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Dynamic Effects of Corporate Taxation in Open Economy

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DYNAMIC EFFECTS OF CORPORATE TAXATION IN OPEN ECONOMY*

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Abstract

By exploiting the downward trend of profits' taxation observed in OECD countries which is rooted into international competition to attract capital, we identify exogenous variations in the corporate income tax rate. Estimating a SVAR model with long-run restrictions for a panel of eleven OECD countries over 1973-2017, we find that a permanent decline in profits' taxation leads to significant technology improvements which are concentrated in traded industries. The corporate tax cut has also an expansionary effect on hours concentrated in non-traded industries. The country-split shows that technology significantly improves in English-speaking and Scandinavian countries only while hours persistently increase only in continental European countries. To account for the dynamic effects of a corporate tax cut, we consider a two-sector open economy model with tradables and non-tradables and endogenous technology decisions where both capital and technology can be used more intensively. The model can account for the magnitude of technology improvements we estimate empirically as long as the traded sector is intensive in R&D, experiences low costs in the use of the stock of knowledge and also highly benefits from international R&D spillover. While large elasticities of utilization-adjusted-TFP w.r.t. the domestic and international stock of knowledge must be assumed in English-speaking and Scandinavian countries, in accordance with our estimates, we have to allow for sticky wages in continental European countries to account for our evidence.

Keywords: Corporate taxation; SVAR; Open economy; Endogenous technological change; R&D; Hours worked; Tradables and non-tradables; Labor reallocation; Wage stickiness.
JEL Classification: E23; E62; F11; F41; H25; O33

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1 Introduction

The average corporate income tax rate has dropped from 50% in 1970 to 32.5% in 2000 and has settled at 23.9% in 2018 in advanced economies. Evidence documented by Devereux et al. [2002], [2008] reveals that the gradual decline in corporate taxation is driven by the competition between OECD countries to attract capital after the removal of capital controls in the 1980s. We use the existence of such a downward trend in corporate income taxation which is common to a large set of OECD countries to identify exogenous and permanent variations in corporate taxation. By estimating a VAR model with long-run restrictions, we find that technology improvements are concentrated within traded industries after a cut in corporate taxation while the rise in hours is concentrated within non-traded industries. By taking advantage of our panel data dimension, we perform a country-split which shows that technology improves only in English-speaking and Scandinavian countries while hours significantly increase only in continental Europe. A two-sector open economy model with endogenous technology decisions can rationalize the evidence conditional on a set of elements which characterize households' preferences and firms' ability to improve technology.

Besides pointing out the importance of differentiating the effects of a cut in corporate taxation between sectors, our evidence also stresses the importance of differentiating its impact between countries. While the recent research works by Cloyne et al. [2022], [2023] also uncover the productivity gains driven by a corporate tax cut and contrast the investment and employment effects between two broad sectors (i.e., goods vs. services), our work provides new insights about the drivers of technology improvements at a sectoral level and importantly highlights that productivity does not increase across all OECD countries after a corporate tax cut.

By increasing the return on innovation activities, low corporate tax rates can potentially increase utilization-adjusted-total factor productivity (TFP) which is a major driver of economic growth. The macroeconomics literature has highlighted this strong link between profits' taxation and innovation in the U.S. data, see e.g., Akcigit et al. [2022], Cloyne et al. [2022]. Whilst there is a broad consensus about the causes that gave rise to the downward trend in corporate tax and its positive impact on real GDP and investment, a systematic analysis of the sectoral effects of corporate taxation on labor and investment in both tangible (i.e., physical capital) and intangible (i.e., the stock of knowledge) assets and how these effects vary across countries is still lacking. In this paper, we provide an attempt to answer the question: Do corporate tax cuts increase innovation and labor uniformly across sectors and across countries? It is essential to quantify their impact as so far, to our knowledge, the effects of corporate tax cuts have not been contrasted between OECD (or group of OECD) countries and have not been investigated at a sectoral level, except on

U.S. data.

One major challenge is to identify exogenous variations in corporate tax rates, i.e., variations in tax rates that are exogenous to the current state of the economy. While we are using the top marginal statutory corporate tax rate like Akcigit et al. [2022], we cannot exclude that the country-level tax rate is correlated with economic activity. In contrast, because the international component of corporate taxation is driven by tax competition motives, this measure should be disconnected from country-specific demand shocks (which is confirmed by the exogeneity test we have performed).

The assumption of international tax competition paves the way for the identification of exogenous (and permanent) corporate tax cuts as this hypothesis ensures that the tax rates display a clear downward trend which is common across countries. To capture more accurately the degree of international competition faced by each country, we construct an international tax rate for each country by considering the trade intensity between the home country and its trade partner within eleven countries as a weight. The attractive feature of this measure is that it captures the tax pressure from neighbor countries. According to the evidence documented by Davies et al. [2009], country-level tax rates are positively related to other countries' tax rates and especially neighbor countries. Indeed, we find empirically that corporate taxation is negatively correlated with financial openness in OECD countries and this correlation turns out to be as much negative as profits' taxation of trade partners are closer to that of the home country's. One additional important aspect of this tax measure is that it does not contain the country's own corporate tax rate which strengthens the exogeneity of the international tax rate to the country's economic conditions. To identify the exogenous shock to corporate taxation, we replace the country-level corporate tax rate with its international measure and estimate a VAR model by imposing long-run restrictions.

Our sample includes eleven OECD countries over the period 1973-2017 as the corporate income tax is available over a long enough time horizon for these countries which also share the existence of a common downward trend (on which we base our identification approach). By increasing the return on innovation and lowering the cost of capital, it is natural to expect a decline in the corporate tax rate to result in an increase in investment in intangible and tangible assets. Higher tangible and intangible assets should have also an expansionary effect on hours by raising the marginal product of labor. We investigate whether corporate tax cuts boost innovation and labor at a sectoral level in OECD countries by differentiating between exporting and non-exporting sectors. This dichotomy is particularly suited to the investigation of the effects of corporate tax cuts as advanced countries' production structure is characterized by R&D intensive (mainly exporting) vs. labor-intensive and low productivity growth industries (mostly non-exporting). Our evidence reveals that a permanent decline in corporate taxation has a strong expansionary effect on technology but only in the traded sector while the rise in hours is concentrated in the non-traded sector.

Besides varying across sectors, we also expect the effects of corporate taxation on utilization-adjusted TFP to vary widely across countries due to differences in the costs or the ability of industries to transform R&D expenditure into ideas. Differently, international differences in the effects on hours will depend on the extent of wage stickiness which itself depends on country-specific wage bargaining process. When we apply a clustering analysis based on several dimensions of wage bargaining organization (union density, collective bargaining coverage, level of centralization of wage bargaining and share of permanent contracts), we find that continental European countries display more regulated labor markets giving rise to wage stickiness. Building on this dichotomy based on wage bargaining institutions, we perform a split-sample analysis and investigate the effects of a corporate tax shock for two groups of countries: continental European countries (including Austria, Belgium, France, and Germany) on one hand and English-Speaking (Australia, the UK, the US) and Scandinavian countries (Finland, Sweden) plus Japan and Luxembourg on the other. Our results reveal that following a decline in profits' taxation, continental European countries experience a more pronounced increase in hours concentrated in non-traded industries while traded firms in English-speaking and Scandinavian countries dramatically improve their technology, as captured by a permanent rise in utilization-adjusted-TFP of tradables.

To rationalize our evidence, building on the open economy setup by Kehoe and Ruhl [2009], Chodorow-Reich et al. [2023], we develop and simulate a model with a traded and a non-traded sector where the domestic traded good and imported goods are imperfect substitutes. In the lines of Corhay et al. [2020], households (who are firms' owners) choose investment in both tangible and intangible assets which determine the stock of physical capital and the stock of knowledge. In doing this, we endogenize innovation which is the result of R&D expenditure decisions and depends on the cost of transforming R&D into ideas (i.e., in new products). The allocation of tangible and intangible assets between traded and non-traded industries is determined by the firm's profit maximization problem at a sectoral level. Building on Bianchi et al. [2019], we endogenize both capital and technology utilization rates. This is a crucial feature as changes in utilization-adjusted TFP are driven by the variations in the stock of knowledge (caused by higher R&D expenditure) and also by changes in the intensity in the use of the stock of knowledge. As long as technology utilization adjustment costs are low, it is optimal for firms to increase productivity by raising the intensity in the use of the stock of knowledge in order to meet a higher demand for their product.

The model can generate a strong technology improvement in traded industries after a corporate income tax cut conditionally on three key elements: a high intensity of traded output in domestic and international R&D, low technology utilization adjustment costs and international R&D spillovers. In line with our estimates, we assume large elasticities of utilization-adjusted-TFP w.r.t. the domestic and international stock of knowledge for tradables while they are essentially zero in non-traded industries. Because the corporate income tax cut produces a positive wealth effect which increases consumption in traded goods, traded firms find it optimal to make efficiency efficiency gains by increasing the intensity in the use of the stock of ideas to meet a higher demand while avoiding a rise in production costs. Because the stock of knowledge only builds up gradually, the domestic stock of R&D does not contribute to technology improvements in the short-run and at the margin in the long-run. By contrast, the bulk of technology improvements in traded industries in the short-run is driven by international R&D spillover.

The ability of the model to account for the positive and significant effect of a corporate income tax cut on hours rests on three key elements. First, we have to allow for Greenwood et al. [1988] (GHH henceforth) preferences to eliminate the negative impact of the positive wealth effect on labor supply. However, GHH preferences are not sufficient on their own to generate the rise in hours we estimate empirically. When sectoral wages are flexible, endogenous technology improvements are essential to provide higher incentives to increase labor supply by pushing wages up. The third element is consumption habits. Intuitively, by increasing the curvature of the utility function, a higher stock of habits mitigates the incentives to increase consumption. Habits curb the rise in consumption and amplify the rise in leisure. If we abstract from consumption habits, the model predicts a rise in hours which is three times larger than what we estimate empirically. Conversely, when we assume Shimer [2009] preferences (which allow for a wealth effect on labor supply) and shut down consumption habits, the model understates the rise in hours.

The model can also account for the concentration of labor growth within non-traded industries. Intuitively, higher demand for non-traded goods prices strongly appreciate over time. Because the elasticity between traded and non-traded goods is low, in line with our estimate and the estimated value reported by Stockman and Tesaer [1995], the share of consumption expenditure spent on non-tradables rises which shifts labor away from traded industries and toward non-traded industries. Labor reallocation contributes to the persistent increase in non-traded hours.

To account for the distinct effects on technology we detect empirically between English-speaking and Scandinavian countries on one hand and continental European countries on the other, we have to allow for large elasticities of utilization-adjusted-TFP w.r.t. the domestic and international stock of knowledge in the former group of countries, in accordance with our estimates. While technology is essentially unchanged in continental Europe, hours significantly increase. Following Chodorow-Reich et al. [2023], we introduce wage stickiness at a sectoral level, which fits the behavior of wages for this group of countries. As long as wages are sticky, the model can reproduce the response of hours while the same model with flexible wages predicts a rise in labor which is three times smaller.

Outline. In section 2, we set the stage of the SVAR identification of exogenous changes in corporate taxation and document a set of evidence related to the effects on technology and hours caused by a permanent decline in profits' taxation. In section 3, we develop a two-sector open economy model with tradables and non-tradables and endogenous technology choices. In section 4, we uncover the key elements of the model which are necessary to account for our SVAR evidence. The Online Appendix contains more empirical results, conducts robustness checks, details the solution method, and shows extensions of the baseline model.

Literature. Our paper fits into several different literature strands, as we bring several distinct threads in the existing literature together.

Narrative approach. Most of the papers in the literature use narratively-identified tax changes based on the policy changes in governments' sources. The narratively identified shocks are only available for the U.S., and the standard for choosing exogenous changes to taxation may not be completely reliable, as decision-makers could assert that their only focus is on the long-term shortage or the public debt level, when in truth they may be reacting to various temporary factors, see e.g., Perotti [2012]. Because we want to compare the effects across countries or groups of OECD economies and since we are interested in the impact of corporate tax cuts on innovation in the long-run, it is essential to propose a simple and robust identification of highly persistent changes in tax rates which allows international comparisons. Because the international component of tax rates is not correlated with country-specific economic activity, our identification approach avoids any potential endogeneity issue with economic activity within the same year.

Common component approach. We adapt the ingenious idea of Dupaigne and Fève [2009] for SVAR who average TFP across countries to extract pure technology effects which are not contaminated by country-specific persistent demand shocks. The cross-country average corporate income tax captures the common component of corporate taxation across OECD countries which is by construction not correlated with the country-level economic activity. The assumption of international tax competition paves the way for the identification of permanent shocks as this hypothesis ensures that the tax rates display a clear downward trend which is common across countries. In the same spirit as Liu and Williams [2019] who focus on U.S. states, each state being considered as a small open economy, we avoid endogeneity by considering a broad (i.e., international) measure of corporate tax rates.

Corporate taxation lowers output, investment, labor. Can corporate tax cuts stimulate the economy in the long-run? As exemplified by the review of the literature on the subject by Gechert and Heinberger [2022], the debate is still open although a large span of the literature reveals that corporate taxation has a significant impact on economic activity. Mertens and Ravn [2013] find that the federal corporate tax cuts increase investment, do not influence or even lower private consumption, and have no impact on employment. Djankov et al. [2010] use a cross-country empirical analysis to show the negative impact of effective corporate tax on aggregate investment, FDI, and entrepreneurial activity. Also, their results indicate that corporate taxes are correlated with investment in the manufacturing sector, whereas they are not in the services sector. Arulampalam et al. [2012] and Fuest et al. [2018] show that corporate tax leads to a decline in wages for European firms and German firms. Backus et al. [2008] find that capital taxation can rationalize international differences in capital-output. Suarez Serrato and Zidar [2016] find that lower corporate tax rates attract firms, which boosts local labor demand and encourages migration to that U.S. state. Thus, the location decisions of both firms and workers determine the impact of tax cuts.

Corporate taxation lowers innovation. According to the model' predictions by Jaimovich and Rebelo [2017], corporate income taxes have negative effects on innovation. Akcigit et al. [2022] empirically show that corporate income taxes negatively affect the number of patents at both firm and state levels in the United States. The research work by Cloyne et al. [2022] is the closest to ours as they investigate the effects of a corporate tax cut on technology and rationalize their findings by using a model with endogenous innovation. Like them, we find that a tax cut stimulates innovation but in contrast to the authors, we show that technology improvements are concentrated within traded industries. In addition we show that innovation does not increase in continental European countries. While we corroborate the muted response of labor for English speaking/Scandinavian countries, we find a strong and significant response of labor in continental European countries.

International comparison of the effects of corporate. The recent agreement on global minimum tax on profits has put corporate taxation at the forefront of the scene. Although the literature reports positive effects of a cut in profits taxation on real GDP and productivity on U.S. data, a clear understanding of how the effects vary across sectors and countries is still lacking. In this regard, by enabling us to assess international differences in the effects of corporate tax cuts and to contrast the effects between sectors, our simple and robust SVAR identification can provide information of primary importance about the effectiveness of profits taxation.

2 Dynamic Effects of Corporate Taxation: Evidence

In this section, we document evidence about the dynamic effects of corporate taxation on hours and technology for a panel of eleven OECD countries. Below, we denote the percentage deviation from initial steady-state (or the rate of change) with a hat.

2.1 Data

We use the top statutory corporate income tax rates which taken from Bachas et al. [2022]. They combine data from Vegh and Vuletin [2015], Egger et al. [2019], Tax Foundation and country-specific sources. They use the lower rate if there are conflicting estimates. The largest period available between 1973 and 2017 [1] for eleven OECD countries: Australia (AUS), Austria (AUT), Belgium (BEL), France (FRA), Germany (DEU), Finland (FIN), United Kingdom (GBR), Japan(JPN), Luxembourg (LUX), Sweden (SWE), and United States (USA). Spain, Norway, and Italy are dropped because they do not have a declining corporate income tax rate trend. We drop Canada, Netherlands, Greece, Ireland, Korea, Portugal, and Denmark because of the lack of data before 1980s.

The primary sources for sectoral data are the OECD and EU KLEMS databases. Our dataset includes eleven industries that are split into a traded and a non-traded sector. We use the following macroeconomic variables in the VAR estimations. All quantity variables are divided by the working-age population (15-64 years old) taken from OECD ALFS Database.

In Online Appendix A, we detail the source and the construction of time series for sectoral hours worked, L^j_{it}, the hours worked share of sector $j = H, N$, $\nu^{L,j}_{it}$, sectoral value added at constant prices, Y^j_{it}, and the value added share at constant prices, $\nu^{Y,j}_{it}$ where the subscripts i and t denote the country and the year. While we mainly focus on the labor effects, we also build intuition about the transmission mechanism of a technology improvement in a two-sector open economy by analyzing the movements in sectoral value added and relative prices. The terms of trade $P^H_{it} = \mathsf{P}^H_{it}/\mathsf{P}^{H,\star}_{it}$ are constructed as the ratio of the traded value added deflator of the home country i to the geometric average of the traded value added deflator of trade partners of the corresponding country i, the weight being equal to the share $\alpha^{M,k}_i$ of imports from the trade partner k (averaged over 1973-2017).[2] The price of non-traded goods is computed as the ratio of the non-traded value added deflator to price index of foreign goods, i.e., $P^N_{it} = \mathsf{P}^N_{it}/\mathsf{P}^{H,\star}_{it}$.

Utilization-adjusted sectoral TFPs. Sectoral TFPs are Solow residuals calculated from constant-price (domestic currency) series of value added, Y^j_{it}, capital stock, K^j_{it}, and hours worked, L^j_{it}, i.e., $\hat{\text{TFP}}^j_{it} = \hat{Y}^j_{it} - s^j_{L,i}\hat{L}^j_{it} - \left(1 - s^j_{L,i}\right)\hat{K}^j_{it}$ where $s^j_{L,i}$ is the labor income

[1] The corporate income tax rate data is unavailable before 1973 for Australia and the United Kingdom.

[2] While our sample includes eleven OECD countries, we consider twenty trade partners to ensure that the foreign price deflator accounts for a significant fraction of the home country's trade.

share (LIS henceforth) in sector j averaged over the period 1973-2017. To obtain series for the capital stock in sector j, we first compute the overall capital stock by adopting the perpetual inventory approach, using constant-price investment series taken from the OECD's Annual National Accounts. Following Garofalo and Yamarik [2002], we split the gross capital stock into traded and non-traded industries by using sectoral value added shares. In Online Appendix, we use the EU KLEMS dataset which provides disaggregated capital stock data (at constant prices) at the 1-digit ISIC-rev.3 level for thirteen countries of our sample over the period 1973-2017. Our estimates show that our empirical findings are unsensitive to the way the sectoral capital stocks are constructed in the data. Once we have constructed the Solow residual for the traded and the non-traded sectors, we construct a measure for technological change by adjusting the Solow residual with the capital utilization rate, denoted by $u^{K,j}_{it}$:

$$\hat{Z}^j_{it} = \hat{\text{TFP}}^j_{it} - \left(1 - s^j_{L,i}\right) \hat{u}^{K,j}_{it}, \tag{1}$$

where we follow Imbs [1999] in constructing time series for $u^{K,j}_{it}$, see Cardi and Restout [2023], as utilization-adjusted-TFP is not available at a sectoral level for most of the OECD countries of our sample. In Online Appendix C.5, we find that our empirical findings are little sensitive to the use of alternative measures of technology which include i) Basu's [1996] approach which has the advantage of controlling for unobserved changes in both capital utilization and labor effort, ii) and the use of time series for utilization-adjusted-TFP from Huo et al. [2023] and Basu et al. [2006]. Our preferred measure is based on Imbs's [1999] method because it fits our model setup where we consider an endogenous capital utilization rate and the last two measures can only be constructed over a shorter period of time and for a limited number of OECD countries.

2.2 Tax Competition and Exogenous Corporate Tax Shocks

One major challenge when analyzing the dynamic effects of corporate taxation is to identify exogenous shocks. The identification of exogenous shocks to economic activity prevents the econometrician from using country-level corporate income tax rates as there is a clear endogeneity issue: when labor is low, the government might be tempted to cut the corporate tax. To overcome this difficulty, Romer and Romer [2010], Mertens and Ravn [2013] and Cloyne [2013] use narratively identified tax changes as proxies for structural tax shocks. The main problem of this approach is that narratively identified shocks are only available for a few countries and might also display some bias; as emphasized by Perotti [2012], decision-makers could assert that they focus on public debt while they are interested in mitigating the effects of a recession which in turn will bias the estimated effect (from the narrative approach) of a tax cut on value added downward.

Our identification of a permanent shock to the corporate tax rate lies on the assumption that persistent changes in corporate income tax rates are not driven by the stage of the business cycle of the country. Instead, our identification of a permanent shock to corporate taxation lies on the observation that tax competition has given rise to a downward trend in the corporate tax rates in most of OECD countries. In addition to generating a gradual decline in corporate taxation, the willingness to attract capital implies that country-level tax rates share a common component which is specific to corporate taxation, i.e., the entity which is taxed can cross the borders. Tax competition refers to the process whereby countries compete with each other to attract businesses by offering lower tax rates and other favorable tax conditions. This competition can have a permanent effect on corporate income tax rates because businesses will continue to seek out countries with lower tax rates, leading to a downward pressure on tax rates in other countries. As businesses move to countries with lower tax rates, governments in other countries may be forced to lower their own tax rates in order to remain competitive. This creates a cycle of tax competition, as each country continually lowers its tax rates in an effort to attract businesses. Persson and Tabellini [2002] show theoretically that in the Nash equilibrium, tax competition leads to a reduction in taxes of the mobile factor (capital) more than the immobile factor (labor). Evidence documented by Devereux et al. [2008] reveals that corporate tax cuts aimed at attracting multinational and more profitable firms.

Fig. 1 plots the country corporate tax rate against time in the solid blue line for the eleven OECD countries of our sample. As it stands out, corporate taxation displays a downward trend from the end of the seventies or the beginning of the eighties which coincide with the removal of capital controls. As mentioned above, our identification assumption is based on the existing of a downward trend which is common to the countries of our sample. One way to visualize this idea is to plot the simple country average of corporate tax rates which is shown in the dashed green line. It is striking to see that domestic corporate income tax rates track well the cross-country average. Indeed, The correlation between the country-level corporate income tax rate, τ_{it}, and the cross-country average tax rate, $\bar{\tau}_t^{int}$, averages 0.86, see Online Appendix D.1.

Because the downward trend is driven by international tax competition, to better reflect the intensity of competition between countries to attract capital which is perfectly mobile between countries, we consider the import-share-weighted-average of trade partners' corporate tax rates. Davies and Voget [2009] show that domestic tax levels are positively related to taxes of other countries, especially close countries like neighbors, and find robust evidence for tax competition. In the same vein, to capture more accurately the degree of international competition faced by each country i, we construct an international tax rate $k = 1...10$ of each country i by considering the trade intensity between the home country and its trade partner within ten countries as a weight:

$$\tau_{it}^{int} = \sum_{k \neq i}^{10} \alpha_{IM}^{i,k}, \tau_{kt} \tag{2}$$

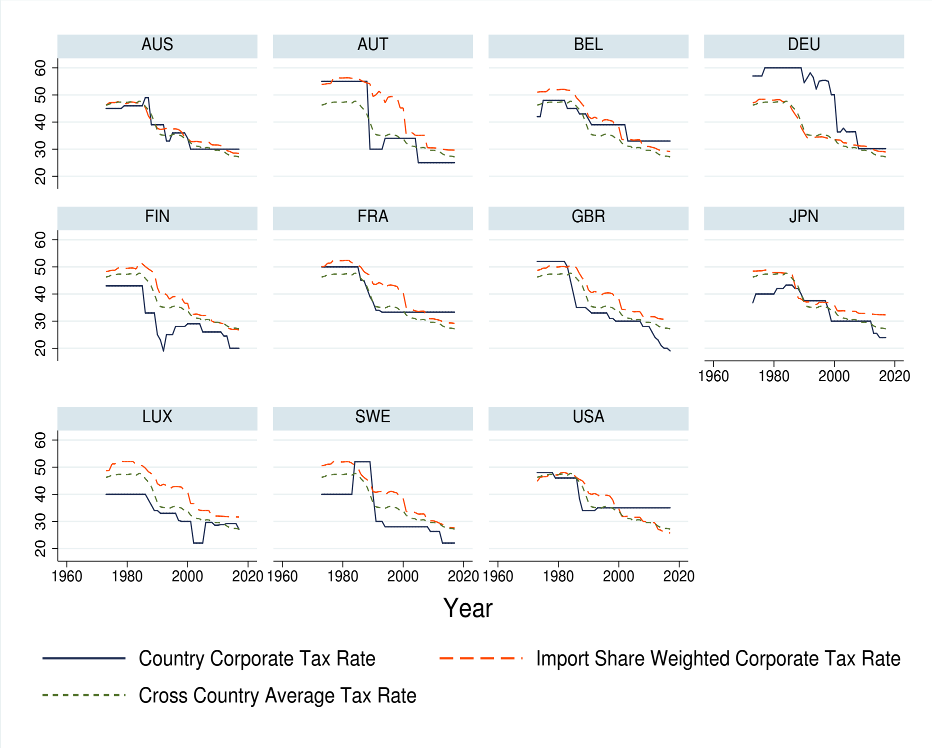


Figure 1: Evolution of Corporate Tax Rates in Eleven OECD Countries 1973-2017. Notes In Fig. 1, we plot the top statutory corporate income tax rates for each country i, τ_{it}, in the solid blue line (vertical axis) against time. In the dashed green line, we plot the country average of corporate tax rates, $\bar{\tau}_t^{int}$, and in the dashed red line, we plot the import-share-weighted-average of trade partners' corporate tax rates of country i, τ_{it}^{int}. Sample: 11 OECD countries, 1973-2017, annual data.

where $\alpha_{IM}^{i,k}$ is the trade share of home countries i with the partner country k and τ_{kt} is the statutory corporate income tax rate of the partner country. The most important feature of this tax measure is that it does not contain the countries own corporate tax rate. This makes international tax rate exogenous to the country's economic conditions.

The correlation between the country-level corporate income tax rate, τ_{it}, and the import-share-weighted-average tax rates of trade partners of the home country, τ_{it}^{int}, averages 0.93. Therefore the intensity of tax competition is better captured when we consider the intensity of trade links. While high correlation between the country-level corporate tax rate and its international component shown in the dashed red line is obvious from Fig. 1, we have to test formally that there is a common stochastic trend for the eleven OECD countries of our sample. We use the panel cointegration test proposed by Westerlund [2007] which allows for cross-sectional dependence. As shown in Online Appendix D.3, we can conclude that there is a cointegration relationship between the logged country income corporate tax rate and logged of import-share-weighted-average of trade partners' tax rates.

Our VAR identification is based on the assumption that corporate tax rates among OECD countries share a common downward trend as a result of financial openness. Building on time series for assets and liabilities taken from the dataset from Lane and Milesi-Ferretti [2007], we have calculated the financial openness index. As expected, Fig. 2 indicates a negative correlation between financial openness and the corporate tax rate, meaning that countries-years with more open capital markets tend to have lower corporate tax rates.

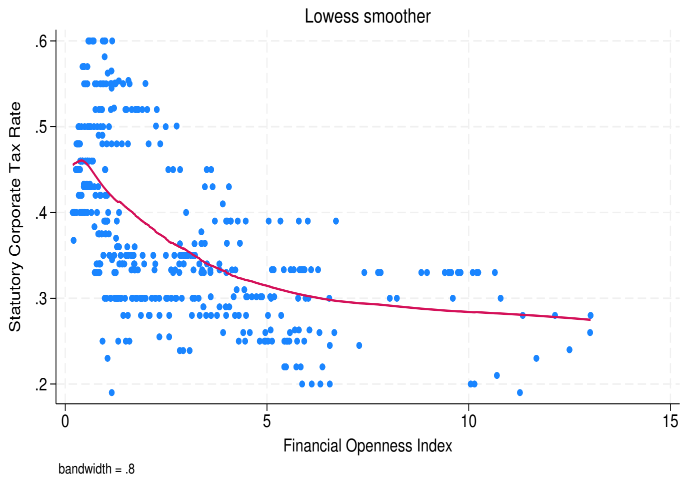


Figure 2: Corporate Tax Rates vs. Financial Openness across Time and Space. Notes We plot the corporate tax rates (vertical axis) against the measure of financial openness Data for the current account balance are taken from Lane and Milesi-Ferretti [2007]. For profits' taxation measure, we use the top statutory corporate income tax rate. We are using a Locally Weighted Scatterplot Smoothing (LOESS) method which is a non-parametric regression technique used for fitting a smooth curve or surface to a scatterplot of data points. Sample: 11 OECD countries, 1973-2017, annual data.

While financial openness and capital mobility has given rise to international tax competition which has produced a common downward trend in corporate taxation among OECD countries, tax setting in the home country will depend on the level of the tax rates of its trade partners. Building on Devereux et al. [2008], in situations where capital can easily move across borders, the decision to invest in a particular country, denoted as i hinges on that country's corporate tax rates compared to those of other countries j where $j \neq i$. In this analysis, we used more sophisticated capital openness index which is the Chinn-Ito index (KAOPEN) [3]

[3]KAOPEN represents the first principal component derived from the initial variables related to regulatory restrictions on current or capital account movements, the presence of multiple exchange rates, and mandates concerning the submission of export earnings. The Chinn-Ito index normalized to range between zero and one. More details are provided by Chinn et al. [2008].

Table 1: Regression results

	(1)	(2)	(3)	(4)
	τ_{it}	τ_{it}	τ_{it}	τ_{it}
κ_{it}	-0.298***	-0.459***	-0.382***	-0.414***
	(-6.22)	(-10.86)	(-5.48)	(-9.80)
$\tau_{it}^{int} * \kappa_{it}$		0.815***	0.637***	
		(6.83)	(4.55)	
Log of Population			-0.00971	
			(-0.08)	
Log of public debt to GDP			-0.00628	
			(-0.31)	
Unemployment Rate			-0.170	
			(-0.42)	
$\hat{\tau}_{it}^{int} * \kappa_{it}$				0.678***
				(7.79)
_cons	0.636***	0.500***	0.617	0.498***
	(15.23)	(14.04)	(0.51)	(17.34)
Country FE	Yes	Yes	Yes	Yes
adj. R^2	0.476	0.714	0.676	0.667

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

To test our assumption, we run the regression of corporate tax rates on capital openness and a measure of the intensity of tax competition:

$$\tau_{it} = \beta_1 \kappa_{it} + \beta_2 \kappa_{it} \tau_{it}^{int} + \beta_3 X_{it} + \nu_{it}, \tag{3}$$

where τ_{it} is statutory corporate income tax rate for country i at year t, κ_{it} is the capital openness index and X is for the control variables such as country size, public debt to GDP ratio and unemployment rate.

Table 1 displays the results of the regression specified in eq. 3. As shown in the first row which displays the impact of capital openness, the variable has a significant and strong negative impact on the corporate tax rate. The interaction term shown in the second row reveals that the impact of capital openness on the home country's tax rate is smaller where corporate tax rates of neighbors (i.e., trade partners) are higher. Even if capital is perfectly mobile between countries, some economies might use the corporate tax rate for other purposes than attracting capital, such as reducing the public debt which in turn reduces the intensity of tax competition. All these conclusions hold even once we add some controls, as shown in column 3.[4] For example, higher unemployment tends to provide some

[4] In row 3, we consider the role of the size of the country which is expected to have a positive impact on corporate taxation: a smaller country will have a greater incentive to lower its tax rate as the loss of tax revenues due to a reduction in the tax rate is more likely to be more than offset by a large capital inflow than a country which has a much larger size. We find however a negative impact on corporate taxation but the point estimate is not significant. The public debt has not a significant effect either.

incentives to cut corporate tax rates but the effect is not statistically significant.

In eq. 3, international tax rates are dependent on the international measure of the corporate income tax rate. Because the regressor τ_{it}^{int} might display some endogeneity, i.e., to ensure the robustness of our empirical results, we have adopted an instrumental variable approach. As a first stage, we first regress τ_{it}^{int} on its lag and on a set of control variables X_{it}, and derive predicted values of the international tax rate are denoted by $\hat{\tau}_{it}^{int}$. The result of this IV regression is shown in column 4 of the Table 1. The sign and the size of the coefficients are consistent with the baseline regression.

2.3 SVAR Identification and Robustness

In the previous subsection, we have documented a set of evidence which supports our assumption that corporate taxation in OECD countries shares a common downward trend. Such a downward trend is driven by tax competition as countries lower profits' taxation to attract capital which is perfectly mobile between countries or to keep existing businesses from leaving. These variations are exogenous as they are not designed to offset a recession and capture more supply-side reforms with a long-run economic growth perspective or could also reflect "ideological" changes. In the same spirit as Dupaigne and Fève [2009], to avoid any potential variations in profits' taxation designed to offset macroeconomic shocks, we estimate the VAR model by replacing the country-level corporate income tax rate with an international measure which is common to all countries of our sample. While the country average of corporate income tax rates are highly correlated with the country-level tax rate, we consider a measure which better captures the intensity in tax competition. This measure is defined as an import-share-weighted-average of trade partners' corporate tax rates. The advantage of this measure is twofold. It is strongly correlated with the country-level corporate income tax rate as the correlation averages 0.93 and ranges from 0.87 for Germany to 0.98 for Sweden. Because this measure is cointegrated with the country-level tax rate, we can estimate a SVAR model where we replace τ_{it} with τ_{it}^{int}. Because the international measure for profits' taxation which captures the strength of international tax competition is country-specific, the second advantage of using this measure is that we can estimate the SVAR model in panel format which will ensure the accuracy of our estimates as we have almost five hundred observations. After running panel unit root tests to ensure that all variables are integrated of order one, like Gali [1999] who focus on permanent technology improvements, we impose long-run restrictions and identify permanent shocks to corporate taxation as shocks that lower permanently τ_{it}^{int}.

SVAR model and identification. To explore empirically the dynamic effects of a shock to corporate taxation, we consider a vector denoted by X_{it} which includes the corporate income tax rates, τ_{it}^{int}, real GDP, total hours worked, and utilization-adjusted-aggregate-TFP. In the sequel, all quantities are divided by the working age population and all variables enter the VAR model in rate of growth except the corporate income tax which is in variation. Although the SVAR estimations might be subject to small sample biases, a panel data with 11 countries can compensate the limited time horizon. Also, the confidence bounds are tighter in the panel SVAR estimations than when estimations are run at a country level. Our panel VAR estimation includes the international tax rate and the aggregate and sectoral level macroeconomic variables.

We identify a permanent shock to corporate taxation ε_{it}^{τ} by estimating a reduced-form VAR model in panel format on annual data. As is well know, the number of parameters estimated in the reduced form of the VAR model is not sufficient to recover the structural shocks and thus we have to impose long-run restrictions on the structural form. To write down the moving average (MA) representation of the structural VAR model, we assume a linear relationship between reduced form residuals η_{it}^{τ} and structural technology shocks ε_{it}^{τ}

$$\eta_{it}^{\tau} = A_0 \varepsilon_{it}^{\tau}, \tag{4}$$

where A_0 is the matrix that describes the instantaneous effects of structural shocks on observables. The MA representation of the structural VAR model reads:

$$\hat{X}_{it} = B(L) A_0 \varepsilon_{it}^{\tau}, \tag{5}$$

where $B(L) = C(L)^{-1}$ with $C(L) = I_n - \sum_{k=1}^{p} C_k L^k$ a p-order lag polynomial. The matrices C_k and the variance-covariance matrix Σ are assumed to be invariant across time and countries and the VAR is estimated with two lags and country fixed effects. Let us denote $A(L) = B(L)A_0$ with $A(L) = \sum_{k=0}^{\infty} A_k L^k$. To identify permanent corporate income tax changes, ε_{it}^{τ}, we use the restriction that the unit root in τ_{it}^{int} originates exclusively from corporate tax shocks which implies that the upper triangular elements of the long-run cumulative matrix $A(1) = B(1)A_0$ must be zero. This restriction on the long-run cumulative matrix implies that once the reduced form has been estimated using OLS, structural shocks can then be recovered from $\varepsilon_{it}^{\tau} = A(1)^{-1} B(1) \eta_{it}$ where the matrix $A(1)$ is computed as the Cholesky decomposition of $B(1)\Sigma B(1)'$.

Robustness checks. Galí [1999] has pioneered the identification of permanent technology improvement through long-run restrictions. Because the SVAR estimation allows for a limited number of lags, the SVAR critique has formulated some reservations with regard to the ability of the SVAR model to disentangle pure permanent shocks from other shocks (which have long-lasting effects on the variable of interest) when capital adjusts sluggishly. While the SVAR critique has been formulated for the identification of permanent technology shocks, see e.g., Erceg et al. [2005], Chari et al. [2008], we have conducted a series of robustness checks (that we summarize below) related to several aspects of our VAR identification of corporate income tax shocks which are detailed in Online Appendix D.

First, in Online Appendix D.4, we test whether the identified shocks to corporate taxation are correlated with persistent demand shocks. Following Francis and Ramey [2005], we run the regression of identified corporate tax shocks on (three) demand shocks which includes shocks to government spending, to monetary policy, and to tax revenues. The F-test reveals that none of the demand shocks are correlated with our identified corporate income tax shocks. Second, following the recommendation by Chari et al. [2008] and De Graeve and Westermark [2013] who find that raising the number of lags may be a viable strategy to achieve identification when long-run restrictions are imposed on the VAR model, in Online Appendix D.5, we increase the lags from two to five and find that all of our conclusions stand. Third, because the existing literature has recourse to narratively-identified corporate income tax shocks which are only available for the U.S., in Online Appendix D.6, we contrast the dynamic effects of a corporate income tax cut we estimate from a SVAR identification with long-run restrictions with those when exogenous shocks are narratively identified over the period 1970-2006. We find that the effects from the SVAR identification lies within the confidence bounds of the point estimate obtained from the narrative approach.

2.4 Dynamic Effects of Corporate Tax Shocks across Sectors

In this section, we discuss the dynamic effects of a permanent corporate tax cut. The dynamic responses are generated from the estimation of VAR models which include the import-share-weighted-average of trade partners' corporate income tax rates, τ_{it}^{int}, ordered first and a set of variables which are detailed in Online Appendix B. While we replace the country-level corporate income tax rate, τ_{it}, with its international measure, τ_{it}^{int}, to ensure the exogeneity of the tax to country-specific economic activity, we re-scale the shock so that the dynamic responses correspond to the effects to a 1 percentage point permanent decline in the country-level corporate income tax rate.[5] Additionally, we re-scale the response of value added and hours worked in traded and non-traded sectors by the sample average of sectoral value added to GDP and sectoral labor compensation share, respectively. This re-scaling implies that the sum of responses of value added (hours) across sectors collapses to the response of real GDP (total hours worked). Shaded areas display the 90% confidence bounds from bootstrap sampling. Darker areas are 68% confidence intervals.

Aggregate Effects. We start with the aggregate effects displayed by Fig. 3. As shown in Fig. 3(a), the country-level corporate income tax declines by 0.41 ppt on impact following an exogenous decline in the international tax rate, and then decreases by 1 ppt after five years. The corporate tax cut has an expansionary effect on real GDP, total hours worked,

[5] To normalize the shock so that the responses show the effects after a permanent corporate income tax cut by 1 ppt in the long-run, we estimate a VAR model which includes the international corporate tax rate, τ_{it}^{int}, and the country-level corporate tax rate, τ_{it}, and estimate by ho much τ_{it} declines when τ_{it}^{int} declines by 1 ppt in the long-run. Then we re-scale the effects to show the responses to a 1 ppt decline in the country-level corporate income tax rate.

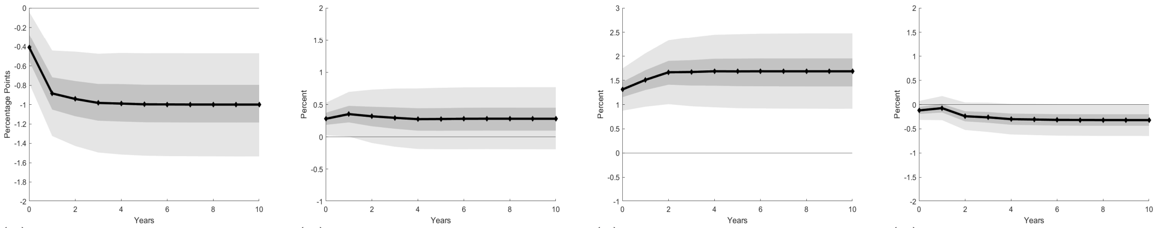
and utilization-adjusted-aggregate-TFP (see Fig. 3(b)). Total hours rise by 0.9% on impact and by 0.63% in the long-run (see Fig. 3(e)). Importantly, the combined effects of higher labor and technology improvements generate a real GDP growth of 1.3% on impact and remains persistently 1% higher than its initial steady-state level (see Fig. 3(i)).

Sectoral technology effects. While aggregate technology improves significantly only on impact, the adjustment is quite distinct when we differentiate the technology effects between the traded and the non-traded sector. As show in Fig. 3(c) and Fig. 3(d), a corporate tax cut leads to a high and significantly technology improvement which is concentrated in the traded sector as Z_{it}^{H} rises by almost 1.7% in the long-run while utilization-adjusted-TFP of non-tradables remains essentially unchanged as the response is not significant. Interestingly, the result is reversed for hours as discussed below. One important question is whether technology improvements are driven by innovation or instead reflects productivity gains due to firm's production reorganization or better management practices. In Online Appendix C.6, we investigate the impact of a permanent corporate tax cut by 1 ppt in the long-run on investment in R&D (for $N = 9$ countries due to limited data availability) and on the stock of R&D (for $N = 10$ countries) at a sectoral level. We find that a decline in corporate taxation has a strong expansionary and significant effect on investment in R&D but only in the traded sector. We also detect a strong effect on the stock of R&D in the traded sector but the response is significant at a significance level of 68% only. As we shall see below, one reason to the lack of significance is that the effects of corporate taxation on R&D varies widely across countries.

