor supply and $\kappa^{n,i}$ is a labor disutility scaling parameter, subject to the per-period budget constraint

$$\begin{aligned}(1+\tau_t^{c,i}) \cdot c_t^i + P_t^{S,i} \cdot S_t^i + nfa_t^i = (1-\tau_t^{n,i}) \cdot w_t^i \cdot n_t^i + R_{t-1}^{nfa,i} \cdot nfa_{t-1}^i \\ + \left[(1-\tau_t^{d,i}) \cdot D_t^i + P_t^{S,i} - \tau_t^{g,i} \cdot (P_t^{S,i} - P_{t-1}^{S,i})\right] \cdot S_{t-1}^i,\end{aligned} \tag{2}$$

plus $n_t^i \in (0,1)$ and $S_t^i \geq 0$. Given the resulting marginal utility of consumption $\lambda_t^i = {c_t^i}^{-\sigma^c}/(1+\tau_t^{c,i})$, the other first-order conditions are

$$\lambda_t^i = \beta \cdot R_t^{nfa,i} \cdot \lambda_{t+1}^i = \beta \cdot (1+r_{t+1}^i) \cdot \lambda_{t+1}^i, \tag{3}$$

$$\lambda_t^i \cdot (1-\tau_t^{n,i}) \cdot w_t^i = \kappa^{n,i} \cdot {n_t^i}^{\Psi} \tag{4}$$

as the consumption-Euler equations based on stock and international asset holdings, respectively, and the consumption-leisure choice. The term

$$(1+r_{t+1}^i) = \frac{(1-\tau_{t+1}^{d,i}) \cdot D_{t+1}^i + P_{t+1}^{S,i} - \tau_{t+1}^{g,i}(P_{t+1}^{S,i} - P_t^{S,i})}{P_t^{S,i}} \tag{5}$$

is tomorrow's (expected) net return of investing in stocks today (including dividend payments and capital gains).

3.2 Firms

The representative firm in region i has the standard constant returns to scale production function $y_t^i = \epsilon^{a,i} \cdot {n_t^i}^{1-\alpha^i} \cdot {k_t^i}^{\alpha^i}$, where $\epsilon^{a,i}$ is total factor productivity (TFP) and k_t^i denotes the capital stock, which is owned by the firm. As usual, α^i depicts the capital share in production. Capital depreciates at rate $\delta^{k,i}$. The dividend payment that the firm can

[5] In the budget constraint (2), capital gains are computed on an accrual basis. If stock prices increase from one period to the other, the household owes a capital gains tax. The contrary is true when stock prices fall (in that case, the household receives a transfer from the government). This is a standard modelling approach in the literature. Alternatives are discussed in Gavin, Kydland, and Pakko (2007) or Dammon, Spatt, and Zhang (2001), for example.

make in period t is given by

$$D_t^i = (1 - \tilde{\tau}_t^{p,i}) \cdot \underbrace{\left[\tilde{y}_t^i - w_t^i \cdot n_t^i - \delta^{k,i} \cdot k_t^i\right]}_{=\Pi_t^i} - k_{t+1}^i + k_t^i. \tag{6}$$

It is the residual of the operating profit, Π_t^i, which is taxed at an average rate $\tilde{\tau}_t^{p,i}$, minus capital investment, $i_t^i = k_{t+1}^i - k_t^i$. In the initial steady state, we assume that $\tilde{\tau}_t^{p,i} = \tau_t^{p,i}$, i.e. the average profit tax rate faced by the representative firm in region i is the tax rate set by region-i authorities. As we discuss below, this changes when re-allocating taxing rights. Furthermore, we have to take into account that firms sell their products at regional producer prices, P_t^i, while real wages, capital costs and so on are deflated by consumer prices, $P_t^{C,i}$. This has to be taken into account when calculating the CPI-deflated operating profit, $\tilde{y}_t^i = P_t^i / P_t^{C,i} \cdot y_t^i$, where actual sales have to be multiplied by the PPI/CPI-relation. In Section 3.4, we derive the latter in detail.

Solving equation (5) for the stock price $P_t^{S,i}$, we get

$$P_t^{S,i} = \frac{1}{1 + \frac{r_{t+1}^i}{1 - \tau_{t+1}^{g,i}}} \cdot \left[\frac{1 - \tau_{t+1}^{d,i}}{1 - \tau_{t+1}^{g,i}} \cdot D_{t+1}^i + P_{t+1}^{S,i}\right]. \tag{7}$$

Today's stock price is the discounted sum of expected future net dividend payments and stock prices. Solving forward and taking into account the transversality condition, we get the objective of the firm. It seeks to maximize the market value to its shareholders composed of dividend payments and the current market price,

$$\sum_{j=0}^{\infty} \left(\prod_{z=1}^{j-1} \frac{1}{1 + \frac{r_{t+1+z}^i}{1 - \tau_{t+1+z}^{g,i}}} \right) \cdot \frac{1 - \tau_{t+1+j}^{d,i}}{1 - \tau_{t+1+j}^{g,i}} \cdot D_{t+1+j}^i \tag{8}$$

with respect to n_t^i, k_{t+1}^i and D_t^i subject to equation (6), $D_t^i \geq 0$ and $K_0 > 0$.[6] The firm's first-order conditions are

$$w_t^i = (1 - \alpha^i) \cdot \frac{\tilde{y}_t^i}{n_t^i}, \tag{9}$$

$$\frac{r_{t+1}^i}{1 - \tau_{t+1}^{g,i}} = (1 - \tilde{\tau}_{t+1}^{p,i}) \cdot \left(\alpha^i \cdot \frac{\tilde{y}_{t+1}^i}{k_{t+1}^i} - \delta^{k,i}\right) \tag{10}$$

and

$$P_t^{S,i} = \frac{1 - \tau_{t+1}^{d,i}}{1 - \tau_{t+1}^{g,i}} \cdot k_{t+1}^i, \tag{11}$$

determining labor input, capital investment and the stock value. As described in detail in Zeida (2019), we need to use equation (10) solved for k_{t+1}^i and use the time $t+1$-version of equation (6) together with the equivalent time $t+1$-version of equation (9) to derive equation (11). It relates the firm's market (or outside) value $P_t^{S,i}$ to the firm's inside value, the (future) capital stock k_{t+1}^i. Whenever capital gains are (expected to be) taxed more

[6] $D_t^i \geq 0$ implies that net operating profits must be split between dividend payment and investment (retained earnings). Firms cannot buy back shares or issue new equity to finance investment.

than dividend payments, i.e. $\tau_{t+1}^{d,i} < \tau_{t+1}^{g,i}$, investors prefer capital investments (retained earnings) to be relatively small and dividend payments to be high. The opposite holds when the relationship is reversed.

3.3 The government

The government in each region i needs to finance its CPI-deflated expenditures $\tilde{G}_t^i$ by its tax revenues, i.e. the government budget constraint is given by

$$\begin{aligned}\tilde{G}_t^i =& \tau_t^{d,i} \cdot D_t^i + \tau_t^{g,i} \cdot \left(P_t^{S,i} - P_{t-1}^{S,i}\right) + \tau_t^{c,i} \cdot c_t^i + \tau_t^{n,i} \cdot w_t^i \cdot n_t^i \\ &+ \tau_t^{p,i} \cdot \left[\varpi_t^{i,i} \cdot \Pi_t^i + \varpi_t^{j,i} \cdot \frac{P_t^{C,j}}{P_t^{C,i}} \cdot \Pi_t^j + \varpi_t^{h,i} \cdot \frac{P_t^{C,h}}{P_t^{C,i}} \cdot \Pi_t^h\right], \end{aligned} \tag{12}$$

where $h, j = a, b, c$ and $i \neq j \neq h$. Hence, $\varpi_t^{j,i}$ is the share of region-j firms' operating profits Π_t^j that is taxed in region i. Given that region-j profits are deflated by consumer prices of region-j, we have to transform these profits into region i-CPI. It is clear that, in the initial steady state of our model, in which firm profits are solely taxed in the region of the firm's origin, it holds that $\varpi_t^{i,i} = 1$ and $\varpi_t^{j,i} = \varpi_t^{h,i} = 0$. As we will describe in more detail below, this changes when re-allocating taxing rights. We follow Gadatsch, Hauzenberger, and Stähler (2016) and assume a full home bias in government consumption (see also Brülhart and Trionfetti, 2001, 2004, for a discussion). Therefore, in analogy to firm sales, it holds that $\tilde{G}_t^i = P_t^i / P_t^{C,i} \cdot G_t^i$, where G_t^i is the actual PPI-deflated amount of goods purchased by the public sector.

3.4 International linkages and market clearing

We assume that households in region i consume goods produced in any of the three regions. The corresponding consumption bundle is given by

$$c_t^i = \left[\left(\vartheta_a^i\right)^{1-\eta^i} \left(c_{a,t}^i\right)^{\eta^i} + \left(\vartheta_b^i\right)^{1-\eta^i} \left(c_{b,t}^i\right)^{\eta^i} + \left(\vartheta_c^i\right)^{1-\eta^i} \left(c_{c,t}^i\right)^{\eta^i}\right]^{\frac{1}{\eta^i}}.$$

Here, $c_{j,t}^i$ denotes goods produced in j and consumed in i and $\eta^i \in (-\infty, 1)$ governs the elasticity of substitution between these goods, which equals $1/(1-\eta^i)$. As $\eta^i \to 0$, the function boils down to a Cobb Douglas aggregator. ϑ_j^i denotes the consumption bias of region i-households towards goods produced in j. Hence, ϑ_i^i can be interpreted as the home bias of region i. It must hold that $\vartheta_a^i + \vartheta_b^i + \vartheta_c^i = 1$. Cost minimization of nominal consumption expenditures, $P_t^{C,i} \cdot c_t^i = P_t^a \cdot c_{a,t}^i + P_t^b \cdot c_{b,t}^i + P_t^c \cdot c_{c,t}^i$, implies that[7]

$$c_{j,t}^i = \vartheta_j^i \left(\frac{P_t^j}{P_t^{C,i}}\right)^{-\frac{1}{1-\eta^i}} \cdot c_t^i, \tag{13}$$

[7]Note that, by assuming that any region-i producer sells his/her product at the price P_t^i, we assume the law of one price to hold. There is no price discrimination between regions. Relaxing this assumption would not affect our results qualitatively. Quantitatively, the relative prices between regions (i.e. international competitiveness) would be affected a bit more though.

where $i, j = a, b, c$. The consumer price index (CPI) is

$$P_t^{C,i} = \left[\vartheta_a^i \cdot (P_t^a)^{-\eta^i/(1-\eta^i)} + \vartheta_b^i \cdot \left(P_t^b\right)^{-\eta^i/(1-\eta^i)} + \vartheta_c^i \cdot (P_t^c)^{-\eta^i/(1-\eta^i)}\right]^{-\frac{1-\eta^i}{\eta^i}}. \tag{14}$$

For simplicity, we assume that an analogous aggregator holds for investment goods such that we can derive analogous equations for i_t^i and $i_{j,t}^i$. CPI-deflated net exports in region i, nx_t^i, are given by

$$\begin{aligned} P_t^{C,i} \cdot nx_t^i =& P_t^i \cdot rs_j^i \cdot \left(c_{i,t}^j + i_{i,t}^j\right) + P_t^i \cdot rs_{\tilde{j}}^i \cdot \left(c_{i,t}^{\tilde{j}} + i_{i,t}^{\tilde{j}}\right) - P_t^j \cdot \left(c_{j,t}^i + i_{j,t}^i\right) \\ & - P_t^{\tilde{j}} \cdot \left(c_{\tilde{j},t}^i + i_{\tilde{j},t}^i\right), \end{aligned} \tag{15}$$

where $i, j, \tilde{j} = a, b, c$, and $i \neq j \neq \tilde{j}$. rs_j^i is the population size of region i relative to region j, which we need to express net exports in per-capita terms of region-i. Given net exports, CPI-deflated net foreign assets in region i evolve according to

$$nfa_t^i = R_{t-1}^{nfa,i} \cdot \frac{P_{t-1}^{C,i}}{P_t^{C,i}} \cdot nfa_{t-1}^i + nx_t^i + TR_t^i. \tag{16}$$

Because international assets traded between regions are in zero net supply, it must hold that $P_t^{C,a} \cdot nfa_t^a + P_t^{C,b} \cdot rs_b^a \cdot nfa_t^b + P_t^{C,c} \cdot rs_c^a \cdot nfa_t^c = 0$. TR_t^i is a payment received by region i from the other regions (or paid to the other regions if $TR_t^i < 0$). It is zero in our initial steady state, but it may turn positive/negative when re-allocating taxing rights, as we will discuss in detail below.

Product market clearing implies that whatever is produced in region i must be purchased somewhere around the world. Formally, we get

$$y_t^i = c_{i,t}^i + i_{i,t}^i + G_t^i + rs_j^i \cdot \left(c_{i,t}^j + i_{i,t}^j\right) + rs_{\tilde{j}}^i \cdot \left(c_{i,t}^{\tilde{j}} + i_{i,t}^{\tilde{j}}\right). \tag{17}$$

At equilibrium, optimizing decisions of households and firms as well as government actions must be mutually consistent. This completes the model description.

3.5 Calibration

In our baseline calibration, we assume countries to be symmetric, with one exception: the level of the profit tax rate. We assume that there is a high, an intermediate and a low profit tax country: country a, b and c, respectively. All countries are of equal size, i.e. $rs_j^i = 1 \forall i, j$. This symmetric calibration allows us to have a detailed look at the economic mechanisms at play when reforming the international profit tax system according to the OECD/G20 BEPS proposals. We also discuss the implications of an asymmetric calibration below. Most parameter changes do not affect the results qualitatively, and even quantitatively, results change only mildly. The baseline calibration is summarized in Table 1.