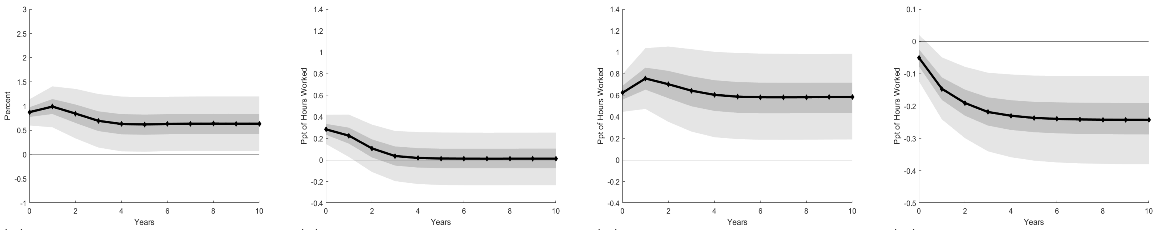
Sectoral hours and value added effects. While the permanent decline in corporate taxation does not increase traded hours worked persistently (see Fig. 3(f)), it gives rise to a significant and persistent rise in hours worked concentrated in non-traded industries by 0.6 ppt of total hours worked. As displayed by Fig. 3(h), the hours worked share of tradables declines which reflects the fact that labor shifts away from traded industries and toward non-traded industries. While on impact, the contribution of the reallocation of labor toward the non-traded sector to the rise in L^{N} is modest, the contribution amounts to more than one-third after three years as the shift of labor is a gradual movement. While labor growth mostly originates from non-traded industries, real GDP growth is significantly driven by traded industries as they account for less than 40% of GDP and contributes 60% to output growth. As shown in Fig. 3(l), the value added share of tradables at constant prices increases persistently by 0.2 ppt of real GDP as a result of technology improvements in the traded sector.

2.5 Dynamic Effects of Corporate Tax Shocks across Countries

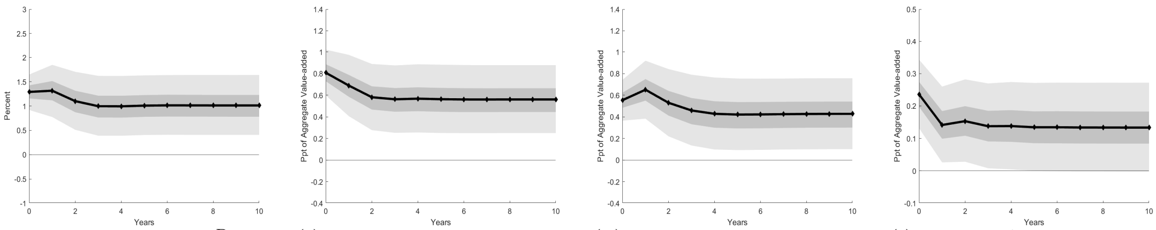
Our evidence reveals that a permanent corporate tax cut has a strong expansionary effect on value added and technology in the traded sector and labor growth is concentrated in



(a) Corporate Income Tax, τ_{it} (b) Utilization-Adjusted-Aggregate-TFP, Z^A_{it} (c) Utilization-Adjusted-TFP of Tradables, Z^H_{it} (d) Utilization-Adjusted-TFP of Non-Tradables, Z^N_{it}



(e) Total Hours Worked, L_{it} (f) Traded Hours Worked, L^H_{it} (g) Non-Traded Hours Worked, L^N_{it} (h) Hours Worked Share of Tradables



(i) Real GDP, Y^R_{it} (j) Traded Value Added, Y^H_{it} (k) Non-Traded Value Added, Y^N_{it} (l) Value Added Share of Tradables

Figure 3: Dynamic Effects of a Corporate Tax Shock in OECD Countries ($N = 11$). Notes: The solid black line shows the response of aggregate and sectoral variables to an exogenous decline in corporate income taxation by 1 percentage point in the long-run. (Darker) Shaded areas indicate the 90 (68) percent confidence bounds based on bootstrap sampling. Horizontal axes indicate years. Vertical axes measure percentage deviation from trend. Sample: 11 OECD countries, 1973-2017, annual data.

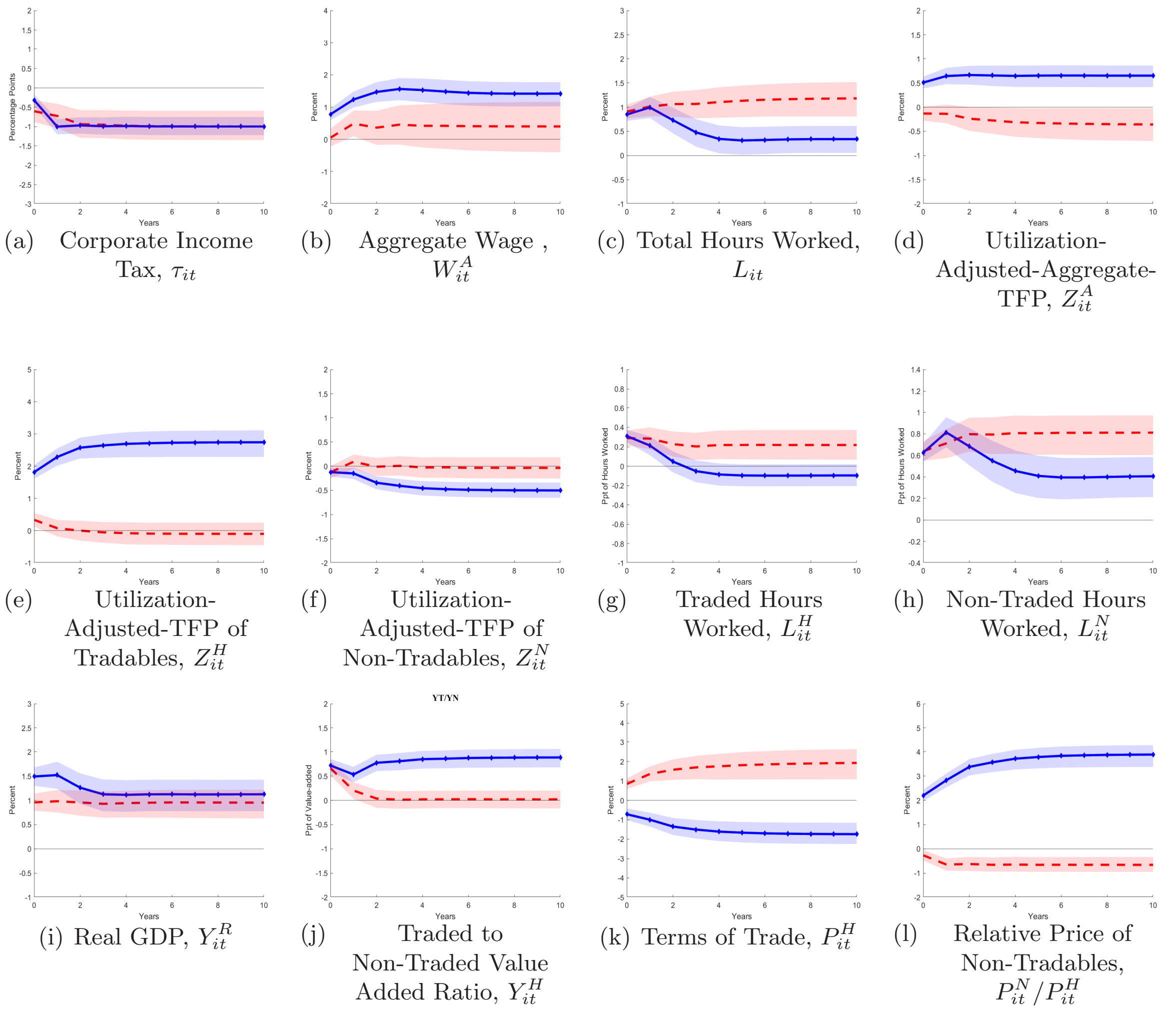
non-traded industries. We now take advantage of the panel data dimension of our sample to investigate whether the effects of a corporate tax cut vary across countries. Because we have only 45 observations per country, we perform a country-split which allows us to use the panel dimension to ensure the accuracy of SVAR estimates.

Country-split. We use a hierarchical cluster tree method to classify the countries into two groups. This method is based on the idea that data points that are more similar to each other should be placed in the same cluster, while those that are less similar should be placed in separate clusters. To split the sample into two sub-groups, we use two dimensions.

The first dimension is related to the degree of wage flexibility and the second dimension is the elasticity of utilization-adjusted-TFP w.r.t. the stock of knowledge. As a first pass, as detailed in Online Appendix C.7, we estimated the responses of a corporate tax cut on the aggregate wage rate for one country at a time and found that wages remain unresponsive to the shock in four continental European countries which include Austria, Belgium, France and Germany. When we estimated the effects of the same shock on technology, our estimates also reveal that utilization-adjusted-TFP remains unchanged in these four economies. In contrast, in the rest of the sample, both wages and technology were relatively responsive. As detailed in Online Appendix C.4, to identify these two clusters, as mentioned above, we use a hierarchical cluster tree method by making use of four labor market indicators suggested by past empirical studies which include the share of permanent employment, union density, the bargaining coverage rate, and the level of centralization in wage bargaining. Empirical results show that the four continental European countries form a cluster with high wage rigidity while the rest of the sample which includes English-speaking and Scandinavian countries along with Japan and Luxembourg form a second cluster which is characterized by a higher wage flexibility.

The second dimension is related to technology improvement. In Online Appendix C.7, we provide evidence which reveals that countries with wage stickiness also experience no technology improvement after a corporate tax cut while the other way around is true for English-speaking and Scandinavian countries. Indeed, when we estimate the elasticity of utilization-adjusted-aggregate-TFP w.r.t. the stock of R&D, our estimates indicate that all continental European countries are characterized by an elasticity which is essentially zero for each country. For simplicity purposes, we will refer indifferently to this cluster as continental European countries or rigid-wages-group and we will refer to the second group as English-speaking and Scandinavian countries or the flexible-wage-group.

International differences in labor and technology effects. In Fig. 4, we contrast the effects of a permanent corporate tax cut between English-speaking and Scandinavian countries on one hand shown in the blue line with diamonds and continental European countries on the other displayed by the dashed red lines. As can be seen in Fig. 4(a),



(a) Corporate Income Tax, τ_{it}
(b) Aggregate Wage , W_{it}^{A}
(c) Total Hours Worked, L_{it}
(d) Utilization-Adjusted-Aggregate-TFP, Z_{it}^{A}
(e) Utilization-Adjusted-TFP of Tradables, Z_{it}^{H}
(f) Utilization-Adjusted-TFP of Non-Tradables, Z_{it}^{N}
(g) Traded Hours Worked, L_{it}^{H}
(h) Non-Traded Hours Worked, L_{it}^{N}
(i) Real GDP, Y_{it}^{R}
(j) Traded to Non-Traded Value Added Ratio, Y_{it}^{H}
(k) Terms of Trade, P_{it}^{H}
(l) Relative Price of Non-Tradables, P_{it}^{N}/P_{it}^{H}

Figure 4: Dynamic Effects of a Corporate Tax Shock: Country-Split. Notes: We investigate the effects of an exogenous decline in corporate income taxation by 1 percentage point in the long-run for two groups of countries. The solid blue line with diamonds shows the responses of the flexible-wage-group of countries while the dashed red line displays the responses of the rigid-wage-group of countries. Shaded areas indicate the 90 percent confidence bounds based on bootstrap sampling. The blue shaded area refers to the flexible-wage-group of countries (i.e., English-speaking and Scandinavian countries) while the red shaded area refers to the rigid-wage-group of countries (i.e., continental European countries). Horizontal axes indicate years. Vertical axes measure percentage deviation from trend. Sample: 7 vs. 4 OECD countries, 1973-2017, annual data.

the adjustment of corporate taxation is similar between the two groups. In contrast, as mentioned above, the adjustment in wages and in technology is distinct between the two groups of countries. As displayed by Fig. 4(c), a corporate tax cut has a significant and persistent effect in total hours in continental European countries while the aggregate wage rate remains mostly unresponsive to the shock as can be seen in the dashed red in Fig. 4(b). By contrast, as shown in Fig. 4(d), technology remains essentially unchanged after a permanent corporate tax cut in continental European countries while utilization-adjusted-aggregate-TFP significantly increases in English-speaking and Scandinavian countries.

When we contrast the effects at a sectoral level in the second row of Fig. 4, we find that a reduction in profits' taxation generates technology improvements in English-speaking and Scandinavian countries which are concentrated in traded industries (see the blue line in Fig. 4(e)) as utilization-adjusted-TFP does not increase in the non-traded sector (see the blue line in Fig. 4(f)). In Online Appendix C.6, we differentiate the effects of a corporate tax cut between the two groups of countries. We find that only investment and the stock of capital in R&D increase significantly in the traded sector and in English-speaking and Scandinavian countries while R&D does not respond to the shock in continental European countries. While in the latter group of countries, technology is unchanged in both sectors, hours significantly and persistently increase in both the traded and the non-traded sectors (see the dashed red line in Fig. 4(g) and Fig. 4(h)).

International differences in value added and relative price effects. In the last row of Fig. 4, we differentiate the effects of a corporate tax cut between the two groups of countries. While real GDP growth does not display some significant differences, see Fig. 4(i), its sectoral composition is quite distinct between the two clusters. More specifically, as displayed by Fig. 4(j), technology improvements in traded industries raise traded relative to non-traded value added in English-speaking and Scandinavian countries which in turn give rise to an excess supply in the traded goods market leading to a depreciation in the terms of trade, see Fig. 4(k). Differently, the excess demand in the non-traded goods market appreciates non-traded-goods prices in both groups of countries, see Fig. 4(l). Because the price-elasticity of the demand for non-traded goods is low, as corroborated by our own estimates, the appreciation in the relative price of non-traded goods increases the share of non-tradables. By raising the demand for labor in the non-traded sector, a higher fraction of consumption spent on non-tradables shifts hours toward this sector.

Robustness checks: Dividend policy and profit-sharing rules. Because we find that hours does not increase persistently in the long-run in English-speaking and Scandinavian countries while technology does not improve in continental European countries, we have checked whether these results are not driven by the fact that the fall in profits' taxation leads firms to increase dividends instead of investing in R&D or instead of hiring more workers. We find that the response of the ratio of dividends to gross operating surplus is muted for both groups of countries and thus we can conclude that the change in the dividend policy cannot explain high and significant technology improvement we detect empirically, see Online Appendix C.5.

We have also checked if profit sharing rules implemented in OECD countries, see e.g., Nimier-David et al. [2023], could lead firms to increase the share of labor compensation in value added after a permanent decline in corporate taxation. We did not detect any significant effect of a decline in corporate taxation on labor income shares, either in the traded or in the non-traded sector, see Online Appendix C.8. The fact that the labor income shares remain muted after a permanent decline in profits' taxation stand in sharp contrast with the estimates documented by Kaymak and Schott [2023] which indicate that between 30% to 60% of the observed decline in labor income shares should be driven by the fall in corporate taxation due to the shift of the market share from labor- to capital-intensive industries. Besides the fact that the panel, the period, and the empirical strategy are different, we believe that the difference between our results and the findings by the aforementioned authors is based on the fact that we consider traded industries while the authors focus on Manufacturing and the reallocation of market shares may operate within this sector which results in a muted effect at the broad sector level.

3 Open Economy Model with Tradables and Non-Tradables

We consider an open economy that is populated by a constant number of identical households and firms that have perfect foresight and live forever. Like Kehoe and Ruhl [2009] (KR henceforth), Bertinelli et al. [2022], Chodorow-Reich et al. [2023], the country is assumed to be semi-small in the sense that it is a price-taker in international capital markets, and thus faces a given world interest rate, $r^{\star}$, but is large enough on world good markets to influence the price of its export goods so that exports are price-elastic. The open economy produces a traded good which can be exported, consumed or invested and also imports consumption and investment goods. While the home-produced traded good, denoted by the superscript H, faces both a domestic and a foreign demand, a non-traded sector produces a good, denoted by the superscript N, for domestic absorption only. The foreign good is chosen as the numeraire. Households choose consumption and labor supply, invest in tangible and intangible assets, and must decide about the intensity in the use of the capital stock and the stock of knowledge. Firms in the traded and the non-traded sector rent services from labor, physical capital stock and the stock of ideas. Time is continuous and indexed by t. More details about the model can be found in Online Appendices E.

3.1 Households

Consumption in sectoral goods. At each instant the representative household consumes traded and non-traded goods denoted by $C^T(t)$ and $C^N(t)$, respectively, which are aggregated by means of a CES function:

$$C(t) = \left[\varphi^{\frac{1}{\phi}} \left(C^T(t)\right)^{\frac{\phi-1}{\phi}} + (1-\varphi)^{\frac{1}{\phi}} \left(C^N(t)\right)^{\frac{\phi-1}{\phi}}\right]^{\frac{\phi}{\phi-1}}, \tag{6}$$

where $0 < \varphi < 1$ is the weight of the traded good in the overall consumption bundle and ϕ corresponds to the elasticity of substitution between traded goods and non-traded goods. The traded consumption index $C^T(t)$ is defined as a CES aggregator of home-produced traded goods, $C^H(t)$, and foreign-produced traded goods, $C^F(t)$:

$$C^T(t) = \left[\left(\varphi^H\right)^{\frac{1}{\rho}} \left(C^H(t)\right)^{\frac{\rho-1}{\rho}} + \left(1-\varphi^H\right)^{\frac{1}{\rho}} \left(C^F(t)\right)^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}}, \tag{7}$$

where $0 < \varphi^H < 1$ is the weight of the home-produced traded good and ρ corresponds to the elasticity of substitution between home- and foreign-produced traded goods.

Labor supply across sectors. The representative household supplies labor to the traded and non-traded sectors, denoted by $L^H(t)$ and $L^N(t)$, respectively. To put frictions into the movement of labor between the traded sector and the non-traded sector, we assume that sectoral hours worked are imperfect substitutes, in lines with Horvath [2000]:

$$L(t) = \left[\vartheta_L^{-1/\epsilon_L} \left(L^H(t)\right)^{\frac{\epsilon_L+1}{\epsilon_L}} + (1-\vartheta_L)^{-1/\epsilon_L} \left(L^N(t)\right)^{\frac{\epsilon_L+1}{\epsilon_L}}\right]^{\frac{\epsilon_L}{\epsilon_L+1}}, \tag{8}$$

where $0 < \vartheta_L < 1$ parametrizes the weight attached to the supply of hours worked in the traded sector and ϵ_L is the elasticity of substitution between sectoral hours worked.

Supply of tangible and intangible assets across sectors. Like labor, we generate imperfect capital mobility by assuming that traded $K^H(t)$ and non-traded $K^N(t)$ capital stock are imperfect substitutes:

$$K(t) = \left[\vartheta_K^{-1/\epsilon_K} \left(K^H(t)\right)^{\frac{\epsilon_K+1}{\epsilon_K}} + (1-\vartheta_K)^{-1/\epsilon_K} \left(K^N(t)\right)^{\frac{\epsilon_K+1}{\epsilon}}\right]^{\frac{\epsilon_K}{\epsilon_K+1}}, \tag{9}$$

where $0 < \vartheta_K < 1$ is the weight of capital supply to the traded sector in the aggregate capital index $K(.)$ and ϵ_K measures the ease with which sectoral capital can be substituted for each other and thereby captures the degree of capital mobility across sectors. We also allow for imperfect mobility of intangible assets by assuming that traded $Z^H(t)$ and non-traded $Z^N(t)$ stock of ideas are imperfect substitutes:

$$Z^A(t) = \left[\vartheta_Z^{-1/\epsilon_Z} \left(Z^H(t)\right)^{\frac{\epsilon_Z+1}{\epsilon_Z}} + (1-\vartheta_Z)^{-1/\epsilon_Z} \left(Z^N(t)\right)^{\frac{\epsilon_Z+1}{\epsilon}}\right]^{\frac{\epsilon_Z}{\epsilon_Z+1}}, \tag{10}$$

where $0 < \vartheta_Z < 1$ is the weight of traded intangible assets and ϵ_Z measures the ease with which sectoral intangible assets can be substituted for each other and thereby captures the degree of mobility of ideas across sectors.

Preferences. The representative agent is endowed with one unit of time, supplies a fraction $L(t)$ as labor, and consumes the remainder $1 - L(t)$ as leisure. Denoting the time discount rate by $\beta > 0$, at any instant of time, households derive utility from their consumption and experience disutility from working and maximize the following objective function:

$$\mathcal{U} = \int_0^\infty \Lambda\left(C(t), L(t)\right) e^{-\beta t} \mathrm{d}t, \tag{11}$$

where we consider the utility specification proposed by Greenwood, Hercowitz and Huffman (GHH thereafter) [1988] so as to eliminate the wealth effect in the household's labor supply decision:

$$\Lambda\left(C, S, L\right) \equiv \frac{X^{1-\sigma} - 1}{1-\sigma}, \quad X\left(C, S, L\right) \equiv CS^{-\gamma_S} - \frac{\sigma_L}{1+\sigma_L}\gamma_L L^{\frac{1+\sigma_L}{\sigma_L}}, \tag{12}$$

where S is the stock of habits and γ_S is the weight of relative consumption:. If $\gamma_S = 0$, the case of time separability in preferences obtains.

Consumption habits. To keep things simple, we consider the case of external habits which implies that *outward-looking* consumers do not take into account the impact of their consumption decisions on the aggregate stock of habits. Since individuals are identical, the average values of consumption and the stock of habit collapse to the values prevailing for each individual. In eq. (13), the reference stock is thus formed as an exponentially declining weighted average of past economy-wide average levels of consumption C:

$$S(t) = \delta_S \int_{-\infty}^{t} C\left(\tau\right) e^{-\delta_S (t-\tau)} \mathrm{d}\tau, \qquad \delta_S > 0. \tag{13}$$

According to eq. (13), the habitual standard of living is defined as a distributed lag over past consumption where the parameter δ_S indexes the relative weight of recent consumption in determining the reference stock $S(t)$. The larger δ_S is, the greater the weight of consumption in the recent past in determining the stock of habits, and the faster the reference stock S adjusts to current consumption. Differentiating eq. (13) with respect to time gives the law of motion of the stock of habits:

$$\dot{S}(t) = \delta_S \left[C(t) - S(t)\right]. \tag{14}$$

According to this specification, the reference stock is defined as an exponentially declining weighted average of past economy-wide levels of consumption.

Capital and technology utilization rates. We assume that the households own tangible $K^j(t)$ and intangible assets $Z^j(t)$ and lease both services from tangible and intangible assets to firms in sector j at rental rates $R^{K,j}(t)$ and $R^{Z,j}(t)$, respectively. Thus income from leasing activity received by households reads $\sum_j \left(R^{K,j}(t)u^{K,j}(t)K^j(t) + R^{Z,j}(t)u^{Z,j}(t)Z^j(t)\right)$ where we assume that households also choose the intensity $u^{K,j}(t)$ and $u^{Z,j}(t)$ in the use of the physical capital stock and in the stock of knowledge, respectively, like Bianchi et al. [2019]. Both the capital $u^{K,j}(t)$ and the technology utilization rate $u^{Z,j}(t)$ collapse to one at the steady-state. We let the functions $C^{K,j}(t)$ and $C^{Z,j}(t)$ denote the adjustment costs associated with the choice of capital and technology utilization rates, which are increasing and convex functions of utilization rates:

$$C^{K,j}(t) = \xi_1^j \left(u^{K,j}(t) - 1\right) + \frac{\xi_2^j}{2} \left(u^{K,j}(t) - 1\right)^2, \tag{15a}$$

$$C^{Z,j}(t) = \chi_1^j \left(u^{Z,j}(t) - 1\right) + \frac{\chi_2^j}{2} \left(u^{Z,j}(t) - 1\right)^2, \tag{15b}$$

where $\xi_2^j > 0$, $\chi_2^j > 0$ are free parameters; as $\xi_2^j \to \infty$, $\chi_2^j \to \infty$, utilization is fixed at unity.

Budget constraint. Households supply labor services to firms in sector j at a wage rate $W^j(t)$. Thus labor income received by households reads $\sum_j W^j(t)L^j(t)$. Households can accumulate internationally traded bonds (expressed in foreign good units), $N(t)$, that yield net interest rate earnings of $r^\star N(t)$. Denoting lump-sum taxes by $T(t)$, households' flow budget constraint states that real disposable income can be saved by accumulating traded bonds, consumed, $P_C(t)C(t)$, invested in tangible assets, $P_J^K(t)J^K(t)$, invested in intangible assets, $P_J^Z(t)J^Z(t)$, and covers capital and technology utilization costs:

$$\dot{N}(t) + P_C(t)C(t) + P_J^K(t)J^Kt) + P_J^Z(t)J^Z(t) + \sum_{j=H,N} P^j(t)\left(C^{K,j}(t)\nu^{K,j}(t)K(t) + C^{Z,j}(t)\nu^{Z,j}(t)Z^A(t)\right)$$
$$= r^\star N(t) + W(t)L(t) + R^K(t)K(t)\sum_{j=H,N}\alpha_K^j(t)u^{K,j} + R^Z(t)Z^A(t)\sum_{j=H,N}\alpha_Z^j(t)u^{Z,j} - T(t),$$

where we denote the share of sectoral tangible (intangible) assets in the aggregate stock of capital (knowledge) by $\nu^{K,j}(t) = K^j(t)/K(t)$ ($\nu^{Z,j}(t) = Z^j(t)/Z(t)$), and the compensation share of sector $j = H, N$ by $\alpha_K^j(t) = \frac{R^{K,j}(t)K^j(t)}{R^K(t)K(t)}$ ($\alpha_Z^j(t) = \frac{R^{Z,j}(t)Z^j(t)}{R^Z(t)Z(t)}$) for capital (ideas). As shall be useful, we denote the labor compensation share by $\alpha_L^j(t) = \frac{W^j(t)L^j(t)}{W(t)L(t)}$.

Investment in tangible assets. The investment good is (costlessly) produced using inputs of the traded good and the non-traded good by means of a CES technology:

$$J^K(t) = \left[\varphi_K^{\frac{1}{\phi_K}}\left(J^T(t)\right)^{\frac{\phi_K-1}{\phi_K}} + (1-\varphi_K)^{\frac{1}{\phi_K}}\left(J^N(t)\right)^{\frac{\phi_K-1}{\phi_K}}\right]^{\frac{\phi_K}{\phi_K-1}}, \tag{17}$$

where $0 < \varphi_K < 1$ is the weight of the investment traded input and ϕ_K corresponds to the elasticity of substitution between investment traded goods and investment non-traded goods. The index $J^T(t)$ is defined as a CES aggregator of home-produced traded inputs, $J^H(t)$, and foreign-produced traded inputs, $J^F(t)$:

$$J^T(t) = \left[\left(\iota^H\right)^{\frac{1}{\rho_J}}\left(J^H(t)\right)^{\frac{\rho_J-1}{\rho_J}} + \left(1-\iota^H\right)^{\frac{1}{\rho_J}}\left(J^F(t)\right)^{\frac{\rho_J-1}{\rho_J}}\right]^{\frac{\rho_J}{\rho_J-1}}, \tag{18}$$

where $0 < \iota^H < 1$ is the weight of the home-produced traded input and ρ_J corresponds to the elasticity of substitution between home- and foreign-produced traded inputs.

Installation of new investment goods involves convex costs, assumed to be quadratic. Thus, total investment $J^K(t)$ differs from effectively installed new capital:

$$J^K(t) = I^K(t) + \frac{\kappa}{2}\left(\frac{I^K(t)}{K(t)} - \delta_K\right)^2 K(t), \tag{19}$$

where the parameter $\kappa > 0$ governs the magnitude of adjustment costs to capital accumulation. Denoting the fixed capital depreciation rate by $0 \leq \delta_K < 1$, aggregate investment, $I^K(t)$, gives rise to capital accumulation according to the dynamic equation:

$$\dot{K}(t) = I^K(t) - \delta_K K(t). \tag{20}$$

Investment in intangible assets. The intangible good is produced using inputs of the home-produced traded good and the non-traded good according to a constant-returns-to-scale function which is assumed to take a CES form:

$$J^Z(t) = \left[\iota_Z^{\frac{1}{\phi_Z}} \left(J^{Z,H}(t)\right)^{\frac{\phi_Z-1}{\phi_Z}} + (1-\iota_Z)^{\frac{1}{\phi_Z}} \left(J^{Z,N}(t)\right)^{\frac{\phi_Z-1}{\phi_Z}}\right]^{\frac{\phi_Z}{\phi_Z-1}}, \tag{21}$$

where ι_Z is the weight of the intangible traded input $(0 < \iota_Z < 1)$ and ϕ_Z corresponds to the elasticity of substitution in investment between traded and non-traded intangible inputs. Accumulation of intangible assets is governed by the following law of motion:

$$\dot{Z}^A(t) = I^Z(t) - \delta_Z Z^A(t), \tag{22}$$

where I^Z is investment in intangible assets and $0 \leq \delta_Z < 1$ is a fixed depreciation rate of ideas. We assume that accumulation of intangible assets also is subject to increasing and convex cost of net investment in R&D:

$$J^Z(t) = I^Z(t) + \frac{\zeta}{2}\left(\frac{I^Z(t)}{Z^A(t)} - \delta_Z\right)^2 Z^A(t), \tag{23}$$

where the parameter $\zeta > 0$ governs the magnitude of adjustment costs to accumulation of intangible assets.

Household's optimal plan. Households choose consumption, worked hours, capital and technology utilization rates, investment in tangible and intangible assets by maximizing lifetime utility (11) subject to (16), (20) and (22). Denoting by λ, $Q^{K,\prime}$, $Q^{Z,\prime}$ the co-state variables associated with the budget constraint and the law of motion of physical capital and ideas, the first-order conditions characterizing the representative household's optimal plans are:

$$\Lambda_C\left(C(t),S(t),L(t)\right) = \bar{\lambda} P_C(t), \tag{24a}$$

$$-\Lambda_L\left(C(t),S(t),L(t)\right) = \bar{\lambda} W(t), \tag{24b}$$

$$Q^K(t) = P_J^K(t)\left[1+\kappa\left(\frac{I^K(t)}{K(t)}-\delta_K\right)\right], \tag{24c}$$

$$Q^Z(t) = P_J^Z(t)\left[1+\zeta\left(\frac{I^Z(t)}{Z^A(t)}-\delta_Z\right)\right], \tag{24d}$$

$$\frac{R^{K,j}(t)}{P^j(t)} = \xi_1^j + \xi_2^j\left(u^{K,j}(t)-1\right), \quad j=H,N, \tag{24e}$$

$$\frac{R^{Z,j}(t)}{P^j(t)} = \chi_1^j + \chi_2^j\left(u^{Z,j}(t)-1\right), \quad j=H,N, \tag{24f}$$

$$\dot{\lambda}(t) = \lambda\left(\beta - r^\star\right), \tag{24g}$$

$$\dot{Q}^K(t) = \left(r^\star+\delta_K\right)Q^K(t) - \Big\{ \sum_{j=H,N} \alpha_K^j(t) u^{K,j}(t) R^K(t) - \sum_{j=H,N} P^j(t) C^{K,j}(t)\nu^{K,j}(t) - P_J^K(t)\frac{\partial J^K(t)}{\partial K(t)} \Big\}, \tag{24h}$$

$$\dot{Q}^Z(t) = \left(r^\star+\delta_Z\right)Q^Z(t) - \Big\{ \sum_{j=H,N} \alpha_Z^j(t) u^{Z,j}(t) R^Z(t) - \sum_{j=H,N} P^j(t) C^{Z,j}(t)\nu^{Z,j}(t) - P_J^Z(t)\frac{\partial J^Z(t)}{\partial Z^A(t)} \Big\}, \tag{24i}$$

and the transversality conditions $\lim_{t\to\infty} \bar{\lambda} N(t) e^{-\beta t} = 0$, $\lim_{t\to\infty} Q^K(t) K(t) e^{-\beta t} = 0$, and $\lim_{t\to\infty} Q^Z(t) Z^A(t) e^{-\beta t} = 0$; to derive (24h) and (24i), we used the fact that $Q^K(t) = Q^{K,\prime}(t)/\lambda(t)$, $Q^Z(t) = Q^{Z,\prime}(t)/\lambda(t)$, respectively. In an open economy model with a representative agent having perfect foresight, a constant rate of time preference and perfect access to world capital markets, we impose $\beta = r^\star$ in order to generate an interior solution which implies that when new information about a shock arrives, λ jumps to fulfill the intertemporal solvency condition and remains constant afterwards.

Reallocation incentives. A permanent corporate income tax cut produces a positive wealth effect which increases consumption and modifies sectoral prices and thus provides incentives to reallocate productive resources across sectors. Once households have determined aggregate consumption, they allocate consumption expenditure to traded and non-traded goods according to the following optimal rule:

$$1-\alpha_C(t) = \frac{P^N(t)C^N(t)}{P_C(t)C(t)} = (1-\varphi)\left(\frac{P^N(t)}{P_C(t)}\right)^{1-\phi}. \tag{25}$$

Because technology improvements are concentrated within traded industries, a corporate income tax cut gives rise to an excess supply in the traded goods market and an excess demand in the non-traded goods market. According to (25), an appreciation in non-traded goods prices $P^N(t)$ increases the share of expenditure allocated to non-traded goods, $1-\alpha_C(t)$, as long as $\phi < 1$, as evidence suggests. This assumption ensures that a corporate tax cut has a strong expansionary effect on non-traded hours worked, in accordance with our empirical findings, by shifting productive resources, especially labor, toward the non-traded sector.

3.2 Firms

We assume that within each sector, there are a large number of intermediate good producers which produce differentiated varieties and thus are imperfectly competitive. They choose to rent labor services from households along with services from tangible and intangible assets.

Final Goods Firms. The final non-traded output, Y^j, is produced in a competitive retail sector using a constant-returns-to-scale production function which aggregates a continuum measure one of sectoral goods:

$$Y^j = \left[\int_0^1 \left(X_i^j \right)^{\frac{\omega^j - 1}{\omega^j}} \mathrm{d}i \right]^{\frac{\omega^j}{\omega^j - 1}}, \tag{26}$$

where $\omega^j > 0$ represents the elasticity of substitution between any two different varieties and X_i^j stands for intermediate consumption of ith-variety (with $i \in (0,1)$) within sector j. Total cost minimization for a given level of final output gives the (intratemporal) demand function for each input: $X_i^j = \left(\frac{P_i^j}{P^j} \right)^{-\omega^j} Y^j$ where P_i^j is the price of variety i in sector j and P^j is the price of the final good in sector $j = H, N$.

Intermediate Goods Firms. Within each sector j, there are firms producing differentiated goods. Each intermediate good producer uses labor services, $L^j(t)$, services from tangible assets $\tilde{K}_i^j(t)$, and intangible assets, Z_t^j, both inclusive of the intensity in the use of tangible and intangible assets, to produce a final good according to a technology of production:

$$X_i^j(t) = T^j(t) \left(L_i^j(t) \right)^{\theta^j} \left(\tilde{K}_i^j(t) \right)^{1-\theta^j}, \tag{27}$$

where $T^j(t)$ stands for utilization-adjusted-TFP in sector j. The production technology(27) displays increasing returns to scale because intangible assets is an input which gives rise to technology in sector j denoted by $T^j(t)$. In line with the assumption by Buera and Obserfield [2020], and in accordance with the evidence documented by Keller [2002], Griffith et al. [2004], we assume that firms within each sector benefit from international R&D spillovers. We assume that the stock of ideas Z_t^j has a domestic component $\tilde{Z}_t^j$ (inclusive of the technology utilization rate) and an international component as captured by the stock of knowledge $Z^{W,j}(t)$:

$$\mathsf{Z}^j(t) = \left(\tilde{Z}_i^j(t) \right)^{\theta_Z^j} \left(Z^{W,j}(t) \right)^{1-\theta_Z^j}, \tag{28}$$

where θ_Z^j captures the domestic content of the stock of knowledge accessible to domestic firms in sector j. Both the domestic $\tilde{Z}_t^j$ and the international stock of ideas $Z^{W,j}(t)$ are sector-specific.[6] We assume that the domestic and the international stock of knowledge

[6] Cai et al. [2022] find some spillover across sectors both for the home and the international stock of knowledge. When we estimated the effect of the international stock of knowledge of tradables (non-tradables)

produces differentiated effects on utilization-adjusted-TFP in sector j:

$$T_t^j = \left(\tilde{Z}_i^j(t)\right)^{\nu^j \theta_Z^j} \left(Z^W(t)\right)^{\nu^{W,j}\left(1-\theta_Z^j\right)}, \tag{29}$$

where ν^j ($\nu^{W,j}$) is the elasticity of technology w.r.t. the domestic (international) stock of knowledge. Our objective is to estimate this parameter at a sector level to calibrate our model.

Firms face three cost components: a labor cost equal to the wage rate $W^j(t)$, and a sector-specific rental cost for tangible and intangible assets equal to $R^{K,j}(t)$ and $R^{Z,j}(t)$, respectively. We assume that the government levies a tax τ on firms' profits. In line with the common practice, see e.g., Backus et al. [2008], firms' taxable earnings are defined as output less wage payments and physical capital depreciation. Both sectors are assumed to be imperfectly competitive and thus choose prices along with the amount of services from labor, tangible assets and intangible assets rented to households:

$$\begin{aligned} \Pi_i^j(t) \quad \equiv \quad & (1-\tau)\left[P_i^j(t)X_i^j(t) - W^j(t)L_i^j(t) - \delta_K \tilde{K}_i^j(t)\right] - \left(R^K(t)-\delta_K\right)\tilde{K}_i^j(t) \\ & -R^{Z,j}(t)\tilde{Z}_i^j(t) - P^j F^j, \end{aligned} \tag{30}$$

where F^j is a fixed cost which is symmetric across all intermediate good producers but varies across sectors. Denoting the markup charged by intermediate good producers by $\mu^j = \frac{\omega^j}{\omega^j-1} > 1$, first-order conditions can be rewritten as follows (see Online Appendix E.2):

$$P_i^j \theta^j \frac{X_i^j}{L_i^j} = \mu^j W^j, \tag{31a}$$

$$P_i^j\left(1-\theta^j\right)\frac{X_i^j}{\tilde{K}_i^j} = \mu^j\left[\left(\frac{R^{K,j}-\delta_K}{1-\tau}\right)+\delta_K\right], \tag{31b}$$

$$(1-\tau) P_i^j \nu_Z^j \left(1-\theta^j\right)\frac{X_i^j}{\tilde{Z}_i^j} = \mu^j R^{Z,j}, \tag{31c}$$

where we used the fact that $\frac{\partial X_i^j}{\partial L_i^j} = \theta^j \frac{X_i^j}{L_i^j}$, $\frac{\partial X_i^j}{\partial \tilde{K}_i^j} = \left(1-\theta^j\right)\frac{X_i^j}{\tilde{K}_i^j}$, and $\frac{\partial X_i^j}{\partial \tilde{Z}_i^j} = \nu_Z^j \frac{X_i^j}{\tilde{Z}_i^j}$.

Free entry condition. We assume free entry in the goods markets so that the movement of firms in and out of the goods market drives profits to zero at each instant of time, i.e., $\Pi_i^j(t) = (1-\tau)\,\mathrm{NOS}_i^j(t) - \left(R^{K,j}(t)-\delta_K\right)\tilde{K}_i^j(t) - R^{Z,j}(t)\tilde{Z}_i^j(t) - P_i^j F^j = 0$ where the net operating surplus (NOS henceforth) is $\mathrm{NOS}_i^j(t) = P_i^j(t)X_i^j(t) - W^j(t)L_i^j(t) - \delta_K\tilde{K}_i^j(t)$. After-tax value added covers the payment of after-tax labor services, $(1-\tau)W^jL^j$, rental payments of services from tangible and intangible assets to households, i.e., $\left[R^{K,j}-\tau\delta_K\right]\tilde{K}^j$ and $R^{Z,j}\tilde{Z}^j$, and also covers the payment of the fixed cost P^jF^j.

Inserting first-order conditions (31a)-(31c) into profit (30), and setting to zero implies that $(1-\tau)P_i^jX_i^j\left[1-\frac{1+\nu_Z^j\theta_Z^j}{\mu^j}\right] - P_i^jF^j = 0$. We require the markup denoted by μ^j to be

on utilization-adjusted-TFP of non-tradables (tradables), we did not detect spillover across sectors as the coefficients are not statistically significant. However, some knowledge spillover can occur between industries of the same broad sector.

larger than the degree of increasing returns to scale, i.e.,

$$1+\nu^j\theta^j_Z<\mu^j, \tag{32}$$

so that the excess of after-tax value added over the payment of factors of production, i.e., $(1-\tau)\,P^j_iX^j_i\left[1-\frac{1+\nu^j_Z\theta^j_Z}{\mu^j}\right]$, is large enough to cover fixed costs.

Because intermediate good producers are symmetric, they face the same costs of factors and the same price elasticity of demand. Therefore, they set same prices which collapse to final good prices, i.e., $P^j_i=P^j$ and they produce the same quantity, i.e., $X^j_i=X^j=Y^j$. We denote output net of fixed costs by $Q^j=Y^j-F^j$. By using the free entry condition, i.e., $P^j_iF^j=(1-\tau)\,P^jY^j\left[1-\frac{1+\nu^j_Z\theta^j_Z}{\mu^j}\right]$, value added in sector j net of fixed cost reads as follows:

$$Q^j=Y^j\left[1-(1-\tau)\left(1-\frac{1+\nu^j_Z\theta^j_Z}{\mu^j}\right)\right]. \tag{33}$$

3.3 Government

The final agent in the economy is the government which finances government expenditure on traded and non traded goods, $G=P^HG^H+P^NG^N$, raising taxes T that are assumed to be lump-sum in addition to corporate taxes levied on firms' profits:

$$P^H(t)G^H+P^N(t)G^N=T(t)+\sum_{j=H,N}\tau\mathrm{NOS}^j(t). \tag{34}$$

Note that we abstract from imports from the government as data indicates that they are negligible relative to home-produced and non-traded goods components.

3.4 Model Closure and Equilibrium

Market clearing conditions and the current account. To fully describe the equilibrium, denoting exports of home-produced goods by X^H, we impose goods market clearing conditions for non-traded and home-produced traded goods:

$$Y^N(t)=C^N(t)+J^N(t)+G^N(t)+C^{K,N}(t)K^N(t)+C^{Z,N}(t)Z^N(t), \tag{35a}$$

$$Y^H(t)=C^H(t)+J^H(t)+G^H(t)+X^H(t)+C^{K,H}(t)K^H(t)+C^{Z,H}(t)Z^H(t), \tag{35b}$$

where exports are assumed to be a decreasing function of the terms of trade, P^H:

$$X^H(t)=\varphi_X\left(P^H(t)\right)^{-\phi_X}, \tag{36}$$

where $\varphi_X>0$ is a scaling parameter, and ϕ_X is the elasticity of exports w.r.t. P^H. Using the properties of constant returns to scale in production, identities $P_C(t)C(t)=\sum_g P^g(t)C^g(t)$ and $P_J(t)J(t)=\sum_g P^g(t)J^g(t)$ (with $g=F,H,N$) along with market clearing conditions (35), the current account equation (16) can be rewritten as a function of the trade balance:

$$\dot{N}(t)=r^\star N(t)+P^H(t)X^H(t)-M^F(t), \tag{37}$$

where $M^F(t) = C^F(t) + G^F(t) + J^F(t)$ stands for imports.

Corporate income tax dynamics. We drop the time index below to denote steady-state values. The adjustment of the corporate income tax rate $\tau(t)$ toward its long-run (lower) level expressed in deviation from initial steady-state is governed by the following continuous time process:

$$d\tau(t) = d\tau + x_T e^{-\xi_T t}, \tag{38}$$

where x_T is a parameter which is calibrated to match the impact response of the tax rate and $\xi_T > 0$ measures the speed at which the tax rate closes the gap with its long-run level.

Solving the model. The adjustment of the open economy toward the steady state is described by a dynamic system which comprises seven equations that are functions of the domestic stock of tangible assets, $K(t)$, the shadow price of the physical capital stock, $Q^K(t)$, the domestic stock of intangible assets, $Z^A(t)$, the shadow price of the stock of ideas, $Q^Z(t)$, the stock of habits, $S(t)$, the corporate income tax rate, $\tau(t)$, and the international stock of knowledge, $Z^W(t)$. Denoting the vector of state variables by $X_S = \left(K(t), Z^A(t), S(t)\right)$, the vector of control variables by $X_C = \left(Q^K(t), Q^Z(t)\right)$, the dynamic system comprises seven equations, including (20), (24h), (22), (24i), that are functions of state and control variables together with the corporate income tax rate and the international stock of knowledge:

$$\dot{V}_S(t) = \Delta\left(V_S(t), V_C(t), \tau(t), Z^W(t)\right), \tag{39a}$$

$$\dot{V}_C(t) = \Psi\left(V_S(t), V_C(t), \tau(t), Z^W(t)\right), \tag{39b}$$

$$\dot{\tau}(t) = -\xi_T\left(\tau(t) - \tau\right), \tag{39c}$$

where (39c) is the time derivative of (38). As explained in the quantitative analysis (detailed in the next section), we assume that firms within each sector can freely benefit from the international stock of ideas which is captured by a time-varying international stock of knowledge $Z^W(t)$ (specified later) that can potentially improve the technology of firms in sector j; as we shall see, this element is crucial to generate the magnitude of the technology improvement we estimate empirically. Linearizing the dynamic equations (39) in the neighborhood of the steady-state leads to a system of first-order linear differential equations which can be solved by applying standard methods. See Online Appendix E.4 which details the solution method for continuous time models.

4 Quantitative Analysis

In this section, we take the model to the data. For this purpose we solve the model numerically.[7] Therefore, first we discuss parameter values before turning to the effects of a permanent corporate tax cut.

[7]Technically, the assumption $\beta = r^\star$ requires the joint determination of the transition and the steady state since the constancy of the marginal utility of wealth implies that the intertemporal solvency condition depends on eigenvalues' and eigenvectors' elements, see e.g., Turnovsky [1997].

4.1 Calibration

Calibration strategy. At the steady-state, capital utilization rates, $u^{K,j}$, collapse to one so that $\tilde{K}^j = K^j$. To calibrate the reference model with flexible wages, we have estimated a set of ratios and parameters for the eleven OECD economies in our dataset, see Table 17 relegated to Online Appendix G.1. Our reference period for the calibration is 1973-2017. Because we calibrate the reference model to a representative OECD economy, we take unweighted average values of ratios and parameters which are summarized in Table 2. Among the 43 parameters that the model contains, 26 have empirical counterparts while the remaining 17 parameters plus initial conditions must be endogenously calibrated to match ratios.

Seventeen parameters plus initial conditions must be set to target ratios. Parameters including φ, ι, ι_Z, φ^H, ι^H, ϑ_L, ϑ_K, ϑ_Z, δ_K, δ_Z, G, G^N, G^H must be set to target a tradable content of consumption and investment expenditure in tangible and intangible assets of $\alpha_C = 42\%$, $\alpha_J^K = 29\%$, $\alpha_J^Z = 58\%$, respectively, a home content of consumption and investment (in physical capital) expenditure in tradables of $\alpha^H = 63\%$ and $\alpha_J^H = 44\%$, respectively, a weight of labor supply of $L^H/L = 36\%$, a weight of tangible and intangible assets supply to the traded sector of $K^H/K = 38\%$ and $Z^H/Z^A = 59\%$, respectively, an investment share of GDP in physical capital and in R&D of $\omega_J^K = 20.7\%$ and $\omega_J^K = 2.7\%$, respectively, a ratio of government spending to GDP of $\omega_G = 19.4\%$ $(= G/Y)$, a tradable and home-tradable share of government spending of $\omega_{G^T} = 17\%$ $(= 1 - (P^N G^N/G))$, and $\omega_{G^H} = 14\%$ $(= P^H G^H/G)$, and we choose initial conditions so as trade is balanced, i.e., $\upsilon_{NX} = \frac{NX}{P^H Y^H} = 0$ with $NX = P^H X^H - C^F - I^F - G^F$. Because $u^{K,j} = u^{Z,j} = 1$ at the steady-state, four parameters related to capital ξ_1^H, ξ_1^N, and technology, χ_1^H, χ_1^N, adjustment cost functions are set to be equal to $R^{K,H}/P^H$, $R^{K,N}/P^N$, $R^{Z,H}/P^H$, $R^{Z,N}/P^N$, respectively.

Seventeen parameters are assigned values which are taken directly or estimated from our own data. We choose the model period to be one year. In accordance with column 28 of Table 2, the world interest rate, $r^\star$, which is equal to the subjective time discount rate, β, is set to 2.5%. In line with mean values shown in columns 10 and 11 of Table 2, the shares of labor income in traded and non-traded value added, θ^H and θ^N, are set to 0.65 and 0.68, respectively, which leads to an aggregate LIS of 66%.

According to the optimal allocation of investment expenditure between traded and non-traded inputs, the tradable share of investment expenditure is constant over time if the elasticity of substitution, ϕ_J, between investment in tradables, J^T, and investment in non-tradables, J^N, is equal to one. To pin down this value, we have plotted the tradable content of GFCF, i.e., $\alpha_J = \frac{P^T J^T}{P_J J}$ where $P_J J = P_J^K J^K + P_J^Z J^Z$. We find that α_J is stable over time, see Online Appendix G.6. This finding is in line with the evidence documented by Bems

[2008] which reveals that the non-tradable content of investment expenditure is stable in OECD countries. We also find that the tradable content of investment expenditure in R&D is stable over time at 58%. In the calibration, we choose a value of one for the elasticity of substitution ϕ_K between traded and non-traded investment inputs in tangible assets, and a value of one for the elasticity of substitution ϕ_Z between traded and non-traded investment inputs in intangible assets.

Because barriers to factors' mobility play a key role in our model, we have estimated empirically the degree of labor mobility between sectors, ϵ_L, for one country at a time. As shown in Online Appendix G.2 where we derive a structural equation, we pin down ϵ_L by running the regression in panel format on annual data of the percentage change in the hours worked share of sector j on the percentage change in the relative share of value added paid to labor in sector j over 1973-2017. The degree of labor mobility across sectors is set to 1 (see column 16 of Table 2), in line with the average of our estimates. It is worth mentioning that this value collapses to the value estimated by Horvath [2000] on U.S. data over 1948-1985 and commonly chosen in the literature allowing for imperfect mobility of labor. We have also estimated the degree of mobility of tangible assets across sectors by running the regression of the percentage change in K^j_{it}/K_{it} on the percentage change in the relative share of value added paid to capital in sector j over 1973-2017, see Online Appendix G.3 for a detailed description of our empirical strategy and data source and construction. We choose a degree of capital mobility across sectors of 0.17 (see column 17 of Table 2), in line with the average of our estimates. Due to a lack of data, we cannot estimate the degree of mobility of intangible assets between sectors, ϵ_Z, and thus set this parameter to 0.17.[8]

To pin down the elasticity of substitution between traded and non-traded consumption goods ϕ, we use the optimal allocation of consumption expenditure between C^T and C^N and run the regression of the logged share of non-tradables on logged $P^N(t)/P_C(t)$. Time series for $1-\alpha_C(t)$ are constructed by using the market clearing condition for non-tradables, see Online Appendix G.4. Building on our panel data estimates, the elasticity of substitution ϕ between traded and non-traded goods is set to 0.45 (see column 15 of Table 2), since this value corresponds to our panel data estimates. It is worth mentioning that our value is close to the estimated elasticity by Stockman and Tesar [1995] who report a value of 0.44 by using cross-section data for the year 1975.

To determine values for the elasticity of technology w.r.t. the domestic and international stock of ideas, we run the regression of utilization-adjusted-TFP in sector j on the domestic stock of R&D in the corresponding sector and the international stock of R&D defined as

[8] To estimate the degree of mobility of intangible assets, we would need data about the share of value added paid to innovation. While we could use labor compensation of researchers, these data are not available at a sectoral level which prevents us from estimating ϵ_Z.

an import-share-weighted-average of the stock of R&D in sector j of the ten trade partners of the home country. All variables are logged and we estimate the relationship by using cointegration methods. As detailed in Online Appendix G.5, FMOLS are positive and statistically significant for the elasticity of utilization-adjusted-TFP w.r.t. the domestic (0.292) and international stock of R&D (0.104) but only for the traded sector. Therefore we have $\nu^N = \nu^{W,N} = 0$, see columns 19 and 21 of Table 2. Because the elasticities involve the domestic and world component of technology, we have recourse to a principal component analysis applied to utilization-adjusted-TFP to extract the common component across countries for home technology; from these estimates of the common component of technology across countries, we infer values for the domestic component of technology for the traded and the non-traded sectors, i.e., $\theta_Z^H = 0.56$ and $\theta_Z^N = 0.63$ (see columns 22 and 23 of Table 2). From FMOLS estimates for the traded sector and the value for θ_Z^H, we find a value for the effect of the stock of knowledge on the corresponding component of technology of $\nu^H = 0.52$ ($= 0.292/0.56$) for the domestic stock of R&D and $\nu^{W,H} = 0.24$ ($= 0.104/0.44$) for the international stock of knowledge, see columns 18 and 20 of Table 2.

Finally, we have estimated the markup for the whole economy by using the adaptation of the empirical strategy pioneered by Roeger [1995] developed by Amador and Soares [2017] who consider imperfectly competitive labor markets in addition to imperfectly competitive goods markets. According to our estimates, the markup averages 1.35 for the whole sample, as shown in column 27 of Table 2.

Nine parameters are taken from external research works. As pointed out recently by Best et al. [2020], there exists no consensus on a reasonable value for the intertemporal elasticity of substitution for consumption as estimates in the literature range between 0 and 2. We choose a value of $\sigma = 1$ which implies that the intertemporal elasticity of substitution for consumption is equal to 1. In line with the estimates recently documented by Peterman [2016], we set the Frisch elasticity of labor supply σ_L to 3. Like Carroll et al. [2000], we choose a value for the the weight attached to consumption habits, γ_S, to 0.7, and a depreciation rate for the stock of consumption habits, δ_S, of 0.2.

We choose the value of parameter κ which captures the magnitude of capital adjustment costs so that the elasticity of I/K with respect to Tobin's q, i.e., Q/P_J, is equal to the value implied by estimates in Eberly et al. [2008]. The resulting value of κ is equal to 17. Because estimates for intangible assets are not available, we also choose a value of 17 for ζ which measures the magnitude of adjustment costs to accumulation of ideas.

In accordance with the evidence documented by Bajzik et al. [2020], we set the elasticity of substitution between home- and foreign-produced traded goods to 3 for consumption and investment, i.e., $\rho = \rho_J^K$. Assuming that all countries have the same elasticities, since the price elasticity of exports is a weighted average of ρ and ρ_J, we set $\phi_X = 3$. A value larger

Table 2: Data to Calibrate the Two Open Economy Sector Model, 1973-2017

Tradable share					Home share				LIS		Input ratios		
Y^H	C^T	$I^{K,T}$	$I^{Z,H}$	G^T	X^H	C^H	$I^{K,H}$	G^H	θ^H	θ^N	L^H/L	K^H/K	Z^H/Z^A
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
0.35	0.42	0.29	0.58	0.17	0.14	0.63	0.44	0.16	0.65	0.68	0.36	0.38	0.59
Elasticities									Aggregate ratios			Markup	i.r.
ϕ	ϵ_L	ϵ_K	ν^H	ν^N	$\nu^{W,H}$	$\nu^{W,N}$	θ_Z^H	θ_Z^N	I^K/Y	I^Z/Y	G/Y	μ	r
(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)
0.45	1.00	0.17	0.52	0.00	0.24	0.00	0.56	0.63	0.21	0.027	0.19	1.35	0.025

Notes: Columns 1-5 show the GDP share of tradables, the tradable content of consumption expenditure, the tradable content of investment expenditure in tangible and intangible assets, the tradable content of government expenditure. Column 6 gives the ratio of exports of final goods and services to GDP; columns 7 and 8 show the home share of consumption and investment expenditure in tradables and column 9 shows the content of government spending in home-produced traded goods; columns 10-11 show the labor income shares for tradables and non-tradables. Columns 12-15 display the hours worked share of tradables, the ratio of traded capital stock to the aggregate physical capital stock and the ratio of the stock of R&D of tradables to the aggregate stock of R&D. Columns show elasticities we have estimated empirically. ϕ is the elasticity of substitution between traded and non-traded goods in consumption; ϵ_L is the elasticity of labor supply across sectors; ϵ_K is the elasticity of capital supply across sectors; θ_Z^H (θ_Z^N) is the domestic component of traded (non-traded) technology and ν^H (ν^N) pins down the elasticity of the domestic component of technology w.r.t. the domestic stock of ideas in the traded (non-traded) sector while $\nu^{W,H}$ ($\nu^{W,N}$) captures the elasticity of the international component of traded (non-traded) technology w.r.t. to the international stock of ideas of trade partners in the traded (non-traded) sector. I^K/Y is the investment-to-GDP ratio for tangible assets and I^Z/Y is the investment-to-GDP ratio for tangible assets and G/Y is government spending as a share of GDP. μ is the markup for the whole economy. The interest rate is measured by the real long-term interest rate calculated as the nominal interest rate on 10 years government bonds minus the rate of inflation which is the rate of change of the Consumption Price Index.

than one is in line with the structural estimates of the price elasticities of aggregate exports documented by Imbs and Mejean [2015].

Setting the dynamics for endogenous response of domestic corporate income tax. We identify a shock to the international component of corporate income tax rate which is relevant to each country of our sample and then estimate the endogenous response of the domestic corporate income tax rate to its international component. We have to choose values for three parameters in eq. (38) to reproduce the dynamics from the VAR model for $\tau(t)$. First, we normalize the steady-state variation in the domestic corporate income tax rate to 1 percentage point, i.e., $d\tau = 0.01$. We choose a value of 0.35 for $x_T = d\tau(0) - d\tau$ and a value of 0.9 for ξ_T so as to reproduce the estimated response of τ from the VAR model.

International diffusion of innovation. The identification assumption is based on the existence of a downward trend in corporate taxation which is common to OECD countries. When one country lowers its tax rate, as evidence shows, technology improves (in an average OECD economy) and because all trade partners also lower their tax rate and increase investment in R&D, domestic firms in the home country can take advantage of the higher international stock of knowledge. We can interpret the positive impact of $Z^{W,H}$ on T^H by using the fact that traded firms increase $u^{Z,H}(t)$ and $Z^H(t)$ and this increase the absorption capacity of international ideas or symmetrically reduces the the adoption costs of foreign innovation. The adjustment of the international stock of ideas $Z^W(t)$ toward its long-run (higher) level expressed in deviation from initial steady-state is governed by the following continuous time process:

$$dZ^{W,j}(t) = dZ^{W,j} + x_Z^j e^{-\xi_Z^j t}, \tag{40}$$

where $dZ^{W,j}(t) = Z^{W,j}(t) - Z_0^{W,j}$ and $dZ^{W,j} = Z^{W,j} - Z_0^{W,j}$ with $Z_0^{W,j}$ the initial steady-state level for $Z^{W,j}$; x_Z^j and $\xi_Z^j > 0$ are parameters which determine the change in the international stock of knowledge on impact and its persistence, respectively. Because only the traded sector takes advantage of international spillovers (since $\nu^{W,N} = 0$ while $\nu^{W,H} > 0$) and since we assume that there is no knowledge spillover across sectors, the international stock of knowledge relevant for traded industries just collapses to utilization-adjusted-TFP of tradables of a representative OECD economy. We choose a value for x_Z^H of -0.0157 and a value of 0.9 for ξ_Z^H to reproduce the adjustment of world technology for tradables which collapses to the dynamics of the utilization-adjusted-TFP of tradables for an average OECD economy since we allow for spillover within the same sector and not between sectors.

Capital and technology utilization adjustment costs. We set the magnitude of the adjustment cost in the capital utilization rate, i.e., ξ_2^j, so as to account for empirical responses of $u^{K,j}(t)$ after a permanent decline in corporate taxation. We choose $\xi_2^H = \xi_2^N = 0.2$ in the baseline calibration. The technology utilization rate $u^{Z,j}(t)$ measures the intensity in the use of the stock of ideas $Z^j(t)$. The product of these two magnitudes $u^{Z,j}Z^j(t)$ determines the domestic component of technology in sector j, i.e., $\mathcal{T}_t^{c,j} = \left(\tilde{Z}_i^j(t)\right)^{\nu^j\theta_Z^j}$ where the superscript c refers to the country-specific component of utilization-adjusted-TFP in sector j. In the data, we can approximate the stock of ideas with the stock of R&D. We find that both

4.2 Decomposition of Model's Performance

In this subsection, we analyze the role of the model's ingredients in driving the effects of a permanent technology improvement on hours. We show that the ability of the model to account for the effects of a corporate income tax cut we estimate empirically depends on technology and preferences' specification.

Our baseline model includes two sets of elements. The first set of element is related to endogenous technology decisions which include three dimension. While households invest in R&D to accumulate a stock of knowledge $Z^A(t)$ over time, the stock of ideas is allocated to sectors in accordance with its marginal revenue, our model also includes two additional features. We allow for an endogenous intensity in the use of the stock of innovation ($\chi_2^j < \infty$) and firms are supposed to take advantage of international R&D spillovers ($\nu^{W,j} > 0$). The second set of elements is related to preferences which include two key dimensions. More specifically, we allow for GHH preferences which have the advantage to eliminate the wealth effect on labor supply. In addition, we assume consumption habits. As we show below, the model can reproduce well the evidence but only once we consider the aforementioned ingredients.

In Table 3, we report the simulated impact (i.e., at $t = 0$) and long-run (i.e., at $t = 10$) effects. While columns 1 and 8 show impact and long-run responses from our VAR model for comparison purposes, columns 2 and 9 show results for the baseline model. Columns 7 and 14 display results for a restricted version of our model which collapses to the KR model with GHH preferences. In this restricted model 'No R&D', we assume that production of sectoral goods does not depend on intangible assets (i.e., $\nu^j = 0$). In the second variant of the restricted model ('No tech') displayed by columns 6 and 13, we assume that production is intensive in intangible assets (i.e., $\nu^j > 0$) but we assume that the adjustment costs of the technology utilization rate $u^{Z,j}(t)$ are prohibitive (i.e., $\chi_2^j \to \infty$) so that $u^{Z,j}(t) = 1$ and firms have no access to international R&D spillovers (i.e., $\nu^{W,j} = 0$). Columns 5 and 12 show a variant of the baseline model with endogenous technology decisions and international R&D spillover but where we abstract from consumption habits. In columns 4 and 11, we consider the same model as the baseline but with Shimer [2009] preferences which allow for a negative impact of the wealth effect on labor supply. While columns 2 and 9 display the baseline model's predictions, columns 3 and 10 show results when we shut down the technology utilization rate (i.e., $\chi_2^j \to \infty$ so that $u^{Z,j}(t) = 1$) and abstract from international R&D spillover (i.e., $\nu^{W,j} = 0$).

Table 3 reports the impact and long-run effects of selected variables, including total hours worked, $L(t)$, traded and non-traded hours worked, $L^H(t)$ and $L^N(t)$, the hours worked share of tradables, $\nu^{L,H}(t)$, utilization-adjusted-aggregate-TFP, $T^A(t)$, utilization-adjusted-TFP of tradables, $T^H(t)$. To further illustrate the transmission mechanism, we also show the adjustment in real GDP, $Q^R(t)$, in the real value added share of tradables, $d\nu^{Q,H}(t)$, non-traded goods' prices and the terms of trade, $P^N(t)$ and $P^H(t)$, households' consumption, $C(t)$, and total investment in tangible and intangible assets including capital installation costs, $J(t) = J^K(t) + J^Z(t)$.

Corporate income tax shock. Across all model's variants, we consider a permanent decline in the corporate income tax rate τ by 1 percentage point. On impact, the corporate income tax declines by -0.65 ppt which is slightly larger what we estimate empirically but lies within the confidence bounds of the point estimate.

First ingredient: Investment in R&D. In columns 7 and 14 of Table 3, we report results from a restricted version of the baseline model where we consider a two-sector small open economy model which collapses to the KR model with GHH preferences. In this model's version, we assume that firms do not use intangible assets to produce sectoral goods, i.e., $\nu^j = 0$, and abstract from an endogenous intensity in the use of the stock of ideas, i.e., $u^{Z,j} = 1$, and we suppose that firms do not take advantage of innovation abroad, i.e., $\nu^{W,j} = 0$. Because the return on innovation is zero, households do not accumulate ideas so that utilization-adjusted-TFP remain unchanged as can be seen in panel B, in contrast to the evidence. Without technology improvements, sectoral wages doe not increase enough to generate the increase in hours we estimate empirically evidence; more specifically, total hours worked increase by 0.21% only on impact which is much lower that the estimated

Table 3: Impact and Long-Run Effects of a Permanent Corporate Income Tax Cut by 1 ppt

	VAR ($t=0$)	Impact ($t=0$) Theoretical Responses						VAR ($t=10$)	Long-run ($t=10$) Theoretical Responses					
	Data	Benchmarch		Shimer	GHH			Data	Benchmarck		Shimer	GHH		
			No tech		No hab	No tech	No R&D			No tech		No hab	No tech	No R&D
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
A. Hours Worked														
Total hours, $dL(t)$	0.91	0.91	0.24	0.76	0.93	0.36	0.21	0.59	0.66	0.49	0.69	1.83	0.73	0.57
H-hours, $dL^H(t)$	0.28	0.21	-0.01	0.15	0.09	-0.01	0.02	0.01	0.11	0.06	0.13	0.47	0.11	0.14
N-hours, $dL^N(t)$	0.62	0.70	0.26	0.61	0.85	0.37	0.19	0.58	0.55	0.43	0.56	1.36	0.62	0.42
Hours share of H, $d\nu^{L,H}(t)$	-0.05	-0.06	-0.09	-0.06	-0.14	-0.10	-0.04	-0.21	-0.09	-0.08	-0.06	0.01	-0.07	-0.02
B. Technology														
Agg. ut-adj.TFP, $dT^A(t)$	0.43	0.32	0.01	0.24	0.25	0.00	0.00	0.45	0.46	0.06	-0.20	0.61	0.06	0.00
Ut-adj-TFP of H, $dT^H(t)$	1.31	1.01	0.01	0.96	0.90	0.00	0.00	1.68	1.46	0.16	0.20	2.00	0.20	0.00
C. Real GDP														
Real GDP, $dQ_R(t)$	1.37	0.99	0.08	0.86	0.85	0.15	0.04	0.99	1.17	0.46	1.23	2.25	0.67	0.43
VA share of H, $d\nu^{Q,H}(t)$	0.29	0.19	-0.06	0.16	0.03	-0.10	-0.04	0.19	0.32	0.01	0.32	0.43	-0.01	-0.02
D. Relative Prices														
N-prices, $\hat{P}^N(t)$	1.05	0.97	0.56	0.87	1.20	0.56	0.29	1.85	1.55	0.53	1.29	0.69	0.31	0.06
H-prices, $\hat{P}^H(t)$	-0.17	-0.29	0.18	-0.29	-0.25	0.12	0.08	-0.59	-0.39	-0.02	-0.50	-0.95	-0.14	-0.05
E. Cons. and Inv.														
Consumption $dC(t)$	0.51	0.43	-0.05	0.36	0.67	0.07	-0.09	0.60	0.51	0.13	0.52	1.20	0.30	0.10
Investment, $dJ(t)$	0.90	0.35	0.21	0.32	-0.01	0.02	0.00	0.63	0.41	0.29	0.42	0.21	0.14	0.09

Notes: Impact ($t=0$) and long-run ($t=10$) effects of a permanent decline in the corporate income tax by one percentage point in the long-run. Panels A,B,C,D,E show the deviation in percentage relative to steady-state. Panel A shows the effects on hours worked inclduing total, traded, non-traded hours and the hours worked share of tradables. Panel B displays the responses of aggregate and traded utilization-adjusted-TFP. Panel C shows the responses of real GDP and the real value added share of tradables. Panel D displays the responses of non-traded goods prices and the relative price of home-produced traded goods prices (or the terms of trade). Panel E shows the responses of consumption and investment, both expressed in percentage point of GDP. Investment involves investment in tangible and intangible assets and includes installation costs. In columns 1 and 7, we show impact ten-year-horizon responses we estimate empirically in the VAR model. In columns 2 and 8, we show responses for the baseline model with GHH preferences, consumption habits, and technology endogenous technology utilization rate, international R&D spillover. In columns 3 and 9, we consider the same model as in columns 2 and 8 except that we shut down the technology endogenous technology utilization rate and international R&D spillover. In columns 4 and 10, we consider the baseline model with Shimer [2009] preferences. In columns 5 and 11, we consider the baseline model without consumption habits. Columns 6 and 12 consider the baseline model with consumption habits and shut down the technology endogenous technology utilization rate and international R&D spillover.

response in the VAR model (0.91% at $t = 0$).

Second ingredient: Endogenous technology utilization rate and international R&D spillovers. In columns 6 and 13 of Table 3, we assume that the production of sectoral goods is intensive in intangible assets, i.e., we let $\nu^H > 0$, but we shut down the intensity in the use of the stock of innovation, i.e., we let $\chi_2^j \to \infty$, so that $u^{Z,j} = 1$, and impose $\nu^{W,j} = 0$ so that innovation from abroad does not spillover on domestic firms' technology. Because the aggregate stock of ideas is a state variable which adjusts only gradually, aggregate-utilization-adjusted-TFP remains unchanged on impact. While the stock of ideas can shift across sectors, mobility costs imply that sectoral stock of ideas remain also unchanged. Therefore, allowing for endogenous innovation is not sufficient to generate the magnitude of technology improvements shown in panel B of column 1. It is only once the stock of ideas has built up that productivity gains amount to 0.20% in the traded sector, thus leading to an increase in utilization-adjusted-aggregate-TFP by 0.06% (see panel B of column 13). This figure is however far below what we estimate empirically in the long-run. The model also understates real GDP growth in the long-run due to the considerable lack of investment in physical capital. While the model cannot account for the adjustment in hours on impact as technology remains unchanged, as shown in panel A of column 13, the model can produce a rise in total hours of 0.73%.

Third ingredient: Consumption habits. In columns 5 and 12 of Table 3, we consider the same model as the baseline setup shown in columns 2 and 9 except that we abstract from consumption habits, i.e., we set $\gamma_S = 0$ into (12). By allowing for an endogenous technology utilization-rate in the traded sector, i.e., $\chi_2^H < \infty$, and international R&D spillovers, i.e., $\nu^{W,H} > 0$, the model with endogenous technology decisions can generate a rise in utilization-adjusted-TFP of tradables of 0.9% and an increase in utiliation-adjusted-aggregate-TFP of 0.25%. The rise in the international stock of R&D improves the technology of tradables by 0.6%. The remaining share is the result of the adjustment in the intensity in the use of the stock of innovation. Intuitively, by increasing the return on tangible and intangible assets, a corporate tax cut produces a positive wealth effect which increases consumption. Because technology adjustment costs are prohibitive in the non-traded sector, non-traded goods prices appreciate by 1.20%, see panel D of column 5. Differently, to meet a higher demand for home-produced traded goods, traded firms increase the technology utilization rate $u^{Z,H}(t)$ by 0.9% which further increases $T^H(t)$ by 0.3%.

By pushing up the aggregate wage, technology improvements provide a strong intensive to increase labor supply. As shown in panel A, the model generates a rise in total hours by 0.93% see column 5) which squares well with our estimated impact response for total hours by 0.81% (see column 1). However, contrasting the long-run response of hours of

1.83% shown in column 12 with the rise in hours we estimate empirically over a ten-year horizon which stands at 0.59%, the model considerably overestimates the positive impact on labor supply. The rise in hours is three times larger in the model than in the data in the long-run because the model abstracts from consumption habits. As can be seen in panel E, the model with habits produces a rise in consumption by 1.20 ppt of GDP while in the data, we find a rise of 0.5 ppt only. Consumption habits are crucial to account for the effects of a corporate tax cut on hours as they mitigate the rise in consumption and amplify the rise in leisure. Intuitively, the expected higher level of consumption habits increase the curvature of the utility function which encourages households to consume less goods (as the marginal utility of consumption decreases more rapidly) and more leisure; therefore consumption habits mitigate the rise in labor supply.

Fourth ingredient: GHH preferences. We allow for GHH preferences as only this specification ensures that the model can generate the rise in hours in the short- and long-run which squares with our evidence. To show this point, in columns 4 and 11, we show results when we consider the same setup as the baseline except that we assume that preferences are those proposed by Shimer [2009]. In contrast to GHH preferences, these preferences imply that labor supply is influenced negatively by a wealth effect. As shown in column 4, assuming Shimer [2009] preferences leads the model to produce a rise in hours by 0.76% which somewhat understates the rise in total hours we estimate empirically (0.91%).

In contrast, the baseline model with GHH preferences reproduces well the effects of a corporate tax cut on hours and technology both on impact and in the long-run, as displayed by columns 2 and 9. The combined effect of a higher intensity in the use of the stock of knowledge on impact in the traded sector and international R&D spillover immediately improve technology of tradables by 1.01% which leads to a rise in utilization-adjusted-aggregate TFP of 0.32% close to our empirical estimate (0.43%). By stimulating wages, technology improvements have a positive impact on labor supply which raises hours by 0.91%, a magnitude which collapses to what we estimate empirically. While the specification of GHH preferences implies that the wealth effect does not exert a negative impact on hours, consumption habits do avoid an excessive increase in consumption in the short- and especially in the long-run (0.51 ppt in the model vs. 0.60 ppt of GDP in the data) which ensures that the model does not exaggerate the increase in hours when the economy is close to the steady-state. Indeed, over a ten-year horizon, hours increase by 0.66% in the model and 0.59% in the data.

Reallocation of productive resources in two-sector open economy setup. Because we consider a two-sector open economy model, resources are reallocated between industries. Because technology improvements are concentrated within traded industries, an excess demand for non-traded goods shows up which appreciates non-traded goods by

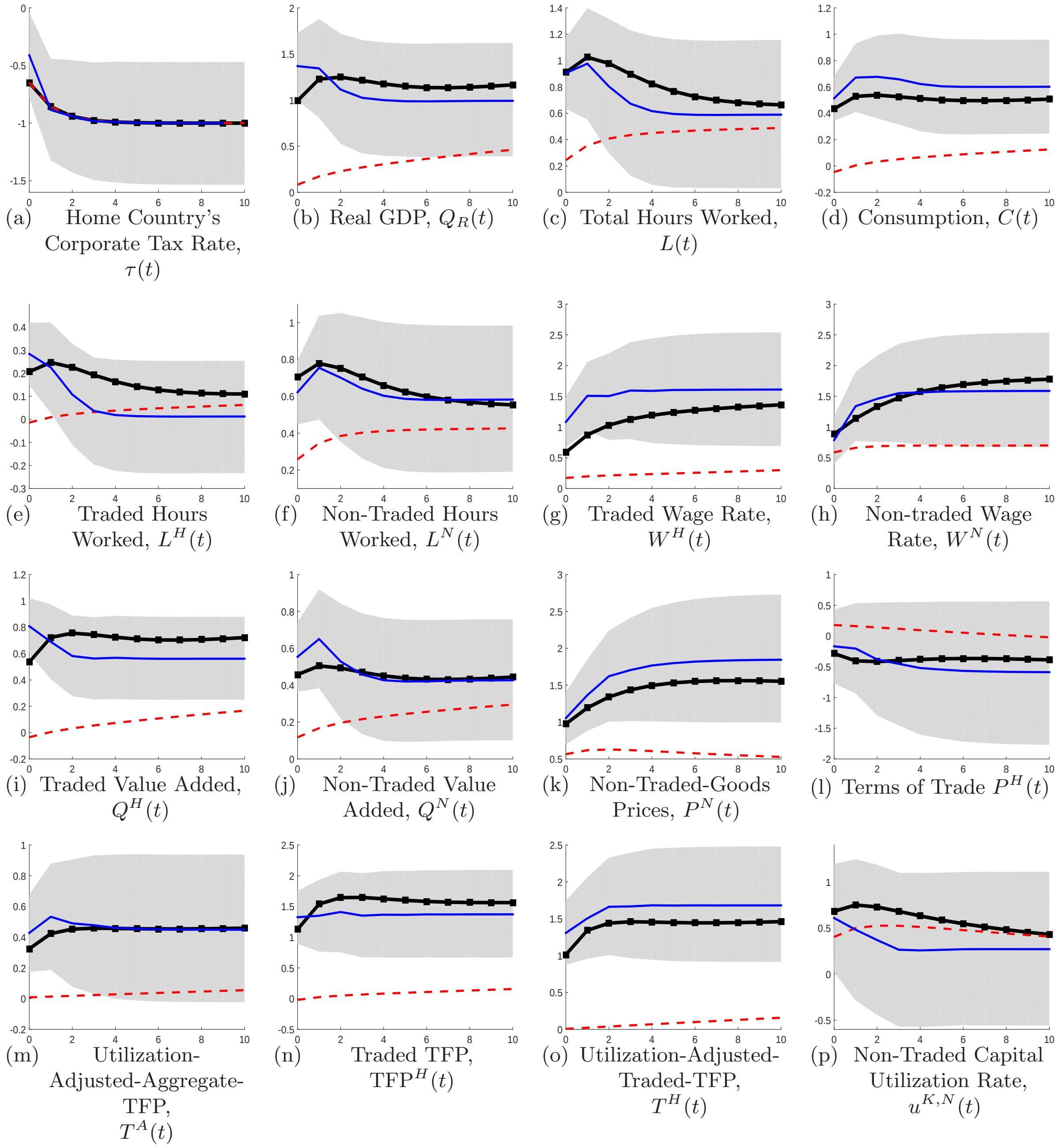
0.97% on impact (1.05% in the data) and by 1.55% in the long-run (1.85% in the data). Because the elasticity of substitution between traded and non-traded goods is smaller than one, as shown in the last row of panel A, hours are reallocated toward the non-traded traded as reflected in a decline in the hours worked share of tradables by -0.06 ppt (-0.05 ppt in the data). Differently, an excess supply shows up in the traded goods market which depreciates the terms of trade by -0.29% on impact (-0.17% in the data) and by -0.39% (-0.59% in the data) in the long-run. Because home- and foreign-produced-traded goods are high substitutes (i.e., $\rho = \rho_J = \phi_X = 3$), the terms of trade depreciation mitigates the shift of productive resources toward the non-traded sector. Imposing that domestic and foreign goods are perfect substitutes would lead the model to considerably overstate the reallocation of labor toward the non-traded sector which is also hampered by labor mobility costs.

4.3 Dynamic Effects of a Permanent Coporate Income Tax Cut

While in Table 3, we restrict our attention to impact and long-run effects, in Fig. 5, we contrast theoretical (displayed by solid black lines with squares) with empirical (displayed by solid blue lines) dynamic responses with the shaded area indicating the 90% confidence bounds. We also contrast theoretical responses from the baseline model with the predictions of a restricted model shown in dashed red lines which imposes prohibitive technology utilization adjustment costs in both sectors (i.e., $\chi_2^j \to \infty$) so that $u^{Z,j}$ is constant and domestic firms do not benefit from international R&D spillovers, i.e;, we set ${}_n u^{W,H} = \nu^{W,N} = 0$. As can be seen in Fig. 5(a), we consider the same corporate tax cut for baseline model and its restricted version.

Dynamics. As shown in the first row of Fig. 5, the baseline model reproduces well the expansionary effect of a permanent corporate income tax cut on real GDP, total hours and consu:ption while the same model abstracting from the endogenous technology rate in the traded sector and international R&D spillover fails to account for the evidence. The reason is that as shown in the last row of Fig. 5, the restricted model cannot generate the technology improvement we estimate empirically as the stock of ideas also builds up gradually. Because technology remains unchanged, as shown in Fig. 5(g) and Fig. 5(h), the corporate tax cut has a mitigated impact on traded and non-traded wages which in turn results in small increases in traded and non-traded hours, as displayed by Fig. 5(e) and Fig. 5(f).

In contrast, the baseline model can generate a rise in total hours by 0.9% on impact as traded firms increase the intensity in the use of stock of ideas on impact before gradually increasing the stock of knowledge. In addition, traded firms benefit from international R&D spillovers which further raise utilization-adjusted-TFP of tradables, as shown in the black line of Fig. 5(o). Besides putting upward pressure on the aggregate wage and encouraging



(a) Home Country's Corporate Tax Rate, $\tau(t)$
(b) Real GDP, $Q_R(t)$
(c) Total Hours Worked, $L(t)$
(d) Consumption, $C(t)$
(e) Traded Hours Worked, $L^H(t)$
(f) Non-Traded Hours Worked, $L^N(t)$
(g) Traded Wage Rate, $W^H(t)$
(h) Non-traded Wage Rate, $W^N(t)$
(i) Traded Value Added, $Q^H(t)$
(j) Non-Traded Value Added, $Q^N(t)$
(k) Non-Traded-Goods Prices, $P^N(t)$
(l) Terms of Trade $P^H(t)$
(m) Utilization-Adjusted-Aggregate-TFP, $T^A(t)$
(n) Traded TFP, $\text{TFP}^H(t)$
(o) Utilization-Adjusted-Traded-TFP, $T^H(t)$
(p) Non-Traded Capital Utilization Rate, $u^{K,N}(t)$

Figure 5: Theoretical vs. Empirical Responses Following a 1 ppt Permanent Corporate Tax Cut. Notes: The solid blue line which displays point estimate from the VAR model with shaded areas indicating 90% confidence bounds; the thick solid black line with squares displays model predictions in the baseline scenario.

households to supply more labor, the significant technology improvement in the traded sector produces an increase in traded value (see Fig. 5(i)) and in real GDP which is in line with the evidence. While traded value added growth is driven by higher hours and productivity gains in the short-run, Fig. 5(j) shows that the tax cut has also an expansionary effect on non-traded value added which is driven by higher hours and the increase in the capital utilization rate (see Fig. 5(p)).

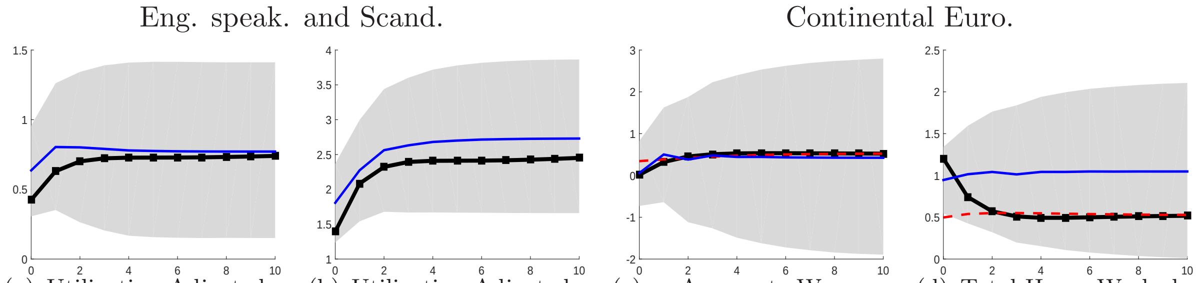
Because an excess demand shows up on the non-traded goods market, non-traded goods appreciate over time. In contrast, higher traded value added generates an excess supply in the traded goods market which depreciates the terms of trade (see Fig. 5(l)). Because productivity gains are insignificant in the short-run, the restricted model cannot account for the terms of trade depreciation as can be seen in the dashed red lines in Fig. 5(l). Despite the positive impact of the wealth effect on consumption, the restricted model also fails to account for the dynamics for consumption, as displayed by Fig. 5(d). In contrast, the combined effect of productivity gains and of the terms of trade depreciation more than offsets the negative impact of the appreciation in non-traded goods prices which leads the baseline model to reproduce well the dynamics of consumption.

4.4 English-Speaking/Scandinavian vs. Continental European Countries

Calibration. In this subsection, we calibrate our baseline model to two different sub-samples. The first sub-sample is made up of seven OECD countries which are characterized by flexible wages and by a high elasticity of technology of tradables w.r.t. to the domestic and the international stock of knowledge. The second sub-sample is made up of four OECD countries which are characterized by sticky wages, a low elasticity of technology of tradables w.r.t. to the domestic stock of knowledge, and low international R&D spillovers. We provide more details about the calibration to the data in the Online Appendix H.1 for both groups of countries.

English-speaking and Scandinavian countries. The parameters are set to target the averaged ratios of the first sub-sample made up of English-speaking and Scandinavian countries. We choose ϵ_L, ϵ_K, ϵ_Z to be 0.95, 0.21, 0.21, respectively. Other parameters are identical to those set for the representative economy except for η^H and $\eta^{W,H}$; building on our estimates, we set η^H and $\eta^{W,H}$ to 0.62 and 0.51, respectively; while our estimates suggest low but statistically significant positive values for the elasticity of utilization-adjusted-TFP of non-tradables w.r.t. to the domestic and international stock of R&D, we set $\eta^N = \eta^{W,N} = 0$ because our evidence shows that there is no technology improvements in the non-traded sector.