Table 1: Baseline calibration

Variable/Parameter	Symbol	Value
Discount factor	β	0.990
Elasticity of intertemporal substitution	σ^c	1.000
Inverse of Frisch elasticity of lab. supply	Ψ	2.000
Labor supply^T	$\bar{n}^i$	0.333
Disutility weighting parameter^e	$\kappa^{n,a}$; $\kappa^{n,b}$; $\kappa^{n,c}$	24.816; 24.762; 24.713
Per-capita output^T	$\bar{y}^i$	1.000
Capital share in production	α^i	0.333
Capital depreciation rate	$\delta^{k,i}$	0.025
Total factor productivity^e	$\epsilon^{a,a}$; $\epsilon^{a,b}$; $\epsilon^{a,c}$	1.012; 1.005; 0.999
Government spending-to-GDP ratio^T	G/Y	0.200
Labor tax rate	$\bar{\tau}^{n,i}$	0.116
Dividend tax rate	$\bar{\tau}^{d,i}$	0.200
Capital gains tax rate	$\bar{\tau}^{g,i}$	0.200
Profit tax rate	$\bar{\tau}^{p,a}$; $\bar{\tau}^{p,b}$; $\bar{\tau}^{p,c}$	0.200; 0.150; 0.100
Consumption tax rate^e	$\bar{\tau}^{c,a}$; $\bar{\tau}^{c,b}$; $\bar{\tau}^{c,c}$	0.143; 0.154; 0.165
Bias for goods produced in country a	ϑ^a_a; ϑ^b_a; ϑ^c_a	0.600; 0.200; 0.200
Bias for goods produced in country b	ϑ^a_b; ϑ^b_b; ϑ^c_b	0.200; 0.600; 0.200
Bias for goods produced in country c	ϑ^a_c; ϑ^b_c; ϑ^c_c	0.200; 0.200; 0.600
Substitution elasticity home/foreign	$1/(1-\eta^i)$	1.500
Relative country size	rs^i_j	1.000

Notes: Target variables and parameters as described in the main text. The superscript T marks targets, e endogenously derived parameter values to meet these targets. Parameters without a mark are set exogenously as described in the main text.

We calibrate the model to quarterly frequency and chose rather standard values from the RBC literature. We set $\beta = 0.99$, which delivers an annual interest rate close to 4%. The value is in line with the values reported for annual mutual fund after-tax interest rates reported by Gourio and Miao (2010). We set $\sigma^c = 1$ and, hence, assume log consumption utility, and we opt for a Frisch elasticity of labor supply of 0.5 (i.e. $\Psi = 2$) following Coenen, Straub, and Trabandt (2013) and Gadatsch et al. (2016); see also Gali, Smets, and Wouters (2012) and Whalen and Reichling (2017) for a discussion. With a target value for employment of $\bar{n}^i = 0.33$, which is a standard assumption, we can derive the parameter $\kappa^{n,i}$.

We assume a capital income share of $\alpha^i = 0.33$ and assume that capital depreciates 10% annually, i.e. $\delta^{k,i} = 0.025$ (see Cooley and Prescott, 1995). We normalize per-capita production in each region to one. Given the values of the fiscal variables below, the productivity parameter $\epsilon^{a,i}$ will then be derived such that we meet this target.

On the fiscal policy side, we set the government spending-to-output ratio to 20%, which

is a standard assumption in the literature (see also Coenen et al., 2013, and Gadatsch et al., 2016). We follow Coenen et al. (2013), who estimate a fiscal model for the Euro area, and set $\bar{\tau}^{n,i} = 0.116$. As regards the capital gains and dividend tax rates, we follow Zeida (2019) and set $\bar{\tau}^{g,i} = \bar{\tau}^{d,i} = 0.2$. For the profit tax rate, we set $\bar{\tau}^{p,a} = 0.2$, $\bar{\tau}^{p,b} = 0.15$ and $\bar{\tau}^{p,c} = 0.1$ for the high, the intermediate and the low tax rate country. We then calculate the corresponding consumption tax rate, $\bar{\tau}^{c,i}$, to close the budget.

As regards international trade, we follow the standard approach in the literature and assume that, in the initial steady state, net foreign assets are zero and relative prices are one. To achieve stationary net foreign asset positions, we also assume that countries face a risk premium when deviating from the steady-state value.[8] Furthermore, we assume a substitution elasticity between home and foreign goods of 1.5, which is in the range of standard values in the literature (see, for example, Gadatsch et al., 2016, Jacquinot, Lozej, and Pisani, 2018, or Schön and Stähler, 2020). This implies $\eta^i = 0.33$. According to Balta and Delgado (2009), home bias for goods in a typical EU country is a bit above 60%, and the import content from other European economies is around 20%. We hence set a home bias parameter of 0.6 for domestic goods in the European economies (implying a domestic consumption share of about two thirds when including public consumption) and a bias towards the goods produced in the other regions of 0.2. We discuss how a more asymmetric calibration affects results in Section 5.3.

4 Simulation design

We undertake several simulations. Fisrt, we introduce a minimum profit tax rate which is equal to the intermediate rate charged by country b. Taxes in the low-tax country c thus have to be increased by 5 PP as a result. Second, we simulate a situation in which the high-tax country a reduces its rate by 5 PP to the newly chosen minimum rate.

For simplicity, we assume that all simulations (also those that follow) start at the initial steady state. There are no other shocks hitting the economy after the policy change. Hence, we can attribute all changes in the macroeconomic variables to the policy change itself. The model and the simulations are solved in a fully non-linear fashion under perfect foresight.

Third, we assume that regional profit tax rates remain unchanged, but that taxing rights are re-allocated. After the reform, firm profits are taxed wherever the corresponding goods are sold. To calculate the share of operating profit of a firm in region $i = a, b, c$ that is taxed by region $j = a, b, c$, we first calculate the share of sales going to each region. The domestic share is given by $\left(c^j_{i,t} + i^j_{i,t} + G^i_t\right)/y^i_t$, while the share exported to region

[8] In standard open-economy DSGE models (Obstfeld and Rogoff, 1995), the net foreign asset position is set exogenous. Stationarity is reached by adding a friction to the financial market that kicks in whenever the exogenously fixed reference level is missed (see Schmitt-Grohe and Uribe, 2003, Hunt and Rebucci, 2005, Lubik, 2007, and Benigno, 2009, for an in-depth discussion). In our model, we assume that a risk premium has to be paid for trade in international assets in this case. The sensitivity parameter is set to 0.01, as is standard in the literature. Larger and lower values do not affect our results as long as the parameter is different from zero and positive. Targeting per-capita output of one while, at the same time, assuming different profit tax rates, a net foreign asset position of zero and relative prices of one is responsible for different TFP productivity, $\epsilon^{a,i}$, and labor disutility scaling parameters, $\kappa^{n,i}$, as reported in Table 1.

j is given by $rs_j^i \cdot \left(c_{i,t}^j + i_{i,t}^j\right)/y_t^i$. We assume that, to calculate the regional profits, we subtract an analogous share from total operating costs, $w_t^i \cdot n_t^i + \delta^{k,i} \cdot k_t^i$, from the regional sales to get the regional profits.[9] This implies that the share of operating profits of a firm of region i that is attributed to region j is given by

$$\varpi_t^{i,i} = \left(c_{i,t}^j + i_{i,t}^j + G_t^i\right)/y_t^i, \tag{18}$$

and

$$\varpi_t^{i,j} = rs_j^i \cdot \left(c_{i,t}^j + i_{i,t}^j\right)/y_t^i. \tag{19}$$

Once the policy change takes place, this changes the average profit tax rate faced by a firm producing in region i. It is now given by

$$\tilde{\tau}_t^{p,i} = \varpi_t^{i,i} \cdot \tau_t^{p,i} + \varpi_t^{i,j} \cdot \tau_t^{p,j} + \varpi_t^{i,h} \cdot \tau_t^{p,h}, \tag{20}$$

where $i, h, j = a, b, c$ and $i \neq j \neq h$. As long as $\tau_t^{p,i} > \tau_t^{p,j}, \tau_t^{p,h}$, the tax burden of the region-i firm clearly falls. This is the case for firms of region a in our baseline model economy. For region c, the tax rate clearly increases. For region b, the effect is unclear ex ante, as it will depend on the change in trade between regions.

In addition, we have to take into account that, after the re-allocation of taxing rights, part of region i's profit income is transferred to the other regions (via taxes), while the other regions transfer some of their income to region i. The net effect, captured by the term TR_t^i in equation (16), which was zero in our initial steady state, now becomes

$$TR_t^i = \tau_t^{p,i} \cdot \left[\varpi_t^{j,i} \cdot \frac{P_t^{C,j}}{P_t^{C,i}} \cdot \Pi_t^j + \varpi_t^{h,i} \cdot \frac{P_t^{C,h}}{P_t^{C,i}} \cdot \Pi_t^h - \varpi_t^{i,j} \cdot \Pi_t^i - \varpi_t^{i,h} \cdot \Pi_t^i\right]. \tag{21}$$

Again, we have to transform CPI-deflated profits of region j into profits deflated by the CPI of region i, as we did for government revenues in equation (12).

Fourth, we simulate both, the re-allocation of taxing rights and the introduction of minimum profit taxation, assuming that they happen at the same time. Again, we differentiate a situation in which the high tax-country leaves its tax rate unchanged or in which it reduces the rate to the minimum rate (the fifth simulation).

It is clear from the description in Section 3.3 that, due to the balanced budget requirement of the government, any change in the profit taxation will generate fiscal losses or gains for the regional fiscal authorities. In our baseline simulation, we assume that the labor tax rate takes care of balancing the budget (to make our transitional dynamics comparable to those presented by Zeida, 2019). Transition dynamics and long-run results are analogous when using other fiscal instruments.[10]

[9] This seems to be a reasonable assumption: Currently, it is planned to re-allocate some fraction of the *excess* profit at the level of the multinational enterprise group to the market countries (see Saint-Amans, 2020, p. 4, and Fuest, 2020, p. 9). It is not clear yet, however, what the *excess* profit will actually be. As discussed above, we assume that the entire profit is allocated to market countries to simplify matters. A lower share would reduce the effects described here accordingly.

[10] Changes in labor income taxation imply that wages and, thereby, employment are affected a bit more, whereas this is true for consumption when using consumption taxation and government purchases (the

5 Results

We start by describing the taxation change-implied transitional dynamics and long-run implications stepwise (starting with step 1 and moving to 3) before discussing potential welfare implications in the following subsection. In the last subsection, we discuss implications of an asymmetric calibration.

5.1 Transitional dynamics and long-run implications

Figures 1 to 3 show the implications for selected region a, b and c-specific variables of introducing minimum tax rates and re-allocating taxing rights separately. International spillovers are depicted in Figure 4. We assume that the policy change takes place in 2020. We depict years on the x-axis. Long-run implications (of all simulations) are summarized in Table 2.

Let us start by having a look at what happens in the low tax country c when it is forced to increase the profit tax rate by 5 PP in Figure 1 (solid blue line). Because of the higher profit tax rate, after-tax profits are reduced. This is the case even though higher revenues from profit income taxation allow the government to reduce the labor income tax rate by 0.6 PP. The latter increases profits because households are willing to accept lower gross wages (due to the fact that their net labor income rises after the labor tax decrease). However, the labor income tax reduction does not overcompensate the profit tax increase from the firm's perspective. Hence, net profits of investing in firms fall, which is also pictured by the reduction in the capital interest rate and the lower stock price of firms of region c.

To compensate for the profit loss, firms in region c increase prices (relative to firms in the other regions), which implies a fall in international competitiveness (see Figure 4). Demand for goods produced in region c falls. This reduces output and the incentive to invest in physical capital (Figure 1). Because capital is pre-determined in the initial period of the tax change, employment falls on impact (to reduce output given lower demand for goods of region c). However, it increases thereafter as a result of lower gross wages (resulting from lower wage income taxation and the fact that households are, therefore, willing to accept lower gross wages). The falling capital stock then takes care of reducing output. On impact, dividend payments increase because operating profits must be split between dividend payments and capital investment, and the latter is clearly reduced. As operating profits start falling due to lower demand for region c-goods (resulting in falling output), dividends payments start doing the same (after their increase on impact).

Interestingly, however, the decrease in output and international competitiveness does not harm private consumption in region c in the medium term as higher dividend payments (resulting from lower capital investment of firms) increase the household's disposable income. Moreover, a lower labor income tax rate increase net wage income of households (i.e. the tax cut is not compensated for by the fall in gross wages and the initial drop in employment). Therefore, households expand consumption. At least during the first 20 years after the reform, households of the low tax country benefit from an increase

latter sets free or ties up output that may otherwise be used by private agents). Overall, macroeconomic variables are affected in a very similar manner, both qualitatively and quantitatively. We show the corresponding graphs in the Appendix to save space.

in the profit income tax rate. After around 2040, consumption falls below its initial steady-state level, but only mildly (see Table 2). The reason is that dividend payments have fallen sufficiently to now overcompensate for a relatively higher net wage income. Summarizing, we find that the profit tax increase in the low-tax region reduces domestic output but benefits domestic consumption for more than 20 years because households start dis-saving and because labor income taxation is reduced.

What happens in the other regions? Although they gain international competitiveness, they face (very) small losses in output, consumption and investment eventually. Employment increases. The transition is best visible in Figure 2 for country b (analogous for country a). On impact, price competitiveness vis-a-vis region c rises. This makes goods produced in regions a and b relatively cheaper and increases demand. Given that capital is pre-determined, employment must rise to augment output. Capital investment and, thus, stock prices experience a short spike, too. This reduces dividend payments and, thereby, consumption possibilities. However, the positive output effect is only short-lived. Demand in region c, also for goods produced in regions a and b, eventually falls (whenever the positive effect on consumption of region c fades out). Hence, domestic output and investment in regions a and b start falling soon, too. This reduces consumption of agents living there. Because consumption and leisure are normal goods, employment rises and wages fall. Due to the positive employment effect, the government can reduce the labor income tax rate by tiny 0.01 PP.

When, in addition to the profit tax increase in region c, the high profit tax region a decides to reduce its tax rate to the new minimum rate also (which is levied in region b already), the effects in region a are opposite to what has been described above for the tax increase in region c (see Figure 3, dashed green line). In terms of international competitiveness, region a now gains with respect to region b, too, and over-proportionately does so relative to region c (see Figure 4). In terms of spillovers, higher investment demand in region a fosters aggregate world demand (relative to the situation in which only region c changes its tax policy). Thereby, the tax cut of region a alleviates long-run output and consumption losses in c (see Figure 1) and also spills over positively to region b (see Figure 2).

Turning to the re-allocation of taxing rights, we note that the average profit tax rates faced by firms of region i now change to the values presented at the bottom of Table 2, although domestic tax rates now remain unchanged. As firms sell goods to every region, they now have to pay a weighted average of the regional tax rates depending on their regional sales (see also equation (20) in Section 4 for a detailed description).

Changes in the profit tax rate are, in terms of direction, analogous to the changes of the scenario in which the low tax country increases and high tax country decreases its tax rates. But the magnitude of the change is smaller. The reason is that only a fraction of sales goes to the foreign economies. For most variables, the macroeconomic consequences of this scenario are, hence, analogous but smaller. We can confirm this in Figures 1 to 3. Nevertheless, there are still some structural differences when re-allocating taxing rights relative to changing (domestic) tax rates.