Continental European countries. The parameters are set to target the averaged ratios of the second sub-sample made up of continental European countries. We choose ϵ_L, ϵ_K, ϵ_Z to be 1.08, 0.14, 0.14, respectively. Other parameters are identical to those set for the representative economy except for η^H and $\eta^{W,H}$; building on our estimates, we set $\eta^H = \eta^N = \eta^{W,N} = 0$ while $\eta^{W,H} = 0.135$ which implies that traded firms benefit from international R&D spillover, although the impact is more than three times smaller than the first group of countries. For this group of countries, we consider two variants. We consider the baseline model with flexible wages and we contrast its predictions with those obtained in a model with sticky wages. Our estimates for the group of continental European countries reveal that the aggregate wage rate remains unchanged on impact and muted over a ten-year horizon as the point estimate is positive but not statistically significant. Households supply labor, L, and must decide on the allocation of total hours worked between the traded sector, L^H, and the non-traded sector, L^N. We assume that these labor services are sold



(a) Utilization-Adjusted-Aggregate-TFP, $T^A(t)$
(b) Utilization-Adjusted-Traded-TFP, $T^H(t)$
(c) Aggregate Wage Rate, $W(t)$
(d) Total Hours Worked, $L(t)$

Figure 6: Theoretical vs. Empirical Responses Following a 1 ppt Permanent Corporate Tax Cut: English-speaking and Scandinavian countries vs. continental European countries.
Notes: The solid blue line which displays point estimate from the VAR model with shaded areas indicating 90% confidence bounds; the thick solid black line with squares displays model predictions in the baseline scenario where we consider sticky wages in the traded and the non-traded sector. The dashed red lines in Fig. 6(c) and Fig. 6(d) shows the model's predictions when we assume that wages are flexible.

to employment agencies in the traded and the non-traded sector which differentiate these labor services and then aggregate them to sell them to final good producers. Households receive an income in exchange for labor services and also rent tangible and intangible assets to domestic firms. In the same spirit as Rotemberg costs for price adjustment costs, see e.g., Kaplan et al. [2018], we assume adjustment costs faced by employment agencies in adjusting the price of labor services. Adjustment costs are assumed to be quadratic in the rate of change of the wage rate and are proportional to labor compensation in sector j:

$$\Theta^j\left(\frac{\dot{W}_i^j}{W_i^j}\right) = \frac{\phi_W^j}{2}\left(\frac{\dot{W}_i^j}{W_i^j}\right)^2 W^j L^j, \tag{41}$$

where $\phi_W^j > 0$ and $\pi_i^{W,j} = \frac{\dot{W}_i^j}{W_i^j}$ is the individual wage inflation; ϕ_W^j determines the degree of wage stickiness in sector j. Adjustment costs are the source of sticky wages and generate a gap between wages received by workers $R^{W,j}$ and the labor cost paid by intermediate good producers, W^j, to employment agencies. Like Chodorow-Reich et al. [2023], we consider sticky wages at a sectoral level and choose the elasticity of substitution between labor varieties ϵ_W^j of 10 which is a value commonly chosen in the literature; we set $\phi_W^j = 10$ in both sectors; this value is a lower than the value commonly chosen in the literature who consider quarterly data while our time series are available at an annual frequency; a value of 10 for the degree of wage stickiness gives rise to a response in the aggregate wage rate which reproduces what we estimate empirically for this group of countries.

Model's prediction vs. SVAR evidence. While in Online Appendix H.2 we provide numerical results for all variables considered in the empirical part, in the main text, for reasons of space, we focus on a limited set of variables shown in Table 4 where we consider impact and long-run effects. Columns 1 and 3 show impact and long-run responses we estimate empirically for English-speaking and Scandinavian countries while columns 2 and 4 show the predictions of the baseline model with flexible wages which is calibrated so as to replicate the characteristics of an average economy of this sub-sample. Columns 5

Table 4: Impact and Long-Run Effects of a Corporate Income Tax Cut: English-speaking and Scandinavian countries vs. Continental European countries

	Eng. and Scand. countries				Cont. Europ. countries					
	VAR ($t=0$)	Model ($t=0$)	VAR ($t=10$)	Model ($t=10$)	VAR ($t=0$)	Model ($t=0$)		VAR ($t=10$)	Model ($t=10$)	
	Data	Flex. W	Data	Flex. W	Data	Rigid W	Flex. W	Data	Rigid W	flex. W
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
A. Corporate Tax										
Corp. Income. Tax, $d\tau(t)$	-0.32	-0.32	-1.00	-1.00	-0.60	-0.80	-0.80	-1.00	-1.00	-1.00
B. Total Hours										
Total hours, $dL(t)$	0.93	1.11	0.30	0.75	0.95	1.20	0.50	1.05	0.53	0.52
C. Technology Improvement										
Agg. ut-adj.TFP, $dT^A(t)$	0.64	0.42	0.77	0.74	0.04	0.08	0.06	-0.07	0.15	0.12
Ut-adj-TFP of tradables, $dT^H(t)$	1.81	1.39	2.73	2.45	0.33	0.33	0.32	-0.12	0.42	0.42

Notes: Impact ($t=0$) and long-run ($t=10$) effects of a permanent decline in the corporate income tax: English-speaking and Scandinavian countries vs. Continental European countries. Panels A,B,C show the deviation in percentage relative to steady-state. Panel B shows the effects on total hours worked including total while panel C displays the responses of aggregate and traded utilization-adjusted-TFP. In columns 1-4, we calibrate the model to the group of countries made up of English-speaking and Scandinavian economies. While columns 1 and 3 show the impact ($t=0$) and long-run ($t=10$) effects estimated empirically, columns 2 and 4 show the impact ($t=0$) and long-run ($t=10$) effects estimated numerically. In columns 5-10, we calibrate the model to the group of countries made up of continental European economies. We consider two variants. In the first variant show in columns 6 and 9, we consider a model with wage stickiness while in columns 7 and 10, we consider a model with flexible wages.

and 8 display impact and long-run effects estimated empirically for continental European countries and the results should be contrasted with the predictions of the baseline model with sticky wages displayed by columns 6 and 9. To quantify the role of sticky wages in driving the effects on hours, we also show the predictions of the same model with flexible wages, as displayed by columns 7 and 10. The first column of Fig. 6 displays the dynamic effects on technology improvements for English-speaking and Scandinavian countries while the second column shows responses for continental European countries.

Productivity gains. Let us focus first on technology improvements which are shown in panel C. Contrasting the model's predictions in columns 2 and 4 with the empirical estimates displayed by columns 1 and 3, the model with endogenous technology decisions can generate a technology improvement which is close to what we estimate empirically. The ability of the model to generate a large increase in productivity rests on three key factors. First, in line with our empirical estimates, the production function displays a highly intensity in domestic R&D and also in international R&D (as captured by high values for ν^H and $\nu^{W,H}$ which are set to 0.62 and 0.51, respectively). However, the domestic stock of innovation only builds up gradually and thus remains unchanged on impact. To account for the strong productivity gains in the short-run, we have to allow for an endogenous technology utilization rate and international R&D spillovers. More specifically, because the traded sector faces low technology utilization adjustment costs, χ_2^H, the sector finds it optimal to meet the demand for home-produced traded goods caused by the tax cut by increasing productivity as reflected in the rise in the technology utilization rate $u^{Z,H}(t)$. This factor contributes only 12% to the technology improvement on impact while it accounts for one-third of the increase in utilization-adjusted-TFP in the long-run. International R&D spillovers accounts for 88% of productivity gains on impact and 63% over a ten-year horizon. The contribution of the increase in the stock of knowledge is lower at 4% at $t = 10$.

While technology improvements are significant in English-speaking and Scandinavian countries, see Fig. 6(a) and Fig. 6(b), columns 6 and 9 show that the model predicts insignificant productivity gains at any horizon for continental European countries, in accordance with the data.

Hours worked. Whereas technology does not improve in continental European countries, hours worked increase significantly in these countries by 0.95% on impact and 1.05% in the long-run as can be seen in columns 5 and 8 of panel B. The model can generate the increase we estimate empirically, but only in the short-run, as shown in columns 6 and 9. More specifically, wage stickiness is essential to produce the increase in hours we find in the data. Intuitively, in a model with flexible wages, both traded and non-traded firms increase wages in face of a higher demand to attract workers. In a model with wage stickiness, workers obtains higher wages from employment agencies but the labor cost paid by firms remains unchanged in the short-run. The appreciation in non-traded goods has an expansionary effect on labor demand in the non-traded sector while small productivity gains due to international R&D spillover also stimulates labor demand in the traded sector. Because wages are unchanged, this provides high incentives to increase hours but only in the short-run. As can be seen in Fig. 6(c) and Fig. 6(d), the model with flexible wages shown in dashed red lines cannot account for the expansionary effect of the corporate tax cut on hours the first three years. Once the wages have adjusted to their steady-state level, the baseline model with sticky wages understates the rise in hours.

We have considered some alternative explanations such as the rise in the labor intensity of production to generate the persistent and strong increase in hours in the long-run concentrated in the non-traded sector. This increase could reflect profit sharing rules implemented in OECD countries, see e.g., Nimier-David et al. [2023]. However, our evidence reveals that the response of the labor income share is not significant in both the traded and the non-traded sector, see Online Appendix C.8. This finding also reveals that corporate taxation does not generate facto-biased technological change. The persistent increase in hours in the long-run thus remains puzzling and we leave this puzzle for future research.

5 Conclusion

The identification of exogenous shocks to economic activity prevents the econometrician from using country-level corporate income tax rates as there is a clear endogeneity issue: when economic activity and/or employment is low, the government might be tempted to cut the corporate tax. While so far the literature has mostly relied upon narratively-identified shocks of corporate income taxation, these data are available for a very limited set of countries, and the standard for choosing exogenous changes to taxation may not be completely reliable, see e.g., Perotti [2012]. In this paper, we propose a new identification of exogenous and permanent shocks to corporate taxation based on the downward trend of profits taxation which is common to a large set of OECD countries. Because the downward trend in corporate taxation is driven by tax competition motives, there exists a common trend shares by a large set of OECD countries. We thus construct an international measure of the corporate income tax rate as an import share weighted average of corporate income tax rates of trade partners of the home country. This measure has the advantage to capture the downward pressure on profits taxation driven by the tax competition which has led to the race to the bottom on corporate tax.

Estimating the VAR model with long-run restrictions over 1973-2017, we find that an exogenous permanent decline in the corporate income tax rate has a strong expansionary effect on productivity but only in traded industries while it has a significant and persistent positive effect on hours which is concentrated in non-traded industries. We propose a structural interpretation of these results by developing a two-sector open model with endogenous technology decisions in the traded and the non-traded sector. Our quantitative analysis reveals that our model can generate an increase in utilization-adjusted-TFP of tradables larger than 1% after a corporate income tax cut by 1 percentage point once the model has three elements. While the elasticities of productivity w.r.t. the domestic and the international stock of knowledge must be high enough, we have to allow traded firms to use more intensively the existing stock of knowledge to meet a higher demand to curb upward pressure on production costs. The additional key element is to allow for international R&D spillovers.

While these three elements are crucial to account for technology improvements, they are not sufficient on their own to produce the rise in hours we estimate empirically. We show that we have to choose Greenwood et al. [1988] preferences which remove the wealth effect from labor supply while at the same time households must have consumption habits otherwise the model overstates labor growth in the long-run. Our model can also generate the concentration of labor growth in the non-traded sector by assuming an elasticity of substitution between traded and non-traded goods smaller than one; the low value for the price-elasticity of demand for non-traded goods implies that the appreciation in non-traded goods prices raises the share of non-tradables which provides incentives for labor to shift away from traded industries.

When we split the sample of countries into two sub-samples, our SVAR evidence shows that lower corporate taxes have sizeable effect on R&D investment and productivity among traded industries but only in English-speaking and Scandinavian countries. While R&D investment and technology are essentially unchanged across all sectors in continental European countries, hours increase more in this group of countries and labor growth is concentrated among non-traded industries. Building on our model's predictions, the distinct effects across the two groups of countries we estimate empirically after a corporate income tax cut rest on the R&D intensity of production among traded firms. While the elasticities of technology of tradables w.r.t. the domestic and international stock of knowledge are zero for the group of continental European countries, they are large for English-speaking and Scandinavian countries which ensures sizeable productivity gains in the traded sector. Because of wage stickiness and low capital utilization adjustment costs, continental European countries experience a larger increase in hours although technology improvements are absent. The model understates the persistent and significant increase in hours in the long-run however. We believe that a model with entry/exit of firms could potentially rationalize the persistent increase in non-traded hours in continental European countries.

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A Data Description for Empirical Analysis

Sources: Our primary sources for sectoral data are the OECD and EU KLEMS databases. We use data from EU KLEMS ([2011], [2017]) March 2011 and July 2017 releases. The EU KLEMS dataset covers all countries of our sample. For EU KLEMS, the March 2011 release provides data for eleven 1-digit ISIC-rev.3 industries over the period 1973-2007 while the July 2017 release provides data for thirteen 1-digit-rev.4 industries over the period 1995-2017.

The construction of time series for sectoral variables over the period 1973-2017 involves two steps. First, we identify tradable and non-tradable sectors. The methodology adopted to classify industries as tradables or non-tradables is described in section 2.1 in the main text and also detailed in section C.1. We map the ISIC-rev.4 classification into the ISIC-rev.3 classification in accordance with the concordance Table 5. Once industries have been classified as traded or non-traded, for any macroeconomic variable X, its sectoral counterpart X^j for $j = H, N$ is constructed by adding the X_k of all sub-industries k classified in sector $j = H, N$ as follows $X^j = \sum_{k \in j} X_k$. Second, series for tradables and non-tradables variables from EU KLEMS [2011] and OECD [2011] databases (available over the period 1970-2007) are extended forward up to 2017 using annual growth rate estimated from EU KLEMS [2017] and OECD [2017] series (available over the period 1995-2017).

Table 5: Summary of Sectoral Classifications

Sector	ISIC-rev.4 Classification (sources: EU KLEMS [2017] and OECD ([2017]))		ISIC-rev.3 Classification (sources: EU KLEMS [2011] and OECD ([2011]))	
	Industry	Code	Industry	Code
Tradables (H)	Agriculture, Forestry and Fishing	A	Agriculture, Hunting, Forestry and Fishing	AtB
	Mining and Quarrying	B	Mining and Quarrying	C
	Total Manufacturing	C	Total Manufacturing	D
	Transport and Storage	H	Transport, Storage and Communication	I
	Information and Communication	J		
	Financial and Insurance Activities	K	Financial Intermediation	J
Non Tradables (N)	Electricity, Gas and Water Supply	D-E	Electricity, Gas and Water Supply	E
	Construction	F	Construction	F
	Wholesale and Retail Trade, Repair of Motor Vehicles and Motorcycles	G	Wholesale and Retail Trade	G
	Accommodation and Food Service Activities	I	Hotels and Restaurants	H
	Real Estate Activities	L	Real Estate, Renting and Business Services	K
	Professional, Scientific, Technical, Administrative and Support Service Activities	M-N		
	Community Social and Personal Services	O-U	Community Social and Personal Services	LtQ

The definition of aggregate and sectoral variables are as follows (mnemonics are in parentheses):

- Aggregate variables: real GDP (Y) is the sum of traded and non-traded value added at constant prices. Total hours worked (L) is the sum of traded and non-traded hours worked.
- Sectoral quantities: traded value added at constant prices (Y_T), non-traded value added at constant prices (Y_N). Sectoral value added are constructed by adding value added for all sub-industries k in sector $j = T, N$
- Sectoral hours worked: traded hours worked (L_j), non-traded hours worked (L_j) which correspond to hours worked by persons engaged in sector j. Sectoral hours worked are constructed by adding hours worked for all sub-industries k in sector $j = T, N$
- Sectoral hours worked share (L_j/L), is the ratio of hours worked in sector j to total hours worked for $j = T, N$.
- Labor income share (LIS) is constructed as the ratio of labor compensation which is the total of compensation of employees and compensation of self-employed in sector $j = T, N$ to value added at current prices of that sector.
- Sectoral value added share is the ratio of value added at constant prices in sector j to GDP at constant prices, i.e., Y_j/Y for $j = T, N$
- Capital utilization adjusted total factor productivity, TFP, is constructed as the Solow residual from constant-price domestic currency series of GDP, labor income share and capital stock. The time-varying capital utilization series is constructed by adapting the methodology proposed by Imbs [1999]. We describe its construction below.
- R&D capital stock is the net capital stock in constant prices in Research and Development. R&D investment is gross fixed capital formation in constant prices in Research and Development. Source: Stehrer et al. [2019].

Table 6: Sample Range for Empirical and Numerical Analysis

Country	Code	Period	Obs.
Australia	(AUS)	1973 - 2017	45
Austria	(AUT)	1973 - 2017	45
Belgium	(BEL)	1973 - 2017	45
Germany	(DEU)	1973 - 2017	45
Finland	(FIN)	1973 - 2017	45
France	(FRA)	1973 - 2017	45
Great Britain	(GBR)	1973 - 2016	44
Japan	(JPN)	1973 - 2015	43
Luxembourg	(LUX)	1973 - 2017	45
Sweden	(SWE)	1973 - 2017	45
United States	(USA)	1973 - 2017	45
Total number of obs.			492
Main data sources		EU KLEMS & OECD STAN	

Notes: Column 'period' gives the first and last observation available. Obs. refers to the number of observations available for each country.

- Sectoral nominal wage is calculated as the ratio of the labor compensation in sector $j = T, N$ to total hours worked by persons engaged in that sector. Nominal wages are divided to foreign price ($W_j/P_j^\star$ for $j = T, N$) which is exogenous geometric weighted sum of the traded value added deflator of the ten trade partners of the corresponding country i, the weight being equal to the share of imports from the trade partner k.
- Relative price of non-tradables, P_N/P_T. Normalizing base year price indices $\bar{P}_j$ to 1, the relative price of non-tradables is constructed as the ratio of the non-traded value added deflator to the traded value added deflator. The sectoral value added deflator P_j for sector $j = T, N$ is calculated by dividing value added at current prices (VA) by value added at constant prices in sector j.
- Terms of trade, $\text{TOT}_{it} = P_T/P_T^\star$ is computed as the ratio of the traded value added deflator of the home country i, $P_{T,it}$, to the geometric average of the traded value added deflator of the twenty trade partners of the corresponding country i, the weight being equal to the share of imports from the trade partner. We use the traded value added deflator to approximate foreign prices as it corresponds to a value-added concept.

Construction of time series for sectoral capital stock, K_t^j. To construct the series for the sectoral capital stock, we proceed as follows. We first construct time series for the aggregate capital stock for each country in our sample. To construct K_t, we adopt the perpetual inventory approach. The inputs necessary to construct the capital stock series are a i) capital stock at the beginning of the investment series, K_{1973}, ii) a value for the constant depreciation rate, δ_K, iii) real gross capital formation series, I_t. Real gross capital formation is obtained from OECD National Accounts Database [2017] (data in millions of national currency, constant prices). We construct the series for the capital stock using the law of motion for capital in the model:

$$K_{t+1} = I_t + (1 - \delta_K) K_t. \tag{42}$$

for $t = 1974, ..., 2017$. The value of δ_K is chosen to be consistent with the ratio of capital depreciation to GDP observed in the data and averaged over 1973-2017:

$$\frac{1}{45} \sum_{t=1973}^{2017} \frac{\delta_K P_{J,t} K_t}{Y_t} = \frac{CFC}{Y}, \tag{43}$$

where $P_{J,t}$ is the deflator of gross capital formation series, Y_t is GDP at current prices, and CFC/Y is the ratio of consumption of fixed capital at current prices to nominal GDP averaged over 1973-2017. Deflator of gross capital formation, GDP at current prices and consumption of fixed capital are taken from the OECD National Account Database [2017]. The capital depreciation rate averages to 5%.

To have data on the capital stock at the beginning of the investment series, we use the following formula:

$$K_{1973} = \frac{I_{1973}}{g_I + \delta_K}, \tag{44}$$

where I_{1973} corresponds to the real gross capital formation in the base year 1973, g_I is the average growth rate from 1973 to 2017 of the real gross capital formation series. The system of equations (42), (43) and (44) allows us to use data on investment to solve for the sequence of capital stocks and for the depreciation rate, δ_K. There are 46 unknowns: K_{1973}, δ_K, K_{1974}, ..., and K_{2017}, in 46 equations: 44 equations (42), where $t = 1974, ..., 2017$, (43), and (44). Solving this system of equations, we obtain the sequence of capital stocks and a calibrated value for depreciation, δ_K. Following Garofalo and Yamarik [2002], the gross capital stock is then allocated to traded and non-traded industries by using the sectoral value added share.

Construction of time series for sectoral TFPs. Sectoral TFPs, TFP_t^j, at time t are constructed as Solow residuals from constant-price (domestic currency) series of value added, Y_t^j, capital stock, K_t^j, and hours worked, L_t^j, by using $T\hat{F}P_t^j = \hat{Y}_t^j - s_L^j \hat{L}_t^j - \left(1 - s_L^j\right) \hat{K}_t^j$. The LIS in sector j, s_L^j, is the ratio of labor compensation (compensation of employees plus compensation of self-employed) to nominal value added in sector $j = H, N$, averaged over the period 1973-2017 (except Japan: 1973-2015 and United-Kingdon: 1973-2016). Data for the series of constant price value added (VA_QI), current price value added (VA), hours worked (H_EMP) and labor compensation (LAB) are taken from the EU KLEMS ([2011], [2017]) and OECD STAN ([2011], [2017]) databases.

Construction of time series for capital utilization, $u_t^{K,j}$. To construct time series for the capital utilization rate, $u_t^{K,j}$, we proceed as follows. We use time series for the real interest rate, $r^\star$ and for the capital depreciation rate, δ_K to compute $\phi = \frac{r^\star + \delta_K}{\delta_K}$. Once we have calculated ϕ for each country, we use time series for the LIS in sector j, $s_{L,t}^j$, GDP at current prices, $P_t Y_{R,t} = Y_t$, the deflator for investment, $P_{J,t}$, and times series for the aggregate capital stock, K_t to compute time series for $u_t^{K,j}$ by using the formula (see Cardi and Restout [2023]):

$$u_t^{K,j} = \left[\frac{\left(1 - s_{L,t}^j\right)}{\delta_K \phi_K} \frac{P_t Y_{R,t}}{P_{J,t} K_t} \right]^{\frac{1}{\phi_K}}, \tag{45}$$

where $\phi_K = \frac{r^\star + \delta_K}{\delta_K}$

Construction of time series for utilization-adjusted TFP, Z_t^j. Utilization-adjusted-TFP expressed in percentage deviation relative to the steady-state reads:

$$\begin{aligned} \hat{Z}_t^j &= \hat{\text{TFP}}_t^j - \left(1 - s_L^j\right) \hat{u}_t^{K,j}, \\ \ln Z_t^j - \ln \bar{Z}_t^j &= \left(\ln \text{TFP}_t^j - \ln \bar{\text{TFP}}_t^j\right) - \left(1 - s_L^j\right) \left(\ln u_t^{K,j} - \ln \bar{u}_t^{K,j}\right). \end{aligned} \tag{46}$$

The percentage deviation of variable X_t from initial steady-state is denoted by $\hat{X}_t = \ln X_t - \ln \bar{X}_t$ where we let the steady-state vary over time; the time-varying trend $\ln \bar{X}_t$ is obtained by applying a HP filter with a smoothing parameter of 100 to logged time series. To compute $T\hat{F}P_t^j$, we take the log of TFP_t^j and subtract the trend component extracted from a HP filter applied to logged TFP_t^j, i.e., $\ln \text{TFP}_t^j - \ln \bar{\text{TFP}}_t^j$. The same logic applies to $u_t^{K,j}$. Once we have computed the percentage deviation $\ln Z_t^j - \ln \bar{Z}_t^j$, we reconstruct time series for $\ln Z_t^j$:

$$\ln Z_t^j = \left(\ln Z_t^j - \ln \bar{Z}_t^j\right) + \ln \bar{Z}_t^j. \tag{47}$$

The construction of time series of logged sectoral TFP, $\ln \text{TFP}_t^j$, capital utilization-adjusted sectoral TFP, $\ln Z_t^j$, is consistent with the movement of capital utilization along the business cycle.

B SVAR Identification and Specifications

In this section we detail the SVAR identification of corporate income tax shocks and the VAR specifications considered.

B.1 SVAR Identification of Corporate Income Tax Shocks

Empirical identification of corporate tax shocks. To identify a permanent change in corporate taxation, we consider a vector of n observables $\hat{X}_{it} = [d\tau_{it}, \hat{V}_{it}]$ where $d\tau_{it}$ captures the variation in the international component of the corporate income tax rate (as defined in eq. (1)) and $\hat{V}_{it}$ denotes the $n-1$ variables of interest (in growth rate) detailed later. Let us consider the following reduced form of the VAR(p) model:

$$C(L)\hat{X}_{it} = \eta_{it}, \tag{48}$$

where $C(L) = I_n - \sum_{k=1}^{p} C_k L^k$ is a p-order lag polynomial and η_{it} is a vector of reduced-form innovations with a variance-covariance matrix given by Σ. We estimate the reduced form of the VAR model by panel OLS regression with country fixed effects which are omitted in (48) for expositional convenience. The matrices C_k and Σ are assumed to be invariant across time and countries and all VARs have two lags. The vector of orthogonal structural shocks $\varepsilon_{it} = [\varepsilon^Z_{it}, \varepsilon^V_{it}]$ is related to the vector of reduced form residuals η_{it} through:

$$\eta_{it} = A_0 \varepsilon_{it}, \tag{49}$$

which implies $\Sigma = A_0 A_0'$ with A_0 the matrix that describes the instantaneous effects of structural shocks on observables. The linear mapping between the reduced-form innovations and structural shocks leads to the structural moving average representation of the VAR model:

$$\hat{X}_{it} = B(L) A_0 \varepsilon_{it}, \tag{50}$$

where $B(L) = C(L)^{-1}$. Let us denote $A(L) = B(L)A_0$ with $A(L) = \sum_{k=0}^{\infty} A_k L^k$. To identify a permanent change in corporate taxation, ε^Z_{it}, we use the restriction that the unit root in intertemporal measure of corporate taxation originates exclusively from corporate income tax shocks which implies that the upper triangular elements of the long-run cumulative matrix $A(1) = B(1)A_0$ must be zero. Once the reduced form has been estimated using OLS, structural shocks can then be recovered from $\varepsilon_{it} = A(1)^{-1} B(1) \eta_{it}$ where the matrix $A(1)$ is computed as the Cholesky decomposition of $B(1)\Sigma B(1)'$.

B.2 SVAR Specifications

We estimate the reduced form of the VAR model by panel OLS regression with country fixed effects. VAR model includes the international corporate tax rate τ_{it} a vector of aggregate and sectoral variables such as value added at constant prices ${Y^j}_{it}$, hours worked ${L^j}_{it}$, capital utilization adjusted ${T^j}_{it}$ for $j = H, N$. Our vector of endogenous variables are as follows:

- Aggreagate economy: $\hat{x}^{agg}_{it} = [\Delta\tau_{it}, \hat{Y}_{it}, \hat{L}_{it}, \hat{T}^A_{it}]$
- Sectoral level: $\hat{x}^{sec}_{it} = [\Delta\tau_{it}, \hat{Y^j}_{it}, \hat{L^j}_{it}]$ for $j = H, N$
- Capital utilization adjusted TFP: $\hat{x}^{tech}_{it} = [\Delta\tau_{it}, \hat{T^H}_{it}, \hat{T^N}_{it}]$
- Sectoral composition and labor allocation: $\hat{x}^{share}_{it} = [\Delta\tau_{it}, \widehat{Y^H_{it}/Y_{it}}, \widehat{L^H_{it}/L_{it}}]$
- Labor income share: $\hat{x}^{LIS}_{it} = [\Delta\tau_{it}, \widehat{LIST}_{it}, \widehat{LISN}_{it}]$
- R&D capital stock and investment: $\hat{x}^{rd}_{it} = [\Delta\tau_{it}, \hat{Z^j}_{it}, \hat{T^j}_{it}]$ for $j = H, N$ R&D capital stock. $[\Delta\tau_{it}, \hat{I^{Z,H}}_{it}, \hat{I^{Z,j}}_{it}]$ where $I^{Z,j}$ is for R&D investment.
- Wage rigidity: $\hat{x}^{pw}_{it} = [\Delta\tau_{it}, \widehat{\frac{W^H_{it}}{P^{H,\star}_{it}}}, \widehat{\frac{W^N_{it}}{P^{H,\star}_{it}}}]$

All variables except international tax rate enter the VAR model in growth rate (denoted by a hat).

C More Empirical Results and Robustness Checks

Due to data availability, we use annual data for eleven 1-digit ISIC-rev.3 industries that we classify as tradables or non-tradables. At this level of disaggregation, the classification is somewhat ambiguous because some broad sectors are made-up of heterogenous sub-industries, a fraction being tradables and the remaining industries being non-tradables. Since we consider a sample of 11 OECD countries over a period running from 1973 to 2017, the classification of some sectors may vary across time and countries. Industries such as 'Finance Intermediation' classified as tradables, 'Hotels and Restaurants' classified as non-tradables display intermediate levels of tradedness which may vary considerably across countries but also across time. Subsection C.1 deals with this issue and conducts a robustness check to investigate the sensitivity of our empirical results to the classification of industries as tradables or non-tradables.

Our dataset covers eleven industries which are classified as tradables or non tradables. The traded sector is made up of five industries and the non-traded sector of six industries. In subsection C.2, we conduct our empirical analysis at a more disaggregated level. The objective is twofold. First, we investigate whether all industries classified as tradables or non-tradables behave homogeneously or heterogeneously. Second, we explore empirically which industry drives the responses of broad sectors following corporate income tax shock.

In the main text, we use a measure of technology based on the Solow residual with is adjusted with the intensity in the use of the capital stock. Time series for the capital utilization rate are based on Imbs's [1999] methodology. In subsection C.3, we conduct a robustness check by considering three alternative measures: i) the Solow residual adjusted with the utilization rate from Basu [1996], ii) the utilization-adjusted TFP from Huo et al. [2023], iii) utilization-adjusted TFP from Basu et al. [2006].

One of our main contribution is to show that the effects of corporate tax shocks vary across countries. To conduct our analysis, we split our sample into two groups of countries. We consider a first group of countries where wages are flexible and a second group of countries where wages are less flexible and that we qualify of rigid-wages group of economies. In subsection C.4, because there are several factors underlying the wage flexibility vs. rigidity, we use the hierarchical cluster tree method which allows us to classify countries in two groups according to intensity of similarities related to wage flexibility. We find that the first group of flexible-wage-countries is made up of English-speaking, Scandinavian countries, Japan and Luxembourg. The second group of rigid-wage-countries includes continental European countries.

C.1 Classification of Industries as Tradables vs. Non-Tradables

Due to data availability, we use annual data for eleven 1-digit ISIC-rev.3 industries that we classify as tradables or non-tradables. At this level of disaggregation, the classification is somewhat ambiguous because some broad sectors are made-up of heterogenous sub-industries, a fraction being tradables and the remaining industries being non-tradables. Since we consider a sample of 11 OECD countries and a period running from 1973 to 2017, the classification of some sectors may vary across time and countries. Industries such as 'Transport and Communication', 'Finance Intermediation' classified as tradables, 'Hotels and Restaurants' classified as non-tradables display intermediate levels of tradedness which may vary considerably across countries but also across time. This subsection deals with this issue and conducts a robustness check to investigate the sensitivity of our empirical results to the classification of industries as tradables or non-tradables.

Following De Gregorio et al. [1994], we define the tradability of an industry by constructing its openness to international trade given by the ratio of total trade (imports + exports) to gross output. Data for trade and output are provided by the World Input-Output Databases. Table 7 gives the openness ratio (averaged over 1995-2014) for each industry in all countries of our sample. Unsurprisingly, "Agriculture, Hunting, Forestry and Fishing", "Mining and Quarrying", "Total Manufacturing" and "Transport, Storage and Communication" exhibit high openness ratios (0.54 in average if "Mining and Quarrying", due to its relatively low weight in GDP, is not considered). These four sectors are consequently classified as tradables. At the opposite, "Electricity, Gas and Water Supply", "Construction", "Wholesale and Retail Trade" and "Community Social and Personal Services" are considered as non tradables since the openness ratio in this group of industries is low (0.07 in average). For the three remaining industries "Hotels and Restaurants", "Financial Intermediation", "Real Estate, Renting and Business Services" the results are less clearcut since the average openness ratio amounts to 0.18 which is halfway between the two aforementioned averages. In the benchmark classification, we adopt the standard classification of De Gregorio et al. [1994] by treating "Real Estate, Renting and Business Services" and "Hotels and Restaurants" as non traded industry. Given the dramatic increase in financial openness that OECD countries have experienced since the end of the eighties, we allocate "Financial Intermediation" to the traded sector. This choice is also consistent with the classification of Jensen and Kletzer [2006] who categorize "Finance and Insurance" as tradable. They use locational Gini coefficients to measure the geographical concentration of different sectors and classify sectors with a Gini coefficient below 0.1 as non-tradable and all others as tradable (the authors classify activities that are traded domestically as potentially tradable internationally).

Table 7: Openness Ratios per Industry: 1995-2014 Averages

	Agri.	Minig	Manuf.	Elect.	Const.	Trade	Hotels	Trans.	Finance	Real Est.	Public
AUS	0.242	0.721	0.643	0.007	0.005	0.025	0.255	0.247	0.054	0.051	0.054
AUT	0.344	2.070	1.152	0.178	0.075	0.135	0.241	0.491	0.302	0.221	0.043
BEL	1.198	13.374	1.414	0.739	0.067	0.186	0.389	0.536	0.265	0.251	0.042
DEU	0.553	2.594	0.868	0.115	0.037	0.072	0.139	0.266	0.101	0.086	0.017
FIN	0.228	2.899	0.796	0.117	0.006	0.094	0.131	0.280	0.153	0.256	0.021
FRA	0.280	3.632	0.815	0.049	0.004	0.048	0.001	0.224	0.068	0.070	0.014
GBR	0.360	0.853	0.958	0.017	0.010	0.024	0.148	0.209	0.233	0.147	0.041
JPN	0.158	3.923	0.293	0.004	0.000	0.067	0.021	0.159	0.034	0.020	0.005
LUX	1.656	2.729	2.046	0.466	0.020	0.260	0.069	0.935	1.229	0.767	0.237
SWE	0.294	2.263	0.969	0.119	0.020	0.163	0.019	0.392	0.274	0.256	0.026
USA	0.207	0.541	0.428	0.012	0.001	0.055	0.003	0.109	0.066	0.052	0.008
Mean $N = 1$	0.50	3.24	0.94	0.17	0.02	0.10	0.13	0.35	0.25	0.20	0.05
H/N	H	H	H	N	N	N	N	H	H	N	N

Notes: The complete designations for each industry are as follows (EU KLEMS codes are given in parentheses). "Agri.": "Agriculture, Hunting, Forestry and Fishing" (AtB), "Minig": "Mining and Quarrying" (C), "Manuf.": "Total Manufacturing" (D), "Elect.": "Electricity, Gas and Water Supply" (E), "Const.": "Construction" (F), "Trade": "Wholesale and Retail Trade" (G), "Hotels": "Hotels and Restaurants" (H), "Trans.": "Transport, Storage and Communication" (I), "Finance": "Financial Intermediation" (J), "Real Est.": "Real Estate, Renting and Business Services" (K), "Public": "Community Social and Personal Services" (LtQ). The openness ratio is the ratio of total trade (imports + exports) to gross output (source: World Input-Output Databases.

We conduct below a sensitivity analysis with respect to the three industries ("Real Estate, Renting and Business Services", "Hotels and Restaurants" and "Financial Intermediation") which display some ambiguity in terms of tradedness to ensure that the benchmark classification does not drive the results. In order to address this issue, we re-estimate the dynamic responses to a government spending shock for the main variables of interest using local projections for different classifications in which one of the three above industries initially marked as tradable (non tradable resp.) is classified as non tradable (tradable resp.), all other industries staying in their original sector. In doing so, the classification of only one industry is altered, allowing us to see if the results are sensitive to the inclusion of a particular industry in the traded or the non traded sector.

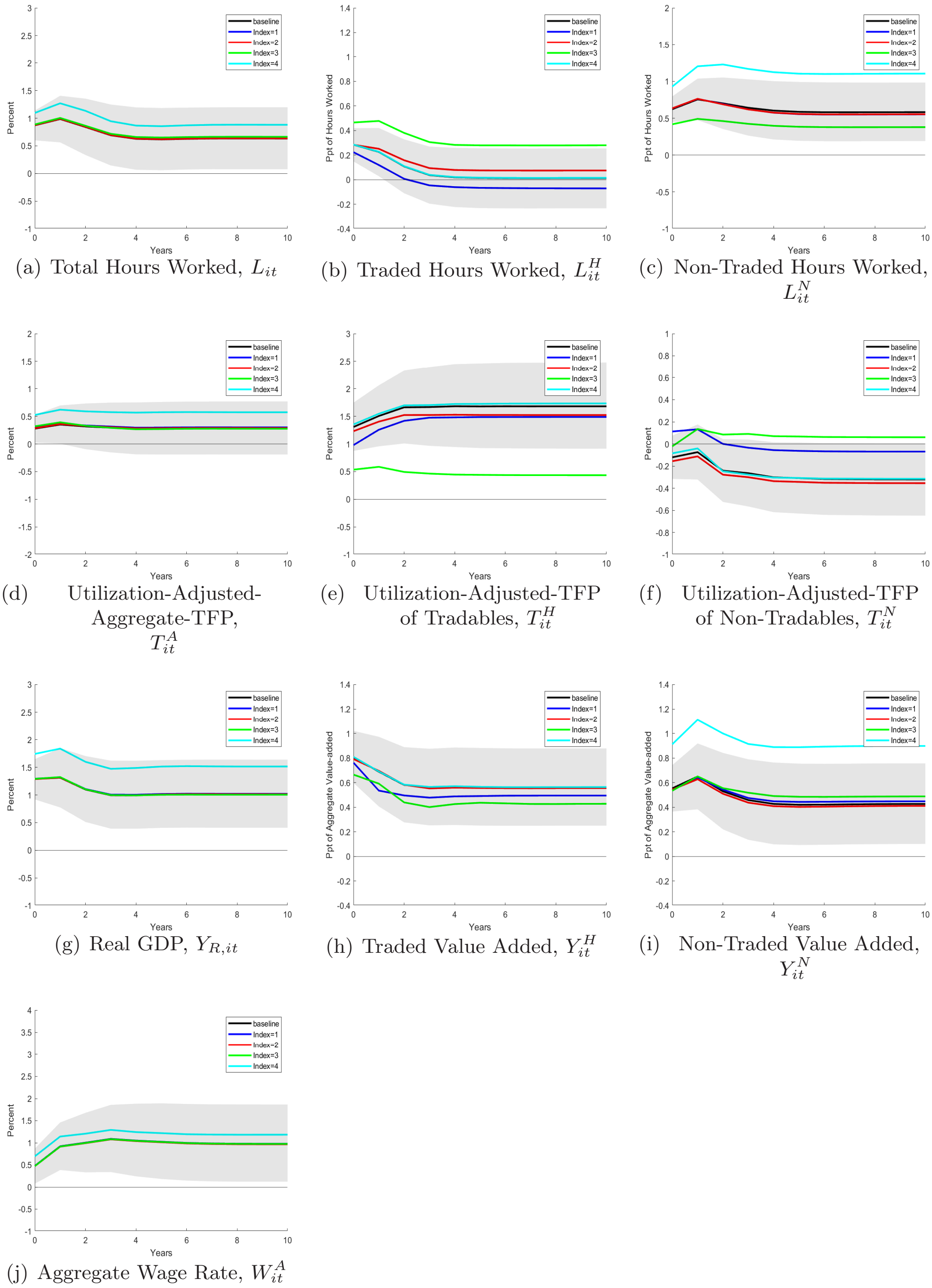
As an additional robustness check, we also exclude the industry "Community Social and Personal Services" from the non-tradable industries' set. This robustness analysis is based on the presumption that among the industries provided by the EU KLEMS and STAN databases, this industry is government-dominated. This exercise is interesting as it allows us to explore the size of the impact of a corporate income tax shock on the business sector. The baseline and the four alternative classifications considered in this exercise are shown in Table 8. The last line provides the matching between the color line (when displaying IRFs below) and the classification between tradables and non tradables.

Table 8: Robustness check: Classification of Industries as Tradables or Non Tradables

	KLEMS code	Classification				
		Baseline	#1	#2	#3	#4
Agriculture, Hunting, Forestry and Fishing	AtB	T	T	T	T	T
Mining and Quarrying	C	T	T	T	T	T
Total Manufacturing	D	T	T	T	T	T
Electricity, Gas and Water Supply	E	N	N	N	N	N
Construction	F	N	N	N	N	N
Wholesale and Retail Trade	G	N	N	N	N	N
Hotels and Restaurants	H	N	N	N	**T**	N
Transport, Storage and Communication	I	T	T	T	T	T
Financial Intermediation	J	T	**N**	T	T	T
Real Estate, Renting and Business Services	K	N	N	**T**	N	N
Community Social and Personal Services	LtQ	N	N	N	N	**neither T or N**
Color line in Figure 7		black	blue	red	green	cyan

Notes: T stands for the Traded sector and N for the Non traded sector.

Fig. 7 reports the effects of an exogenous decrease in international corporate tax rate that leads to decrease country corporate tax rate by 1% in the long-run on selected variables shown in Fig. 2 in the main text. The green line and the red line show results when 'Hotels and restaurants' and 'Real Estate, Renting and Business Services' are treated as tradables,



(a) Total Hours Worked, L_{it} (b) Traded Hours Worked, L^H_{it} (c) Non-Traded Hours Worked, L^N_{it}

(d) Utilization-Adjusted-Aggregate-TFP, T^A_{it} (e) Utilization-Adjusted-TFP of Tradables, T^H_{it} (f) Utilization-Adjusted-TFP of Non-Tradables, T^N_{it}

(g) Real GDP, $Y_{R,it}$ (h) Traded Value Added, Y^H_{it} (i) Non-Traded Value Added, Y^N_{it}

(j) Aggregate Wage Rate, W^A_{it}

Figure 7: Dynamic Effects of a Corporate Tax Shock: Robustness Check w.r.t. the Classification of Industries as Tradables or Non-Tradables. Notes: The solid black line shows the response of aggregate and sectoral variables to an exogenous decrease in international corporate tax rate that leads to decrease country corporate tax rate by 1% in the long-run. Shaded areas indicate the 90 percent confidence bounds based on Newey-West standard errors. Horizontal axes indicate years. Vertical axes measure percentage deviation from trend. The green line and the red line show results when 'Hotels and restaurants' and 'Real Estate, renting and business services' are treated as tradables, respectively. The blue line shows results when 'Financial intermediation' is classified as non-tradables. Finally, the cyan line displays results when Public services ('Community Social and Personal Services') is excluded. Sample: 11 OECD countries, 1973-2017, annual data.

respectively. The blue line shows results when 'Financial intermediation' is classified as non-tradables. Finally, the cyan line displays results when Public services ('Community Social and Personal Services') is excluded.

In each panel, the shaded area corresponds to the 90% confidence bounds for the baseline. The first row of Fig. 7 contrasts the responses of total, traded and non-traded hours worked. The second row of Fig. 7 displays the responses of utilization-adjusted-TFP for whole whole economy, the traded sector and the non-traded sector. The third row shows results for real GDP and both traded and non-traded value added. The last panel (fourth row) shows results for the aggregate wage rate.

For aggregate variables shown in the first column, including utilization-adjusted-aggregate-TFP, total hours worked and real GDP, the responses are remarkably similar across the baseline and alternative classifications. As shown in the cyan line which displays the response for the market sector only, the response of variables is little sensitive to the inclusion or not of the pubic services. Inspection of the first row reveals that the classification of industries as tradables or non-tradables has an impact on the utilization-adjusted-TFP of tradables relative to non-tradables. In particular, 'Hotels and restaurants' treated as tradables (classification #3 and shown in the green line) mitigates the rise in traded relative to non-traded technology. But the shape of the dynamic adjustment is similar to the benchmark classification. Utilization-adjusted-aggregate-TFP is not sensitive to the classification.

Alternative responses are fairly close to those estimated for the baseline classification as they lie within the confidence interval (for the baseline classification) for all the selected horizons. In conclusion, our main findings hold and remain unsensitive to the classification of one specific industry as tradable or non-tradable. In this regard, the specific treatment of "Hotels and Restaurants", "Real Estate, Renting and Business Services", "Financial Intermediation" or "Community Social and Personal Services" does not drive the results.

C.2 How Value Added, Hours and Technology Respond to Corporate Income Tax Shocks at an Industry Level: A Disaggregate Approach

Our dataset covers eleven industries which are classified as tradables or non-tradables. The traded sector is made up of five industries and the non-traded sector of six industries. In this subsection, we conduct our empirical analysis at a more disaggregate level. The objective is twofold. First, we investigate whether all industries classified as tradables or non-tradables behave homogeneously or heterogeneously. Second, we explore empirically which industry drives the responses of broad sectors following a 1 percentage point cut in corporate tax.

Empirical analysis at a disaggregate sectoral level. To conduct a decomposition of the sectoral effects at a sub-sector level, we estimate the responses of sub-sectors to the same identified coporate tax shock by adopting the two-step approach detailed in the main text. More specifically, indexing countries with i, time with t, sectors with j, and sub-sectors with k, we first identify the permanent shock to the corporate income tax rate, by estimating a VAR model which the import-share-weighted-average corporate income tax rate, τ_{it}, real GDP, total hours worked, the real consumption wage (all quantities are divided by the working age population and all variables are in rate of growth except the tax rate which is in variation) and next we generate responses from the VAR model.

To express the results in meaningful units, i.e., we multiply the responses of TFP of sub-sector k by the share of industry k in the value added of the broad sector j (at current prices), i.e., $\omega^{Y,k,j} = \frac{P^{k,j}Y^{k,j}}{P^j Y^j}$. We multiply the responses of hours worked within the broad sector j by its labor compensation share, i.e., $\alpha^{L,k,j} = \frac{W^{k,j}L^{k,j}}{W^j L^j}$. We detail below the mapping between the responses of broad sector's variables and responses of variables in sub-sector k of one broad sector j.

The response of $L^{k,j}$ to a corporate income tax shock is the percentage deviation of hours worked in sub-sector $k \in j$ relative to initial steady-state: $\ln L_t^{k,j} - \ln L^{k,j} \simeq \frac{dL_t^{k,j}}{L^{k,j}} = \hat{L}_t^{k,H}$ where $L^{k,j}$ is the initial steady-state. We assume that hours worked of the broad sector is an aggregate of sub-sector hours worked which are imperfect substitutes. Therefore, the response of hours worked in the broad sector $\hat{L}_t^j$ is a weighted average of the responses of hours worked $\frac{W^{k,j}L^{k,j}}{W^j L^j}\hat{L}_t^{k,j}$ where $\frac{W^{k,j}L^{k,j}}{W^j L^j}$ is the share of labor compensation of sub-sector

k in labor compensation of the broad sector j:

$$\begin{aligned}
\hat{L}_t^j &= \sum_{k\in j} \frac{W^{k,j}L^{k,j}}{W^jL^j}\hat{L}_t^{k,j}, \\
\frac{W^jL^j}{WL}\hat{L}_t^j &= \sum_{k\in j} \frac{W^{k,j}L^{k,j}}{WL}\hat{L}_t^j, \\
\alpha^{L,j}\hat{L}_t^j &= \sum_{k\in j} \alpha^{L,k}\hat{L}_t^{k,j}, \qquad (51)
\end{aligned}$$

where $\sum_j \sum_k \alpha^{L,k} = 1$. Above equation breaks down the response of hours worked in broad sector j into the responses of hours worked in sub-sectors $k \in j$ weighted by their labor compensation share $\alpha^{L,k} = \frac{W^{k,j}L^{k,j}}{W^jL^j}$ averaged over 1973-2017. In multiplying $\hat{L}_t^{k,j}$ by $\alpha^{L,k}$, we express the response of hours worked in sub-sector $k \in j$ in percentage point of hours worked in the broad sector $j = H, N$.

The response of TFP in the broad sector j is a weighted average of responses $\text{TFP}_t^{k,j}$ of TFP in sub-sector $k \in j$ where the weight collapses to the value added share of sub-sector k:

$$\begin{aligned}
\text{TFP}_t^{k,j} &= \sum_{k\in j} \frac{P^{k,j}Y^{k,j}}{P^jY^j}\hat{\text{TFP}}_t^{k,j}, \\
\text{TFP}_t^j &= \sum_{k\in j} \frac{P^{k,j}Y^{k,j}}{P^jY^j}\hat{\text{TFP}}_t^{k,j}, \\
\text{TFP}_t^j &= \sum_{k\in j} \omega^{Y,k,j}\hat{\text{TFP}}_t^{k,j}, \qquad (52)
\end{aligned}$$

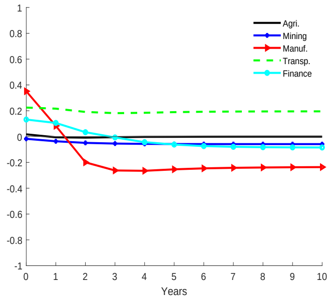
where $\omega^{Y,k,j} = \frac{P^{k,j}Y^{k,j}}{P^jY^j}$ averaged over 1973-2017 is the value added share at current prices of sub-sector $k \in j$ which collapses (at the initial steady-state) to the value added share at constant prices as prices at the base year are prices at the initial steady-state. Note that $\sum_k \sum_{k\in j} \omega^{Y,k,j} = 1$. In multiplying the response of value added at constant prices in sub-sector $k \in j$ by its value added share $\omega^{Y,k,j}$, we express the response of value added at constant prices in sub-sector $k \in j$ in percentage point of GDP.

The first column of Fig. 8 shows responses of TFP, hours worked, and value added for sub-sectors classified in the traded sector to a permanent cut in corporate taxation. The second column of Fig. 8 shows responses of TFP, hours worked, and value added for sub-sectors classified in the non-traded sector. All industries behave as the broad sector after a fall in profits' taxation as they all experience a permanent technology improvement, except 'Agriculature' and 'Transport and Communication' shown in the black line and the green line for which the rise in TFP vanishes in the long-run. More interestingly, the rise in traded TFP is driven by technology improvement in 'Manufacturing' because this sector accounts for the greatest value added share of the traded sector and also experiences a significant increase in TFP. With regard to non-traded industries, 'Real Estate, Renting, and Business Services' drives the rise in non-traded hours worked followed by 'Construction' and 'Wholesale and Retail Trade'. Hours worked doesn't increase for 'Community Social and Personal Services' (i.e., the public sector which also includes health and education services).

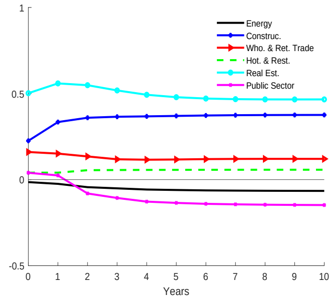
C.3 Alternative Measures of Technology

In this subsection, we conduct a robustness check with respect to the measure of utilization-adjusted TFP. We replace the measure of utilization-adjusted-TFP based on the Solow residual adjusted with the capital utilization rate obtained by applying the Imbs method with three alternative measures: i) Solow residual adjusted with the utilization rate from Basu [1996], ii) utilization-adjusted-TFP from Huo et al. [2023] and iii) Basu et al. [2006].

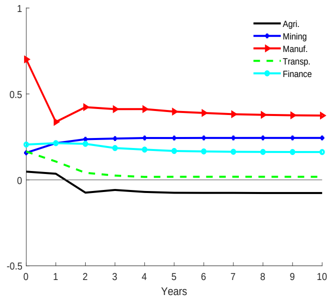
Basu's [1996] approach has the advantage of controlling for unobserved changes in both capital utilization and intensity of work effort while we control for the intensity in the use



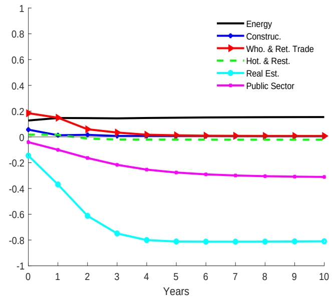
(a) Traded Hours Worked, L_{it}^{H}



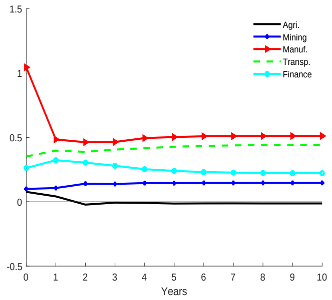
(b) Non-Traded Hours Worked, L_{it}^{N}



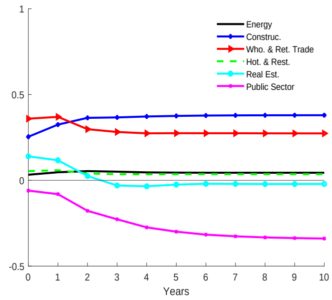
(c) Utilization-Adjusted-TFP of Tradables, T_{it}^{H}



(d) Utilization-Adjusted-TFP of Non-Tradables, T_{it}^{N}

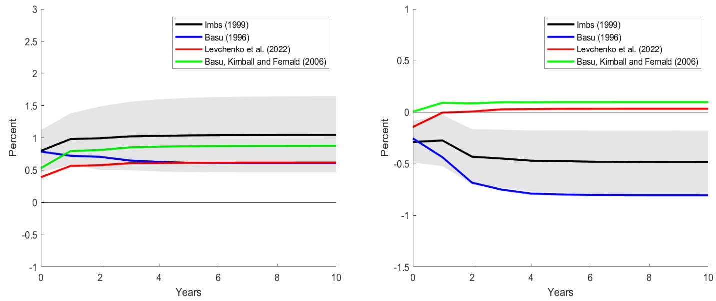


(e) Traded Value Added, Y_{it}^{H}



(f) Non-Traded Value Added, Y_{it}^{N}

Figure 8: Dynamic Effects of Corporate Tax Shocks at an Industry LevelNotes: Because the traded and non-traded sector are made up of industries, we conduct a decomposition of the sectoral effects at a sub-sector level following a an exogenous decrease in the corporrate tax rate by 1% in the long-run. Shaded areas indicate the 90 percent confidence bounds based on Newey-West standard errors. Horizontal axes indicate years. Vertical axes measure percentage deviation from trend. To express the results in meaningful units, i.e., total hours worked units, we multiply the responses of hours worked sub-sector k by its labor compensation share (in the traded sector of traded industries or in the non-traded sector for non-traded industries), i.e., $\frac{W^{k,j}L^{j,j}}{W^{j}L^{j}}$. The first column shows results for traded industries. For tradable industries: the black line shows results for 'Agriculture', the blue line for 'Mining and Quarrying', the red line for 'Manufacturing', the green line for 'Transport and Communication', and the light blue line for 'Financial Intermediation'. The second columns show results for sub-sectors classified in the non-traded sector. For non-tradable industries: the black line shows results for 'Electricity, Gas and Water Supply', the blue line for 'Construction', the red line for 'Wholesale and Retail Trade', the green line for 'Hotels and Restaurants', the cyan line for "Real Estate, Renting and Business Services" and the purple line is for 'Community Social and Personal Services' Sample: 11 OECD countries, 11 industries, 1973-2017, annual data.



(a) Utilization-Adjusted-TFP of Tradables, T_{it}^{H}

(b) Utilization-Adjusted-TFP of Non-Tradables, T_{it}^{N}

Figure 9: Effects Corporate Tax Shocks on Technology: Robustness Check w.r.t. Alternative Technology Measures<u>Notes</u>: We replace the measure of utilization adjusted TFP based on the Solow residual adjusted with the capital utilization rate obtained by applying the Imbs method with three alternative measures. Black line shows results when adjusting the Solow residual with the capital utilization rate constructed by adopting the methodology of Imbs [1999], the blue line shows results when using TFP adjusted with the production capacity utilization rate pioneered by Basu [1996]), the red line displays results when using utilization-adjusted-TFP time series from Huo et al. [2023], and the green line when using utilization-adjusted-TFP time series from Basu et al. [2006]. Sample: 11 OECD countries, 1973-2007 (for some countries, the time horizon is shorter). We dropped Luxembourg since data are not available for two technology measures, i.e., Huo et al. [2023] and Basu et al. [2006].

of capital only by adapting Imbs's [1999] method. Basu's [1996] approach is based on the ingenious idea that intermediate inputs do not have an extra effort or intensity dimension and thus variations in the use of intermediate inputs relative to measured capital and labor are an index of unmeasured capital and labor input. Fig. 9 shows that there is no significant differences between our own measure of technological change and that based on Basu's [1996]. Our measure based on Imbs [1999] is preferred as it is consistent with our modelling strategy where we adjust sectoral TFP with the capital utilization rate. We do not detect significant differences either when using utilization-adjusted-TFP from Huo et al. [2023] or the measure of technology by Basu et al. [2006]. In all cases, technology significantly improves in traded industries while technology is essentially unchanged in non-traded industries.

C.4 Wage Flexibility vs. Wage Rigidity: Hierarchical Cluster Tree Method

The literature categorizes the OECD countries into three groups Continental European countries, Scandinavian (Nordic) countries, and English-speaking (Anglo-Saxon) countries, see e.g., Faggio and Nickell [2019]. Continental European countries and Scandinavian countries have comparatively regulated and coordinated labor markets, but Scandinavian countries have more centralized bargaining power and a more generous unemployment benefit system. English-speaking countries have has less regulated and uncoordinated labor market relative to the other OECD countries.

However, factors underlying wage rigidity are not necessarily related to employment rigidity like firing costs. Dickens et al. [2007] show that unionization and collective bargaining coverage at the country level are positively related to wage rigidity. Du Caju et al. [2012] find empirically that wages are more rigid in sectors with predominant centralized wage-setting at the sector level as opposed to firm-level agreements. Druant et al. [2009] document evidence on European countries which show that the share of full time permanent workers increases wage stickiness. To split the sample into two groups of countries, we build on these empirical studies and we use the share of permanent contracts, the union density, the bargaining coverage, the centralization of wage bargaining which are negatively correlated with wage flexibility and ranks countries by adopting a hierarchical tree methodology.

Source: Time series for union density, the bargaining coverage, and the level of centralization in wage bargaining are taken from ICTWSS Database constructed by Visser [2019]. Data are available from 1973 to 2017 for the three labor market indicators for all countries. The variable (104 in the ICTWSS 6.1 code book) 'union density rate (UD)' is the net union membership as a proportion of wage and salary earners in employment. The variable (111 in the ICTWSS 6.1 code book) 'AdjCov' is Adjusted bargaining (or union) coverage rate

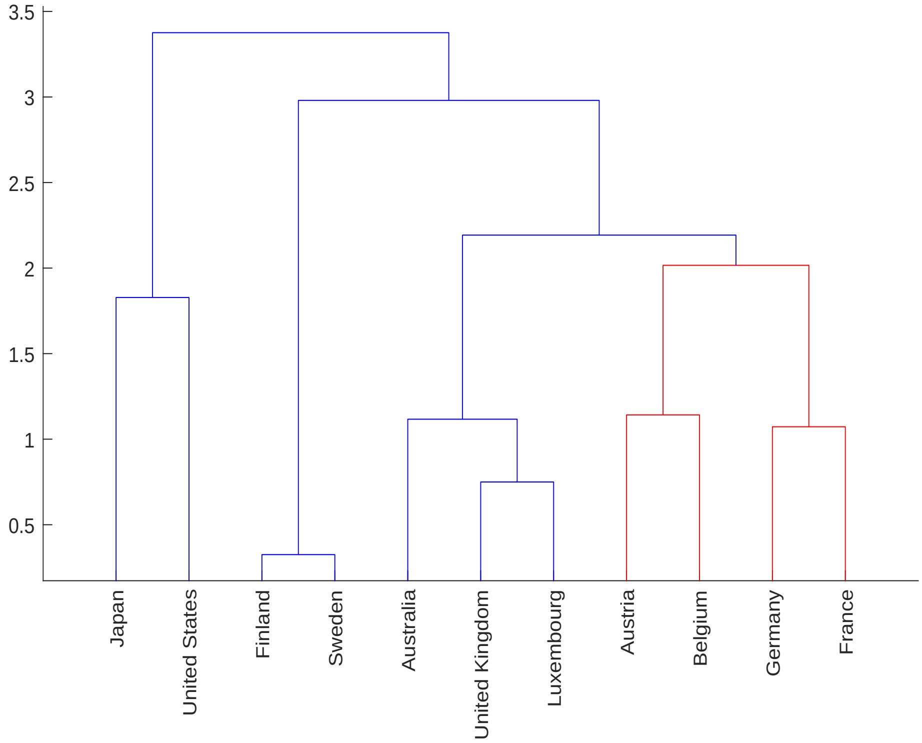


Figure 10: Clustering of Countries Based on Hierarchical Cluster Tree Method: Notes In Fig. 10, We adopt a hierarchical cluster tree method to cluster countries by using four labor market indicators: union density rate, adjusted bargaining coverage rate, the predominant level at which wage bargaining takes place (in terms of coverage of employees), and the share of permanent employment. Sample: 11 OECD countries, 1973-2017, annual data.

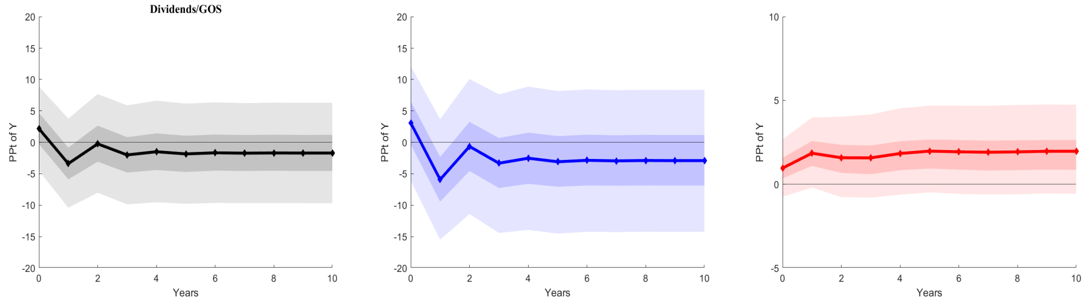
(0-100) which gives employees covered by valid collective (wage) bargaining agreements as a proportion of all wage and salary earners in employment with the right to bargaining, expressed as percentage, adjusted for the possibility that some sectors or occupations are excluded from the right to bargain. The variable (13 in the ICTWSS 6.1 code book) 'level' gives the predominant level at which wage bargaining takes place (in terms of coverage of employees). The indicator takes a value of 1 when bargaining predominantly takes place at the local or company level. The indicator takes a value of 5 when bargaining predominantly takes place at central or cross-industry level negotiated at lower levels.

Source: Time series for the share of permanent employment are taken from the dataset Incidence of permanent employment made available from the OECD. Data are available from 1985 to 2017 except for Australia (1998-2017), Austria (1995-2017), Finland (1997-2017), Sweden (1997-2017), United States (1995-2017). We use a linear interpolation to replace missing values.

The hierarchical cluster tree method is based on the idea that data points that are more similar to each other should be placed in the same cluster, while those that are less similar should be placed in separate clusters. In a hierarchical cluster tree, the height of the link represents the distance between the two clusters that include two countries. Our clustering provides valuable insights us with categorization of countries. Continental European countries (Austria, Belgium, Germany, and France) are closest to each other than the other countries. Scandinavian countries (Finland and Sweden) are most relative to each other.

C.5 Dividends

As stressed in the main text, we find that in English-speaking (including the U.S.) and Scandinavian countries, a corporate tax cut gives rise to permanent technology improvements which are concentrated in the traded sector while hours worked significantly increase only in the short-run. By using U.S. data, Cloyne et al. [2023] find that the goods-produced-sector increases both employment and investment following a corporate income tax cut while the service sector increases dividends instead of increasing employment. Because we find that hours does not increase persistently in the long-run in English-speaking and Scandinavian



(a) Dividend to GOS Ratio, $N = 11$ (b) Dividend to GOS Ratio, $N = 7$ (c) Dividend to GOS Ratio, $N = 4$

Figure 11: Dynamic Effects of a Corporate Tax Shock on Dividends Notes: Effects of an exogenous shock that gives rise to a 1 percentage point cut in the corporate tax rate. The solid line shows the response the dividend to gross operating surplus (GOS) to an exogenous decline in the corporate tax rate by 1% in the long-run. The solid line with diamonds shows the dynamic effects when we consider the whole sample of $N = 11$ OECD countries. Shaded areas indicate the 90 (68) percent confidence bounds obtained by bootstrap sampling. Horizontal axes indicate years. Vertical axes measure deviation from trend expressed in percentage point of GDP. The solid blue line displays results where we estimate the same VAR model for the flexible-wage-countries-group (i.e., $N = 7$) while the solid red line displays the effects for the rigid-wage-countries-group (i.e., $N = 4$). Sample: 11 OECD countries, 1973-2017, annual data..

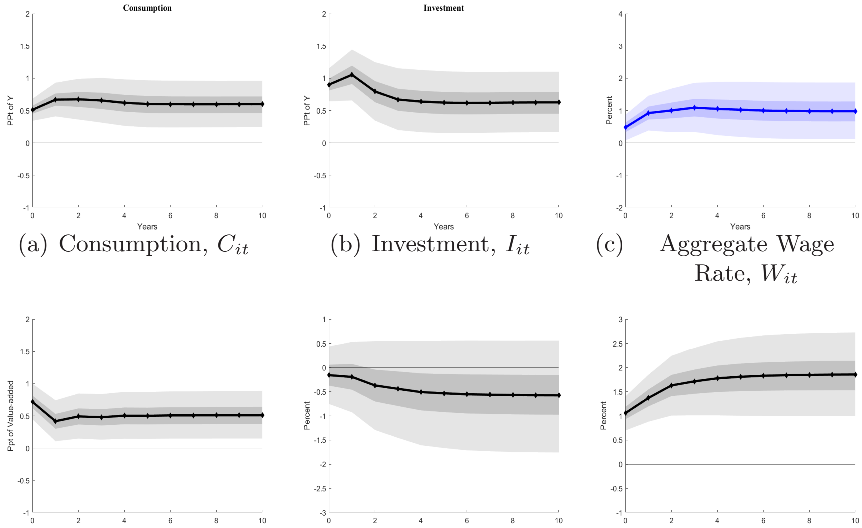
countries while technology does not improve in continental European countries, we check whether these results are not driven by the fact that the fall in profits' taxation leads firms to increase dividends instead of investing in R&D or hiring more workers.

To investigate the effect of a permanent tax cut on the ratio of dividend to gross operating surplus (GOS), we consider a panel SVAR which includes the international corporate tax rate, τ_{it}^{int}, investment as a share of GDP, and the ratio of dividend to GOS. Sample: Time series come form the OECD which provides data from 1973 to 2017 for a few countries and for most of the countries between 1995 and 2017. Table 9 displays the period for the dividend to gross operating surplus ratio for the eleven OECD countries. We consider both financial and non-financial corporations.

Our objective is to check whether a permanent decline in corporate taxation gives rise to a significant increase in dividends. Fig. 11 shows the dynamic response of the dividend to GOS ratio after a 1 ppt corporate income tax cut in the long-run for the whole sample (i.e., $N = 11$ OECD countries), as displayed in the black line with diamonds. The response is not significant and thus we can conclude that the change in the dividend policy cannot explain high and significant technology improvement we detect empirically. We have also conducted the same investigation for the two sub-groups of countries. The solid blue line displays results when we estimate the same VAR model for the flexible-wage-countries-group (i.e., $N = 7$) while the solid red line displays the effects for the rigid-wage-countries-group (i.e., $N = 4$). For English-speaking and Scandinavian countries, dividends remain unchanged, while for continental European countries, dividends slightly increase but the response is not statistically significant.

Table 9: Dividend to Gross Operating Surplus (GOS) Ratio Time Series: Data Availability

	Div. to GOS ratio
AUS	1973-2017
AUT	1995-2017
BEL	1995-2017
DEU	1995-2017
FIN	1975-2017
FRA	1993-2017
GBR	1995-2017
JPN	1994-2017
LUX	1995-2017
SWE	1973-2017
USA	1973-2017



(a) Consumption, C_{it} (b) Investment, I_{it} (c) Aggregate Wage Rate, W_{it}

(d) Ratio of Traded to Non-Traded Value Added, $(Y^H/Y^N)_{it}$ (e) Terms of Trade, P^H_{it} (f) Non-Traded Goods Prices, P^N_{it}

Figure 12: Dynamic Effects of a Corporate Tax Shock in OECD Countries ($N = 11$): More Empirical Results. Notes: The solid black line shows the response of aggregate and sectoral variables to an exogenous decline in corporate income taxation by 1 percentage point in the long-run. (Darker) Shaded areas indicate the 90 (68) percent confidence bounds based on bootstrap sampling. Horizontal axes indicate years. Vertical axes measure percentage deviation from trend. Sample: 11 OECD countries, 1973-2017, annual data.

C.6 Additional Empirical Results: Effects on R&D

In the main text, for reasons of space, we concentrate on the effects of a corporate tax cut on value added, hours, and utilization-adjusted-TFP. In this subsection, we show additional empirical results.

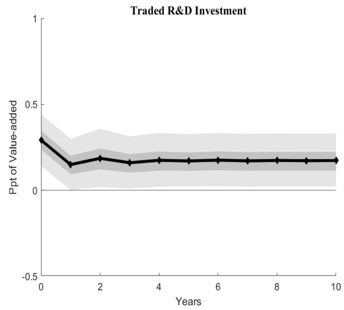
Aggregate Effects for $N = 11$ Countries. in Fig. 12, we show results for consumption, investment, the aggregate wage together with the terms of trade and non-traded-goods prices.

Table 10: Investment in R&D and Stocks of R&D: Data Availability

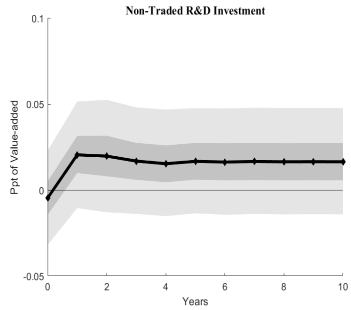
	$GFCF_{RD}$	K_{RD}
AUS	n.a.	n.a.
AUT	1995-2017	1995-2017
BEL	n.a.	1995-2017
DEU	1995-2017	1995-2017
FIN	1995-2017	1995-2017
FRA	1995-2017	1995-2017
GBR	1995-2017	1995-2017
LUX	1995-2017	1995-2017
JPN	1995-2017	1995-2017
SWE	1995-2017	1995-2017
USA	1995-2017	1995-2017

Effects on R&D for $N = 9, 10$ Countries. In Fig. 13, we investigate the impact of a permanent corporate tax cut by 1 ppt in the long-run on investment in R&D (for $N = 9$ countries due to limited data availability) and on the stock of R&D (for $N = 10$ countries) at a sectoral level.

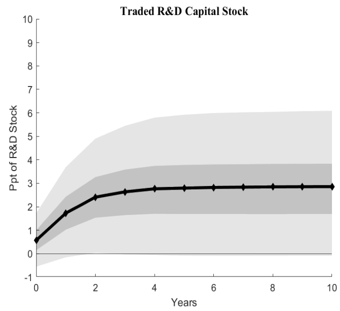
Source. We take data from EU KLEMS, Stehrer et al. [2019], which includes time series for gross fixed capital formation (GFCF) in volume in research and development (mnemonic Iq_RD) and time series for the capital stock in research and development, volume 2010 reference prices (mnemonic Kq_RD). Table 10 summarizes data availability. Data coverage for GFCF in R&D: 9 countries (AUT, DEU, FIN, FRA, GBR, JPN, LUX, SWE, and USA) over 1995-2017, annual data. Data coverage for capital stock in R&D:



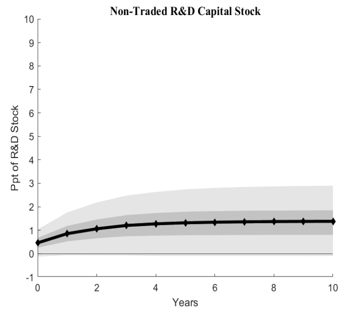
(a) R&D Investment in Tradables, $I_{it}^{Z,H}$



(b) R&D Investment in Non-Tradables, $I_{it}^{Z,N}$



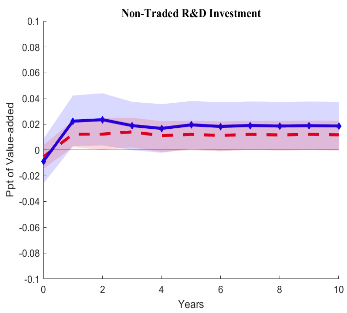
(c) R&D Stock in Tradables, $\mathcal{Z}_{it}^{H}$



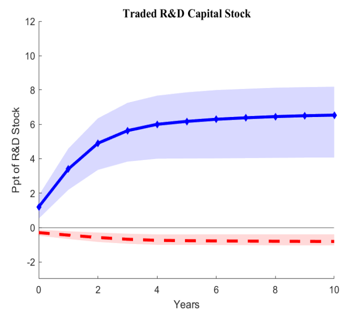
(d) R&D Stock in Non-Tradables, $\mathcal{Z}_{it}^{N}$

Figure 13: Dynamic Effects of a Corporate Tax Shock in OECD Countries ($N = 0, 10$) on R&D. Notes: The solid black line shows the response of aggregate and sectoral variables to an exogenous decline in corporate income taxation by 1 percentage point in the long-run. (Darker) Shaded areas indicate the 90 (68) percent confidence bounds based on bootstrap sampling. Horizontal axes indicate years. Vertical axes measure percentage deviation from trend. Sample: Capital stock (Gross Fixed Capital Formation, GFCF, in volume) in R&D in the traded and the non-traded sector, 10 (9) OECD countries, 1995-2017, annual data.

(a) R&D Investment in Tradables, $I_{it}^{Z,H}$



(b) R&D Investment in Non-Tradables, $I_{it}^{Z,N}$



(c) R&D Stock in Tradables, $\mathcal{Z}_{it}^{H}$

Figure 14: Dynamic Effects of a Corporate Tax Shock on R&D: International Differences. Notes: The solid black line shows the response of aggregate and sectoral variables to an exogenous decline in corporate income taxation by 1 percentage point in the long-run. Shaded areas indicate the 90 percent confidence bounds based on bootstrap sampling. The blue line refers to the point estimate for the flexible-wage-group of countries (i.e., English-speaking and Scandinavian countries) while the red line refers to the point estimate for the rigid-wage-group of countries (i.e., continental European countries). Horizontal axes indicate years. Vertical axes measure percentage deviation from trend. Vertical axes measure percentage deviation from trend. Sample: Capital stock (Gross Fixed Capital Formation, GFCF, in volume) in R&D in the traded and the non-traded sector, 4 (3) vs. 7 (6) OECD countries, 1995-2017, annual data.

10 countries (AUT, BEL, DEU, FIN, FRA, GBR, JPN, LUX, SWE, and USA) over 1995-2017, annual data. While no data is available for Australia, the difference between the two samples is that Belgium has data for the capital stock in R&D only.

International Differences in the Effects on R&D. Fig. 14 shows the dynamic responses of GFCF in R&D and the stock of R&D to a corporate tax cut by differentiating the effects between the English-speaking and Scandinavian countries on one hand and the continental European countries on the other.

C.7 Empirical Results Supporting our Country-Split

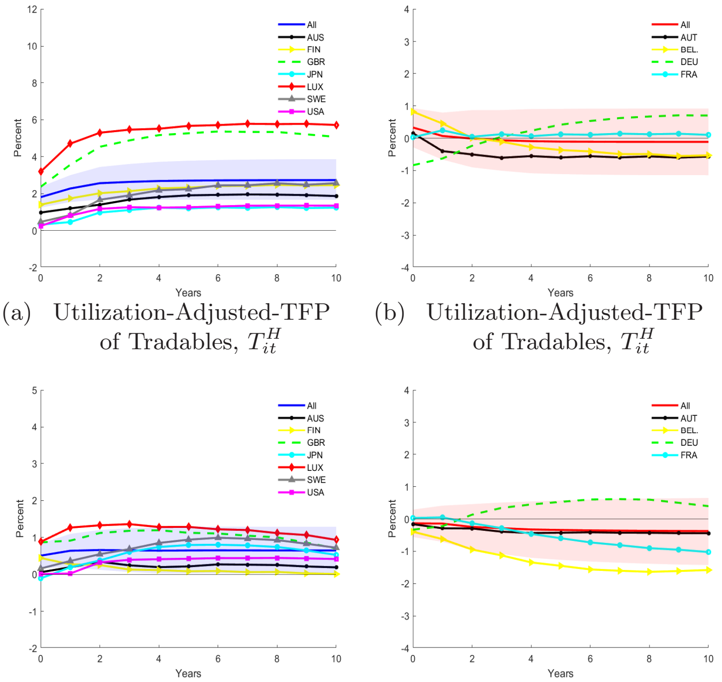
Before performing the country split, we have estimated a VAR model with long-run restrictions for one country at a time where the corporate tax rate is the cross-country average dynamic responses so that each country faces the same shock. We base our country split on one key dimension which is the extent of wage stickiness but we also take a second key dimension which is the significant and persistent technology improvement after a corporate income tax cut. In this subsection, we document a set of empirical findings which support our country-split.

Dynamic effects of corporate tax cut on technology improvement at country level. Fig. 15 shows the dynamic responses of utilization-adjusted-TFP of tradables (first row) and utilization-adjusted-aggregate-TFP (second row) for each sub-sample. The first column shows results for English-speaking and Scandinavian countries while the second column shows results for continental European countries. The blue line in Fig. 15(a) and Fig. 15(c) shows the point estimate from the VAR model estimated in panel data for the sub-sample made up of English-speaking and Scandinavian countries. The red line in Fig. 15(b) and Fig. 15(d) shows the point estimate from the VAR model estimated in panel data for the sub-sample made up of continental European countries. For each sub-sample, we have estimated the effects for one country at a time by estimating the same VAR model as in the main text except that the international measure of the corporate tax rate is the cross-country average of corporate tax rates. As can be seen in the first column of Fig. 15, a permanent decline in the corporate income tax rate generates a significant technology improvement in the traded sector and leads to a persistent increase in utilization-adjusted-aggregate-TFP. Inspection of Fig. 15(c) reveals that all countries' of this sub-sample experience a technology improvement. In contrast, As can be seen in the second column of Fig. 15, technology is at best unresponsive on impact for continental European countries. We may notice an exception for Germany which experiences a slight increase in utilization-adjusted-TFP of tradables in the long-run which is not statistically significant although technology declines sizeably on impact, see Fig. 15(b). A similar conclusion emerges from Fig. 15(d).

Dynamic effects of corporate tax cut on aggregate wages at country level. Fig. 16 shows the dynamic responses of the aggregate wage rate for each sub-sample. The first column shows results for English-speaking and Scandinavian countries while the second column shows results for continental European countries. Inspection of Fig. 16(a) reveals that all countries from the English-speaking and Scandinavian countries' group experience a rise in the wage rate on impact, except for the UK which experiences a gradual increase with persistent effects in the long-run. Conversely, while Finland experiences a significant increase in the short-run, the impact becomes insignificant in the long-run. Fig. 16(b) reveals that the response of the aggregate wage rate is muted on impact in the four continental European countries. We may notice that the aggregate wage rate slightly increases in Belgium and Germany in the long-run but both responses remain not statistically significant. We may also notice that the aggregate wage rate declines in the long-run in France.

C.8 Additional Empirical Results: Effects on Labor Income Shares

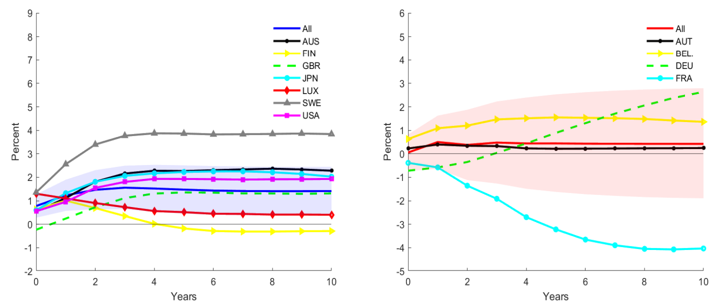
The estimates documented by Kaymak and Schott [2023] indicate that between 30% to 60% of the observed decline in labor income shares should be driven by the fall in corporate taxation due to the shift of the market share from labor- to capital-intensive industries. In



(a) Utilization-Adjusted-TFP of Tradables, T_{it}^{H} (b) Utilization-Adjusted-TFP of Tradables, T_{it}^{H}

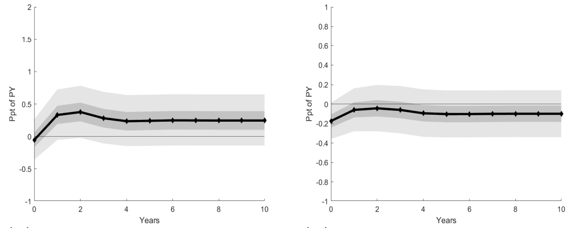
(c) Utilization-Adjusted-TFP of Tradables, T_{it}^{H} (d) Utilization-Adjusted-TFP of Tradables, T_{it}^{H}

Figure 15: Dynamic Effects of a Corporate Tax Shock on Technology: International Differences. Notes: The blue line in Fig. 15(a) and Fig. 15(c) shows the point estimate from the VAR model estimated in panel data for the sub-sample made up of English-speaking and Scandinavian countries. Other colored lines (black: Australia, yellow: Finland, dashed green: Great-Britain, cyan: Japan, red with diamonds: Luxembourg, grey: Sweden, magenta: United States) show impulse responses for each country which is part of this sub-sample. The red line in Fig. 15(b) and Fig. 15(d) shows the point estimate from the VAR model estimated in panel data for the sub-sample made up of continental European countries. Other colored lines (black: Austria, yellow with diamonds: Belgium, dashed green: Germany, cyan: France) show impulse responses for each country which is part of this sub-sample. The first row of Fig. 15 shows responses for utilization-adjusted-TFP of tradables and the second row shows dynamic responses for utilization-adjusted-aggregate-TFP. Horizontal axes indicate years. Vertical axes measure percentage deviation from trend. Vertical axes measure percentage deviation from trend. Sample: 11 OECD countries, 1970-2017, annual data.



(a) Aggregate Wage Rate, W_{it}^{A} (b) Aggregate Wage Rate, W_{it}^{A}

Figure 16: Dynamic Effects of a Corporate Tax Shock on Aggregate Wages: International Differences. Notes: All lines in Fig. 16 show dynamic responses for the aggregate wage rate. The blue line in Fig. 16(a) shows the point estimate from the VAR model estimated in panel data for the sub-sample made up of English-speaking and Scandinavian countries. Other colored lines (black: Australia, yellow: Finland, dashed green: Great-Britain, cyan: Japan, red with diamonds: Luxembourg, grey: Sweden, magenta: United States) show impulse responses for each country which is part of this sub-sample. The red line in Fig. 16(b) shows the point estimate from the VAR model estimated in panel data for the sub-sample made up of continental European countries. Other colored lines (black: Austria, yellow with diamonds: Belgium, dashed green: Germany, cyan: France) show impulse responses for each country which is part of this sub-sample. Horizontal axes indicate years. Vertical axes measure percentage deviation from trend. Vertical axes measure percentage deviation from trend. Sample: 11 OECD countries, 1970-2017, annual data.



(a) Traded Labor Income Share, $s^H_{L,it}$ (b) Non-Traded Labor Income Share, $s^N_{L,it}$

Figure 17: Dynamic Effects of a Corporate Tax Shock in OECD Countries ($N = 11$) on Sectoral Labor Income Shares. Notes: The solid black line shows the response of aggregate and sectoral variables to an exogenous decline in corporate income taxation by 1 percentage point in the long-run. (Darker) Shaded areas indicate the 90 (68) percent confidence bounds based on bootstrap sampling. Horizontal axes indicate years. Vertical axes measure percentage deviation from trend. Sample: 11 OECD countries, 1973-2017, annual data.

contrast to us, the authors concentrate on Manufacturing only. Fig. 17 shows the responses of the labor income shares in the traded and the non-traded sector to a permanent decline in corporate taxation. Our evidence reveals that both responses are muted and the decline in corporate income taxation does not have a significant impact on the labor income shares.