Table 2: Long-run changes of selected variables

Variable	$\tau^{p,c}\uparrow$	$\tau^{p,c}\uparrow+\tau^{p,a}\downarrow$	Re-allo	Re-allo+ $\tau^{p,c}\uparrow$	Re-allo+$\tau^{p,c}\uparrow+\tau^{p,a}\downarrow$
Output in a	-0.04	0.76	0.48	0.27	0.74
Consumption in a	-0.16	-0.07	0.02	-0.15	-0.10
Investment in a	-0.14	2.46	1.26	0.69	2.44
Employment in a	0.01	-0.07	0.10	0.07	-0.10
Wages in a	-0.15	0.51	0.17	-0.03	0.53
Net exports in a	0.00	0.00	0.02	0.02	0.00
Lab. tax in a	-0.02	0.65	-0.04	-0.01	0.73
Output in b	-0.04	0.00	0.00	-0.20	0.01
Consumption in b	-0.16	0.02	0.01	-0.17	0.02
Investment in b	-0.14	0.02	0.01	-0.53	0.02
Employment in b	0.01	-0.00	-0.00	-0.03	0.00
Wages in b	-0.15	0.02	0.01	-0.19	0.02
Net exports in b	0.00	0.00	-0.00	-0.01	-0.00
Lab. tax in b	-0.01	0.00	-0.00	0.04	-0.00
Output in c	-0.72	-0.67	-0.42	-0.86	-0.65
Consumption in c	-0.06	0.12	0.01	-0.04	0.14
Investment in c	-2.30	-2.14	-1.06	-2.66	-2.13
Employment in c	0.08	0.07	-0.10	0.06	0.10
Wages in c	-0.60	-0.43	-0.12	-0.65	-0.44
Net exports in c	0.00	0.00	-0.02	-0.01	-0.00
Lab. tax in c	-0.62	-0.61	0.07	-0.65	-0.69
Rel. price b/a	0.00	0.56	0.37	0.36	0.54
Rel. price c/a	0.51	1.07	0.70	0.86	1.03
Rel. price c/b	0.51	0.51	0.33	0.49	0.49
Av. prof. tax rate in a	0.200	0.150	0.176	0.184	0.150
Av. prof. tax rate in b	0.150	0.150	0.150	0.158	0.150
Av. prof. tax rate in c	0.150	0.150	0.124	0.158	0.150

Notes: Table shows deviation of selected variables from initial steady state in percent (percentage points for labor tax rates, net exports and relative prices). The average profit tax rate is given in levels (which are 0.20, 0.15 and 0.10 for regions a, b and c in the initial steady state, respectively).

Figure 1: Implications on macro variables in low tax country c

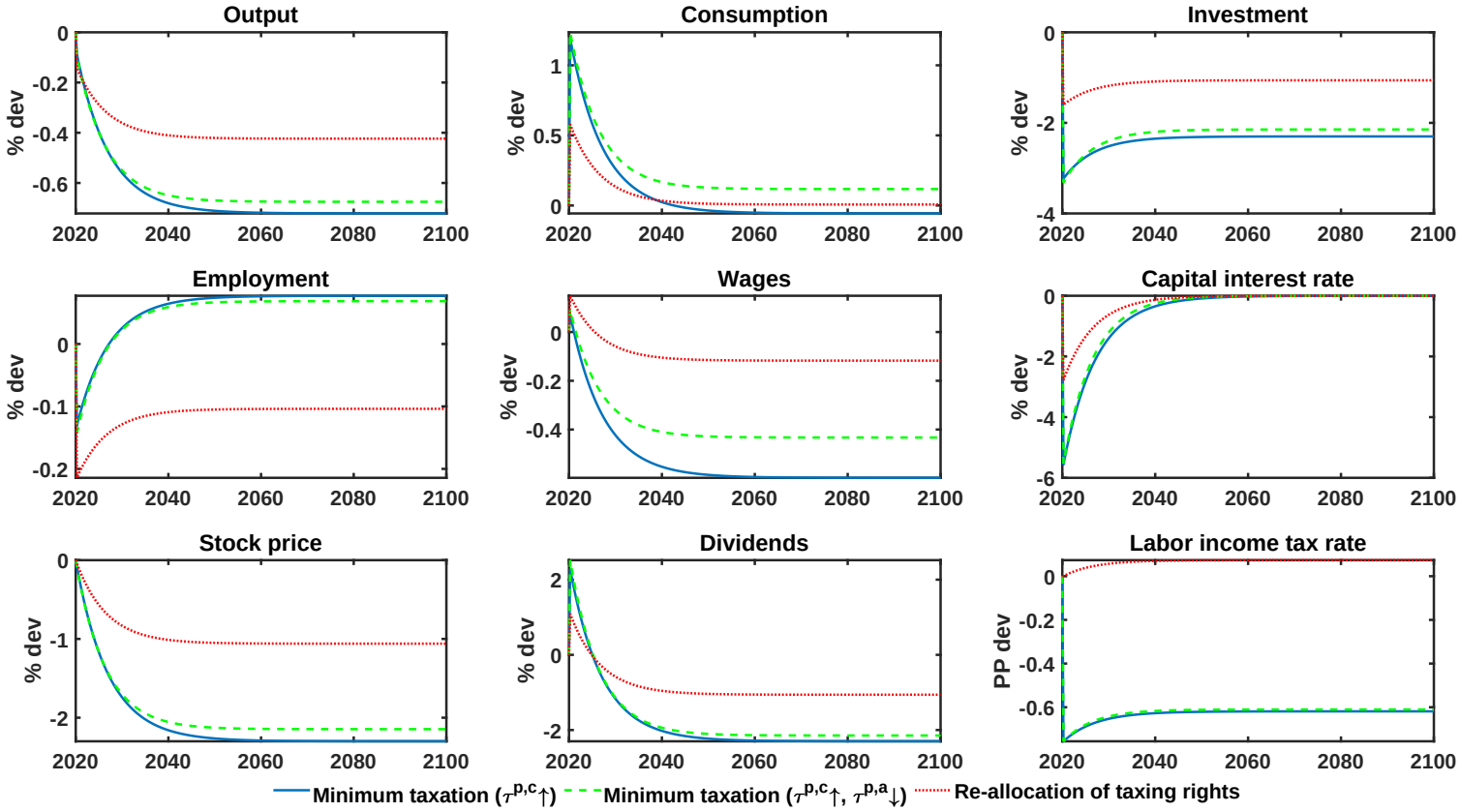


Figure 2: Implications on macro variables in intermediate tax country b

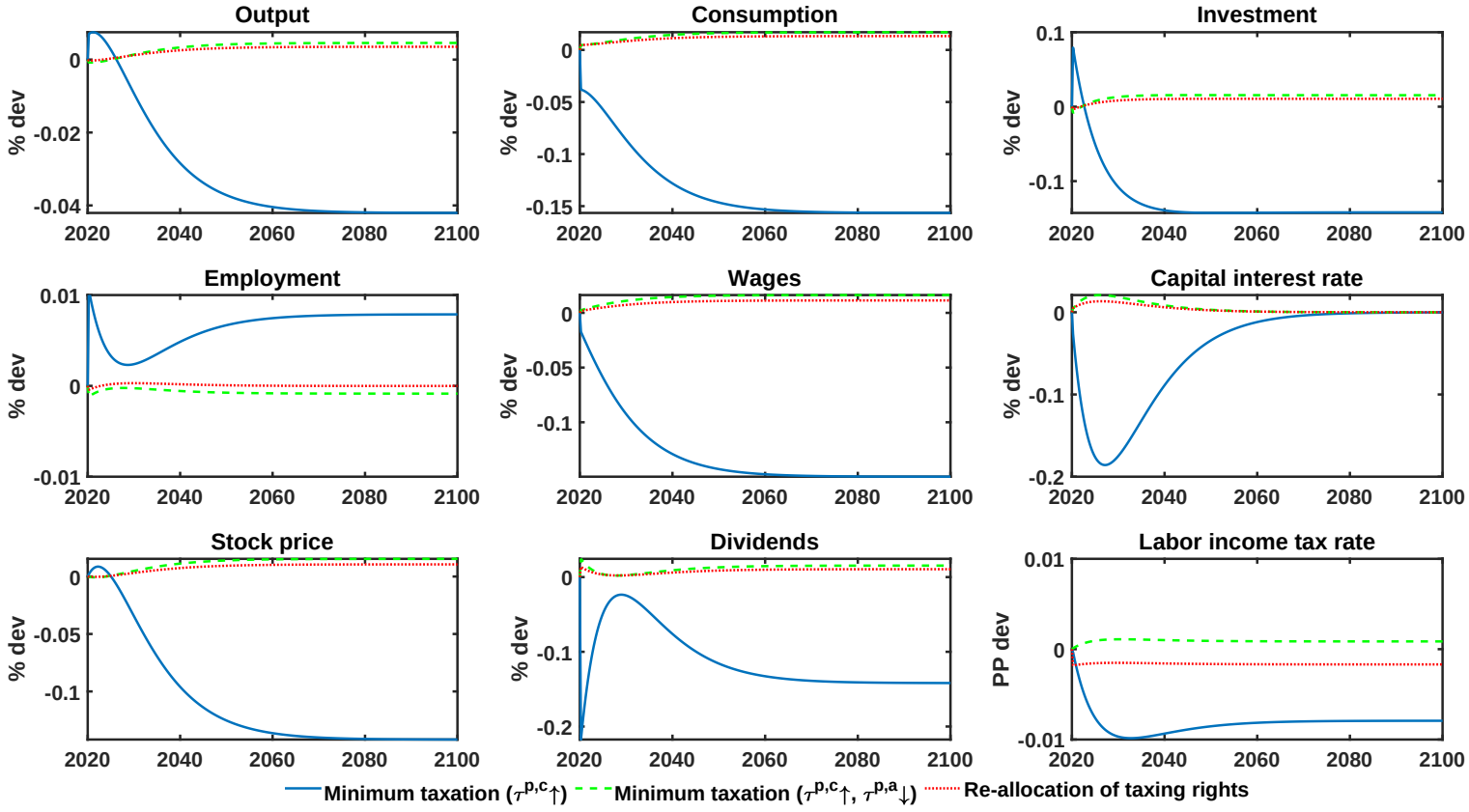


Figure 3: Implications on macro variables in high tax country a

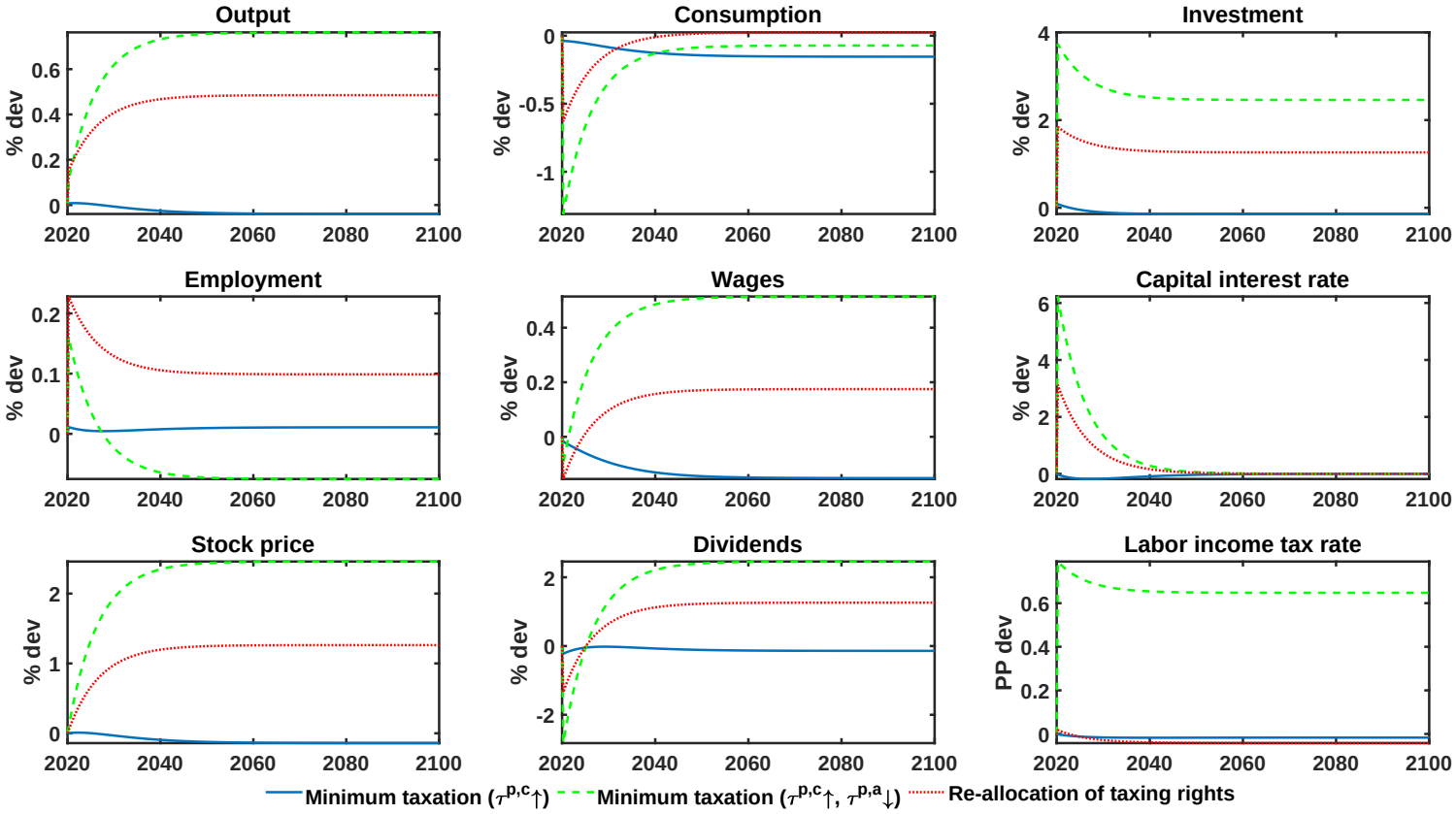
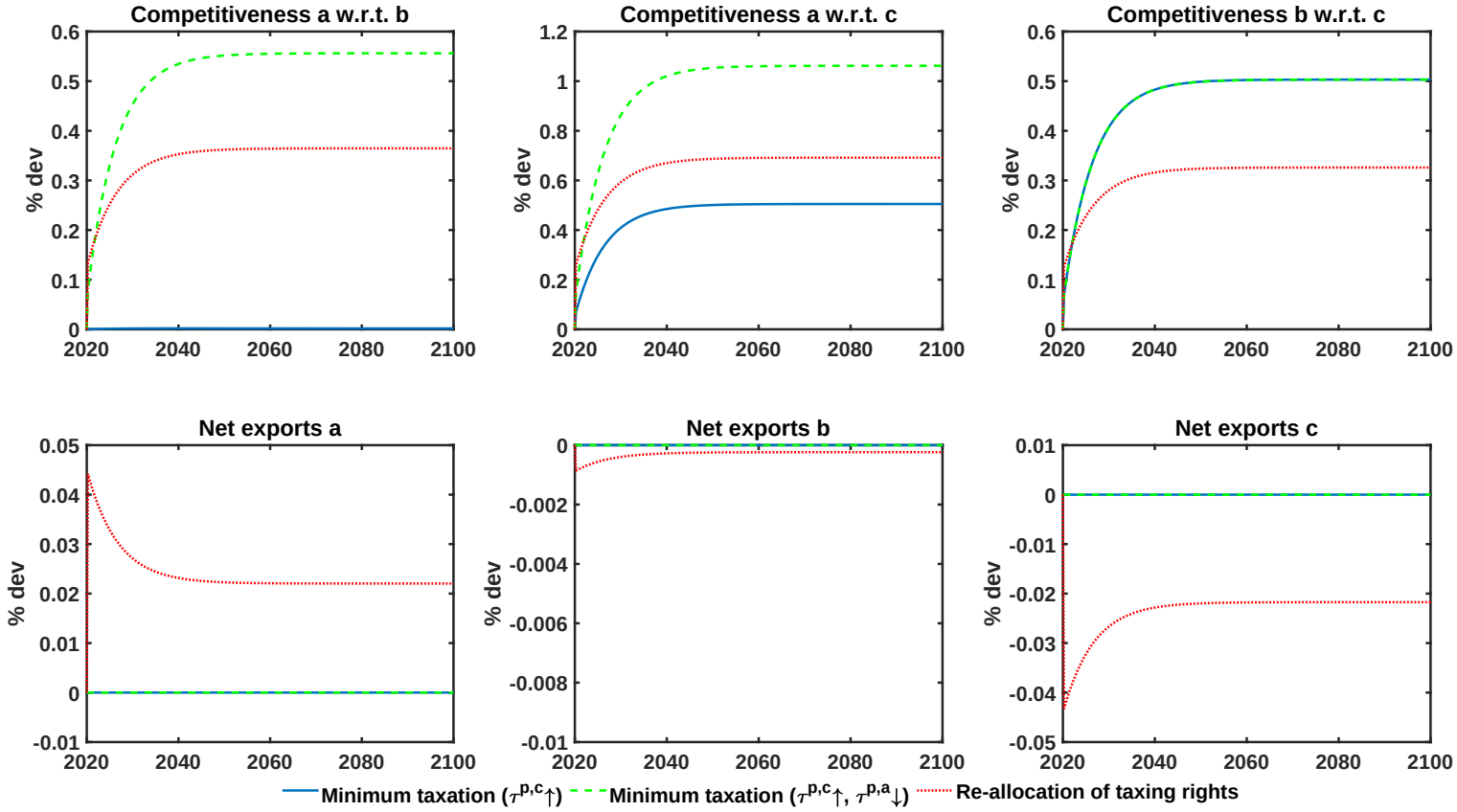


Figure 4: Implications on international spillovers



As we can see in Figure 4 and Table 2, net exports change permanently in this scenario. The reason is that, by taxing profits according sales shares of region-j firms in region i, there is a transfer of (profit) wealth from one region to the other. The net effect is opposite to the developments of net exports in Figure 4.[11] Hence, in addition to the effects resulting from the changes in the average profit tax rates, we have a transfer of wealth from the high tax countries (where net exports increase to finance the transfer, also in the long-run) to the low tax region (where net exports fall). As a result of this transfer, households in the low-tax economy are able to slightly increase consumption, whereas the transfer is not high enough to completely sap the output gains in the high-tax region.

The second notable difference is that government revenue changes differently. This translates into different changes in the labor income tax rate. Instead of being able to decrease the labor income tax rate (which was the case for the pure profit tax rate increase in region c), region c now has to actually increase the labor income tax rate eventually. The reason is that it loses part of its fiscal revenue (the loss in profit tax revenues must be financed by higher labor income taxes). The opposite is true for region a. It no longer has to increase its labor income tax rate. Opposite signs on the change of the labor income tax rate, of course, have opposite implications for the development of labor market variables and net labor income that we have described previously. These effects mitigate the positive (negative) labor market effects resulting from higher (lower) production. Overall, re-allocating taxing rights is, on the one hand, similar to introducing minimum profit tax rates presuming that, at least eventually, all regions will set a rate close to this minimum rate. On the other hand, there is an additional wealth transfer which implies that consumption gains and losses are mitigated and fiscal reactions may be of opposite sign.

A natural question arising now is what happens if both measures, the reallocation of taxing rights and the introduction of a minimum tax rate, are implemented simultaneously? Transition dynamics of such a policy change are summarized in Figures 5 to 8. We repeat the transition of the pure re-allocation for illustrative purposes in the graphs (dotted red lines). Long-run changes are summarized in Table 2. Again, we differentiate between a situation in which only region c increases the profit tax rate (solid blue lines) and another situation in which region a reduces its profit tax rate (dashed green lines), too.

Simultaneously implementing both measures is, in principle, an average of implementing each measure separately. However, there are some noteworthy implications. We again start with describing the situation in which only region c increases the regional profit tax rate to the minimum level (by 5 PP) and taxing rights are re-allocated. In Table 2 we see that this situation generates the highest increase in firms' profit taxation in region c (relative to all other scenarios), while it represents the most modest reduction in region a output. The reason is that, in addition to the increase in the domestic tax rate by 5 PP in region c, part of region-c firms' profits are now taxed by the high tax region a (because of the re-allocation). Region-a firms no longer benefit as much from the re-allocation effect as they did before, because region c has increased the domestic rate.[12] The fall in price

[11] Using equation (16) together with (21) and bearing in mind that, in a standard Obstfeld and Rogoff (1995)-open economy model that we have here, net foreign assets return to their initial steady state value (zero), this is easy to verify.

[12] The rise in the tax rate faced by region-b firms is also explained by the fact that, now, region c

competitiveness of c is stronger (see Figure 8), which augments the demand-dampening effects and reduces capital investment and output further both, during the transition and in the long run. Due to the higher domestic profit tax rate, the labor tax rate can be reduced more relative to the re-allocation effect. This reduces gross wages more and positively affects employment. The latter effect alleviates the long-run reduction of private consumption a bit (relative to only increasing the tax rate; see Table 2) and fosters the increase in consumption on impact and for some time thereafter (relative to the pure re-allocation simulation; see Figure 5).

For region a, output and capital investment are affected negatively after the introduction of the minimum profit tax rates in region c (as described above). When simultaneously introducing minimum tax rates and re-allocating profit taxing rights, output and investment are now positively affected (see Figure 7). The reason is that, because of the higher international price competitiveness vis-a-vis both other regions (see Figure 8), demand is tilted significantly towards goods produced in region a. Relative to a pure re-allocation of taxing rights, output effects in region a are muted because of the simultaneous tax shift in region c. This translates into a more negative consumption response compared to what we observe when only re-allocating taxing rights. For region b (Figure 6), we see that the effects are pretty much analogous to those arising from an increase in the profit tax rate in region c alone. Now, the re-allocation of taxing rights additionally increases the average tax rate faced by firms located in region b and, because of the wealth transfer, region b must now also increase the labor tax rate, yielding a reduction in employment.

When, in addition to what we have previously described, region a also reduces its tax rate to the minimum level, we again see that, because of the positive demand effects described in the corresponding simulation above, the negative output effects in regions b and c are reduced, while there is an additional positive output effect in region a. Consumption gains in regions b and c are amplified, while consumption losses in c are reduced, for the same reasons as described above. Because profit tax rates equalize across regions, trade in goods is no longer distorted via profit taxation and relative prices adjust such that demand for regional goods is determined by the home bias. Hence, in the long run, the net exports and wealth transfers revert back to zero (with no inter-regional transfer).

To summarize, we find that the OECD/G20 BEPS proposals increase profit taxation of firms in the low tax country in all our simulations. This is either the case because the country has to increase regional tax rate to a minimum level, because regional sales are taxed at higher foreign rates when taxing rights are re-allocated or because of both. To compensate for the profit loss, firms in that region raise prices (relative to goods produced in other regions), which reduces demand for goods produced there. Output falls. The opposite basically holds in the high tax region, especially if it decides to reduce its profit tax rate to the new minimum rate. For the country with intermediate profit taxation, output effects are small, and, if anything, most likely negative (at least in the long run).

charges a higher rate and some sales of goods produced in b are sold in c and the high-tax region a.

Figure 5: Implications on macro after full reform variables in low tax country c

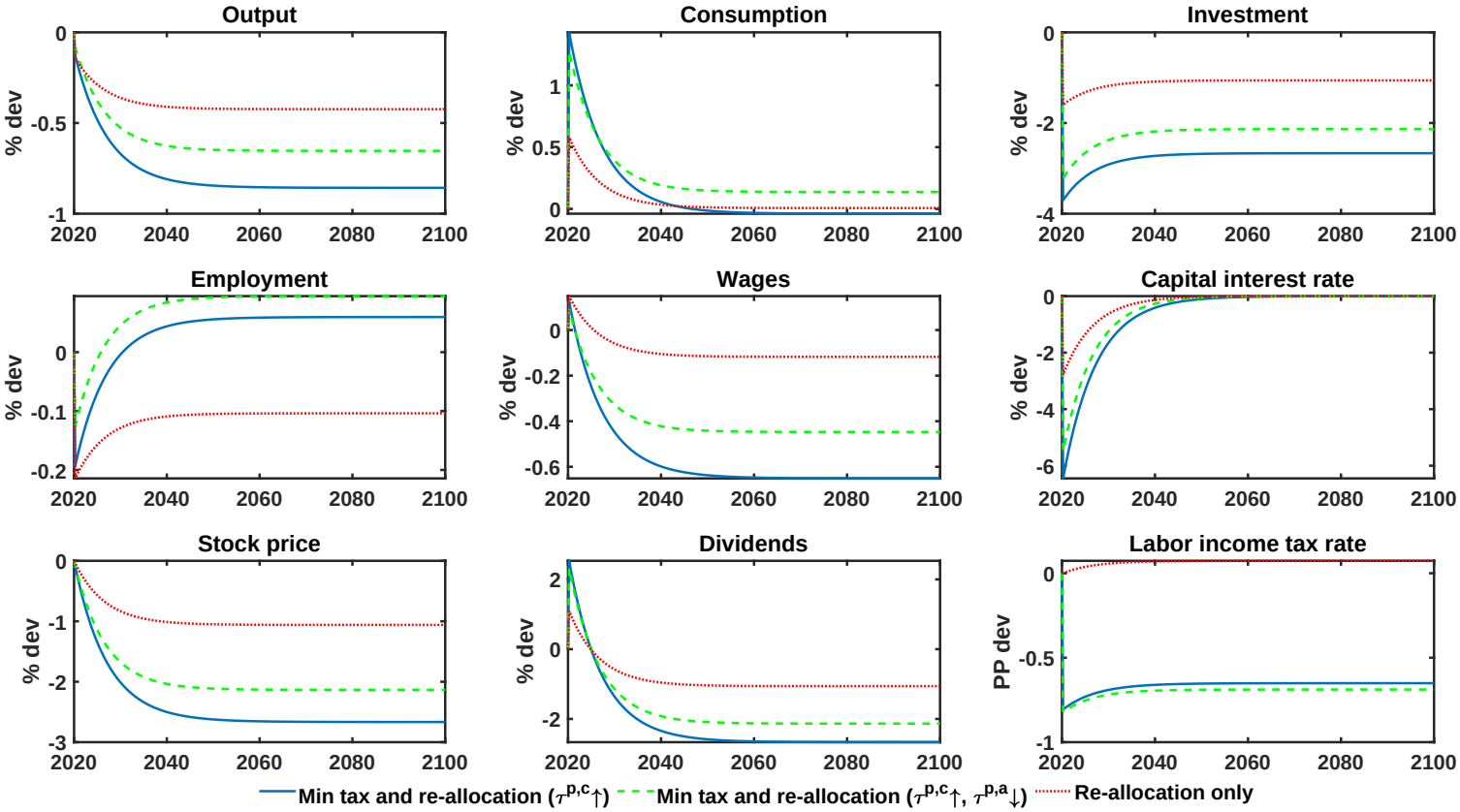


Figure 6: Implications on macro variables after full reform in intermediate tax country b