Table 11: Calibration of Dynamics of Symmetric and Asymmetric Technology Shocks

Parameters	Correlation between τ and τ^{int}	
	$\text{corr}(\tau_{it}, \bar{\tau}_t^{int})$	$\text{corr}(\tau_{it}, \tau_{it}^{int})$
	(1)	(2)
AUS	0.96	0.97
AUT	0.83	0.96
BEL	0.96	0.95
DEU	0.80	0.87
FIN	0.85	0.92
FRA	0.85	0.95
GBR	0.91	0.93
JPN	0.83	0.91
LUX	0.89	0.91
SWE	0.80	0.98
USA	0.76	0.88
OECD (11)	0.86	0.93

Notes: Column 1 shows the correlation between the country-level corporate income tax rate, τ_{it}, and the cross-country average tax rate, $\bar{\tau}_t^{int}$. Column 2 shows the correlation between the country-level corporate income tax rate, τ_{it}, and the import-share-weighted-average tax rates of trade partners of the home country, τ_{it}^{int}. The last row of the table 'OECD (11)' shows the country average.

D SVAR Identification: Robustness Checks

In this section, we conduct some robustness checks. In subsection D.1, we show some instantaneous correlations between the domestic corporate income tax rate and its international measure.

Our identification of corporate tax shocks is based on the assumption that time series for tax rates follow a unit root process. Because in the main text, all variables enter the VAR model in growth rate, we test this assumption in subsection D.2 which shows panel unit tests for all variables considered in the empirical analysis.

By using the property of a common downward trend in corporate taxation, we estimate a SVAR model where we replace the country-level corporate tax rate which displays an obvious endogeneity with the current economic activity with a measure of the intensity of tax competition which drives domestic corporate taxation and is defined as an import-share-weighted-average of trade partners' corporate tax rates. The country-level tax rate can be replaced with the international tax rate as long as it exists a permanent and common corporate income tax shock for the eleven OECD countries. This assumption can be easily tested with actual data, since it implies that the country-level tax rate and the international measure of corporate taxation share a common stochastic trend. In subsection D.3, we test whether the two variables are cointegrated.

The SVAR critique argues that the number of lags in estimating a SVAR is too short to identify consistently a permanent shock to technology. A similar critique could be addressed to the identification of a shock to corporate taxation as the lag truncation bias implies that persistent country-specific persistent demand shocks might contaminate the identification of permanent corporate income tax shocks. In subsection D.4, we run an exogeneity test which confirms that the shock to corporate taxation we identify are not contaminated by persistent demand shocks. In subsection D.5, to check the robustness of our results, we increase the number of lags from 2 to 5. For each variable, we compare the IRF of 2 lags with the three other IRFS by considering our initial confidence interval. In subsection D.6, we compare our results with the effects estimated from narratively-identified shocks.

D.1 Correlations between Country-Level and International Component of Corporate Income Tax Rates

Table 11 shows the correlation between the country-level corporate income tax rate, τ_{it}, and the cross-country average tax rate, $\bar{\tau}_t^{int}$. Column 2 shows the correlation between the country-level corporate income tax rate, τ_{it}, and the import-share-weighted-average tax rates of trade partners of the home country, τ_{it}^{int}.

D.2 Panel Unit Root Tests

Because all variables enter the VAR model in growth rates or in variations such as corporate income tax rates, in order to support our assumption of I(1) variables, we ran panel unit root tests displayed in Table 12. We consider four panel unit root tests among the most commonly used in the literature: Levin, Lin and Chu ([2002], hereafter LLC), Breitung [2000], Im, Pesaran and Shin ([2003], hereafter IPS), and Hadri [2000]. All tests, with the exception of Hadri [2000], consider the null hypothesis of a unit root against the alternative that some members of the panel are stationary. Additionally, they are designed for cross sectionally independent panels. LLC and IPS are based on the use of the Augmented Dickey-Fuller test (ADF hereafter) to each individual series of the form $\Delta x_{i,t} = \alpha_i + \rho_i x_{i,t-1} + \sum_{j=1}^{q_i} \theta_{i,j} \Delta x_{i,t-j} + \varepsilon_{i,t}$, where $\varepsilon_{i,t}$ are assumed to be i.i.d. (the lag length q_i is permitted to vary across individual members of the panel). Under the homogenous alternative the coefficient ρ_i in LLC is required to be identical across all units ($\rho_i = \rho$, $\forall i$). IPS relax this assumption and allow for ρ_i to be individual specific under the alternative hypothesis. MW propose a Fisher type test based on the p-values from individual unit root statistics (ADF for instance). Like IPS, MW allow for heterogeneity of the autoregressive root ρ_i under the alternative. We also apply the pooled panel unit root test developed by Breitung [2000] which does not require bias correction factors when individual specific trends are included in the ADF type regression. This is achieved by an appropriate variable transformation. As a sensitivity analysis, we also employ the test developed by Hadri [2000] which proposes a panel extension of the Kwiatkowski et al. [1992] test of the null that the time series for each cross section is stationary against the alternative of a unit root in the panel data. Breitung' and Hadri's tests, like LLC's test, are pooled tests against the homogenous alternative.[9]

As noted above, IPS test allows for heterogeneity of the autoregressive root, accordingly, we will focus intensively on these tests when testing for unit roots. Across all variables the null hypothesis of a unit root against the alternative of trend stationarity cannot be rejected at conventional significance levels, suggesting that the set of variables of interest are integrated of order one. When considering the Hadri's test for which the null hypothesis implies stationary against the alternative of a unit root in the panel data, we reach the same conclusion and conclude again that all series are nonstationary. Taken together, unit root tests applied to our variables of interest show that non stationarity is pervasive, suggesting that all variables should enter in the VAR models in growth rate.

[9] In all aforementioned tests and for all variables of interest, we allow for country-fixed effects. Appropriate lag length q_i is determined according to the Akaike criterion.

Table 12: Panel Unit Root Tests

	LLC		Breitung		IPS		Hadri	
	Stat.	p-value	Stat.	p-value	Stat.	p-value	Stat.	p-value
τ^c	-0.374	0.354	1.621	0.948	1.810	0.965	115.109	0.000
τ^{int}	-0.234	0.408	4.344	1.000	3.457	1.000	132.449	0.000
Y	-2.940	0.002	5.152	1.000	1.341	0.910	137.498	0.000
Y^T	-2.105	0.018	5.209	1.000	1.886	0.970	134.692	0.000
Y^N	-2.649	0.004	5.355	1.000	1.557	0.940	137.321	0.000
L	0.205	0.581	-0.719	0.236	-0.831	0.203	66.738	0.000
L^T	-3.903	0.000	3.266	0.999	0.639	0.739	133.844	0.000
L^N	2.429	0.992	3.802	1.000	4.488	1.000	118.663	0.000
TFP_{ADJ}	-6.066	0.000	3.774	1.000	-2.042	0.021	131.677	0.000
TFP^T_{ADJ}	-5.287	0.000	3.631	1.000	-0.927	0.177	135.298	0.000
TFP^N_{ADJ}	-3.290	0.001	2.247	0.988	-1.436	0.075	99.252	0.000
G	-2.627	0.004	5.803	1.000	0.961	0.832	133.073	0.000
C	-2.232	0.013	5.832	1.000	1.983	0.976	137.338	0.000
I	-0.242	0.404	3.865	1.000	2.024	0.979	139.024	0.000
P^N/P^T	-2.330	0.010	4.478	1.000	1.405	0.920	132.277	0.000
P^T/P^{T*}	-3.125	0.001	0.383	0.649	-2.527	0.006	79.136	0.000
P^N/P^{T*}	-1.620	0.053	3.297	1.000	1.939	0.974	123.205	0.000
s_L	-1.080	0.140	0.739	0.770	-1.353	0.088	90.021	0.000
s_L^T	0.843	0.800	1.209	0.887	0.170	0.568	90.712	0.000
s_L^N	-1.376	0.084	0.155	0.562	-1.417	0.078	84.638	0.000
T^T/Y^N	-0.057	0.477	2.350	0.991	1.031	0.849	98.278	0.000
Y^T/Y	-0.054	0.479	2.400	0.992	1.015	0.845	98.228	0.000
Y^N/Y	-0.047	0.481	2.271	0.988	1.071	0.858	98.308	0.000
W/P^{T*}	-3.792	0.000	3.136	0.999	-0.079	0.468	126.272	0.000
W^T/W	-1.533	0.063	1.740	0.959	-1.335	0.091	89.347	0.000
W^N/W	-4.398	0.000	1.701	0.956	-3.830	0.000	73.046	0.000
K^T_{RD}	-2.039	0.021	0.080	0.532	1.309	0.905	38.722	0.000
K^N_{RD}	-4.708	0.000	0.770	0.779	1.044	0.852	74.347	0.000

Notes: For LLC, Breitung and IPS, the null of a unit root is not rejected if p-value ≥ 0.05 at a 5% significance level. For Hadri, the null of stationarity is rejected if p-value ≤ 0.05 at a 5% significance level. All tests two lags in the Augmented Dickey-Fuller regressions.

D.3 Tests for Cointegrated Relationship between Country-Level and International Measure of Corporate Taxation

We check for the cross-sectional dependence to show that there is a standard shock that influences eleven countries. We test for weak cross-sectional dependence by applying the Pesaran [2015] test. It rejects the null hypothesis that errors are weakly cross-sectional dependent with CD = 40.82 and p-value = 0.000 for the country's corporate tax rate. Rejects the null hypothesis with CD = 48.16 and p-value = 0.000 for import share weighted corporate tax rate. This result implies that both series present cross-sectional dependence. Thus we have to apply unit root and cointegration tests that consider this dependence. Secondly, we test the unit root null hypothesis in panel data. The panel unit root hypothesis cannot be rejected for country-level corporate tax rates, and import share weighted corporate tax rates. Therefore there is a unit root and series are I(1). Since the international tax rate variables are I(1), we can have permanent shock. As the last step, we estimate the cointegration relationship between the two series. We run Westerlund [2007] panel cointegration tests to show the cointegration between a country's corporate tax rate and import share weighted corporate tax rate. Among the four stats of Westerlund [2007], three of them (Gt, Ga, Pa) reject the no cointegration null hypothesis. As Gt and Ga allow for some heterogeneity in the cointegration vector across individuals, we can conclude that there is a cointegration relationship between log country income corporate tax rate and log of import share weighted tax rate.

D.4 Exogeneity Test

Exogeneity tests. The identified corporate income tax shock should not in principle be correlated with other exogenous demand shifts nor with lagged endogenous variables. To

Table 13: Westerlund ECM panel cointegration tests for country corporate tax rate and import share weighted corporate tax rate

Statistic	Value	Z-value	P-value	Robust P-value
Gt	-2.265	-1.800	0.036	0.01
Ga	-8.678	-0.936	0.175	0.01
Pt	-6.096	-1.302	0.097	0.1
Pa	-6.040	-1.352	0.088	0.09

Notes: ^{a}, ^{b} and ^{c} denote significance at 1%, 5% and 10% levels. Heteroskedasticity and autocorrelation consistent t-statistics are reported in parentheses.

investigate whether the identified shows are really technology shocks is to test whether non-technology variables are correlated with the shocks. We consider three types of demand shocks: unanticipated temporary changes in taxation, in government spending, and in monetary policy. We identify three types of shocks by considering two different VAR models. Our identification of government spending shocks builds on Blanchard and Perotti [2002] and our identification of monetary policy shocks builds on Christiano et al. [2005]. We estimate a Vector Autoregression (VAR) which includes government consumption, real GDP, total hours worked, the real consumption wage, utilization-adjusted aggregate total factor productivity, and the short-term interest rate. For consistency reasons, we adjust the nominal interest rate with foreign prices as foreign goods and services are the numeraire in our model. All quantities are divided by the working age population. All variables enter the VAR model in log level except the interest rate which is in level. Like Blanchard and Perotti [2002], we base the identification scheme on the assumption that there are some delays inherent to the legislative system which prevents government spending from responding endogenously to contemporaneous output developments. We thus order government consumption before the other variables which amounts to adopting the standard Cholesky decomposition. Following Blanchard and Perotti [2002], we identify shocks to taxation by assuming that net taxes do not respond within the year to the other variables includes in the VAR model. To identify shocks related to tax revenues (denoted by ε_{it}^{T}), we estimate a VAR model where we replace government consumption with net taxes which are defined as taxes minus social security benefits paid by the general government (adjusted for inflation using the GDP deflator). We impose the same assumption as for the identification of government consumption shocks. Like Christiano et al. [2005], we identify monetary policy shocks as the innovation to the federal funds rate under a recursive ordering, with the policy rate ordered last. The ordering of the variables embodies the key identifying assumptions according to which the variables do not respond contemporaneously to a monetary policy shock, denoted by ε_{it}^{R}.

Source: Data availability is displayed by Table 14. Government final consumption expenditure (CGV), OECD Economic Outlook Database. The short-term interest rate based on three-month money market rates taken from OECD Economic Outlook Database. The nominal interest rate deflated by the price of foreign goods which is the numeraire in our model and thus we subtract the rate of change of the weighted average of the traded value added deflators of trade partners of the country i from the nominal interest rate. The period is 1973-2017.

Like in the main text, we identity shocks related to corporate taxes by estimating a VAR model which includes the international corporate tax rate, real GDP, total hours worked, and utilization-adjusted-TFP. Using annual data in a panel format, we run the regression of our identified shocks to corporate taxation ε_{it}^{τ}, on shocks to government spending, to short-term interest rates, and to tax revenue:

$$\varepsilon_{it}^{\tau} = d_i + \varepsilon_{it}^{G} + \varepsilon_{it}^{R} + \varepsilon_{it}^{T} + v_{it}, \tag{53}$$

where v_{it} is an i.i.d. error term; country fixed effects are captured by country dummies, d_i. Note that in estimating eq. (53), we add lagged values (we consider four lags) on explanatory variables which allow us to take into account for the persistence of the shocks.

Table 14: Interest Rates, Government Spending, and Net Taxes Time Series: Data Availability

	Interest Rate	Gov. Cons.	Net Taxes
AUS	1973-2017	1973-2017	1989-2017
AUT	1973-2017	1973-2017	1973-2017
BEL	1973-2017	1973-2017	1973-2017
DEU	1991-2017	1973-2017	1991-2017
FIN	1973-2017	1973-2017	1973-2017
FRA	1973-2017	1973-2017	1973-2017
GBR	1978-2016	1973-2016	1973-2016
JPN	1973-2015	1973-2015	1973-2015
LUX	1973-2017	1973-2017	1990-2017
SWE	1982-2017	1973-2017	1973-2017
USA	1973-2017	1973-2017	1973-2017

Table 15: Identified Permanent Corporate Tax Shock: Exogeneity Test

	Dependent Variable: ε^{τ}_{it}			
Explanatory Variable	ε^{G}_{it}	ε^{R}_{it}	$\varepsilon^{T_{it}}$	collectively
P-value for Exogeneity Test	0.7352	0.0246	0.8014	0.4431

Notes: The exogeneity F-test is based on a regression of the identified international corporate tax shock ε^{τ}_{it} it on fixed effects and current and four lags of government spending shocks (ϵ^{G}_{it}), monetary shocks (ϵ^{R}_{it}) and taxes shocks (ϵ^{T}_{it}). The null hypothesis is that all of the coefficients on explanatory variables are jointly equal to zero. If p-value $\geq$ 0.05 at a 5% significance level, the variables are not significant in explaining the identified corporate tax shock ε^{τ}_{it}.

The results of panel data estimations are presented in Table 15. To test the null hypothesis that all coefficients on explanatory variables are collectively equal to zero, we examine the p-value. If the p-value is greater than or equal to 0.05 at a 5% significance level, it indicates that the variables are not significant in explaining the identified corporate tax shock ε^{τ}_{it}. The F-test p-value of 0.443 indicates that none of the variables hold significance in explaining our identified corporate income tax shocks.

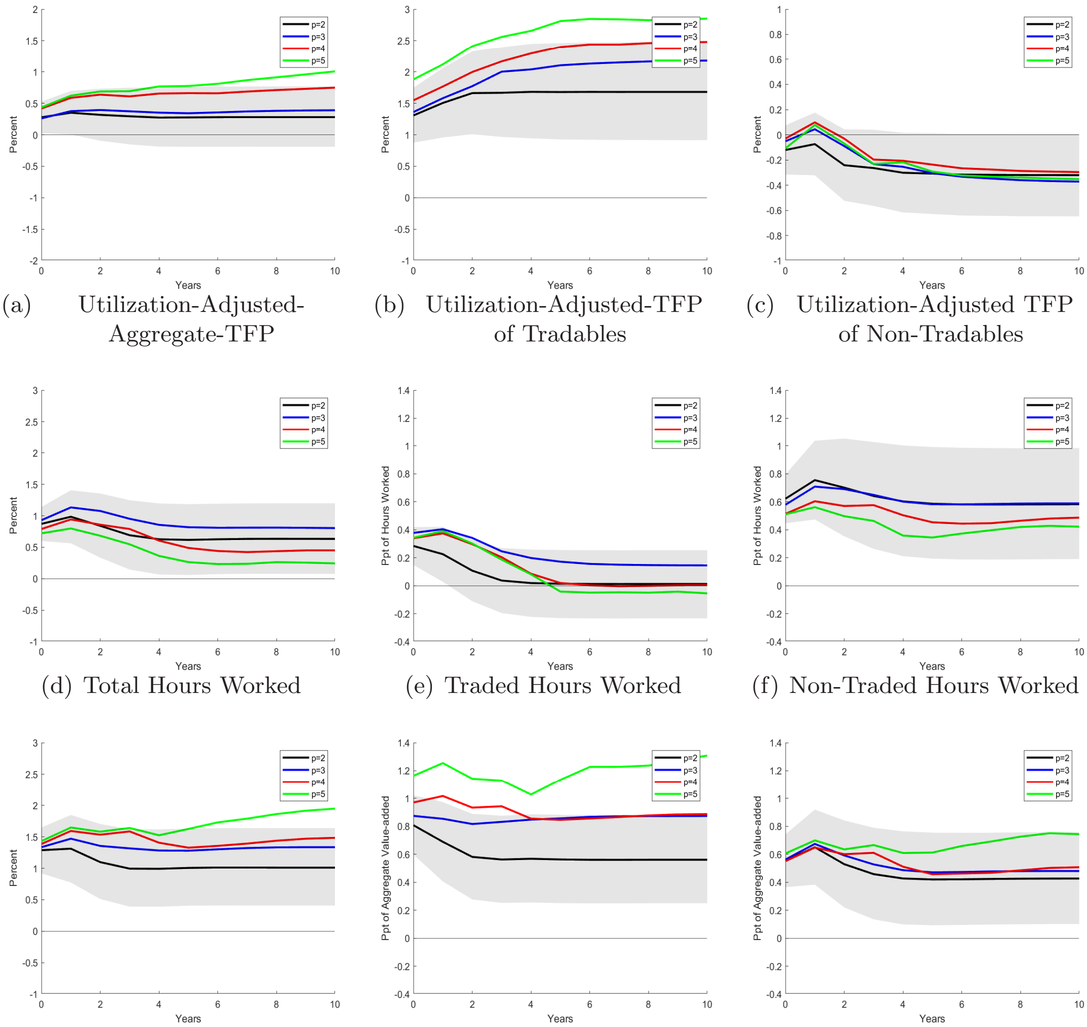
Table 16: Identified Permanent Corporate Tax Shock: Exogeneity Test

Explanatory Variable	Dependent Variable: ε^{τ}_{it}
ε^{G}_{it}	0.47 (.028)
ε^{R}_{it}	0.79 (.039)
$\varepsilon^{T_{it}}$	−0.96 (−.029)
P-value for Exogeneity Test	0.4431
Controls (4 lags on the explanatory variable)	yes
Country Fixed Effects	yes
Countries	8
Observations	295

Notes: t-statistics are reported in parentheses. ^{a}, ^{b} and ^{c} denote significance at 1%, 5% and 10% levels. The exogeneity F-test is based on a regression of the identified international corporate tax shock ε^{τ}_{it} it on fixed effects and current and four lags of government spending shocks (ϵ^{G}_{it}), monetary shocks (ϵ^{R}_{it}) and taxes shocks (ϵ^{T}_{it}). The null hypothesis is that all of the coefficients on explanatory variables are jointly equal to zero. If p-value $\geq$ 0.05 at a 5% significance level, the variables are not significant in explaining the identified corporate tax shock ε^{τ}_{it}.

D.5 The Number of Lags

Chari et al. [2008] recommend to increase the number of lags to avoid the identification of a permanent shock by means of the estimation of a VAR model with long-run restrictions being contaminated by persistent demand shocks. De Graeve and Westermark [2013] find that raising the number of lags may be a viable strategy to achieve identification when

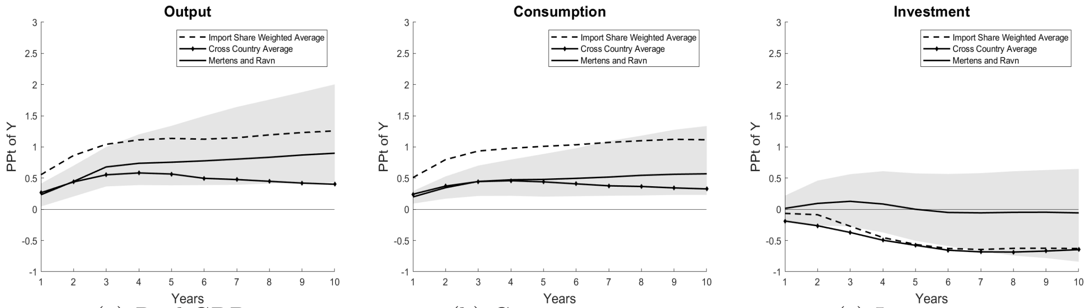


(a) Utilization-Adjusted-Aggregate-TFP
(b) Utilization-Adjusted-TFP of Tradables
(c) Utilization-Adjusted TFP of Non-Tradables
(d) Total Hours Worked
(e) Traded Hours Worked
(f) Non-Traded Hours Worked
(g) Real GDP
(h) Traded Value Added
(i) Non-Traded Value Added

Figure 18: Dynamic Effects of a Corporate Tax Shock: Robustness Check w.r.t. Lags Notes: The solid blue line shows the response of aggregate and sectoral variables to an exogenous decline in the corporate tax rate by 1% in the long-run. Shaded areas indicate the 90 percent confidence bounds. Horizontal axes indicate years. Vertical axes measure percentage deviation from trend. The baseline VAR model which allows for two lags is displayed by the solid black line. Whilst in the blue line we allow for three lags, in the red line we allow for four lags; in the green line, we allow for five lags. Sample: 11 OECD countries, 1973-2017, annual data.

long-run restrictions are imposed on the VAR model. Following this recommendation, we increase the number of lags from 2 to 5 when estimating the VAR models and contrast our estimates with two lags with those with a higher number of lags.

Fig. 18 shows the dynamic effects of a permanent decline in corporate taxation by 1 ppt in the long-run. The baseline VAR model which allows for two lags is displayed by the black line. In the blue line, we allow for three lags; in the red line, we allow for four lags; in the green line, we allow for five lags. Overall, all responses lie within the 90% confidence bounds of the original VAR model and all of our conclusions hold. More specifically, a permanent decline in corporate taxation gives rise to an increase in real GDP, total hours and utilization-adjusted-aggregate-TFP. While traded hours increase only in the short-run, non-traded hours rise persistently. Traded value added increases disproportionately relative to non-traded value added as a result of the high and significant technology improvement in the traded sector. We may notice some quantitative differences; increases of utilization-adjusted-TFP and value added of tradables tend be amplified as the numbers of lags increase. Otherwise, aggregate variables and non-traded sector variables remain unsensitive to the increase in the number of lags.



(a) Real GDP (b) Consumption (c) Investment

Figure 19: Dynamic Effects of a Corporate Tax Shock: SVAR Identification vs. Narratively-Identified Shocks Notes: Responses to an exogenous shock that gives rise to a 1 percentage point cut in the country's corporate tax rate. The solid line shows the response in real GDP, households' final consumption expenditure and gross fixed capital formation by firms to an exogenous decline in the corporate tax rate by 1% in the long-run when the exogenous shock is narratively-identified, as in Mertens and Ravn [2013]. The dashed line shows the dynamic effects when we estimate a VAR model where the import-share-weighted-average of trade partners' corporate income tax rates is ordered first. The solid line with diamonds displays results where we estimate the same VAR model but by using the country average corporate income tax rate. Shaded areas indicate the 90 percent confidence bounds obtained by bootstrap sampling. Horizontal axes indicate years. Vertical axes measure deviation from trend expressed in percentage point of GDP. Sample: United States, 1973-2006, annual data.

D.6 SVAR Identification vs. Narratively-Identified Corporate Income Tax Shocks: The United States Case

The existing literature investigating the effects of shocks to taxation, including variations in corporate income tax rates, consider narratively-identified tax shocks which are classified as exogenous and viewed as one-to-one mapping into the true structural shocks. Narratively-identified shocks to corporate taxation are only available for the United States. One interesting exercise is to contrast the dynamic effects we estimate after a permanent decline in the corporate income tax shock with the dynamic effects of narratively-identified corporate income tax shocks on the same variables by using the dataset from Mertens and Ravn [2013]. Mertens and Ravn [2013] investigate the impact of corporate tax rates by using narrative measure of corporate tax rate for the period between 1950 and 2006 with quarterly data. Their results indicate that a one percentage point cut in the average corporate tax rate increases real GDP per capita by 0.6 percent after one year, raises private sector investment, and has little effect on private consumption in the short run. We estimate a VAR model which identify corporate income tax shocks by using narrative measure, cross-country average tax rate and import-share-weighted-average tax rate. Fig. 19 shows the effects on real GDP, consumption, and investment.

The impulse response functions for real GDP and consumption are close to the results of Mertens and Ravn [2013]. GDP per capita increases by around 0.6 percent, and the rise in consumption is equivalent to a 0.5 percent point rise in GDP per capita. The cross-country average corporate tax rate gives the same results for the first two years for output and five years for consumption with the narrative measure. In the long-run, the cross-country average corporate tax rate underestimates the responses. Conversely, the import-share-weighted-average of corporate tax rates generates effects which are close to the point estimate obtained by using a narrative measure. In the long-run, the international tax measures lie within the 90% confidence bounds associated with the point estimate of the narrative measure. The response for the investment is zero for the narrative measure but negative for international tax rates. The differences between international tax rates and narrative measures may stem from the fact that the narrative measures are computed by summarizing the significant events of a potentially very large information set into account.

E Semi-Small Open Economy Model with Endogenous Technology Decisions

This Appendix puts forward an open economy version of the neoclassical model with tradables and non-tradables, imperfect mobility of inputs across sectors, adjustment costs and endogenous terms of trade. We assume that production functions take a Cobb-Douglas form and importantly, firms must decide about the optimal amount of tangible and intangible assets to rent. To produce a response of hours close to what we estimate empirically, we eliminate the wealth effect from labor supply by assuming Greenwood, Hercovitz and Huffman [1988] preferences; we also allow for time non-separability by introducing outward-looking consumption habits (i.e., external habits or 'catching-up' with the Joneses), see e.g., Carroll, Overland and Weil [2000].

Households accumulate both physical and intangible capital stocks in the economy and rent them out to firms in the production sector. Households supply labor, L, and must decide on the allocation of total hours worked between the traded sector, L^H, and the non-traded sector, L^N. They consume both traded, C^T, and non-traded goods, C^N. Traded goods are a composite of home-produced traded goods, C^H, and foreign-produced foreign (i.e., imported) goods, C^F. Households also choose investment in physical which is produced using inputs of the traded, J^T, and the non-traded good, J^N. As for consumption, input of the traded good to produce tangible investment goods is a composite of home-produced traded goods, J^H, and foreign imported goods, J^F. Households also choose investment in intangible capital which is produced by using domestic inputs only, i.e., J^Z is a composite of home-produced traded goods, $J^{Z,H}$, and non-traded goods, $J^{Z,N}$. The numeraire is the foreign good whose price, P^F, is thus normalized to one. We assume that services from labor, tangible and intangible assets are imperfect substitutes across sectors. While households choose the intensity in the use of the stock of physical capital, the optimal allocation of labor, tangible and intangible assets is determined by optimal conditions from firms' profit maximization.

E.1 Households

Consumption and consumption price index. At each instant the representative household consumes traded and non-traded goods denoted by $C^T(t)$ and $C^N(t)$, respectively, which are aggregated by means of a CES function:

$$C(t) = \left[\varphi^{\frac{1}{\phi}} \left(C^T(t)\right)^{\frac{\phi-1}{\phi}} + (1-\varphi)^{\frac{1}{\phi}} \left(C^N(t)\right)^{\frac{\phi-1}{\phi}}\right]^{\frac{\phi}{\phi-1}}, \tag{54}$$

where $0 < \varphi < 1$ is the weight of the traded good in the overall consumption bundle and ϕ corresponds to the elasticity of substitution between traded goods and non-traded goods. The traded consumption index $C^T(t)$ is defined as a CES aggregator of home-produced traded goods, $C^H(t)$, and foreign-produced traded goods, $C^F(t)$:

$$C^T(t) = \left[\left(\varphi^H\right)^{\frac{1}{\rho}} \left(C^H(t)\right)^{\frac{\rho-1}{\rho}} + \left(1-\varphi^H\right)^{\frac{1}{\rho}} \left(C^F(t)\right)^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}}, \tag{55}$$

where $0 < \varphi^H < 1$ is the weight of the home-produced traded good and ρ corresponds to the elasticity of substitution between home- and foreign-produced traded goods.

Given the above consumption indices, we can derive appropriate price indices. With respect to the general consumption index, we obtain the consumption-based price index P_C:

$$P_C = \left[\varphi \left(P^T\right)^{1-\phi} + (1-\varphi)\left(P^N\right)^{1-\phi}\right]^{\frac{1}{1-\phi}}, \tag{56}$$

where the price index for traded goods is:

$$P^T = \left[\varphi_H \left(P^H\right)^{1-\rho} + (1-\varphi_H)\right]^{\frac{1}{1-\rho}}. \tag{57}$$

Given the consumption-based price index (56), the representative household has the following demand of traded and non-traded goods:

$$C^T = \varphi \left(\frac{P^T}{P_C}\right)^{-\phi} C, \tag{58a}$$

$$C^N = (1-\varphi) \left(\frac{P^N}{P_C}\right)^{-\phi} C. \tag{58b}$$

Given the price indices (56) and (57), the representative household has the following demand of home-produced traded goods and foreign-produced traded goods:

$$C^H = \varphi \left(\frac{P^T}{P_C}\right)^{-\phi} \varphi_H \left(\frac{P^H}{P^T}\right)^{-\rho} C, \tag{59a}$$

$$C^F = \varphi \left(\frac{P^T}{P_C}\right)^{-\phi} (1-\varphi_H) \left(\frac{1}{P_T}\right)^{-\rho} C. \tag{59b}$$

As will be useful later, the percentage change in the consumption price index is a weighted average of percentage changes in the price of traded and non-traded goods in terms of foreign goods:

$$\hat{P}_C = \alpha_C \hat{P}^T + (1-\alpha_C)\, \hat{P}^N, \tag{60a}$$

$$\hat{P}^T = \alpha_H \hat{P}^H, \tag{60b}$$

where α_C is the tradable content of overall consumption expenditure and α^H is the home-produced goods content of consumption expenditure on traded goods:

$$\alpha_C = \varphi \left(\frac{P^T}{P_C}\right)^{1-\phi}, \tag{61a}$$

$$1-\alpha_C = (1-\varphi) \left(\frac{P^N}{P_C}\right)^{1-\phi}, \tag{61b}$$

$$\alpha^H = \varphi_H \left(\frac{P^H}{P^T}\right)^{1-\rho}, \tag{61c}$$

$$1-\alpha^H = (1-\varphi_H) \left(\frac{1}{P^T}\right)^{1-\rho}. \tag{61d}$$

Labor supply and aggregate wage index. The representative household supplies labor to the traded and non-traded sectors, denoted by $L^H(t)$ and $L^N(t)$, respectively. To put frictions into the movement of labor between the traded sector and the non-traded sector, we assume that sectoral hours worked are imperfect substitutes, in lines with Horvath [2000]:

$$L(t) = \left[\vartheta_L^{-1/\epsilon_L} \left(L^H(t)\right)^{\frac{\epsilon_L+1}{\epsilon_L}} + (1-\vartheta_L)^{-1/\epsilon_L} \left(L^N(t)\right)^{\frac{\epsilon_L+1}{\epsilon_L}}\right]^{\frac{\epsilon_L}{\epsilon_L+1}}, \tag{62}$$

where $0 < \vartheta_L < 1$ parametrizes the weight attached to the supply of hours worked in the traded sector and ϵ_L is the elasticity of substitution between sectoral hours worked.

The aggregate wage index, W, associated with the CES aggregator of sectoral hours defined above (62), is:

$$W = \left[\vartheta_L \left(W^H\right)^{\epsilon_L+1} + (1-\vartheta_L) \left(W^N\right)^{\epsilon_L+1}\right]^{\frac{1}{\epsilon_L+1}}, \tag{63}$$

where W^H and W^N are wages paid in the traded and the non-traded sectors, respectively.

Given the aggregate wage index and the aggregate capital rental rate, the allocation of aggregate labor supply and the aggregate capital stock to the traded and the non-traded sector reads:

$$L^H = \vartheta_L \left(\frac{W^H}{W}\right)^{\epsilon_L} L, \quad L^N = (1-\vartheta_L) \left(\frac{W^N}{W}\right)^{\epsilon_L} L. \tag{64}$$

As will be useful later, the percentage change in the aggregate wage index defined as a weighted average of percentage changes in sectoral wages:

$$\hat{W} = \alpha_L \hat{W}^H + (1 - \alpha_L) \hat{W}^N, \tag{65}$$

where α_L is the tradable content of labor compensation:

$$\alpha_L = \vartheta_L \left(\frac{W^H}{W} \right)^{1+\epsilon_L}, \quad 1 - \alpha_L = (1 - \vartheta_L) \left(\frac{W^N}{W} \right)^{1+\epsilon_L}, \tag{66}$$

Physical Capital and aggregate rental rate of physical capital. Like labor, we generate imperfect capital mobility by assuming that traded $K^H(t)$ and non-traded $K^N(t)$ capital stock are imperfect substitutes:

$$K(t) = \left[\vartheta_K^{-1/\epsilon_K} \left(K^H(t) \right)^{\frac{\epsilon_K+1}{\epsilon_K}} + (1 - \vartheta_K)^{-1/\epsilon_K} \left(K^N(t) \right)^{\frac{\epsilon_K+1}{\epsilon}} \right]^{\frac{\epsilon_K}{\epsilon_K+1}}, \tag{67}$$

where $0 < \vartheta_K < 1$ is the weight of capital supply to the traded sector in the aggregate capital index $K(.)$ and ϵ_K measures the ease with which sectoral capital can be substituted for each other and thereby captures the degree of capital mobility across sectors.

The aggregate capital rental rate, R^K, associated with the aggregate capital index defined above (67) is:

$$R^K = \left[\vartheta_K \left(R^{K,H} \right)^{\epsilon_K+1} + (1 - \vartheta_K) \left(R^{K,N} \right)^{\epsilon_K+1} \right]^{\frac{1}{\epsilon_K+1}}, \tag{68}$$

where $R^{K,H}$ and $R^{K,N}$ are capital rental rates paid in the traded and the non-traded sectors, respectively.

Given the aggregate wage index and the aggregate capital rental rate, the allocation of aggregate labor supply and the aggregate capital stock to the traded and the non-traded sector reads:

$$K^H = \vartheta_K \left(\frac{R^{K,H}}{R} \right)^{\epsilon_K} K, \quad K^N = (1 - \vartheta_K) \left(\frac{R^{K,N}}{R} \right)^{\epsilon_K} K, \tag{69}$$

As will be useful later, the percentage change in the aggregate return index capital is a weighted average of percentage changes in sectoral capital rental rates:

$$\hat{R}^K = \alpha_K \hat{R}^{K,H} + (1 - \alpha_K) \hat{R}^{K,N}, \tag{70}$$

where α_K is the tradable content of capital compensation:

$$\alpha_K = \vartheta_K \left(\frac{R^{K,H}}{R^K} \right)^{1+\epsilon_K}, \quad 1 - \alpha_K = (1 - \vartheta_K) \left(\frac{R^{K,N}}{R^K} \right)^{1+\epsilon_K}. \tag{71}$$

Stock of ideas and aggregate rental rate of ideas. Like labor and tangible assets, we allow for imperfect mobility of intangible assets by assuming that traded $Z^H(t)$ and non-traded $Z^N(t)$ stock of ideas are imperfect substitutes:

$$Z^A(t) = \left[\vartheta_Z^{-1/\epsilon_Z} \left(Z^H(t) \right)^{\frac{\epsilon_Z+1}{\epsilon_Z}} + (1 - \vartheta_Z)^{-1/\epsilon_Z} \left(Z^N(t) \right)^{\frac{\epsilon_Z+1}{\epsilon}} \right]^{\frac{\epsilon_Z}{\epsilon_Z+1}}, \tag{72}$$

where $0 < \vartheta_Z < 1$ is the weight of traded intangible assets and ϵ_Z measures the ease with which sectoral intangible assets can be substituted for each other and thereby captures the degree of mobility of ideas across sectors.

Given the aggregate rental rate for intangible assets, R^Z, the allocation of the stock of knowledge to the traded and the non-traded sector reads:

$$Z^H = \vartheta_Z \left(\frac{R^{Z,H}}{R^Z} \right)^{\epsilon_Z} Z^A, \quad Z^N = (1 - \vartheta_Z) \left(\frac{R^{Z,N}}{R^Z} \right)^{\epsilon_Z} Z^A. \tag{73}$$

As will be useful later, the percentage change in the aggregate rental rate of intangible assets is a weighted average of percentage changes in sectoral rental rates:

$$\hat{R}^Z = \alpha_Z \hat{R}^{Z,H} + (1-\alpha_Z)\,\hat{R}^{Z,N}, \tag{74}$$

where α_Z is the tradable content of the aggregate income from intangible assets:

$$\alpha_Z = \vartheta_Z \left(\frac{R^{Z,H}}{R^Z}\right)^{1+\epsilon_Z}, \quad 1-\alpha_Z = (1-\vartheta_Z)\left(\frac{R^{Z,N}}{R^Z}\right)^{1+\epsilon_Z}. \tag{75}$$

GHH Preferences with consumption habits. The representative agent is endowed with one unit of time, supplies a fraction $L(t)$ as labor, and consumes the remainder $1-L(t)$ as leisure. Denoting the time discount rate by $\beta > 0$, at any instant of time, households derive utility from their consumption and experience disutility from working and maximize the following objective function:

$$\mathcal{U} = \int_0^\infty \Lambda\left(C(t), S(t), L(t)\right) e^{-\beta t}\mathrm{d}t, \tag{76}$$

where we consider the utility specification proposed by Greenwood, Hercowitz and Huffman (GHH thereafter) [1988]:

$$\Lambda\left(C,S,L\right) \equiv \frac{X^{1-\sigma}-1}{1-\sigma}, \quad X\left(C,S,L\right) \equiv CS^{-\gamma_S} - \frac{\sigma_L}{1+\sigma_L}\gamma_L L^{\frac{1+\sigma_L}{\sigma_L}}, \tag{77}$$

where S is the stock of habits. We consider GHH [1988] preferences so as to eliminate the wealth effect in the household's labor supply decision.

Consumption habits. The habitual standard of living is defined as a distributed lag over past consumption:

$$S(t) = \delta_S \int_{-\infty}^t C\left(\tau\right) e^{-\delta_S(t-\tau)}\mathrm{d}\tau, \qquad \delta_S > 0. \tag{78}$$

where the parameter δ_S indexes the relative weight of recent consumption in determining the reference stock $S(t)$. Differentiating equation (78) with respect to time gives the law of motion of the stock of habits:

$$\dot{S}(t) = \delta_S\left[C(t) - S(t)\right]. \tag{79}$$

According to this specification, the reference stock is defined as an exponentially declining weighted average of past economy-wide levels of consumption. Intuitively, the larger δ_S is, the greater the weight of consumption in the recent past in determining the stock of habits, and the faster the reference stock S adjusts to current consumption.

Agents derive utility from a geometric weighted average of absolute and relative consumption where γ_S is the weight of relative consumption:

$$U\left(C(t), S(t)\right) = C(t)^{\gamma_S}\left(\frac{C(t)}{S(t)}\right)^{1-\gamma_S}. \tag{80}$$

If $\gamma_S = 0$, the case of time separability in preferences obtains. Hence, the intertemporal marginal rate of substitution between consumption at date $t+1$ and consumption at date t does not depend on consumption at other dates, which implies a fixed rate of time preference along a constant consumption path outside the steady-state. Faced with a positive income shock, habit-forming agents find it optimal to increase their consumption only moderately in the short-run, and thereby to save to sustain their higher standard of living.

As shall be useful below, we write down the partial derivatives of $X = X\left(C,S,L\right)$ (see eq. (77)):

$$X_C = S^{-\gamma_S}, \tag{81a}$$

$$X_{CC} = 0, \tag{81b}$$

$$X_S = -C\gamma_S S^{-(\gamma_S+1)} < 0, \tag{81c}$$

$$X_{SS} = \gamma_S\left(\gamma_S+1\right)CS^{-(\gamma_S+2)} > 0, \tag{81d}$$

$$X_{SC} = -\gamma_S S^{-(\gamma_S+1)} < 0, \tag{81e}$$

$$X_L = -\gamma_L L^{\frac{1}{\sigma_L}} < 0, \tag{81f}$$

$$X_{LL} = -\frac{\gamma_L}{\sigma_L} L^{\frac{1}{\sigma_L}-1} < 0, \tag{81g}$$

and the partial derivatives of $\Lambda = \Lambda((C,S,L)$ (see eq. (77)):

$$\Lambda_C = X^{-\sigma}X_C, \tag{82a}$$

$$\Lambda_{CC} = -\sigma X^{-(\sigma+1)}\left(X_C\right)^2, \tag{82b}$$

$$\Lambda_S = X^{-\sigma}X_S, \tag{82c}$$

$$\Lambda_{SS} = -\sigma X^{-(\sigma+1)}\left(X_S\right)^2 + X^{-\sigma}X_{SS}, \tag{82d}$$

$$\Lambda_{SC} = -\sigma X^{-(\sigma+1)}X_S X_C + X^{-\sigma}X_{SC}, \tag{82e}$$

$$\Lambda_L = X^{-\sigma}X_L, \tag{82f}$$

$$\Lambda_{LL} = -\sigma X^{-(\sigma+1)}\left(X_L\right)^2 + X^{-\sigma}X_{LL}, \tag{82g}$$

$$\Lambda_{CL} = -\sigma X^{-(\sigma+1)}X_C X_L, \tag{82h}$$

$$\Lambda_{SL} = -\sigma X^{-(\sigma+1)}X_S X_L, \tag{82i}$$

where $\Lambda_Z = \frac{\partial\Lambda}{\partial Z}$ with $Z = C, S, L$.