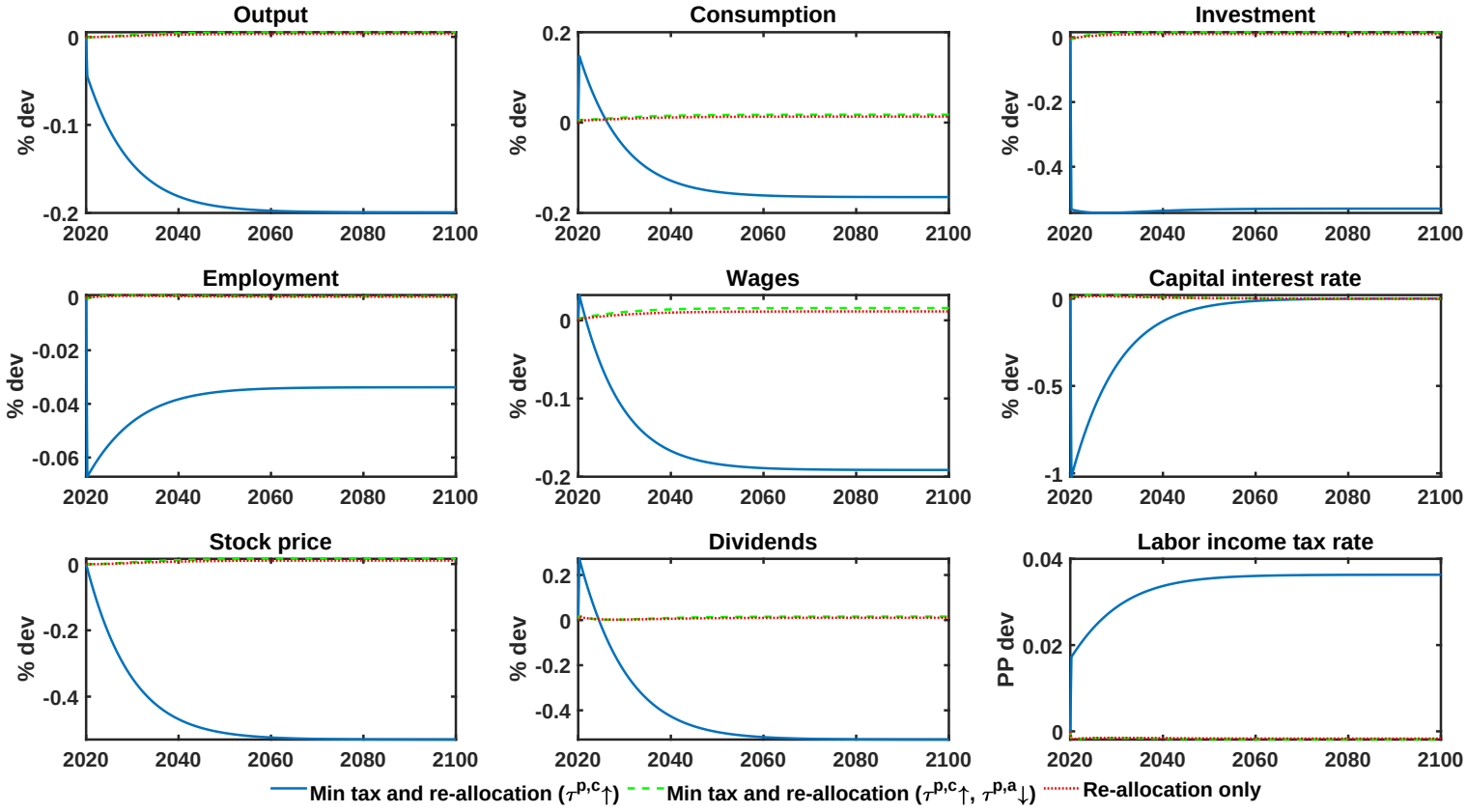


Figure 7: Implications on macro variables after full reform in high tax country a

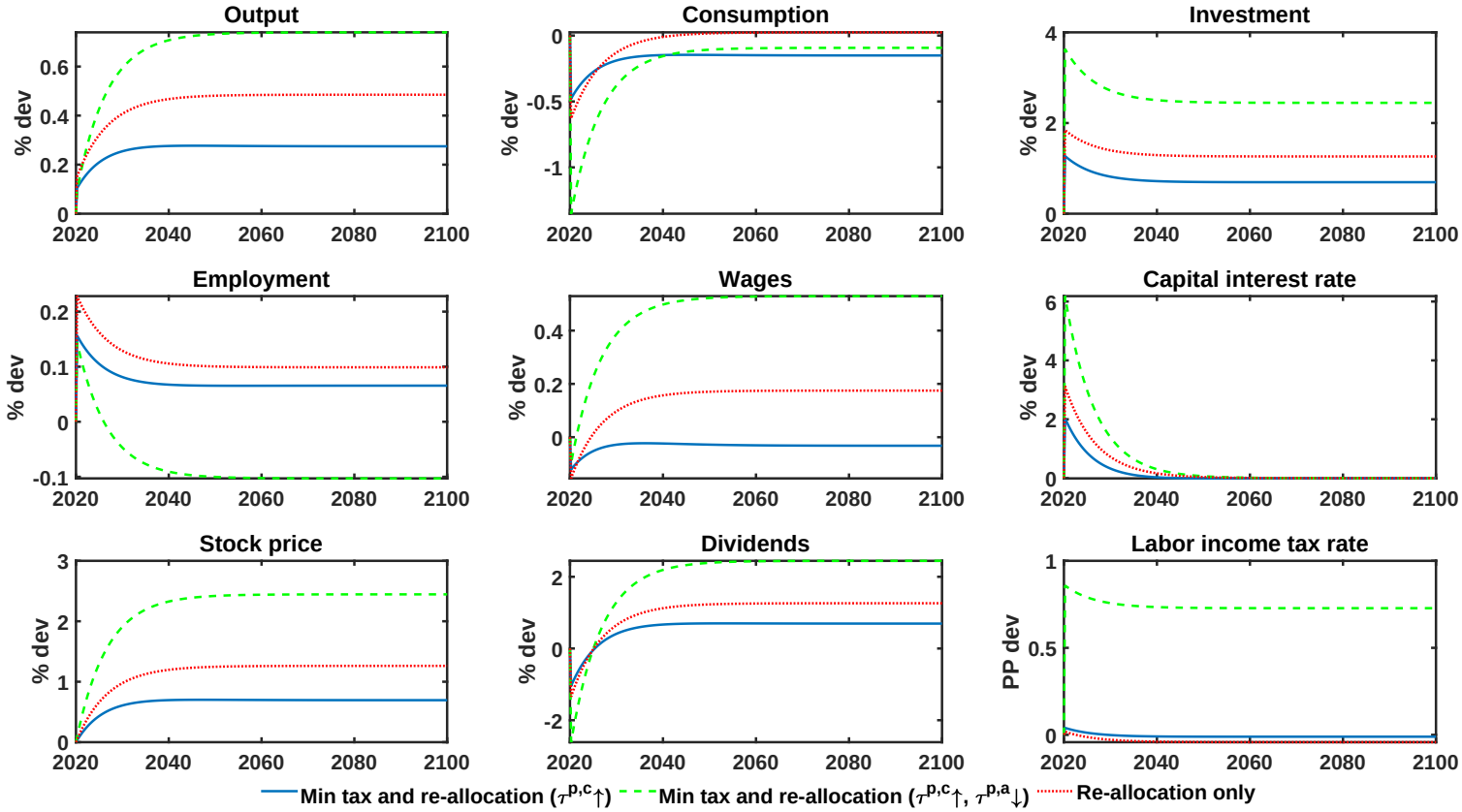
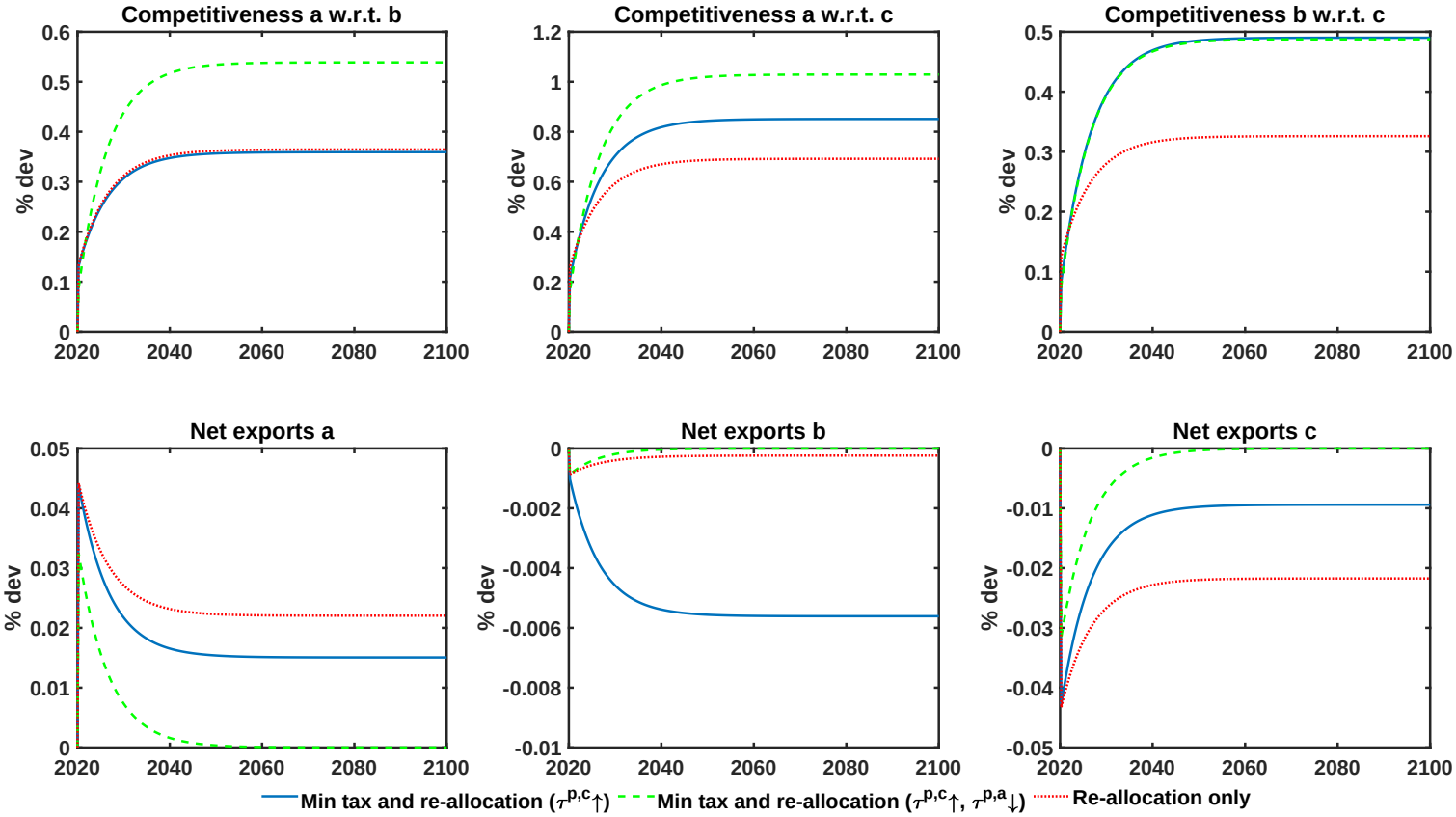


Figure 8: Implications on international spillovers after full reform



Depending on the exact policy change, this is due to one of the two following reasons. Either average world-wide profit taxation increases such that, due to the pricing effects just described, aggregate world demand falls (including the demand for goods produced in the intermediate tax region). Or price competitiveness of the high tax country increases disproportionately (in case it reduces its profit tax rate), which affects demand for goods produced in the intermediate tax region negatively.

More interesting, however, is the finding that the tax change-induced changes in regional output do not necessarily translate into changes in domestic consumption. Households in the low tax region manage to at least temporarily increase consumption notably, although output falls. The opposite holds for the high tax region. The reason is that (i.) long-run output losses (gains) lead to capital (dis-)savings and (ii.) the increase (decrease) in the profit tax rate in the low (high) tax country generates public revenue gains (losses) that the government compensates by lowering (raising) other taxes. Both features, in turn, (at least temporarily) increase (decrease) the disposable income that households can use for consumption. In the region with intermediate profit taxation, consumption falls whenever output in that region is affected negatively. This is the case whenever aggregate world demand falls. It increases slightly if world demand is not affected too much. This is the case when average world-wide profit taxation remains rather stable. The consumption effects basically translate into our welfare evaluation of the tax changes, as we will discuss in the next section.

5.2 Welfare

We now turn to analyzing the welfare implications of the tax changes analyzed above. To evaluate welfare effects, we compute the life-time consumption-equivalent gain of each type of household as a result of the change in fiscal policy (Lucas, 2003). We will take into account the welfare difference between the initial and the final steady state as well as the transition thereto. More precisely, we calculate the consumption-equivalent welfare gain, ce^i, such that

$$\sum_{t=0}^{\infty} \left(\beta^i\right)^t U\left((1+ce^i)\bar{c}^i, \bar{N}^i\right) = \sum_{t=0}^{\infty} \left(\beta^i\right)^t U\left(c_t^i, N_t^i\right),$$

where the exact utility function $U(\cdot)$ is given by equation (1). Utility positively depends on the level of consumption, c_t^i, and negatively on N_t^i, the amount of labor provided (which measures forgone leisure). The bar indicates initial steady-state values. Hence, ce^i represents the amount of initial steady-state consumption a household of region i is willing to give up in order to live in a scenario with the policy change. Positive values imply a welfare gain, while negative values signal a welfare loss. Note that, as ce^i takes into account the transitional dynamics to the new steady state, we also report "pure" steady-state welfare changes (ignoring transitional dynamics). Results are summarized in Table 3.

Table 3: Welfare assessment

	Consumption equivalents				
	$\tau^{p,c}\uparrow$	$\tau^{p,c}\uparrow+\tau^{p,a}\downarrow$	Re-allo	Re-allo+ $\tau^{p,c}\uparrow$	Re-allo+$\tau^{p,c}\uparrow+\tau^{p,a}\downarrow$
Including transition					
Welfare in region a	-0.13	-0.26	-0.20	-0.27	-0.27
Welfare in region b	-0.13	0.01	0.01	-0.06	0.01
Welfare in region c	0.15	0.29	0.22	0.23	0.29
Steady-state comparison					
Welfare in region a	-0.17	-0.01	-0.06	-0.21	-0.01
Welfare in region b	-0.17	0.02	0.01	-0.14	0.02
Welfare in region c	-0.13	0.06	0.10	-0.09	0.06

Note: Welfare presented as life-time consumption equivalents when taking into account the transition and as pure steady-state comparison.

As may have already been guessed from the above analysis, the low tax region c benefits from increasing profit taxation under all (but two) cases analyzed here. The reason is that, due to the tax shift, households in c manage to (at least temporarily) increase consumption and to reduce labor supply in almost all scenarios (see Figure 1 and 5 and Table 2 of the previous section). Higher consumption and lower labor disutility unambiguously increase the well-being of households in region c. There are two reforms under which, in the new steady state, welfare is depressed: a profit tax increase only in region c as well as a tax rate increase in c combined with a re-allocation of taxing rights. As described above, the fall in aggregate world demand (and, thereby, also output in region c) overcompensates the positive effects that the tax shift has on the household's disposable income (as his gross income falls sufficiently). For these reforms, the steady-state comparison indicates that region c-households lose. However, due to the large positive (negative) effects on consumption (employment) in these scenarios on impact (and for some time thereafter, as described), households still benefit when taking into account the transition.[13]

The opposite holds for the high tax region a. Due to the tax shift, households living in region a are forced to reduce consumption and extend employment, both along the transition and in the long run, as described in the pervious sections. Hence, welfare falls. There is only one scenario in which consumption of region-a households increases (mildly) in the long run: the re-allocation of taxing rights (while leaving the regional tax rates unchange, see Table 2). In this case, however, the increase in employment in region a is relatively strong. Therefore, welfare falls in this scenario, too.

Region b with an intermediate profit tax rate is, in general, affected very little but positively in terms of welfare. Exceptions are (i.) the scenario in which only region c increases its tax rate plus (ii.) the scenario in which, in addition to the profit tax rate increase in region c, taxing rights are also re-allocated. In these scenarios, region b loses

[13]The positive welfare effects shortly after the reform overcompensate for the (permanent) discounted utility loss in the new steady state, which lies in the far future.

notably. The reason is that, in these scenarios, world demand (and output) declines, which implies that also demand for goods produced in region b declines. This translates into a reduction in output and, ultimately, consumption (see detailed description in previous sections). The reductions in consumption translates into a welfare loss.

Summarizing, we find that, according to our model simulations, a change in profit taxation as described (and suggested by the OECD/G20 countries) above does not lead to a Pareto improvement when focusing on the macro effects of the reform. But the reforms do not generate significant welfare losses either. Interestingly, welfare in low-tax countries whose firms will face higher average tax rates is positively affected. The main reason for this is that these regions generate fiscal space that can be used to foster households' disposable income. They use this to consume more and, at the same time, enjoy more leisure. The opposite holds for high tax regions.[14]

The results are qualitatively and quantitatively analogous when using other taxes as the fiscal instrument to balance tho government budget, which we show in the appendix. However, once we use government spending as the instrument, we have to bear in mind that higher (lower) public spending crowds out (in) private consumption. When the low tax region receives higher tax revenues from increased profit taxation, which it uses to increase public spending, the positive effects on private consumption are mitigated or even precluded. The opposite holds in the high tax region when it reduces its profit tax rate. Given that public consumption is assumed to be pure waste in our model economy, this then changes the welfare implications accordingly (see appendix, too). Although this is not the focus of our paper, we can use this finding to address the political economy question how to best incentivize the "losers" of the simulated profit tax reform. Those regions that generate fiscal space after the reform should reduce taxes to balance the budget, while those that face fiscal tightening should reduce wasteful government spending. Then, the likelihood for a "loser" becoming "winners" increases.[15]

5.3 An asymmetric calibration (robustness analysis)

It is, of course, of interest whether or not an asymmetric calibration, especially along the international dimension, affects results (and if so, in which direction). For this purpose, we performed several robustness analyses by modifying relevant parameters. Here, we summarize the results.

First, we assume that the low profit tax economy c is a "production" site for regions a and b. More precisely, we assume that the home bias in regions a and b is reduced, while

[14]Keep in mind however, that we did not take into account the reform effects on profit shifting and tax competition. On the one hand, the reform may bring about desirable changes once we do this, which may turn the balance in favor of the reform. On the other hand, the strong opposition of low-tax countries may be explained by their fear that multinationals will leave their country due to the fact that they have not much more to offer than a tax haven. We leave analyzing this question, which would require a significant model extension, for further research.

[15]To put this result into perspective, however, note that government consumption is wasteful in our model by construction. If it was not (because, for example, it positively affected utility directly, because private and public consumption were complements or because it fostered private-sector productivity), the positive effects of reducing government spending would be smaller (up to the point that they do no longer exist potentially). It is beyond the scope of the paper to explicitly evaluate the question how to incentivize/compensate potential losers from the reform to still participate. However, it is an important question that should be addressed in future research.

the bias towards goods produced in region c in both regions increases accordingly.[16] The other parameters remain the same. We find that, qualitatively, economic effects remain analogous. Quantitatively, however, the decline in consumption and, thereby, welfare losses in regions a and b rise. Region c benefits more relative to our baseline calibration.

With a smaller home bias, an increase in the profit tax rate in the low tax region c generates lower output losses (gains) in region c (a and b). This is because, due to higher international trade, relative to our baseline calibration, the incentive for firms in c to increase prices (to compensate for the net profit losses) is muted. Output losses (gains) in c (a and b) are higher when taxing rights are re-allocated, however. Given that a larger share of profits is now taxed at a higher (lower) rate abroad, the increase (decrease) in the effective profit tax rate for firms located in region c (a and b) is then larger. In both cases, disposable income for region-c (-a and -b) households still increases (falls) more compared to our baseline calibration. This is because of relatively lower (higher) output losses and/or relatively higher (lower) profit tax revenues (from taxing foreign firm profits). Consumption and welfare in region c (a and b) are thus more positively (negatively) affected. The opposite holds if we increase the home bias, especially when doing so in all three countries (which could also be due to higher trade barriers, for example).

In a second robustness analysis, we change country size. First, we assume that region c is about twice as large as regions a and b. Second, we assume the opposite, namely that region c is only half of the size of regions a and b. Third, we assume that regions a (b) and c are of the same size, but region b (a) is half the size as a (b). Under all scenarios, we leave the home bias and the remaining parameters unchanged (i.e. we calculate a new steady state before starting the simulations in which we change profit taxation). We find that, as relative size of country c increases, output losses in region c increase while consumption gains fall. If c is large enough, higher output losses can even generate consumption losses along the transition, too. For regions a and b, output gains are less pronounced when region c becomes larger, which then translates into larger consumption losses in a and b. As described above already, the reforms imply an increase in average world-wide profit taxation such that, in the end, aggregate world demand falls. The larger the region in which taxation is increased, and the higher the tax increase is, the less likely it is that (relatively) higher production and income in other regions can compensate for these losses. This effect has the largest impact when the low-tax region is relatively large (which holds for c in our simulations) and the smallest impact when the high tax-region is relatively large (as tax reductions there at least mitigate the world-wide tax increase then). If the intermediate-tax region become relatively large, gains and losses there are mitigated (as spillovers become less important for that region), while gains and losses in the high and low-tax regions are amplified (here, demand spillovers from the large region become more important).

In a third robustness analysis, we change substitutability of regional goods, η^i. As goods become less substitutable, i.e. as η^i falls, the gains and losses that we have identified in the analyses above increase. The reason is that firms in the low-tax region c can pass

[16] We assume that the home bias ϑ_i^i in region $i = a, b$ is reduced from 0.6 to 0.32. The bias towards goods produced in region $j = a, b$, with $i \neq j$ remains at 0.2. This implies that the bias for goods produced in region c within region c must fall as a result (to close the international asset equation). It falls to 0.04, while the import share in c significantly increases (i.e. $\vartheta_c^c = 0.04$ and $\vartheta_c^i = 0.48$).

on more of the "costs" resulting from the profit tax increase to consumers as they cannot (or are not willing to) substitute region-c goods for other goods as much as in the baseline calibration. Hence, output losses (gains) in regions c (a and b) after a tax increase are not as strong as they are in our baseline case. Lower output losses (gains) then increase (decrease) consumption levels in relative terms. The opposite holds when goods produced in the different regions become highly substitutable, i.e. as $\eta^i \to 1$.

Summarizing, we find that, in terms of welfare, gains and losses from the tax shift increase as the home bias falls (i.e. economies become more open). This implies that relatively open low (high) tax economies benefit (lose) from the reforms discussed above, while relatively closed economy are less affected. Turning to country size, we find that, if the low-tax region is relatively large, it is very likely that consumers in all regions will lose from a (large) increase in profit taxation in that region because of a relative increase in world-wide profit taxation. The opposite holds when the high-tax country is relatively large (and potentially reduces taxation to a new minimum level). If the intermediate-tax region is relatively large, effects there are mitigated, while they are amplified in the high and low-tax regions. The less substitutable the goods produced in different region are, the higher will be the gains and losses that we have identified in the above analyses because households still want to consume region-specific goods independent of their price.

6 Conclusion

In this paper, we assess the macroeconomic implications of the OECD/G20 proposals to reform international profit taxation by means of a dynamic macroeconomic model that gives a meaningful role to profit taxation. The reforms entail (i.) the re-allocation of taxing rights away from source countries (where goods are produced) to market countries (where goods are consumed) and (ii.) an introduction of minimum profit tax rates. In the model, each country is inhabited by a representative household and a representative corporate firm. Both take dynamic decisions in the presence of profit taxation. Households own firms which undertake production, employment and investment decisions with a view to maximizing the shareholder value. All regions trade with each other. We assume that the world is represented by a high, an intermediate and a low tax economy, respectively.

Our results show that, when implementing the OECD/G20 BEPS proposals, profit taxation of firms increases in the low tax region. To compensate for the loss of after-tax profits, firms in that region raise prices (relative to goods produced in other regions), which reduces demand for goods produced in the low tax region. Output falls. The opposite basically holds in the high tax region, especially if it decides to reduce its profit tax rate to the new minimum rate when this is introduced, too. However, the tax change-induced effects on output do not necessarily translate into changes in regional consumption. Households in the low tax region manage to at least temporarily increase consumption notably, although output falls. The opposite holds for the high tax regions. The reason is that the (expected long-run) reduction (increase) in output after the change in profit taxation allows firms to raise (lower) dividend payments as they want to reduce (increase) the capital stock used in (future) production. Moreover, the increase (decrease) in the profit tax rate in the low (high) tax country generates public revenue gains (losses) that the government compensates by lowering (raising) other taxes. Higher dividend payments and lower taxes, in turn, increase (decrease) the disposable income that households can

use for consumption. The resulting implications for welfare are analogous.

Our analysis should be considered as a first step towards analyzing the macroeconomic consequences of the OECD/G20 proposals to international profit taxation highlighting some interesting transmission channels. In particular, it shows that there is the possibility that low tax economies lose significantly less from the reform than what is often assumed in public debates. However, there are many additional questions that deserve attention which are not addressed in this paper. For example, a frequent argument made is that, when profit taxation is based on the firms' physical operating presence (as it is currently the case), the choice where to operate (or at least formally have tax residency) is heavily influenced by the international system of profit taxation. It would therefore be interesting to study the effects of a tax reform towards market-based taxation in an extended modeling framework that allows for firm entry and exit or the presence of multinationals able to choose their head office location, a question (plus many others) that we leave for future research for now.

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Appendix

In this Appendix, we will show the plots of using alternative fiscal instruments (consumption taxation and public consumption) to balance the government's budget. As mentioned in the paper, the results are, in general, not changed qualitatively and only mildly quantitatively; see Figures A.1 to A.4 for the use of the consumption tax rate and Figures A.5 to A.8 for the use of public spending to close the budget (to save space, we restrict ourselves to showing the results of simulations 1 to 3). In terms of welfare (see Tables A.1 and A.2), we see that this also holds for using either consumption or labor income taxes to balance the government's budget. Using public consumption, however, does not seem to be a good idea when the government budget is relaxed as a result of a profit tax rate increase. The reason is that public consumption is modelled as pure waste, and the resulting increase in public consumption crowds out private consumption significantly (even driving it in negative terrain; see Figure A.5). The opposite holds when public consumption must be reduced after the profit tax change (see Figure A.7). However, if we assumed public consumption to be utility enhancing (which does not seem to be entirely implausible), the picture could again change whenever public consumption enhances household utility sufficiently.

Table A.1: Welfare assessment when using consumption taxation to balance the government budget

	Consumption equivalents				
	$\tau^{p,c}\uparrow$	$\tau^{p,c}\uparrow+\tau^{p,a}\downarrow$	Re-allo	Re-allo+ $\tau^{p,c}\uparrow$	Re-allo+$\tau^{p,c}\uparrow+\tau^{p,a}\downarrow$
Including transition					
Welfare in region a	-0.12	-0.26	-0.20	-0.26	-0.26
Welfare in region b	-0.12	0.01	0.01	-0.05	0.01
Welfare in region c	0.15	0.28	0.22	0.23	0.29
Steady-state comparison					
Welfare in region a	-0.16	-0.01	-0.07	-0.21	-0.00
Welfare in region b	-0.16	0.02	0.01	-0.14	0.02
Welfare in region c	-0.12	0.06	0.10	-0.09	0.05

Note: Welfare presented as life-time consumption equivalents when taking into account the transition and as pure steady-state comparison when using consumption taxation to balance the government budget.

Table A.2: Welfare assessment when using public consumption to balance the government budget

	Consumption equivalents				
	$\tau^{p,c}\uparrow$	$\tau^{p,c}\uparrow+\tau^{p,a}\downarrow$	Re-allo	Re-allo+ $\tau^{p,c}\uparrow$	Re-allo+$\tau^{p,c}\uparrow+\tau^{p,a}\downarrow$
Including transition					
Welfare in region a	-0.21	0.18	-0.22	-0.33	0.26
Welfare in region b	-0.20	0.02	0.01	-0.10	0.02
Welfare in region c	-0.35	-0.12	0.26	-0.30	-0.20
Steady-state comparison					
Welfare in region a	-0.26	0.41	-0.09	-0.29	0.49
Welfare in region b	-0.25	0.02	0.02	-0.18	0.02
Welfare in region c	-0.59	-0.32	0.15	-0.59	-0.40

Note: Welfare presented as life-time consumption equivalents when taking into account the transition and as pure steady-state comparison when using public consumption to balance the government budget.