Capital and technology utilization adjustment costs. We assume that the households own tangible $K^j(t)$ and intangible assets $Z^j(t)$ and lease both services from tangible and intangible assets to firms in sector j at rental rate $R^{K,j}(t)$ and $R^{Z,j}(t)$, respectively. Thus income from leasing activity received by households reads:

$$\sum_j \left(R^{K,j}(t)u^{K,j}(t)K^j(t) + R^{Z,j}(t)u^{Z,j}(t)Z^j(t)\right),$$

where we assume that households also choose the intensity $u^{K,j}(t)$ and $u^{Z,j}(t)$ in the use of the physical capital stock and in the stock of knowledge, respectively, like Bianchi et al. [2019]. Both the capital $u^{K,j}(t)$ and the technology utilization rate $u^{Z,j}(t)$ collapse to one at the steady-state. We let the functions $C^{K,j}(t)$ and $C^{Z,j}(t)$ denote the adjustment costs associated with the choice of capital and technology utilization rates, which are increasing and convex functions of utilization rates:

$$C^{K,j}(t) = \xi_1^j\left(u^{K,j}(t)-1\right) + \frac{\xi_2^j}{2}\left(u^{K,j}(t)-1\right)^2, \tag{83a}$$

$$C^{Z,j}(t) = \chi_1^j\left(u^{Z,j}(t)-1\right) + \frac{\chi_2^j}{2}\left(u^{Z,j}(t)-1\right)^2, \tag{83b}$$

where $\xi_2^j > 0$, $\chi_2^j > 0$ are free parameters; as $\xi_2^j \to \infty$, $\chi_2^j \to \infty$, utilization is fixed at unity.

Budget constraint. Households supply labor services to firms in sector j at a wage rate $W^j(t)$. Thus labor income received by households reads $\sum_j W^j(t)L^j(t)$. Households can accumulate internationally traded bonds (expressed in foreign good units), $N(t)$, that yield net interest rate earnings of $r^\star N(t)$. Denoting lump-sum taxes by $T(t)$, households' flow budget constraint states that real disposable income can be saved by accumulating traded bonds, consumed, $P_C(t)C(t)$, invested in tangible assets, $P_J^K(t)J^K(t)$, invested in intangible assets, $P_J^Z(t)J^Z(t)$, and covers capital and technology utilization costs:

$$\dot{N}(t) + P_C(t)C(t) + P_J^K(t)J^Kt) + P_J^Z(t)J^Z(t) + \sum_{j=H,N} P^j(t)\left(C^{K,j}(t)\nu^{K,j}(t)K(t) + C^{Z,j}(t)\nu^{Z,j}(t)Z^A(t)\right)$$

$$= r^\star N(t) + W(t)L(t) + R^K(t)K(t)\sum_{j=H,N}\alpha_K^j(t)u^{K,j} + R^Z(t)Z^A(t)\sum_{j=H,N}\alpha_Z^j(t)u^{Z,j} - T(t),$$

where we denote the share of sectoral tangible (intangible) assets in the aggregate stock of capital (knowledge) by $\nu^{K,j}(t) = K^j(t)/K(t)$ ($\nu^{Z,j}(t) = Z^j(t)/Z(t)$), and the compensation share of sector $j = H, N$ by $\alpha_K^j(t) = \frac{R^{K,j}(t)K^j(t)}{R^K(t)K(t)}$ ($\alpha_Z^j(t) = \frac{R^{Z,j}(t)Z^j(t)}{R^Z(t)Z(t)}$) for capital (ideas). As shall be useful, we denote the labor compensation share by $\alpha_L^j(t) = \frac{W^j(t)L^j(t)}{W(t)L(t)}$.

Investment in tangible assets. The investment good is (costlessly) produced using inputs of the traded good and the non-traded good by means of a CES technology:

$$J^K(t) = \left[\varphi_K^{\frac{1}{\phi_K}} \left(J^T(t)\right)^{\frac{\phi_K - 1}{\phi_K}} + (1-\varphi_K)^{\frac{1}{\phi_K}} \left(J^N(t)\right)^{\frac{\phi_K-1}{\phi_K}}\right]^{\frac{\phi_K}{\phi_K-1}}, \tag{85}$$

where $0 < \varphi_K < 1$ is the weight of the investment traded input and ϕ_K corresponds to the elasticity of substitution between investment traded goods and investment non-traded goods. The index $J^T(t)$ is defined as a CES aggregator of home-produced traded inputs, $J^H(t)$, and foreign-produced traded inputs, $J^F(t)$:

$$J^T(t) = \left[\left(\iota^H\right)^{\frac{1}{\rho_K}} \left(J^H(t)\right)^{\frac{\rho_K-1}{\rho_K}} + \left(1-\iota^H\right)^{\frac{1}{\rho_K}} \left(J^F(t)\right)^{\frac{\rho_K-1}{\rho_K}}\right]^{\frac{\rho_K}{\rho_K-1}}, \tag{86}$$

where $0 < \iota^H < 1$ is the weight of the home-produced traded input and ρ_K corresponds to the elasticity of substitution between home- and foreign-produced traded inputs.

Law of motion for tangible assets and installation costs for physical capital. Installation of new investment goods involves convex costs, assumed to be quadratic. Thus, total investment $J^K(t)$ differs from effectively installed new capital:

$$J^K(t) = I^K(t) + \frac{\kappa}{2}\left(\frac{I^K(t)}{K(t)} - \delta_K\right)^2 K(t), \tag{87}$$

where the parameter $\kappa > 0$ governs the magnitude of adjustment costs to capital accumulation. Partial derivatives of total investment expenditure are:

$$\frac{\partial J(t)}{\partial I(t)} = 1 + \kappa\left(\frac{I(t)}{K(t)} - \delta_K\right), \tag{88a}$$

$$\frac{\partial J(t)}{\partial K(t)} = -\frac{\kappa}{2}\left(\frac{I(t)}{K(t)} - \delta_K\right)\left(\frac{I(t)}{K(t)} + \delta_K\right). \tag{88b}$$

Denoting the fixed capital depreciation rate by $0 \leq \delta_K < 1$, aggregate investment, $I^K(t)$, gives rise to capital accumulation according to the dynamic equation:

$$\dot{K}(t) = I^K(t) - \delta_K K(t). \tag{89}$$

Given the CES aggregator functions above, we can derive the appropriate price indices for investment. With respect to the general investment index, we obtain the investment-based price index P_J:

$$P_J^K = \left[\iota\left(P_J^T\right)^{1-\phi_K} + (1-\iota)\left(P^N\right)^{1-\phi_K}\right]^{\frac{1}{1-\phi_K}}, \tag{90}$$

where the price index for traded goods is:

$$P_J^T = \left[\iota^H\left(P^H\right)^{1-\rho_K} + \left(1-\iota^H\right)\right]^{\frac{1}{1-\rho_K}}. \tag{91}$$

Given the investment-based price index (90), we can derive the demand for inputs of the traded good and the non-traded good:

$$J^T = \iota\left(\frac{P_J^T}{P_J^K}\right)^{-\phi_K} J^K, \tag{92a}$$

$$J^N = (1-\iota)\left(\frac{P^N}{P_J^K}\right)^{-\phi_K} J^K. \tag{92b}$$

Given the price indices (90) and (91), we can derive the demand for inputs of home-produced traded goods and foreign-produced traded goods:

$$J^H = \iota \left(\frac{P_J^T}{P_J^K}\right)^{-\phi_K} \iota^H \left(\frac{P^H}{P_J^T}\right)^{-\rho_K} J^K, \tag{93a}$$

$$J^F = \iota \left(\frac{P_J^T}{P_J^K}\right)^{-\phi_K} \left(1-\iota^H\right) \left(\frac{1}{P_J^T}\right)^{-\rho_K} J^K. \tag{93b}$$

As will be useful later, the percentage change in the investment price index is a weighted average of percentage changes in the price of traded and non-traded inputs in terms of foreign inputs:

$$\hat{P}_J = \alpha_J^K \hat{P}^T + \left(1-\alpha_J^K\right) \hat{P}^N, \tag{94a}$$

$$\hat{P}^T = \alpha_J^H \hat{P}^H, \tag{94b}$$

where α_J^K is the tradable content of overall investment expenditure and α_J^H is the home-produced goods content of investment expenditure on traded goods:

$$\alpha_J^K = \iota \left(\frac{P_J^T}{P_J}\right)^{1-\phi_K}, \tag{95a}$$

$$1-\alpha_J^K = (1-\iota) \left(\frac{P^N}{P_J}\right)^{1-\phi_K}, \tag{95b}$$

$$\alpha_J^H = \iota^H \left(\frac{P^H}{P_J^T}\right)^{1-\rho_K}, \tag{95c}$$

$$1-\alpha_J^H = \left(1-\iota^H\right) \left(\frac{1}{P_J^T}\right)^{1-\rho_K}. \tag{95d}$$

Investment in intangible assets. The intangible good is produced using inputs of the home-produced traded good and the non-traded good according to a constant-returns-to-scale function which is assumed to take a CES form:

$$J^Z(t) = \left[\iota_Z^{\frac{1}{\phi_Z}} \left(J^{Z,H}(t)\right)^{\frac{\phi_Z-1}{\phi_Z}} + (1-\iota_Z)^{\frac{1}{\phi_Z}} \left(J^{Z,N}(t)\right)^{\frac{\phi_Z-1}{\phi_Z}}\right]^{\frac{\phi_Z}{\phi_Z-1}}, \tag{96}$$

where ι_Z is the weight of the intangible traded input ($0 < \iota_Z < 1$) and ϕ_Z corresponds to the elasticity of substitution in investment between traded and non-traded intangible inputs. The price index associated with the aggregator function (96) is:

$$P_J^Z = \left[\iota_Z \left(P^H\right)^{1-\phi_Z} + (1-\iota_Z) \left(P^N\right)^{1-\phi_Z}\right]^{\frac{1}{1-\phi_Z}}. \tag{97}$$

Given the knowledge investment-based price index (97), we can derive the demand for inputs of the traded good and the non-traded good:

$$J^{Z,H} = \iota_Z \left(\frac{P^H}{P_J^Z}\right)^{-\phi_Z} J^Z, \tag{98a}$$

$$J^{Z,N} = (1-\iota_Z) \left(\frac{P^N}{P_J^Z}\right)^{-\phi_Z} J^Z. \tag{98b}$$

As will be useful later, the percentage change in the R&D investment price index is a weighted average of percentage changes in the price of traded and non-traded inputs:

$$\hat{P}_Z = \alpha_Z \hat{P}^H + (1-\alpha_Z) \hat{P}^N, \tag{99}$$

where

$$\alpha_J^Z = \frac{P^H J^{Z,H}}{P_J^Z J^Z} = \iota_Z \left(\frac{P^H}{P_J^Z}\right)^{1-\phi_Z}. \tag{100}$$

Law of motion for intangible assets and installation costs for ideas. Accumulation of intangible assets is governed by the following law of motion:

$$\dot{Z}^A(t) = I^Z(t) - \delta_Z Z^A(t), \tag{101}$$

where I^Z is investment in intangible assets and $0 \leq \delta_Z < 1$ is a fixed depreciation rate. We assume that capital accumulation is subject to increasing and convex cost of net investment:

$$J^Z(t) = I^Z(t) + \frac{\zeta}{2}\left(\frac{I^Z(t)}{Z^A(t)} - \delta_Z\right)^2 Z^A(t), \tag{102}$$

with partial derivatives

$$\frac{\partial J^Z(t)}{\partial I^Z(t)} = 1 + \zeta\left(\frac{I^Z(t)}{Z^A(t)} - \delta_Z\right), \tag{103a}$$

$$\frac{\partial J^Z(t)}{\partial Z^A(t)} = -\frac{\zeta}{2}\left(\frac{I^Z(t)}{Z^A(t)} - \delta_Z\right)\left(\frac{I^Z(t)}{Z^A(t)} + \delta_Z\right). \tag{103b}$$

First-order conditions. Households choose consumption, worked hours, capital and technology utilization rates, investment in tangible and intangible assets by maximizing lifetime utility (76) subject to (84), (89) and (101). Denoting the co-state variables associated with the flow budget constraint (84), the physical capital accumulation equation (89) (i.e., $\dot{K}(t) = I(t) - \delta_K K(t)$), and the accumulation equation of ideas (101) by λ, $Q^{K,\prime}$, and $Q^{Z,\prime}$ respectively, the first-order conditions characterizing the representative household's optimal plans are described by

$$\Lambda_C\left(C(t), S(t), L(t)\right) = \bar{\lambda} P_C(t), \tag{104a}$$

$$-\Lambda_L\left(C(t), S(t), L(t)\right) = \bar{\lambda} W(t), \tag{104b}$$

$$Q^K(t) = P_J^K(t)\left[1 + \kappa\left(\frac{I^K(t)}{K(t)} - \delta_K\right)\right], \tag{104c}$$

$$Q^Z(t) = P_J^Z(t)\left[1 + \zeta\left(\frac{I^Z(t)}{Z^A(t)} - \delta_Z\right)\right], \tag{104d}$$

$$\frac{R^{K,j}(t)}{P^j(t)} = \xi_1^j + \xi_2^j\left(u^{K,j}(t) - 1\right), \quad j = H, N, \tag{104e}$$

$$\frac{R^{Z,j}(t)}{P^j(t)} = \chi_1^j + \chi_2^j\left(u^{Z,j}(t) - 1\right), \quad j = H, N, \tag{104f}$$

$$\dot{\lambda}(t) = \lambda\left(\beta - r^\star\right), \tag{104g}$$

$$\begin{aligned}\dot{Q}^K(t) = \left(r^\star + \delta_K\right) Q^K(t) - \Bigg\{ & \sum_{j=H,N} \alpha_K^j(t) u^{K,j}(t) R^K(t) \\ & - \sum_{j=H,N} P^j(t) C^{K,j}(t) \nu^{K,j}(t) - P_J^K(t)\frac{\partial J^K(t)}{\partial K(t)}\Bigg\},\end{aligned} \tag{104h}$$

$$\begin{aligned}\dot{Q}^Z(t) = \left(r^\star + \delta_Z\right) Q^Z(t) - \Bigg\{ & \sum_{j=H,N} \alpha_Z^j(t) u^{Z,j}(t) R^Z(t) \\ & - \sum_{j=H,N} P^j(t) C^{Z,j}(t) \nu^{Z,j}(t) - P_J^Z(t)\frac{\partial J^Z(t)}{\partial Z^A(t)}\Bigg\},\end{aligned} \tag{104i}$$

and the transversality conditions $\lim_{t\to\infty} \bar{\lambda} N(t) e^{-\beta t} = 0$, $\lim_{t\to\infty} Q^K(t) K(t) e^{-\beta t} = 0$, and $\lim_{t\to\infty} Q^Z(t) Z^A(t) e^{-\beta t} = 0$; to derive (104h) and (104i), we used the fact that $Q^K(t) = Q^{K,\prime}(t)/\lambda(t)$, $Q^Z(t) = Q^{Z,\prime}(t)/\lambda(t)$, respectively.

E.2 Final and Intermediate Good Producers

We assume that within each sector, there are a large number of intermediate good producers which produce differentiated varieties and thus are imperfectly competitive. They choose to rent labor services from households along with services from tangible and intangible assets.

Final Goods Firms

The final output in sector $j = H, N$, Y^j, is produced in a competitive retail sector using a constant-returns-to-scale production function which aggregates a continuum measure one of sectoral goods:

$$Y^j = \left[\int_0^1 \left(X_i^j\right)^{\frac{\omega^j - 1}{\omega^j}} \mathrm{d}i\right]^{\frac{\omega^j}{\omega^j - 1}}, \tag{105}$$

where $\omega^j > 0$ represents the elasticity of substitution between any two different sectoral goods and X_i^j stands for intermediate consumption of sector'j variety (with $i \in (0,1)$). The final good producers behave competitively, and the households use the final good for both consumption and investment. While the output of final non-traded good, Y^N, is for domestic absorption only, the final output of home-produced traded good, Y^H, can be consumed domestically, invested or exported.

Denoting by P^j and P_i^j the price of the final good in sector j and the price of the ith variety of the intermediate good, respectively, the profit the final good producer reads:

$$\Pi_F^j = P^j \left[\int_0^1 \left(X_i^j\right)^{\frac{\omega^j - 1}{\omega^j}} \mathrm{d}i\right]^{\frac{\omega^j}{\omega^j}} - \int_0^1 P_i^j X_i^j \mathrm{d}i. \tag{106}$$

Total cost minimization for a given level of final output gives the (intratemporal) demand function for each input:

$$X_i^j = \left(\frac{P_i^j}{P^j}\right)^{-\omega^j} Y^j, \tag{107}$$

and the price of the final output is given by:

$$P^j = \left(\int_0^1 \left(P_i^j\right)^{1-\omega^j} \mathrm{d}i\right)^{\frac{1}{1-\omega^j}}, \tag{108}$$

where P_i^j is the price of variety i in sector j and P^j is the price of the final good in sector $j = H, N$. Making use of eq. (107), the price-elasticity of the demand for output of the ith variety within sector j is:

$$-\frac{\partial X_i^j}{\partial P_i^j} \frac{P_i^j}{X_i^j} = \omega^j. \tag{109}$$

Intermediate Goods Firms

Within each sector j, there are firms producing differentiated goods. Each intermediate good producer uses labor services, $L^j(t)$, services from tangible assets (inclusive of the intensity in the use of tangible assets) $\tilde{K}_i^j(t)$, and services from intangible assets $\mathsf{Z}_i^j(t)$, to produce a final good according to a technology of production which displays increasing returns to scale:

$$X^j(t) = \left(\mathsf{Z}_i^j(t)\right)^{\nu^j} \left(L_i^j(t)\right)^{\theta^j} \left(\tilde{K}_i^j(t)\right)^{1-\theta^j}, \tag{110}$$

where the stock of knowledge Z^j is a stock of ideas used by domestic firms in sector $j = H, N$; this stock of ideas gives rise to utilization-adjusted-TFP, i.e., $\mathcal{T}^j(t) = \left(\mathsf{Z}^j(t)\right)^{\nu^j}$. The stock of ideas $\mathsf{Z}^j(t)$ is made up of a domestic stock of knowledge $\tilde{Z}^j(t)$ (inclusive of the technology utilization rate) and an international stock of knowledge $Z^W(t)$:

$$\mathsf{Z}^j(t) = \left(\tilde{Z}_i^j(t)\right)^{\theta_Z^j} \left(Z^W(t)\right)^{1-\theta_Z^j}, \tag{111}$$

where θ_Z^j captures the domestic content of the stock of knowledge accessible to domestic firms in sector j. Note that because the firm must pay (time-invariant) fixed costs F^j, we require the markup denoted by μ^j to be larger than the degree of increasing returns to scale, i.e.,

$$1 + \nu^j \theta_Z^j < \mu^j, \tag{112}$$

so that the excess of value added over the payment of factors of production is large enough to cover fixed costs.

Firms face three cost components: a labor cost equal to the wage rate $W^j(t)$, and a sector-specific rental cost for tangible and intangible assets equal to $R^{K,j}(t)$ and $R^{Z,j}(t)$, respectively. We assume that the government levies a tax τ on firms' profits. In line with the common practice, see e.g., Backus et al. [2008], firms' taxable earnings are defined as output less wage payments and physical capital depreciation. Both sectors are assumed to be imperfectly competitive and thus choose services from labor, tangible assets and intangible assets:

$$\max_{L_i^j(t),\tilde{K}_i^j(t),\tilde{Z}_i^j(t)} \Pi_i^j(t) \tag{113}$$

where

$$\Pi_i^j(t) \equiv (1-\tau)\left[P_i^j(t)X_i^j(t) - W^j(t)L_i^j(t) - \delta_K \tilde{K}_i^j(t)\right] - \left(R^{K,j}(t)-\delta_K\right)\tilde{K}_i^j(t) - R^{Z,j}(t)\tilde{Z}_i^j(t) - P^j F^j, \tag{114}$$

where F^j is a fixed cost which is symmetric across all intermediate good producers but varies across sectors.

Using the fact that $\left(\frac{P_i^j}{P^j}\right)^{-\omega^j} Y^j = X_i^j$ stands for the demand for variety j, the Lagrangian for the i-th producer in sector j is:

$$\mathcal{L}_i^j = \Pi_i^j(t) + \eta_i^j\left[X_i^j(t) - \left(P_i^j\right)^{-\omega^j}\left(P^j\right)^{\omega^j} Y^j\right]. \tag{115}$$

Firm j chooses its price P_i^j to maximize profits treating factor prices as given. The corresponding first-order necessary conditions (for labor, physical capital, intangible capital, and variety-i price) are:

$$\left[(1-\tau)P_i^j + \eta_i^j\right]\frac{\partial F^j(.)}{\partial L_i^j} = (1-\tau)W^j, \tag{116a}$$

$$\left[(1-\tau)P_i^j + \eta_i^j\right)\frac{\partial F^j(.)}{\partial \tilde{K}_i^j} = \left(R^{K,j}-\delta_K\right) + \delta_K(1-\tau), \tag{116b}$$

$$\left[(1-\tau)P_i^j + \eta_i^j\right]\frac{\partial F^j(.)}{\partial \tilde{Z}_i^j} = R^{Z,j}, \tag{116c}$$

$$(1-\tau)X_i^j = -\eta_i^j\omega^j\left(P_i^j\right)^{-\omega^j-1}\left(P^j\right)^{\omega^j} Y^j, \tag{116d}$$

Using $X_i^j = \left(\frac{P_i^j}{P^j}\right)^{-\omega^j} Y^j$, eq. (116d) can be rewritten as follows:

$$\eta_i^j = -\frac{(1-\tau)P_i^j}{\omega^j}. \tag{117}$$

Denoting the markup charged by intermediate good producers by $\mu^j = \frac{\omega^j}{\omega^j-1} > 1$, and inserting (117) into (116a)-(116c), first-order conditions can be rewritten as follows:

$$P_i^j\theta^j\frac{X_i^j}{L_i^j} = \mu^j W^j, \tag{118a}$$

$$P_i^j\left(1-\theta^j\right)\frac{X_i^j}{\tilde{K}_i^j} = \mu^j\left[\left(\frac{R^{K,j}-\delta_K}{1-\tau}\right)+\delta_K\right], \tag{118b}$$

$$(1-\tau)P_i^j\nu_Z^j\left(1-\theta^j\right)\frac{X_i^j}{\tilde{Z}_i^j} = \mu^j R^{Z,j}, \tag{118c}$$

where we used the fact that $\frac{\partial X_i^j}{\partial L_i^j} = \theta^j\frac{X_i^j}{L_i^j}$, $\frac{\partial X_i^j}{\partial \tilde{K}_i^j} = \left(1-\theta^j\right)\frac{X_i^j}{\tilde{K}_i^j}$, and $\frac{\partial X_i^j}{\partial \tilde{Z}_i^j} = \nu_Z^j\frac{X_i^j}{\tilde{Z}_i^j}$.

Free entry Condition

We assume free entry in the goods markets so that the movement of firms in and out of the goods market drives profits to zero at each instant of time, i.e., $\Pi_i^j(t) = (1-\tau)\,\text{NOS}_i^j(t) - \left(R^{K,j}(t) - \delta_K\right)\tilde{K}_i^j(t) - R^{Z,j}(t)\tilde{Z}_i^j(t) - P_i^j F^j = 0$ where the net operating surplus (NOS henceforth) is $\text{NOS}_i^j(t) = P_i^j(t)X_i^j(t) - W^j(t)L_i^j(t) - \delta_K\tilde{K}_i^j(t)$. Rewriting first-order conditions (118a)-(118c)

$$\frac{P_i^j}{\mu^j}\theta^j X_i^j = W^j L_i^j, \tag{119a}$$

$$\frac{P_i^j}{\mu^j}\left(1-\theta^j\right)X_i^j = \left[\left(\frac{R^{K,j}-\delta_K}{1-\tau}\right)+\delta_K\right]\tilde{K}_i^j, \tag{119b}$$

$$(1-\tau)\frac{P_i^j}{\mu^j}\nu_Z^j X_i^j = \mu^j R^{Z,j}\tilde{Z}_i^j. \tag{119c}$$

Inserting (119a)-(119c) into profit leads to:

$$\begin{aligned}
& P_i^j X_i^j - (1-\tau)\,W^j L_i^j\,(1-\tau)\left[\frac{R^K-\delta_K}{1-\tau}+\delta_K\right]\tilde{K}_i^j - R^Z\tilde{Z}_i^j - P^jF^j = 0, \\
= \;& P_i^j X_i^j - (1-\tau)\frac{P_i^j}{\mu^j}\theta^j X_i^j - (1-\tau)\frac{P_i^j}{\mu^j}\left(1-\theta^j\right)X_i^j - (1-\tau)\frac{P_i^j}{\mu^j}\nu_Z^j X_i^j - P^jF^j = 0, \\
& (1-\tau)\,P_i^j X_i^j\left[1-\frac{\theta^j+\left(1-\theta^j\right)+\nu_Z^j\theta_Z^j}{\mu^j}\right] - P_i^jF^j = 0, \\
& (1-\tau)\,P_i^j X_i^j\left[1-\frac{1+\nu_Z^j\theta_Z^j}{\mu^j}\right] - P_i^jF^j = 0.
\end{aligned} \tag{120}$$

To ensure that profits cannot be negative, we assume that the contribution of the stock of intangible assets to the production of the i-th variety of the intermediate good is lower than the markup:

$$\mu^j > 1+\nu^j\theta_Z^j. \tag{121}$$

Because intermediate good producers are symmetric, they face the same costs of factors and the same price elasticity of demand. Therefore, they set same prices which collapse to final good prices, i.e., $P_i^j = P^j$ and they produce the same quantity, i.e., $X_i^j = X^j = Y^j$. Eq. (120) implies that value added covers the payment of labor services, W^jL^j, rental payments of services from tangible and intangible assets to households, i.e., $R^{K,j}\tilde{K}^j$ and $R^{Z,j}\tilde{Z}^j$, and also covers the payment of the fixed cost:

$$(1-\tau)\,P^jY^j = (1-\tau)\,W^jL^j + \left[R^{K,j}-\tau\delta_K\right]\tilde{K}^j + R^{Z,j}\tilde{Z}^j + P^jF^j. \tag{122}$$

Output Net of Fixed Costs

We denote output net of fixed costs by $Q^j = Y^j - F^j$. By using the free entry condition (120), i.e., $P_i^jF^j = (1-\tau)\,P^jY^j\left[1-\frac{1+\nu_Z^j\theta_Z^j}{\mu^j}\right]$, value added in sector j net of fixed cost reads as follows:

$$\begin{aligned}
Q^j &= Y^j - F^j, \\
&= Y^j\left[1-(1-\tau)\left(1-\frac{1+\nu_Z^j\theta_Z^j}{\mu^j}\right)\right].
\end{aligned} \tag{123}$$

After-tax value added in sector j net of fixed cost covers the payment of inputs:

$$\begin{aligned}
(1-\tau)\,P^jY^j - P^jF^j &= (1-\tau)\,W^jL^j + \left[R^{K,j}-\delta_K\right]\tilde{K}^j + R^{Z,j}\tilde{Z}^j, \\
P^jY^j - P^j\frac{F^j}{1-\tau} &= W^jL^j + \left[\frac{R^{K,j}-\delta_K}{1-\tau}+\delta_K\right]\tilde{K}^j + \frac{R^{Z,j}\tilde{Z}^j}{1-\tau}.
\end{aligned} \tag{124}$$

Unit Cost for Producing

As shall be useful, we derive the unit cost for producing in sector j. Dividing the demand for labor (118a) by the demand for capital (118b), and next dividing the demand for demand for tangible assets (118b) by the demand for intangible assets (118c), and finally the demand for labor (118a) by the demand for intangible assets (118c), we get:

$$\frac{1-\theta^j}{\theta^j}\frac{L^j}{\tilde{K}^j} = \frac{R^{K,j}-\tau\delta_K}{W^j\left(1-\tau\right)}, \tag{125a}$$

$$\frac{1-\theta^j}{\nu_Z^j\theta_Z^j}\frac{\tilde{Z}^j}{\tilde{K}^j} = \frac{R^{K,j}-\tau\delta_K}{R^{Z,j}}, \tag{125b}$$

$$\frac{\nu_Z^j\theta_Z^j}{\theta^j}\frac{L^j}{\tilde{Z}^j} = \frac{R^{Z,j}}{W^j\left(1-\tau\right)}. \tag{125c}$$

Making use of eq. (125a) and (125b) to eliminate L^j and Z^j from the Cobb-Douglas production function (110)-(111) and solving for $\tilde{K}^j$, and next making use of eq. (125a) and (125c) to eliminate $\tilde{K}^j$ and $\tilde{Z}^j$ from the Cobb-Douglas production function (110)-(111) and solving for L^j, and finally making use of eq. (125b) and (125c) to eliminate $\tilde{K}^j$ and L^j from the Cobb-Douglas production function (110)-(111) and solving for $\tilde{Z}^j$ leads to the conditional demand for capital stock, for labor, and for intangible assets:

$$\left(\tilde{K}^j\right)^{1+\nu_Z^j\theta_Z^j} = \frac{Y^j}{\left(Z^W\right)^{(1-\theta_Z^j)\nu_Z^j}}\left(\frac{1-\theta^j}{\theta^j}\right)^{\theta^j}\left(\frac{1-\theta^j}{\nu_Z^j\theta_Z^j}\right)^{\nu_Z^j\theta_Z^j}\frac{\left(R^{Z,j}\right)^{\nu_Z^j\theta_Z^j}\left(W^j\left(1-\tau\right)\right)^{\theta^j}}{\left(R^{K,j}-\tau\delta_K\right)^{\theta^j+\nu_Z^j\theta_Z^j}}, \tag{126a}$$

$$\left(L^j\right)^{1+\nu_Z^j\theta_Z^j} = \frac{Y^j}{\left(Z^W\right)^{(1-\theta_Z^j)\nu_Z^j}}\left(\frac{\theta^j}{1-\theta^j}\right)^{1-\theta^j}\left(\frac{\theta^j}{\nu_Z^j\theta_Z^j}\right)^{\nu_Z^j\theta_Z^j}\frac{\left(R^{Z,j}\right)^{\nu_Z^j\theta_Z^j}\left(R^{K,j}-\tau\delta_K\right)^{1-\theta^j}}{\left(W^j\left(1-\tau\right)\right)^{(1-\theta^j)+\nu_Z^j\theta_Z^j}}, \tag{126b}$$

$$\left(\tilde{Z}^j\right)^{1+\nu_Z^j\theta_Z^j} = \frac{Y^j}{\left(Z^W\right)^{(1-\theta_Z^j)\nu_Z^j}}\frac{\nu_Z^j\theta_Z^j}{\left(1-\theta^j\right)^{1-\theta^j}\left(\theta^j\right)^{\theta^j}}\frac{\left(W^j\left(1-\tau\right)\right)^{\theta^j}\left(R^{K,j}-\tau\delta_K\right)^{1-\theta^j}}{R^{Z,j}}. \tag{126c}$$

Total (variable) cost is equal to the sum of labor compensation, rental cost of tangible and intangible assets:

$$C^j = \left(1-\tau\right)W^jL^j + \left[R^{K,j}-\tau\delta_K\right]\tilde{K}^j + R^{Z,j}\tilde{Z}^j. \tag{127}$$

Inserting conditional demand for inputs (126a)-(126c) into total cost (127), we find that C^j is homogenous of a degree smaller than one with respect to value added due to the fact that the production function displays increasing returns to scale:

$$C^j = \left[\frac{Y^j}{\left(Z^W\right)^{(1-\theta_Z^j)\nu_Z^j}}\right]^{\frac{1}{1+\nu_Z^j\theta_Z^j}}\left(M^j\right)^{\frac{1}{1+\nu_Z^j\theta_Z^j}}\left(1+\nu_Z^j\theta_Z^j\right) \tag{128}$$

where we set

$$M^j = \left(\Psi^j\right)^{-1}\left(W^j\left(1-\tau\right)\right)^{\theta^j}\left(R^{K,j}-\tau\delta_K\right)^{1-\theta^j}\left(R^{Z,j}\right)^{\nu_Z^j\theta_Z^j}, \tag{129}$$

where

$$\Psi^j = \left(\theta^j\right)^{\theta^j}\left(1-\theta^j\right)^{1-\theta^j}\left(\nu_Z^j\theta_Z^j\right)^{\nu_Z^j\theta_Z^j}. \tag{130}$$

By using (124) and the definition of total costs (127)) which implies that $\left(1-\tau\right)P^jY^j - P^jF^j = C^j$ and by using the fact that $P^jY^j - P^j\frac{F^j}{1-\tau} = P^jY^j\left(\frac{1+\nu_Z^j\theta_Z^j}{\mu^j}\right)$ (see eq. (123)), we have $P^jY^j - P^j\frac{F^j}{1-\tau} = \frac{C^j}{1-\tau}$. The unit cost for producing denoted by c^j is obtained by dividing C^j by $Y^j\left(\frac{1+\nu_Z^j\theta_Z^j}{\mu^j}\right)$ which leads to

$$c^j = \left(Y^j\right)^{-\frac{\nu_Z^j\theta_Z^j}{1+\nu_Z^j\theta_Z^j}}\left[\frac{M^{j,\prime}}{\left(Z^W\right)^{(1-\theta_Z^j)\nu_Z^j}}\right]^{\frac{1}{1+\nu_Z^j\theta_Z^j}}, \tag{131}$$

where

$$M^{j,\prime} = \left(\Psi^j\right)^{-1} \left(W^j \left(1-\tau\right)\right)^{\theta^j} \left(\frac{R^{K,j}-\delta_K}{1-\tau}+\delta_K\right)^{1-\theta^j} \left(\frac{R^{Z,j}}{1-\tau}\right)^{\nu_Z^j \theta_Z^j}. \tag{132}$$

The price over the markup P^j/μ^j thus equalizes with the unit cost c^j.

E.3 Solving the Model

Consumption and Labor. Totally differentiating first-order conditions for consumption (104a) and labor (104b) leads to:

$$\frac{\Lambda_{CC}}{\Lambda_C}dC + \frac{\Lambda_{CL}}{\Lambda_C}dL = \frac{d\bar{\lambda}}{\bar{\lambda}} - \frac{\Lambda_{CS}}{\Lambda_C}dS + \frac{\alpha_C \alpha^H}{P^H}dP^H + \frac{1-\alpha_C}{P^N}dP^N, \tag{133a}$$

$$\frac{\Lambda_{LC}}{\Lambda_L}dC + \frac{\Lambda_{LL}}{\Lambda_L}dL = \frac{d\bar{\lambda}}{\bar{\lambda}} + \frac{dW}{W} - \frac{\Lambda_{LS}}{\Lambda_L}dS. \tag{133b}$$

Eqs. (133a)-(133b) can be solved for consumption and hours:

$$C = C\left(\bar{\lambda}, S, P^H, P^N, W\right), \qquad L = L\left(\bar{\lambda}, S, P^H, P^N, W\right) \tag{134}$$

Note that plugging $\frac{X^{-\sigma}}{P_C} = \bar{\lambda}$ into eq. (104b) leads to $-X_L = \frac{W}{P_C}$ and thus labor supply depends only on the wage rate and sectoral prices and does not depend on the wealth effect because of our assumption of GHH preferences, i.e., $L_{\bar{\lambda}} = 0$ and $L_S = 0$.

Consumption in goods $g = H, N, F$. Inserting first the solution for consumption (134) into (58b), (59a)-(59b), allows us to solve for C^g (with $g = H, N, F$)

$$C^g = C^g\left(\bar{\lambda}, P^N, P^H, W^H, W^N\right), \tag{135}$$

where we used the fact that

$$\hat{C}^N = -\phi\alpha_C \hat{P}^N + \phi\alpha_C\alpha^H \hat{P}^H + \hat{C}, \tag{136a}$$

$$\hat{C}^H = -\left[\rho\left(1-\alpha^H\right) + \phi\left(1-\alpha_C\right)\alpha^H\right]\hat{P}^H + \left(1-\alpha_C\right)\phi\hat{P}^N + \hat{C}, \tag{136b}$$

$$\hat{C}^F = \alpha^H\left[\rho - \phi\left(1-\alpha_C\right)\right]\hat{P}^H + \left(1-\alpha_C\right)\phi\hat{P}^N + \hat{C}. \tag{136c}$$

Labor supply to sector $j = H, N$. Inserting first the solution for labor (134) into (64) allows us to solve for L^j (with $j = H, N$):

$$L^j = L^j\left(\bar{\lambda}, P^N, P^H, W^H, W^N\right), \tag{137}$$

with partial derivatives given by:

$$\hat{L}^H = \epsilon_L\left(1-\alpha_L\right)\hat{W}^H - \left(1-\alpha_L\right)\epsilon_L\hat{W}^N + \hat{L}, \tag{138a}$$

$$\hat{L}^N = \epsilon_L\alpha_L\hat{W}^N - \alpha_L\epsilon_L\hat{W}^H + \hat{L}. \tag{138b}$$

Capital supply to sector $j = H, N$. The decision to allocate capital between to the traded and the non-traded sectors (69) allows us to solve for K^H and K^N:

$$K^j = K^j\left(K, R^{K,H}, R^{K,N}\right), \tag{139}$$

with partial derivatives given by:

$$\hat{K}^H = \epsilon_K\left(1-\alpha_K\right)\hat{R}^{K,H} - \left(1-\alpha_K\right)\epsilon_K\hat{R}^{K,N} + \hat{K}, \tag{140a}$$

$$\hat{K}^N = \epsilon_K\alpha_K\hat{R}^{K,N} - \alpha_K\epsilon_K\hat{R}^{K,H} + \hat{K}. \tag{140b}$$

Supply of ideas to sector $j = H, N$. The decision to allocate intangible assets between the traded and the non-traded sectors (73) allows us to solve for Z^H and Z^N:

$$Z^j = Z^j\left(Z^A, R^{Z,H}, R^{Z,N}\right), \tag{141}$$

with partial derivatives given by:

$$\hat{Z}^H = \epsilon_Z (1-\alpha_Z) \hat{R}^{Z,H} - (1-\alpha_Z) \epsilon_Z \hat{R}^{Z,N} + \hat{Z}^A, \tag{142a}$$

$$\hat{Z}^N = \epsilon_Z \alpha_Z \hat{R}^{Z,N} - \alpha_Z \epsilon_Z \hat{R}^{Z,H} + \hat{Z}^A. \tag{142b}$$

Sectoral Wages and Sectoral Rental Rates for Tangible and Intangible Assets First-order conditions from firm's profit maximization are for sector $j = H, N$:

$$\frac{P^j}{\mu^j} \theta^j \left(u^{Z,j} Z^j\right)^{\nu_Z^j \theta_Z^j} \left(Z^W\right)^{(1-\nu_Z^j)\theta_Z^j} \left(L^j\right)^{\theta^j - 1} \left(u^{K,j} K^j\right)^{1-\theta^j} = W^j, \tag{143a}$$

$$\frac{P^j}{\mu^j} \left(1-\theta^j\right) \left(u^{Z,j} Z^j\right)^{\nu_Z^j \theta_Z^j} \left(Z^W\right)^{(1-\nu_Z^j)\theta_Z^j} \left(L^j\right)^{\theta^j} \left(u^{K,j} K^j\right)^{-\theta^j} = R^{K,j}, \tag{143b}$$

$$\frac{P^j}{\mu^j} \nu_Z^j \theta_Z^j \left(u^{Z,j} Z^j\right)^{(\nu_Z^j \theta_Z^j - 1)} \left(Z^W\right)^{(1-\nu_Z^j)\theta_Z^j} \left(L^j\right)^{\theta^j} \left(u^{K,j} K^j\right)^{1-\theta^j} = R^{Z,j}. \tag{143c}$$

Totally differentiating first-order conditions from firm's profit maximization leads to:

$$-\left[\left(1-\theta^j\right) \hat{L}^j + \hat{W}^j\right] + \left(1-\theta^j\right) \left(\hat{u}^{K,j} + \hat{K}^j\right) + \nu_Z^j \theta_Z^j \left(\hat{u}^{Z,j} + \hat{Z}^j\right) = -\hat{P}^j - \left(1-\nu_Z^j\right) \theta_Z^j \hat{Z}^W, \tag{144a}$$

$$\theta^j \hat{L}^j - \left[\theta^j \left(\hat{u}^{K,j} + \hat{K}^j\right) + \hat{R}^{K,j}\right] + \nu_Z^j \theta_Z^j \left(\hat{u}^{Z,j} + \hat{Z}^j\right) = \frac{R^{K,j} - \delta_K}{(1-\tau)\left(R^{K,j} - \tau \delta_K\right)} d\tau - \hat{P}^j - \left(1-\nu_Z^j\right) \theta_Z^j \hat{Z}^W, \tag{144b}$$

$$\theta^j \hat{L}^j + \left(1-\theta^j\right) \left(\hat{u}^{K,j} + \hat{K}^j\right) - \left[\left(1-\nu_Z^j \theta_Z^j\right) \left(\hat{u}^{Z,j} + \hat{Z}^j\right) + \hat{R}^{Z,j}\right] = \frac{d\tau}{1-\tau} - \hat{P}^j - \left(1-\theta_Z^j\right) \nu_Z^j \hat{Z}^W, \tag{144c}$$

where we used the fact that

$$\frac{1}{1-\tau} - \frac{\delta_K}{R^{K,j} - \tau \delta_K} = \frac{R^{K,j} - \delta_K}{(1-\tau)\left(R^{K,j} - \tau \delta_K\right)},$$

to get (144b).