Figure A.1: Implications on macro variables in low tax country c when using consumption taxation to balance the government budget

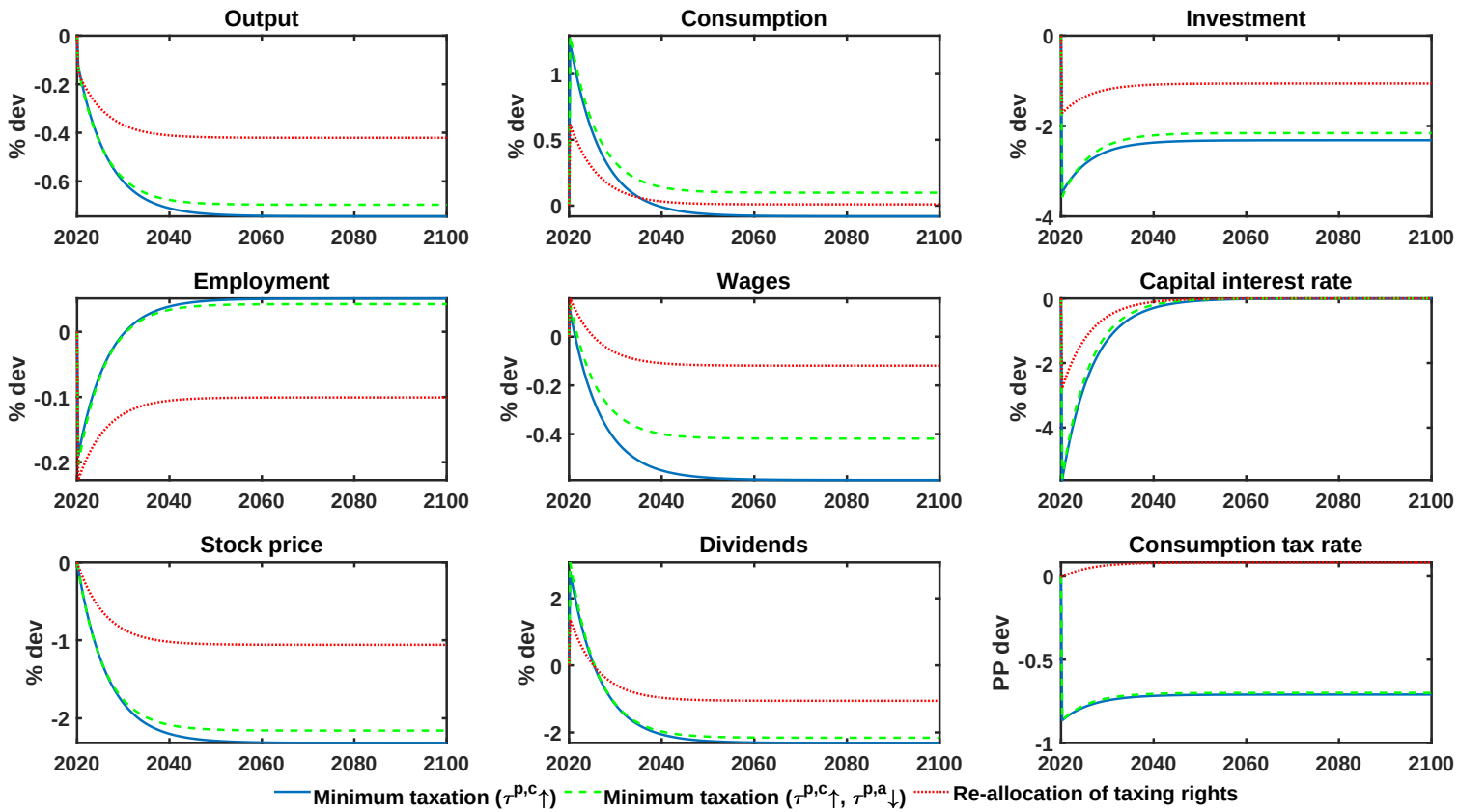

Figure A.2: Implications on macro variables in intermediate tax country b when using consumption taxation to balance the government budget

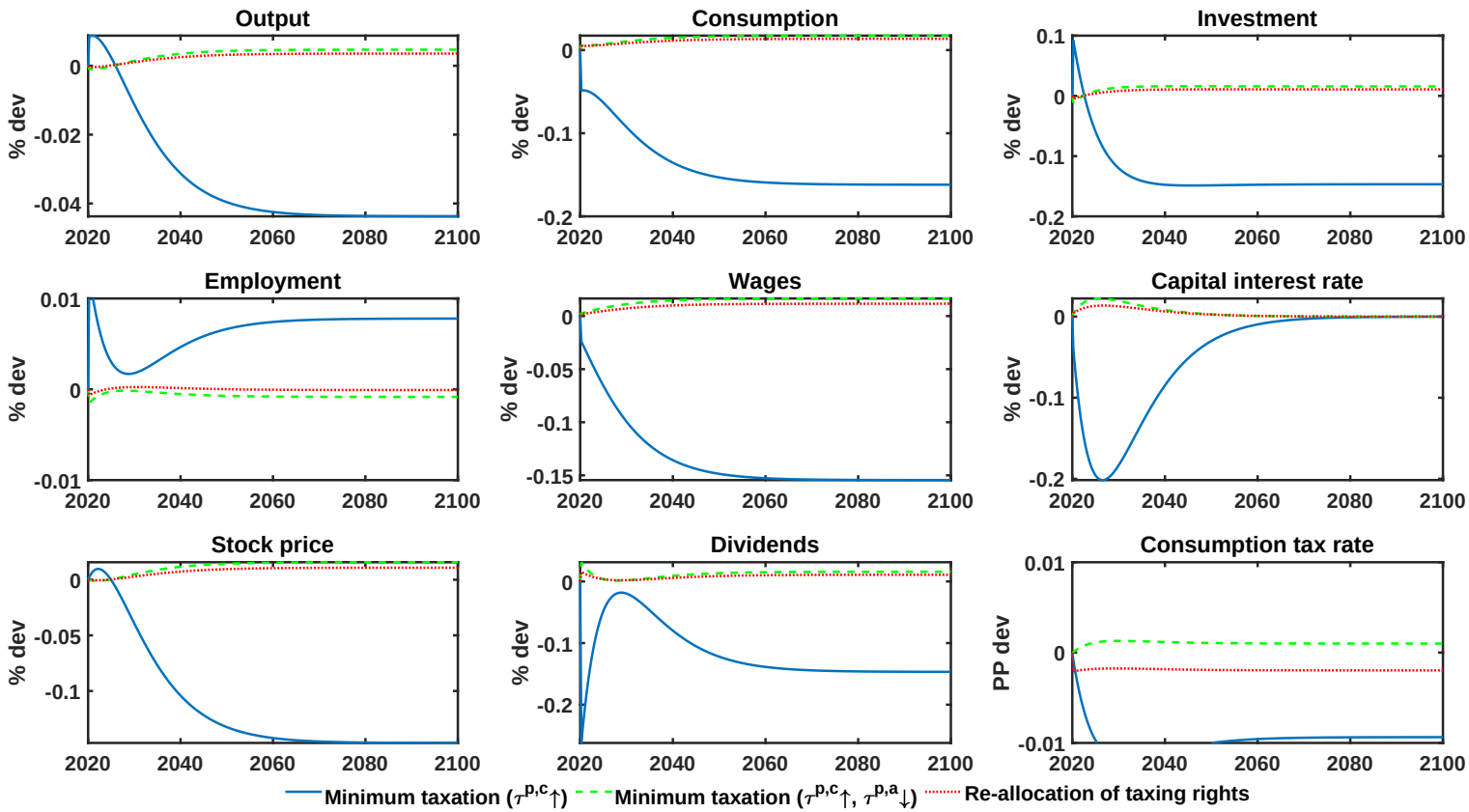

Figure A.3: Implications on macro variables in high tax country a when using consumption taxation to balance the government budget

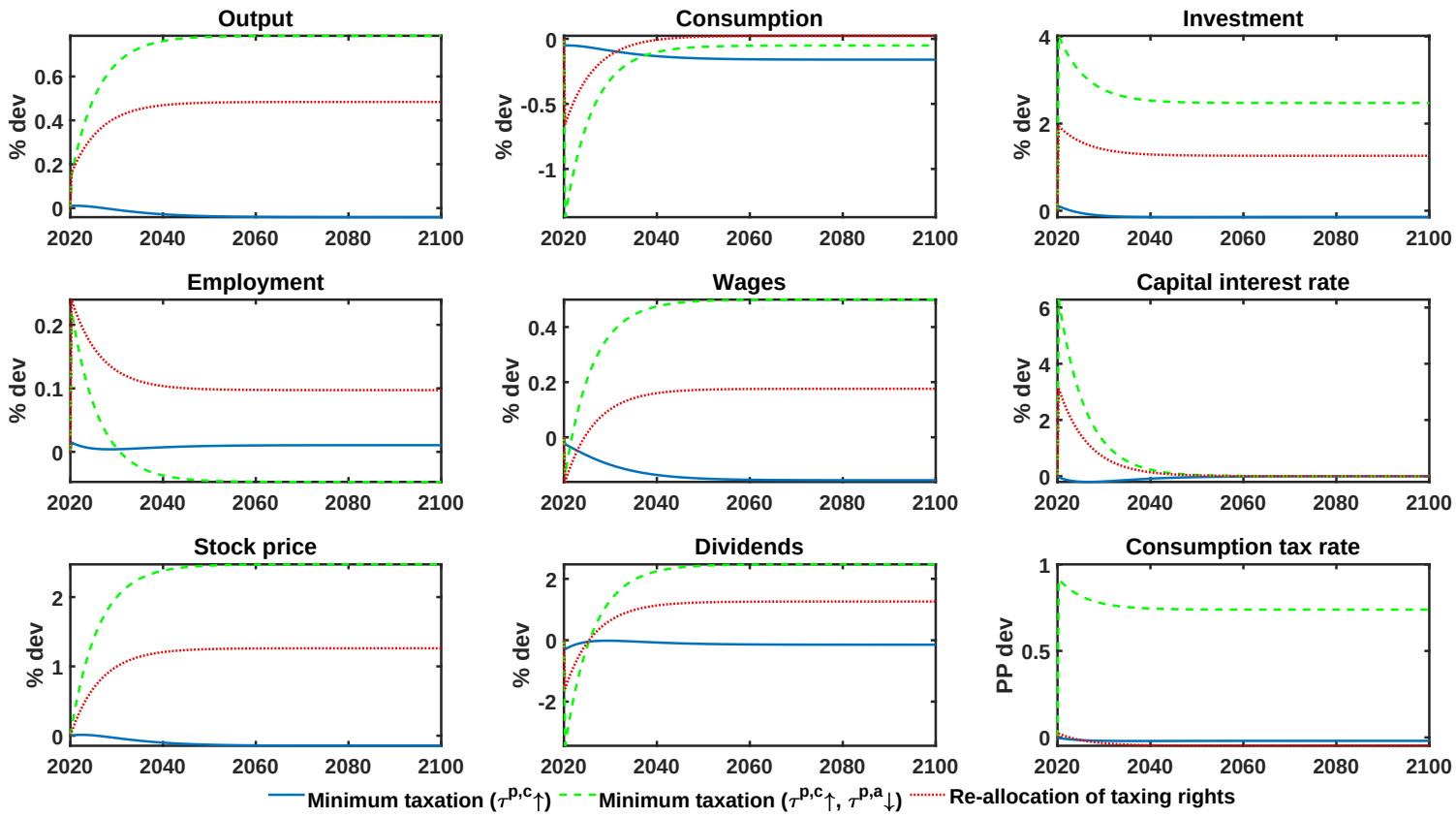

Figure A.4: Implications on international spillovers when using consumption taxation to balance the government budget

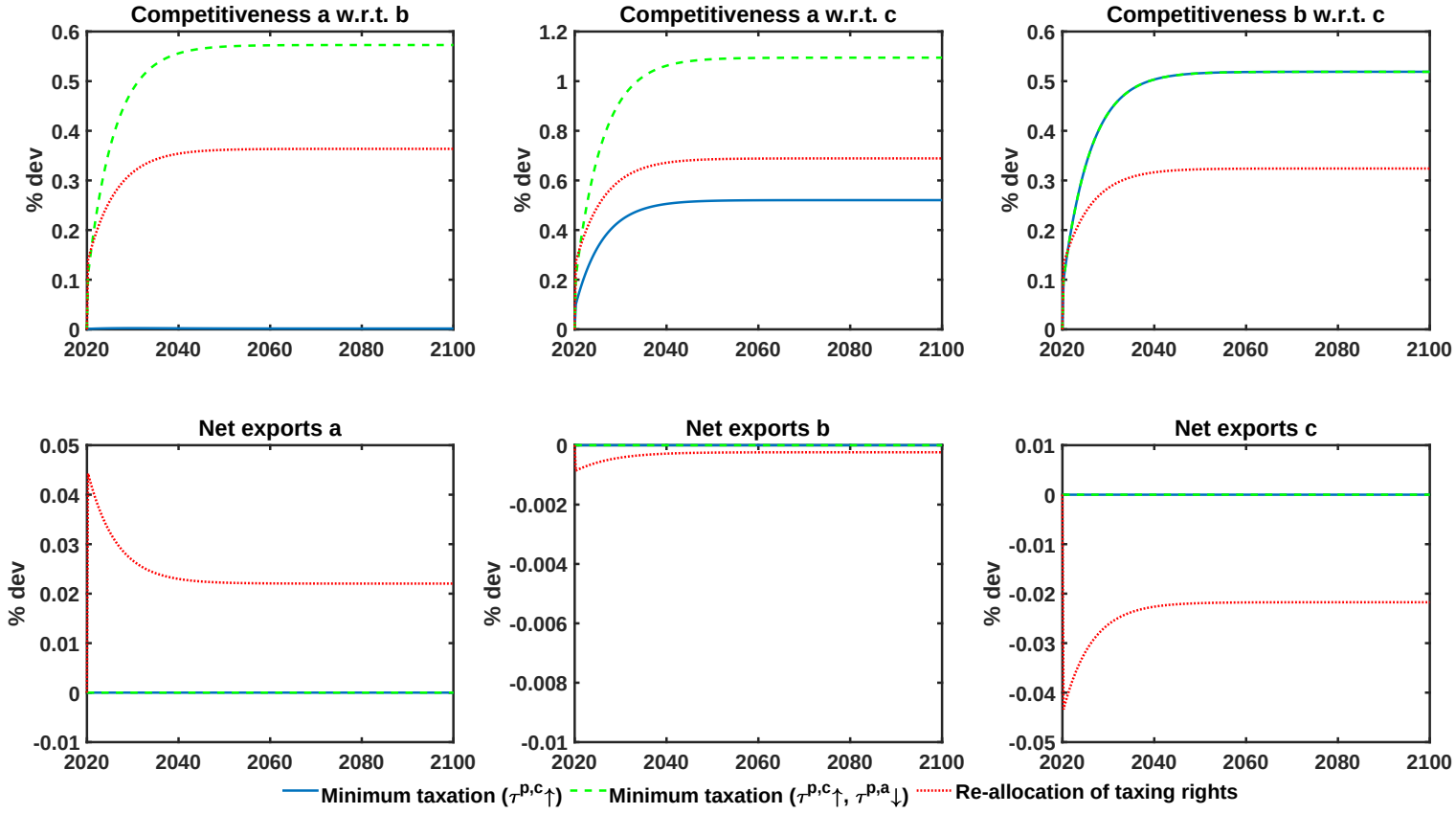

Figure A.5: Implications on macro variables in low tax country c when using public consumption to balance the government budget

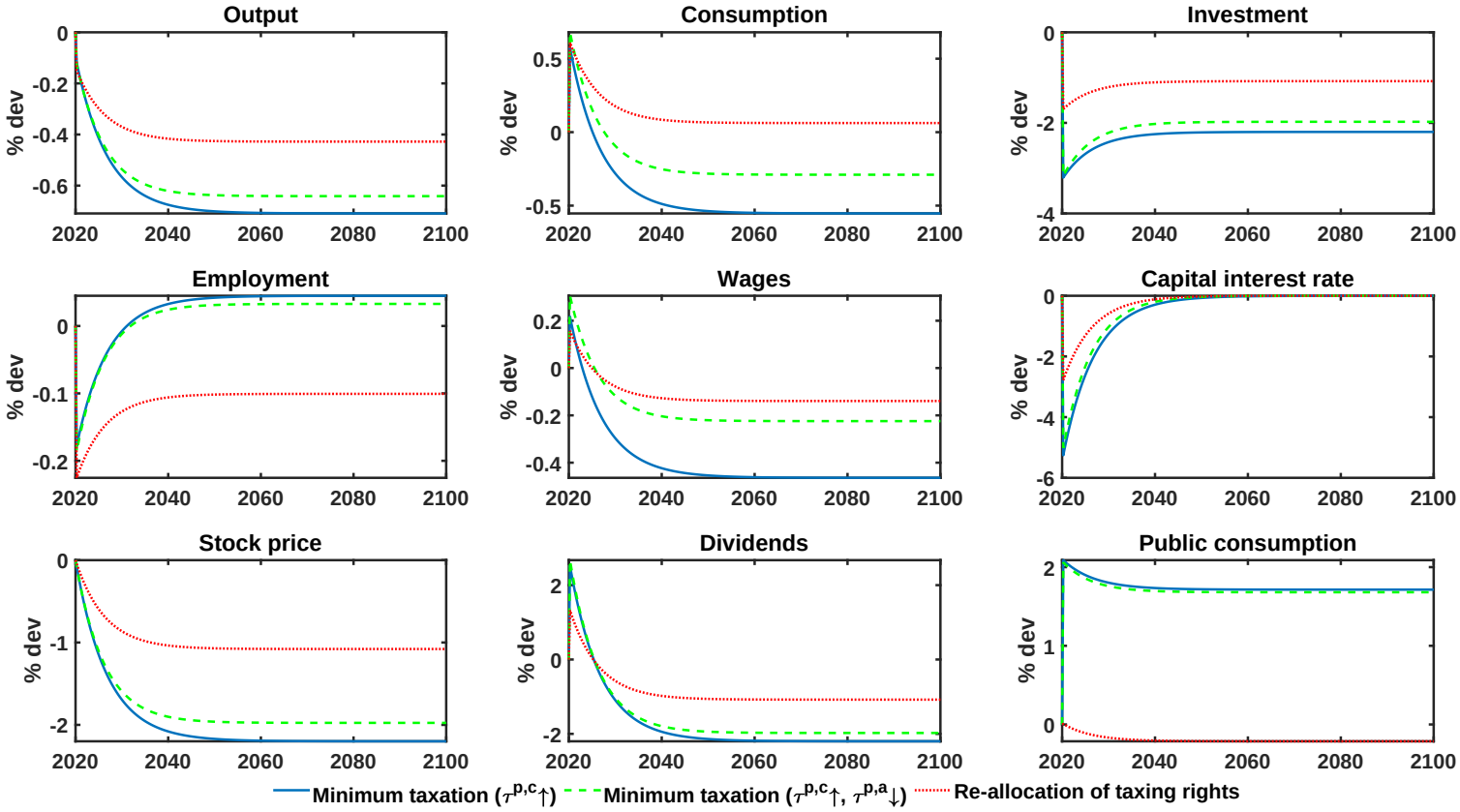

Figure A.6: Implications on macro variables in intermediate tax country b when using public consumption to balance the government budget

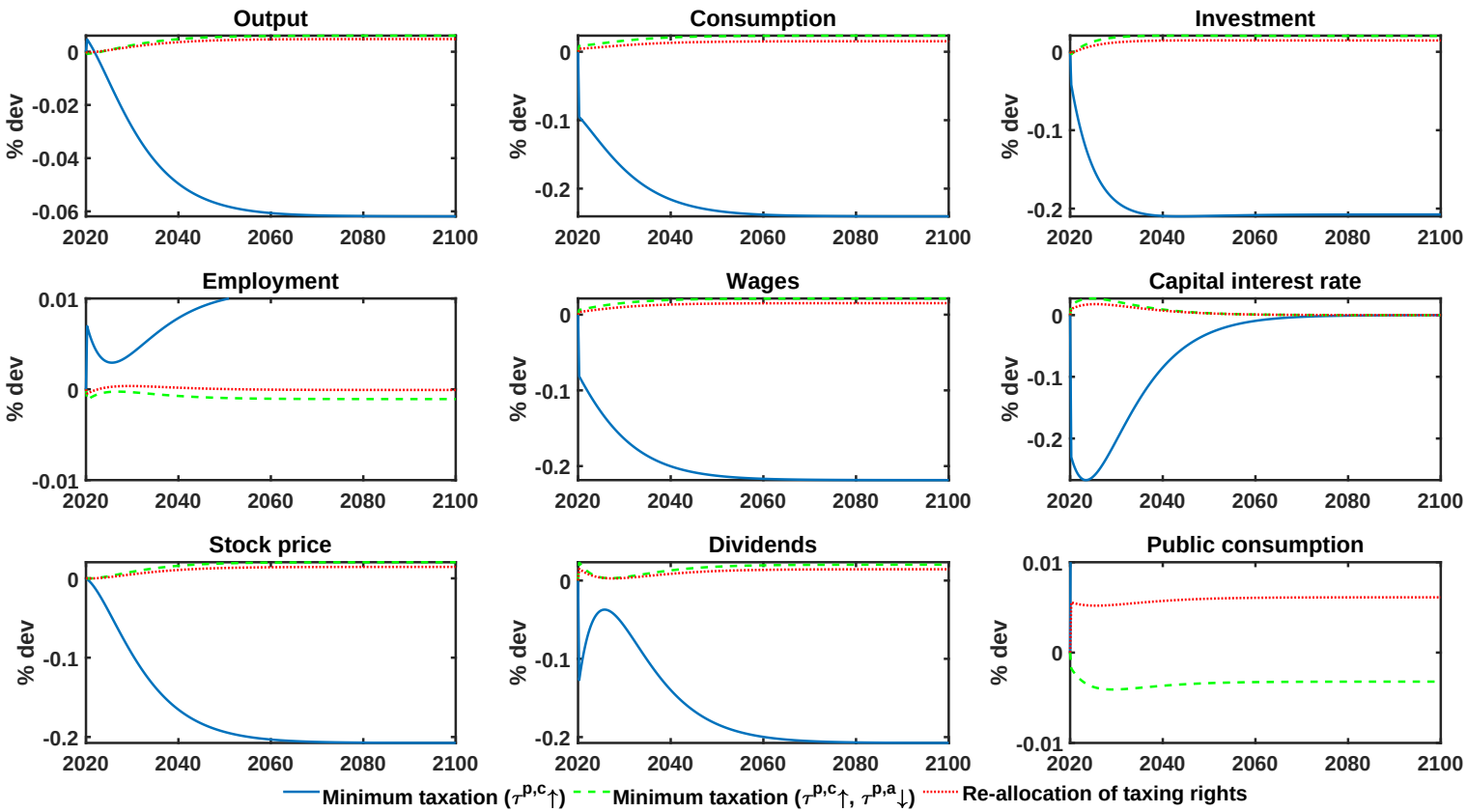

Figure A.7: Implications on macro variables in high tax country a when using public consumption to balance the government budget

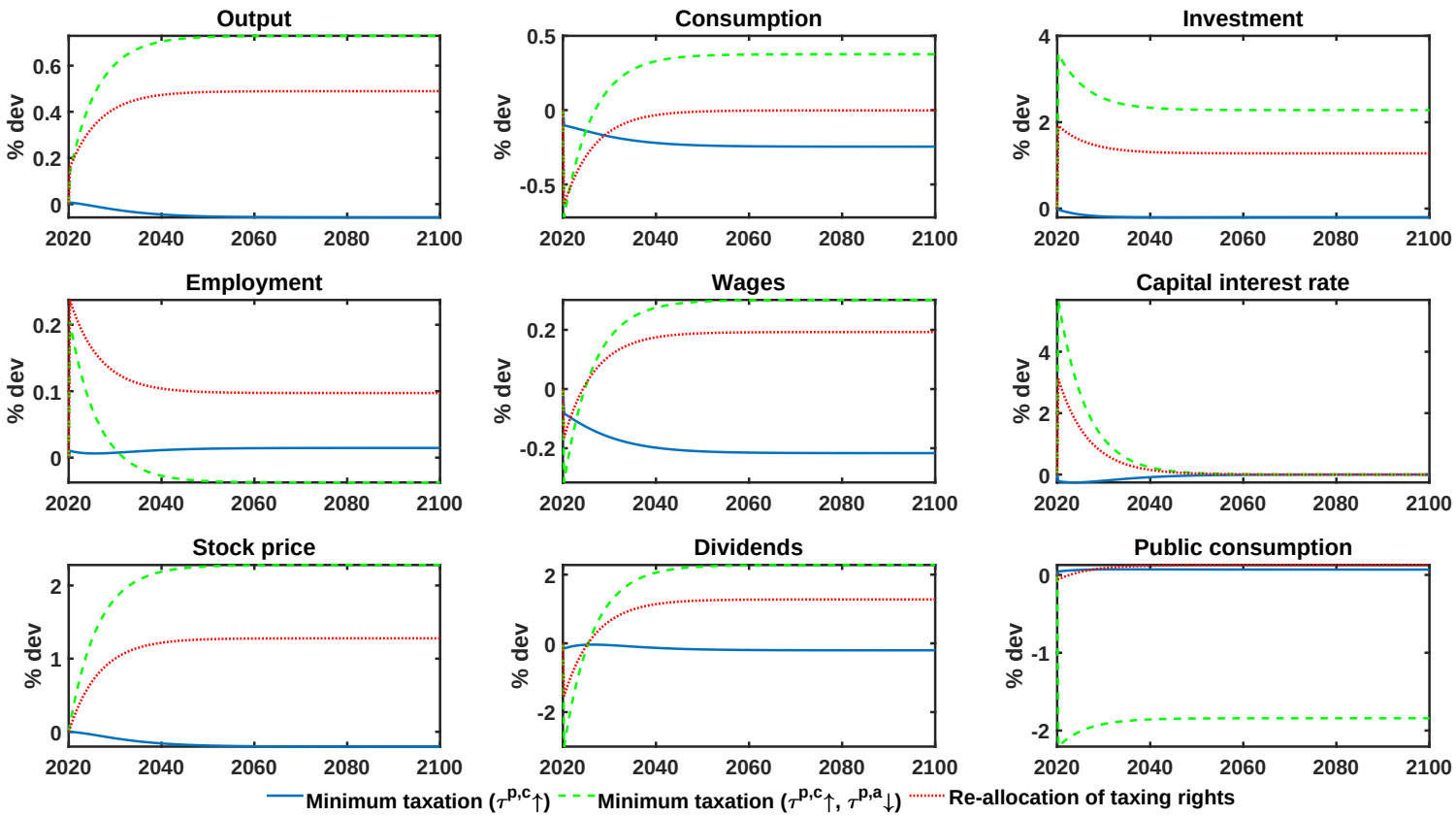
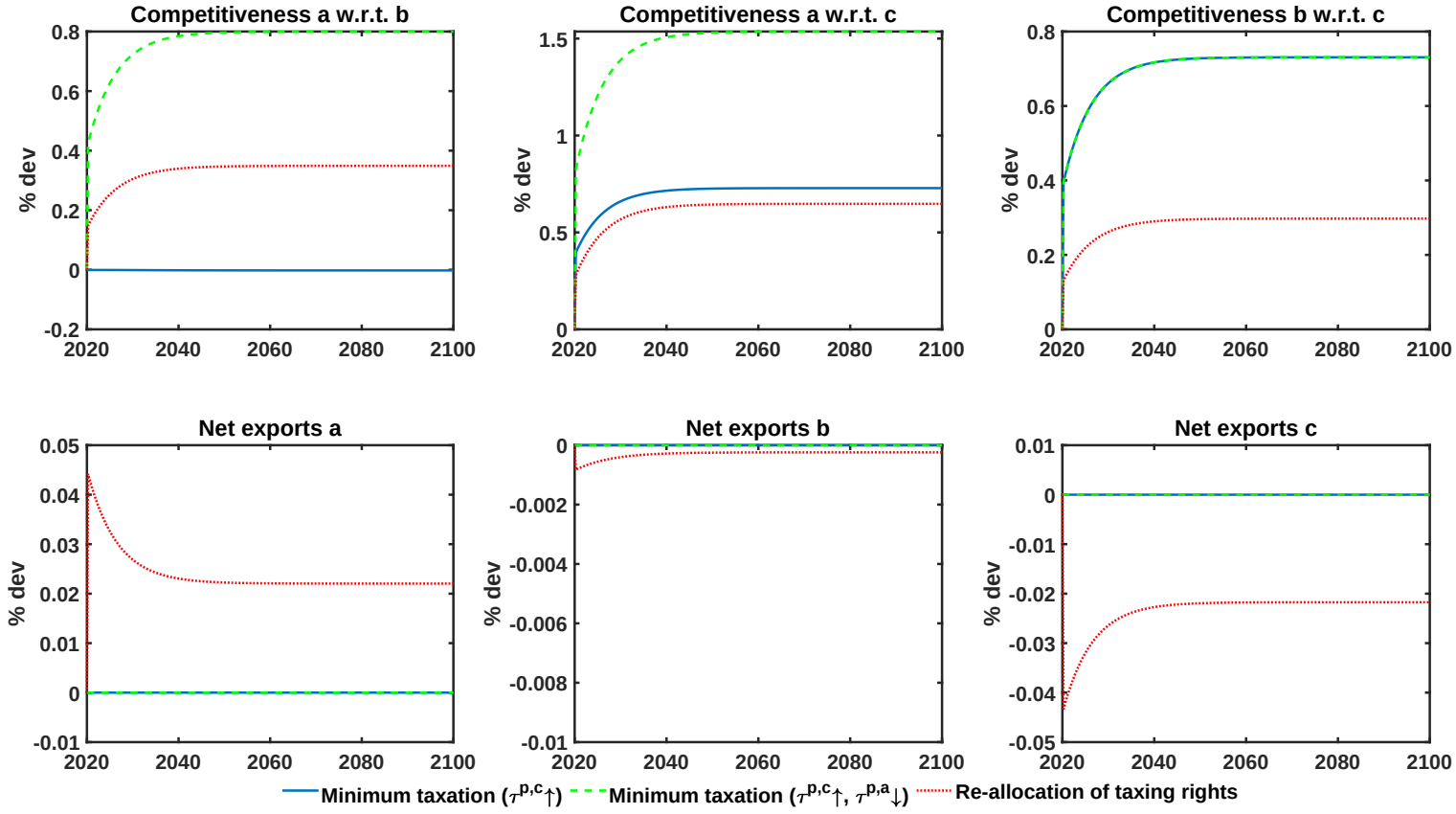
Figure A.8: Implications on international spillovers when using public consumption to balance the government budget