Inserting intermediate solutions for L^j, K^j, Z^j described by (137), (139), (141), respectively, and invoking the theorem of implicit functions leads to:

$$W^j, R^{K,j}, R^{Z,j} \left(P^j, K, Z^A, u^{K,j}, u^{Z,j}, \tau, Z^W\right). \tag{145}$$

Plugging back (145) into (137), (139), (141) leads to solutions for L^j, K^j, Z^j; inserting these solutions into the production function (110)-(111) allows us to solve for Y^j; thus intermediate solutions read:

$$L^j, K^j, Z^j, Y^j \left(P^j, K, Z^A, u^{K,j}, u^{Z,j}, \tau, Z^W\right). \tag{146}$$

Solutions to capital and technology utilization rates in sector $j = H, N$. Inserting first the marginal revenue product of capital (143b) into the optimal decision for the capital utilization rate

$$\begin{aligned} \frac{R^{K,j}(t)}{P^j(t)} &= \xi_1^j + \xi_2^j \left(u^{K,j}(t) - 1\right), \\ &= \frac{\delta_K \tau}{P^j(t)} \frac{(1-\tau)}{\mu^j} \left(1-\theta^j\right) \left(u^{Z,j}(t) Z^j(t)\right)^{\nu_Z^j \theta_Z^j} \left(Z^W(t)\right)^{\nu_Z^j (1-\theta_Z^j)} \left(L^j(t)\right)^{\theta^j} \left(u^{K,j}(t) K^j(t)\right)^{-\theta^j} \end{aligned} \tag{147}$$

Inserting first the marginal revenue product of ideas (143c) into the optimal decision for the technology utilization rate

$$\begin{aligned} \frac{R^{Z,j}(t)}{P^j(t)} &= \chi_1^j + \chi_2^j \left(u^{Z,j}(t) - 1\right), \\ &= \frac{(1-\tau)}{\mu^j} \nu_Z^j \theta_Z^j \left(u^{Z,j}(t) Z^j(t)\right)^{(\nu_Z^j \theta_Z^j - 1)} \left(Z^W(t)\right)^{(1-\nu_Z^j)\theta_Z^j} \left(L^j(t)\right)^{\theta^j} \left(u^{K,j}(t) K^j(t)\right)^{1-\theta^j} \end{aligned} \tag{148}$$

Totally differentiating (147) leads to:

$$\begin{aligned}
& \left[\frac{\xi_2^j}{\xi_1^j - \frac{\delta_K \tau}{P^j}} + \theta^j\right] \hat{u}^{K,j} - \theta^j \hat{L}^j + \theta^j \hat{K}^j - \nu_Z^j \theta_Z^j \left(\hat{u}^{Z,j} + \hat{Z}^j\right) \\
= & \frac{R^{K,j} - \delta_K}{(1-\tau)\left(R^{K,j} - \tau\delta_K\right)} d\tau + \nu_Z^j \left(1 - \theta_Z^j\right) \hat{Z}^W, \qquad (149)
\end{aligned}$$

where we have used the fact that

$$d\log\left[\xi_1^j + \xi_2^j\left(u^{K,j}(t) - 1\right) - \frac{\delta_K \tau}{P^j(t)}\right] = \frac{\xi_2^j du^{K,j}(t) - \frac{\delta_K}{P^j(t)} d\tau + \frac{\delta_K \tau}{P^j(t)} \frac{dP^j(t)}{P^j(t)}}{\frac{R^{K,j}}{P^j} - \frac{\delta_K \tau}{P^j}}.$$

Totally differentiating (148) leads to:

$$\begin{aligned}
& \left[\frac{\chi_2^j}{\chi_1^j} + \left(1 - \nu_Z^j \theta_Z^j\right)\right] \hat{u}^{Z,j} - \theta^j \hat{L}^j - \left(1 - \theta^j\right)\left(\hat{u}^{K,j} + \hat{K}^j\right) + \left(1 - \nu_Z^j \theta_Z^j\right) \hat{Z}^j \\
= & -\frac{d\tau}{(1-\tau)} + \nu_Z^j \left(1 - \theta_Z^j\right) \hat{Z}^W. \qquad (150)
\end{aligned}$$

Inserting (146) into (149) and (150) and invoking the implicit function theorem leads to:

$$u^{K,j}, u^{Z,j}\left(P^j, K, Z^A, Z^W, \tau\right). \qquad (151)$$

Plugging (151) into (145) and (146) leads to

$$W^j, R^{K,j}, R^{Z,j}, L^j, K^j, Y^j\left(P^j, K, Z^A, Z^W, \tau\right). \qquad (152)$$

Optimal investment in tangible assets decision, I^K/K

Eq. (104c) can be solved for the investment rate:

$$\frac{I^K}{K} = v^K\left(\frac{Q^K}{P_J^K\left(P^H, P^N\right)}\right) + \delta_K, \qquad (153)$$

where

$$v^K(.) = \frac{1}{\kappa}\left(\frac{Q^K}{P_J^K} - 1\right), \qquad (154)$$

with

$$v_{Q^K} = \frac{\partial v^K(.)}{\partial Q^K} = \frac{1}{\kappa}\frac{1}{P_J^K} > 0, \qquad (155a)$$

$$v_{P^H} = \frac{\partial v^K(.)}{\partial P^H} = -\frac{1}{\kappa}\frac{Q^K}{P_J^K}\frac{\alpha_J \alpha_J^H}{P^H} < 0, \qquad (155b)$$

$$v_{P^N} = \frac{\partial v^K(.)}{\partial P^N} = -\frac{1}{\kappa}\frac{Q^K}{P_J^K}\frac{\left(1-\alpha_J\right)}{P^N} < 0. \qquad (155c)$$

Inserting (153) into (104c), investment including capital installation costs can be rewritten as follows:

$$\begin{aligned}
J^K &= K\left[\frac{I^k}{K} + \frac{\kappa}{2}\left(\frac{I^K}{K} - \delta_K\right)^2\right], \\
&= K\left[v^K(.) + \delta_K + \frac{\kappa}{2}\left(v^K(.)\right)^2\right]. \qquad (156)
\end{aligned}$$

Eq. (156) can be solved for investment including capital installation costs:

$$J^K = J^K\left(K, Q^K, P^N, P^H\right), \qquad (157)$$

where

$$J_K = \frac{\partial J^K}{\partial K} = \frac{J}{K}, \tag{158a}$$

$$J^K_X = \frac{\partial J^K}{\partial X} = \kappa v_X \left(1 + \kappa v^K(.)\right) > 0, \tag{158b}$$

with $X = Q^K, P^H, P^N$.

Substituting (157) into (92b), (93a), and (93b) allows us to solve for the demand of non-traded, home-produced traded, and foreign inputs:

$$J^{K,g} = J^{K,g}\left(K, Q^K, P^N, P^H\right), \quad g = F, H, N, \tag{159}$$

with partial derivatives given by

$$\hat{J}^{K,N} = -\alpha_J \phi_J \hat{P}^N + \phi_J \alpha_J \alpha_J^H \hat{P}^H + \hat{J}^K, \tag{160a}$$

$$\hat{J}^{K,H} = -\left[\rho_J\left(1-\alpha_J^H\right) + \alpha_J^H \phi_J \left(1-\alpha_J\right)\right]\hat{P}^H + \phi_J\left(1-\alpha_J\right)\hat{P}^N + \hat{J}^K, \tag{160b}$$

$$\hat{J}^{K,F} = \alpha_J^H\left[\rho_J - \phi_J\left(1-\alpha_J\right)\right]\hat{P}^H + \phi_J\left(1-\alpha_J\right)\hat{P}^N + \hat{J}^K, \tag{160c}$$

where

$$\hat{J}^K = \hat{K} + \frac{Q^K}{P_J^K}\frac{\left(1+\kappa v^K(.)\right)}{J^K}\hat{Q^K} - \frac{Q^K}{P_J^K}\frac{\left(1+\kappa v^K(.)\right)}{J^K}\left(1-\alpha_J\right)\hat{P}^N - \alpha_J\alpha_J^H\frac{Q^K}{P_J^K}\frac{\left(1+\kappa v^K(.)\right)}{J^K}\hat{P}^H.$$

Optimal investment in intangible assets decision, I^Z/Z^A

From eq. (104d), we have $\frac{I^Z(t)}{Z^A(t)}$ which is a positive function of $\frac{1}{\zeta}\left(\frac{Q^Z(t)}{P_J^Z(t)} - 1\right) + \delta_Z$. Setting

$$v^Z(.) = \frac{1}{\zeta}\left(\frac{Q^Z}{P_J^Z} - 1\right) \tag{161}$$

we have $J^Z = Z^A\left[\frac{I^Z}{Z^A} + \frac{\zeta}{2}\left(\frac{I^Z}{Z^A} - \delta_Z\right)^2\right]$ which can be solved for R&D investment including installation costs:

$$J^Z = J^Z\left(Z^A, Q^Z, P^N, P^H\right). \tag{162}$$

Inserting first (162) into (98a)-(98b), we can solve for investment in traded and non-traded R&D:

$$J^{Z,H}, J^{Z,N}\left(Z^A, Q^Z, P^N, P^H\right). \tag{163}$$

Market clearing conditions. Denoting by $Q^j = Y^j - F^j$ the value added net of fixed costs, the market clearing conditions for traded and non-traded goods read:

$$Q^H = C^H + G^H + J^{K,H} + J^{Z,H} + X^H + C^{K,H}K^H + C^{Z,H}Z^H, \tag{164a}$$

$$Q^N = C^N + G^N + J^{K,N} + J^{Z,N} + C^{K,N}K^N + C^{Z,N}Z^N. \tag{164b}$$

Inserting first appropriate intermediate solutions and differentiating enables to solve for home-produced traded good and non-traded good prices:

$$P^H, P^N\left(K, Q^K, Z^A, Q^Z, Z^W, \tau\right). \tag{165}$$

Plugging back these solutions (165) into (151), (152) leads to:

$$u^{K,j}, W^j, R^{K,j}, R^{Z,j}, L^j, K^j, Y^j\left(K, Q^K, Z^A, Q^Z, Z^W, \tau\right). \tag{166}$$

Inserting solutions for sectoral prices (165) into intermediate solutions for investment in tangible (159) and intangible assets (163) and consumption (135) in goods $g = H, N, F$, leads to:

$$C^g, J^{K,g}, J^{Z,g}\left(K, Q^K, Z^A, Q^Z, Z^W, \tau\right), \qquad g = H, N, F. \tag{167}$$

E.4 Dynamics

The adjustment of the open economy toward the steady state is described by a dynamic system which comprises seven equations

$$\dot{K}(t) = \frac{Q^N(t) - C^N(t) - G^N(t) - J^{Z,N}(t) - C^{K,N}(t)K^N(t) - C^{Z,N}(t)Z^N(t)}{(1-\iota)\left(\frac{P^N(t)}{P_J(t)}\right)^{-\phi_J}}$$

$$-\delta_K K(t) - \frac{\kappa}{2}\left(\frac{I(t)}{K(t)} - \delta_K\right)^2 K(t), \tag{168a}$$

$$\dot{Q}^K(t) = \left(r^\star + \delta_K\right) Q^K(t) - \left\{ \sum_{j=H,N} \alpha_K^j(t) u^{K,j}(t) R^K(t) \right.$$

$$\left. - \sum_{j=H,N} P^j(t) C^{K,j}(t) \nu^{K,j}(t) - P_J(t)\frac{\partial J(t)}{\partial K(t)} \right\}, \tag{168b}$$

$$\dot{Z}^A(t) = v^Z\left(K(t), Q^K(t), Z^A(t), Q^Z(t), \tau(t), Z^W(t)\right) Z^A(t), \tag{168c}$$

$$\dot{Q}^Z(t) = \left(r^\star + \delta_Z\right) Q^Z(t) - \left[\sum_{j=H,N} \alpha_Z^j(t) u^{Z,j}(t) R^Z(t) \right.$$

$$\left. - \sum_{j=H,N} P^j(t) C^{K,j}(t) \nu^{K,j}(t) - P_J^Z(t)\frac{\partial J^Z(t)}{\partial Z^A(t)} \right], \tag{168d}$$

$$\dot{S}(t) = \delta_S\left(C(t) - S(t)\right), \tag{168e}$$

$$d\tau(t) = a_T e^{-\xi_T t}, \tag{168f}$$

$$dZ^W(t) = a_W e^{-\xi_Z t}, \tag{168g}$$

where we have used the fact that $v^Z = \frac{I^Z}{Z^A} - \delta_Z$ with $v^Z\left(Q^Z(t), P^N(t), P^H(t)\right)$, a_T, a_Z, ξ_T, ξ_Z are parameters which determine the magnitude of the change in τ and Z^W on impact together with its persistence.

The dynamic system can be written in a compact form:

$$\dot{K}(t) = \Upsilon\left(K(t), Q^K(t), Z^A(t), Q^Z(t), S(t), \tau(t), Z^W(t)\right), \tag{169a}$$

$$\dot{Q}^K(t) = \Sigma\left(K(t), Q^K(t), Z^A(t), Q^Z(t), S(t), \tau(t), Z^W(t)\right), \tag{169b}$$

$$\dot{Z}^A(t) = \Pi\left(K(t), Q^K(t), Z^A(t), Q^Z(t), S(t), \tau(t), Z^W(t)\right), \tag{169c}$$

$$\dot{Q}^Z(t) = \Gamma\left(K(t), Q^K(t), Z^A(t), Q^Z(t), S(t), \tau(t), Z^W(t)\right), \tag{169d}$$

$$\dot{S}(t) = \Theta\left(K(t), Q^K(t), Z^A(t), Q^Z(t), S(t), \tau(t), Z^W(t)\right), \tag{169e}$$

$$\dot{\tau}(t) = -\xi_T\left(\tau(t) - \tau\right), \tag{169f}$$

$$\dot{Z}^W(t) = -\xi_Z\left(Z^W(t) - Z^W\right), \tag{169g}$$

where $j = H, N$.

We linearize (169a)-(169g) around the steady-state:

$$\begin{pmatrix} \dot{K}(t) \\ \dot{Q}^K(t) \\ \dot{Z}^A(t) \\ \dot{Q}^Z(t) \\ \dot{S}(t) \\ \dot{\tau}(t) \\ \dot{Z}^W(t) \end{pmatrix} = \begin{pmatrix} \Upsilon_K & \Upsilon_{Q^K} & \Upsilon_{Z^A} & \Upsilon_{Q^Z} & \Upsilon_S & \Upsilon_\tau & \Upsilon_{Z^W} \\ \Sigma_K & \Sigma_{Q^K} & \Sigma_{Z^A} & \Sigma_{Q^Z} & \Sigma_S & \Sigma_\tau & \Sigma_{Z^W} \\ \Pi_K & \Pi_{Q^K} & \Pi_{Z^A} & \Pi_{Q^Z} & \Pi_S & \Pi_\tau & \Pi_{Z^W} \\ \Gamma_K & \Gamma_{Q^K} & \Gamma_{Z^A} & \Gamma_{Q^Z} & \Gamma_S & \Gamma_\tau & \Gamma_{Z^W} \\ \Theta_K & \Theta_{Q^K} & \Theta_{Z^A} & \Theta_{Q^Z} & \Theta_S & \Theta_\tau & \Theta_{Z^W} \\ 0 & 0 & 0 & 0 & 0 & -\xi_T & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & -\xi_Z \end{pmatrix} \begin{pmatrix} dK(t) \\ dQ^K(t) \\ dZ^A(t) \\ dQ^Z(t) \\ dS(t) \\ d\tau(t) \\ dZ^W(t) \end{pmatrix}. \tag{170}$$

Denoting by ω_k^i the kth element of eigenvector ω^i related to eigenvalue ν_i, the general solution that characterizes the adjustment toward the new steady-state can be written as follows: $V(t) - V = \sum_{i=1}^{7} \omega^i D_i e^{\nu_i t}$ where V is the vector of state and control variables. Denoting the positive eigenvalue by $\nu_4, \nu_5 > 0$, we set $D_4 = D_5 = 0$ to eliminate explosive paths and determine the five arbitrary constants D_i (with $i = 1, ..., 7$, $i \neq 4, 5$) by using the five initial conditions, i.e., $K(0) = K_0$, $Z^A(0) = Z_0^A$, $S(0) = S_0$, $\tau(0) = \tau_0$, $Z^W(0) = Z_0^W$. Convergent solutions toward the stable manifold read:

$$dK(t) = D_1 e^{\nu_1 t} + D_2 e^{\nu_2 t} + D_3 e^{\nu_3 t} + \omega_1^6 D_6 e^{\nu_6 t} + \omega_1^7 D_7 e^{\nu_7 t}, \tag{171a}$$

$$dQ^K(t) = \omega_2^1 D_1 e^{\nu_1 t} + \omega_2^2 D_2 e^{\nu_2 t} + \omega_2^3 D_3 e^{\nu_3 t} + \omega_2^6 D_6 e^{\nu_6 t} + \omega_2^7 D_7 e^{\nu_7 t}, \tag{171b}$$

$$dZ^A(t) = \omega_3^1 D_1 e^{\nu_1 t} + \omega_3^2 D_2 e^{\nu_2 t} + \omega_3^3 D_3 e^{\nu_3 t} + \omega_3^6 D_6 e^{\nu_6 t} + \omega_3^7 D_7 e^{\nu_7 t}, \tag{171c}$$

$$dQ^Z(t) = \omega_4^1 D_1 e^{\nu_1 t} + \omega_4^2 D_2 e^{\nu_2 t} + \omega_4^3 D_3 e^{\nu_3 t} + \omega_4^6 D_6 e^{\nu_6 t} + \omega_4^7 D_7 e^{\nu_7 t}, \tag{171d}$$

$$dS(t) = \omega_5^1 D_1 e^{\nu_1 t} + \omega_5^2 D_2 e^{\nu_2 t} + \omega_5^3 D_3 e^{\nu_3 t} + \omega_5^6 D_6 e^{\nu_6 t} + \omega_5^7 D_7 e^{\nu_7 t}, \tag{171e}$$

$$d\tau(t) = D_6 e^{\nu_6 t}, \tag{171f}$$

$$dZ^W(t) = D_7 e^{\nu_7 t}, \tag{171g}$$

where $dX(t) = X(t) - X$ with X corresponding to the steady-state value in the next steady-state, and $\nu_6 = -\xi_T < 0$, $\nu_7 = -\xi_Z < 0$.

Setting $t = 0$ into the solutions for the stock of capital, (171a), the stock of knowledge, (171c), and the stock of consumption habits, (171e), i.e., $\Psi_1 = K_0 - K - \omega_1^6 D_6 - \omega_1^7 D_7 = D_1 + D_2 + D_3$, $\Psi_2 = Z_0^A - Z^A - \omega_3^6 D_6 - \omega_3^7 D_7 = \omega_3^1 D_1 + \omega_3^2 D_2 + \omega_3^3 D_3$, $\Psi_3 = S_0 - S - \omega_5^6 D_6 - \omega_5^7 D_7 = \omega_5^1 D_1 + \omega_5^2 D_2 + \omega_5^3 D_3$, and solving for arbitrary constants:

$$\begin{pmatrix} 1 & 1 & 1 \\ \omega_3^1 D_1 & \omega_3^2 & \omega_3^3 \\ \omega_5^1 & \omega_5^2 & \omega_5^3 \end{pmatrix} \begin{pmatrix} D_1 \\ D_2 \\ D_3 \end{pmatrix} = \begin{pmatrix} \Psi_1 \\ \Psi_2 \\ \Psi_3 \end{pmatrix}, \tag{172}$$

where solutions for arbitrary constants depend on initial conditions and eigenvectors.

To find eigenvectors ω_k^6, we solve

$$\begin{pmatrix} \Upsilon_K - \nu_6 & \Upsilon_{Q^K} & \Upsilon_{Z^A} & \Upsilon_{Q^Z} & \Upsilon_S \\ \Sigma_K & \Sigma_{Q^K} - \nu_6 & \Sigma_{Z^A} & \Sigma_{Q^Z} & \Sigma_S \\ \Pi_K & \Pi_{Q^K} & \Pi_{Z^A} - \nu_6 & \Pi_{Q^Z} & \Pi_S \\ \Gamma_K & \Gamma_{Q^K} & \Gamma_{Z^A} & \Gamma_{Q^Z} - \nu_6 & \Gamma_S \\ \Theta_K & \Theta_{Q^K} & \Theta_{Z^A} & \Theta_{Q^Z} & \Theta_S - \nu_6 \end{pmatrix} \begin{pmatrix} \omega_1^6 \\ \omega_2^6 \\ \omega_3^6 \\ \omega_4^6 \\ \omega_5^6 \end{pmatrix} = \begin{pmatrix} -\Upsilon_\tau \\ -\Sigma_\tau \\ -\Pi_\tau \\ -\Gamma_\tau \\ -\Theta_\tau \end{pmatrix} \tag{173}$$

and to find eigenvectors ω_k^7, we solve:

$$\begin{pmatrix} \Upsilon_K - \nu_7 & \Upsilon_{Q^K} & \Upsilon_{Z^A} & \Upsilon_{Q^Z} & \Upsilon_S \\ \Sigma_K & \Sigma_{Q^K} - \nu_7 & \Sigma_{Z^A} & \Sigma_{Q^Z} & \Sigma_S \\ \Pi_K & \Pi_{Q^K} & \Pi_{Z^A} - \nu_7 & \Pi_{Q^Z} & \Pi_S \\ \Gamma_K & \Gamma_{Q^K} & \Gamma_{Z^A} & \Gamma_{Q^Z} - \nu_7 & \Gamma_S \\ \Theta_K & \Theta_{Q^K} & \Theta_{Z^A} & \Theta_{Q^Z} & \Theta_S - \nu_7 \end{pmatrix} \begin{pmatrix} \omega_1^7 \\ \omega_2^7 \\ \omega_3^7 \\ \omega_4^7 \\ \omega_5^7 \end{pmatrix} = \begin{pmatrix} -\Upsilon_{Z^W} \\ -\Sigma_{Z^W} \\ -\Pi_{Z^W} \\ -\Gamma_{Z^W} \\ -\Theta_{Z^W} \end{pmatrix} \tag{174}$$

E.5 Current Account Equation and Intertemporal Solvency Condition

Current account equation. As shall be useful below, we define before tax rental rates for tangible and intangible assets:

$$R^{K,j,\prime} = \frac{R^{K,j} - \delta_K}{1-\tau} + \delta_K, \tag{175a}$$

$$R^{Z,j,\prime} = \frac{R^{Z,j}}{1-\tau}. \tag{175b}$$

To determine the current account equation, we use the following identities and properties:

$$P_C C = P^H C^H + C^F + P^N C^N, \tag{176a}$$

$$P_J^K J^K = P^H J^{K,H} + J^{K,F} + P^N J^{K,N}, \tag{176b}$$

$$P_J^Z J^Z = P^H J^{Z,H} + P^N J^{Z,N}, \tag{176c}$$

$$T = G = P^H G^H + G^F + P^N G^N, \tag{176d}$$

$$P^j Y^j \left(\frac{1 + \nu_Z^j \theta_Z^j}{\mu^j} \right) = \left(W^j L^j + R^{K,j,\prime} \tilde{K}^j + R^{Z,j,\prime} \tilde{Z}^j \right). \tag{176e}$$

where (176e) follows from Euler theorem and free entry condition. Using (176e), inserting (176a)-(176c) into (84) and invoking market clearing conditions for non-traded goods (164b) and home-produced traded goods (164a) yields:

$$\begin{aligned} \dot{N} &= r^{\star}N + P^H\left(Y^H - C^H - G^H - J^{K,H} - J^{Z,H} - C^{K,H}K^H - C^{Z,H}Z^H\right) - \left(C^F + J^{K,F} + G^F\right), \\ &= r^{\star}N + P^H X^H - M^F, \end{aligned} \quad (177)$$

where $X^H = Y^H - C^H - G^H - J^H$ stands for exports of home goods and we denote by M^F imports of foreign consumption and investment goods:

$$M^F = C^F + G^F + J^{K,F}. \quad (178)$$

Current account solution. The current account reads $\dot{N}(t) = r^{\star}N(t) + P^H(t)X^H(t) - M^F(t)$ where $M^F = C^F + G^F + J^{K,F}$. Linearizing the current account equation (177), inserting solutions (171a)-(171g), integrating over $(0,t)$, solving, invoking the transversality condition leads to the stable convergent path for the stock of net foreign assets:

$$dN(t) = \frac{E_1 D_1}{\nu_1 - r^{\star}}e^{\nu_1 t} + \frac{E_2 D_2}{\nu_2 - r^{\star}}e^{\nu_2 t} + \frac{E_3 D_3}{\nu_3 - r^{\star}}e^{\nu_3 t} + \frac{E_6 D_6}{\nu_6 - r^{\star}}e^{\nu_6 t} + \frac{E_7 D_7}{\nu_7 - r^{\star}}e^{\nu_7 t}, \quad (179)$$

and the intertemporal solvency condition

$$dN + \frac{E_1 D_1}{\nu_1 - r^{\star}} + \frac{E_2 D_2}{\nu_2 - r^{\star}} + \frac{E_3 D_3}{\nu_3 - r^{\star}} + \frac{E_6 D_6}{\nu_6 - r^{\star}} + \frac{E_7 D_7}{\nu_7 - r^{\star}}, \quad (180)$$

where $\nu_1, \nu_2, \nu_3, \nu_6, \nu_7 < 0$, $E_i = \Xi_K + \Xi_{Q^K}\omega_2^i + \Xi_{Z^A}\omega_3^i + \Xi_{Q^Z}\omega_4^i + \Theta_S\omega_5^i$ for $i = 1, 2, 3$, $E_6 = \Xi_K\omega_1^6 + \Xi_{Q^K}\omega_2^6 + \Xi_{Z^A}\omega_3^6 + \Xi_{Q^Z}\omega_4^6 + \Xi_S\omega_5^6 + \Xi_{\tau}$, $E_7 = \Xi_K\omega_1^7 + \Xi_{Q^K}\omega_2^7 + \Xi_{Z^A}\omega_3^7 + \Xi_{Q^Z}\omega_4^7 + \Xi_S\omega_5^7 + \Xi_{Z^W}$.

F Solving for Permanent Corporate Income Tax Shocks

In this section, we provide the main steps for the derivation of formal solutions following a permanent corporate income tax shock.

F.1 Exogenous Dynamic Processes: Corporate Income Tax and International Stock of Knowledge

To ensure that the variation of the corporate income tax rate is exogenous to domestic activity, in estimating the VAR model, we replace the country-level corporate income tax rate with its international measure. While we identify an exogenous variation in the international corporate income tax rate, we estimate the endogenous dynamic response of the country-level tax rate to an exogenous variation in the import-share-weighted average of trade partners' corporate income tax rates. To reproduce this endogenous adjustment, we assume that the adjustment of the corporate income tax rate $\tau(t)$ toward its long-run (lower) level expressed in deviation from initial steady-state, i.e., $d\tau(t) = \tau(t) - \tau_0$, is governed by the following continuous time process:

$$d\tau(t) = d\tau + x_T e^{-\xi_T t}, \quad (181)$$

where x_T is a parameter which is calibrated to match the impact response of the tax rate and $\xi_T > 0$ measures the speed at which the tax rate closes the gap with its long-run level; $d\tau = \tau - \tau_0$ measures the the permanent decline in the corporate income tax rate which is normalized to one percentage point in the long-run. Differentiating (181) w.r.t. time leads to:

$$\dot{\tau}(t) = -\xi_T d\tau(t), \quad (182)$$

where $d\tau(t) = \tau(t) - \tau$ is the deviation of the corporate income tax rate relative to its new steady-state.

The permanent decline in the country-level corporate income tax rate is driven by exogenous reductions of corporate income tax rates by trade partners of the home country.

Because a fall in the corporate income tax rate has an expansionary effect on productivity on average in trade partners of the home country, domestic firms can benefit from the increase in the international stock of knowledge. We can interpret the positive impact of $Z^{W,H}$ on T^H by using the fact that traded firms increase $u^{Z,H}(t)$ and $Z^H(t)$ and this increase the absorption capacity of international ideas or symmetrically reduces the the adoption costs of foreign innovation.

To generate the exogenous adjustment of the international stock of knowledge following a permanent corporate income tax cut, we assume that Z^W evolves according to the following dynamic equation:

$$dZ^W(t) = dZ^W + \bar{x}_Z e^{-\xi_Z t} \tag{183}$$

where $dZ^W(t) = Z^W - Z^W_0$; $\bar{x}_Z$ parametrizes the variation of the international stock of knowledge on impact; ξ_Z is a positive parameter which governs the speed at which the international stock of knowledge converges toward its new long-run level. To be consistent with our VAR specification, we express (183) in percentage deviation from initial steady-state by dividing both sides by the initial level of the international stock of knowledge:

$$\hat{Z}^W(t) = \hat{Z}^W + x_Z e^{-\xi^j_Z t}, \tag{184}$$

where $\hat{Z}^W(\infty) = \hat{Z}^W$ with $\hat{Z}^W$ the steady-state (permanent) change in percentage in the international stock of knowledge. Differentiating (183) w.r.t. time leads to:

$$\dot{Z}^W(t) = -\xi_Z dZ^W(t), \tag{185}$$

where $dZ^W(t) = Z^W(t) - Z^W$ is the deviation of the international stock of knowledge relative to its new steady-state.

F.2 Formal Solutions for $K(t)$, $Q(t)$, $Z^A(t)$, $Q^Z(t)$, $S(t)$

The adjustment of the open economy towards the steady-state is described by a dynamic system which comprises seven equations. Linearizing (169a)-(169g), the linearized system can be written in a matrix form:

$$\begin{pmatrix} \dot{K}(t) \\ \dot{Q}^K(t) \\ \dot{Z}^A(t) \\ \dot{Q}^Z(t) \\ \dot{S}(t) \\ \dot{\tau}(t) \\ \dot{Z}^W(t) \end{pmatrix} = \begin{pmatrix} \Upsilon_K & \Upsilon_{Q^K} & \Upsilon_{Z^A} & \Upsilon_{Q^Z} & \Upsilon_S & \Upsilon_\tau & \Upsilon_{Z^W} \\ \Sigma_K & \Sigma_{Q^K} & \Sigma_{Z^A} & \Sigma_{Q^Z} & \Sigma_{Z^A} & \Sigma_\tau & \Sigma_{Z^W} \\ \Pi_K & \Pi_{Q^K} & \Pi_{Z^A} & \Pi_{Q^Z} & \Pi_S & \Pi_\tau & \Pi_{Z^W} \\ \Gamma_K & \Gamma_{Q^K} & \Gamma_{Z^A} & \Gamma_{Q^Z} & \Gamma_S & \Gamma_\tau & \Gamma_{Z^W} \\ \Theta_K & \Theta_{Q^K} & \Theta_{Z^A} & \Theta_{Q^Z} & \Theta_S & \Theta_\tau & \Theta_{Z^W} \\ 0 & 0 & 0 & 0 & 0 & -\xi_T & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & -\xi_Z \end{pmatrix} \begin{pmatrix} dK(t) \\ dQ^K(t) \\ dZ^A(t) \\ dQ^Z(t) \\ dS(t) \\ d\tau(t) \\ dZ^W(t) \end{pmatrix}. \tag{186}$$

Denoting by ω^i_k the kth element of eigenvector ω^i related to eigenvalue ν_i, the general solution that characterizes the adjustment toward the new steady-state can be written as follows: $V(t) - V = \sum_{i=1}^{7} \omega^i D_i e^{\nu_i t}$ where V is the vector of state and control variables. Denoting the positive eigenvalue by $\nu_4, \nu_5 > 0$, we set $D_4 = D_5 = 0$ to eliminate explosive paths and determine the five arbitrary constants D_i (with $i = 1, ..., 7$, $i \neq 4, 5$) by using the five initial conditions, i.e., $K(0) = K_0$, $Z^A(0) = Z^A_0$, $S(0) = S_0$, $\tau(0) = \tau_0$, $Z^W(0) = Z^W_0$. Convergent solutions toward the stable manifold read:

$$dK(t) = D_1 e^{\nu_1 t} + D_2 e^{\nu_2 t} + D_3 e^{\nu_3 t} + \omega^6_1 D_6 e^{\nu_6 t} + \omega^7_1 D_7 e^{\nu_7 t}, \tag{187a}$$
$$dQ^K(t) = \omega^1_2 D_1 e^{\nu_1 t} + \omega^2_2 D_2 e^{\nu_2 t} + \omega^3_2 D_3 e^{\nu_3 t} + \omega^6_2 D_6 e^{\nu_6 t} + \omega^7_2 D_7 e^{\nu_7 t}, \tag{187b}$$
$$dZ^A(t) = \omega^1_3 D_1 e^{\nu_1 t} + \omega^2_3 D_2 e^{\nu_2 t} + \omega^3_3 D_3 e^{\nu_3 t} + \omega^6_3 D_6 e^{\nu_6 t} + \omega^7_3 D_7 e^{\nu_7 t}, \tag{187c}$$
$$dQ^Z(t) = \omega^1_4 D_1 e^{\nu_1 t} + \omega^2_4 D_2 e^{\nu_2 t} + \omega^3_4 D_3 e^{\nu_3 t} + \omega^6_4 D_6 e^{\nu_6 t} + \omega^7_4 D_7 e^{\nu_7 t}, \tag{187d}$$
$$dS(t) = \omega^1_5 D_1 e^{\nu_1 t} + \omega^2_5 D_2 e^{\nu_2 t} + \omega^3_(D_3 e^{\nu_3 t} + \omega^6_5 D_6 e^{\nu_6 t} + \omega^7_5 D_7 e^{\nu_7 t}, \tag{187e}$$
$$d\tau(t) = D_6 e^{\nu_6 t}, \tag{187f}$$
$$dZ^W(t) = D_7 e^{\nu_7 t}, \tag{187g}$$

where $dX(t) = X(t) - X$ with X corresponding to the steady-state value in the next steady-state, and $\nu_6 = -\xi_T < 0$, $\nu_7 = -\xi_Z < 0$. We normalized ω_1^1, ω_1^2, ω_1^3, ω_6^6, and ω_7^7 to 1.

Setting $t = 0$ into the solutions for the stock of capital, the stock of knowledge, and the stock of habits, i.e., $K_0 - K - \omega_1^6 D_6 - \omega_1^7 D_7 = D_1 + D_2 + D_3$, $Z_0^A - Z^A - \omega_3^6 D_6 - \omega_3^7 D_7 = \omega_3^1 D_1 + \omega_3^2 D_2 + \omega_3^3 D_3$, $S_0 - S - \omega_5^6 D_6 - \omega_5^7 D_7 = \omega_5^1 D_1 + \omega_5^2 D_2 + \omega_5^3 D_3$ which can be rewritten in a matrix form:

$$\begin{pmatrix} 1 & 1 & 1 \\ \omega_3^1 & \omega_3^2 & \omega_3^3 \\ \omega_5^1 & \omega_5^2 & \omega_5^3 \end{pmatrix} \begin{pmatrix} D_1 \\ D_2 \\ D_3 \end{pmatrix} = \begin{pmatrix} K_0 - K - \omega_1^6 D_6 - \omega_1^7 D_7 \\ Z_0^A - Z^A - \omega_3^6 D_6 - \omega_3^7 D_7 \\ S_0 - S - \omega_5^6 D_6 - \omega_5^7 D_7 \end{pmatrix}. \tag{188}$$

The three equations can be jointly solved for the three arbitrary constants D_1, D_2, D_3 associated with the three negative eigenvalues $\nu_1 < 0$, $\nu_2 < 0$, $\nu_3 < 0$.

The arbitrary constants D_6 and D_7:

$$\tau(0) - \tau = \tau_0 - \tau = D_6 = x_T, \tag{189a}$$

$$Z^W(0) - Z^W = Z_0^W - Z^W = D_7 = x_Z. \tag{189b}$$

F.3 Formal Solution for the Net Foreign Asset Position, $N(t)$

To determine the formal solution for the net foreign asset position, we first linearize the current account equation (177) in the neighborhood of the steady-state

$$\dot{N}(t) = r^\star \left(N(t) - \tilde{N}\right) + \sum_X \Xi_X \left(X(t) - \tilde{X}\right), \tag{190}$$

where $X = K, Q^K, Z^A, Q^Z, S, \tau, Z^W$, and substitute the solutions for $K(t)$, $Q^K(t)$, $Z^A(t)$, $Q^Z(t)$, $S(t)$, and the dynamic processers for τ and Z^W, which are described by (187a) and (187g), remembering that $D_2 = 0$, we get:

$$\dot{N}(t) = r^\star \left(N(t) - \tilde{N}\right) + \sum_{i=1,3,4} E_i D_i e^{\nu_i t}, \tag{191}$$

where

$$E_1 = \Xi_K + \Xi_Q \omega_2^1, \tag{192a}$$

$$E_3 = \Xi_K \omega_1^3 + \Xi_Q \omega_2^3 + \Xi_{Z^H}, \tag{192b}$$

$$E_4 = \Xi_K \omega_1^4 + \Xi_Q \omega_2^4 + \Xi_{Z^N}. \tag{192c}$$

Solving the differential equation (192) for $N(t)$ yields the general solution for the net foreign asset position:

$$N(t) - N = \left[\left(N_0 - \tilde{N}\right) + \sum_{i=1,3,4} \Phi_N^i\right] e^{r^\star t} - \sum_{i=1,3,4} \Phi_N^i e^{\nu_i t}. \tag{193}$$

where we set $\Phi_N^i = \frac{E_i D_i}{r^\star - \nu_i}$.

Invoking the transversality condition, one obtains the 'stable' solution for the stock of net foreign assets so that $N(t)$ converges toward its steady-state value N:

$$N(t) - N = \sum_{i=1,3,4} \Phi_N^i e^{\nu_i t}, \tag{194}$$

Eq. (194) gives the trajectory for $N(t)$ consistent with the intertemporal solvency condition:

$$N - N_0 = \sum_{i=1,3,4} \Phi_N^i. \tag{195}$$

Differentiating (194) w.r.t. time gives the trajectory for the current account along the transitional path when the corporate tax rate and the international stock of knowledge follow the temporal path given by eq. (181) and (183):

$$\dot{N}(t) = \nu_i \sum_{i=1,3,4} \Phi_N^i e^{\nu_i t}. \tag{196}$$

F.4 Formal Solution for the Stock of Non Human Wealth, $A(t)$

The stock of financial wealth $A(t)$ is equal to $N(t)+Q^K(t)K(t)+Q^Z(t)Z^A(t)$; differentiating w.r.t. time, i.e., $\dot{A}(t) = \dot{N}(t)+\dot{Q}^K(t)K(t)+Q^K(t)\dot{K}(t)+\dot{Q}^Z(t)Z^A(t)+Q^Z(t)\dot{Z}^A(t)$, plugging the dynamic equation for the marginal value of physical capital (104h) and intangible capital (104i), inserting the accumulation equations for tangible assets (89), intangible assets (101), and for traded bonds (84), yields the accumulation equation for the stock of financial wealth or the dynamic equation for private savings:

$$\dot{A}(t) = r^\star A(t) + \sum_{j=H,N} W^j(t)L^j(t) - T(t) - P_C(t)C(t), \tag{197}$$

where we assume that the government levies lump-sum taxes, T, to finance purchases of foreign-produced, home-produced traded goods and non-traded goods, i.e., $T = G = P^H G^H + P^N G^N$, and we used the fact that the property of homogeneity of degree one of the adjustment costs function for the accumulation of physical capital and intangible assets which implies:

$$P_J J^K = P_J^K \frac{\partial J^K}{\partial I^K} I^K + P_J^K \frac{\partial J^K}{\partial K} K, \tag{198a}$$

$$P_J^Z J^Z = P_J \frac{\partial J^Z}{\partial I^Z} I^Z + P_J^Z \frac{\partial J^Z}{\partial Z^A} Z^A, \tag{198b}$$

where $\frac{\partial J^K}{\partial I^K} = Q^K$ and $\frac{\partial J^Z}{\partial I^Z} = Q^Z$.

To determine the formal solution for the stock of non-human wealth, we first linearize (197) in the neighborhood of the steady-state

$$\dot{A}(t) = r^\star \left(A(t) - \tilde{A}\right) + \sum_X \Lambda_X \left(X(t) - \tilde{X}\right), \tag{199}$$

where $X = K, Q^K, Z^A, Q^Z, S, \tau, Z^W$, and substitute the solutions for $K(t)$, $Q^K(t)$, $Z^A(t)$, $Q^Z(t)$, $S(t)$, and the dynamic processers for τ and Z^W, which are described by (187a) and (187g), remembering that $D_2 = 0$, we get:

$$\dot{A}(t) = r^\star \left(A(t) - A\right) + \sum_{i=1,3,4} M_i D_i e^{\nu_i t}, \tag{200}$$

where

$$M_1 = \Lambda_K + \Lambda_Q \omega_2^1, \tag{201a}$$

$$M_3 = \Lambda_K \omega_1^3 + \Lambda_Q \omega_2^3 + \Lambda_{Z^H}, \tag{201b}$$

$$M_4 = \Lambda_K \omega_1^4 + \Lambda_Q \omega_2^4 + \Lambda_{Z^N}. \tag{201c}$$

Solving the differential equation (200) for $A(t)$ yields the general solution for the stock of non-human wealth:

$$A(t) - A = \left[(A_0 - A) + \sum_{i=1,3,4} \Phi_A^i\right] e^{r^\star t} - \sum_{i=1,3,4} \Phi_A^i e^{\nu_i t}. \tag{202}$$

where we set $\Phi_A^i = \frac{M_i D_i}{r^\star - \nu_i}$.

Invoking the transversality condition, one obtains the 'stable' solution for the stock of non human wealth so that $A(t)$ converges toward its steady-state value A:

$$A(t) - A = \sum_{i=1,3,4} \Phi_A^i e^{\nu_i t}, \tag{203}$$

Eq. (203) gives the trajectory for $A(t)$ consistent with the intertemporal solvency condition:

$$A - A_0 = \sum_{i=1,3,4} \Phi_A^i. \tag{204}$$

Differentiating (204) w.r.t. time gives the trajectory for private savings (equal to national savings as we abstract from public debet) along the transitional path when the corporate tax rate and the international stock of knowledge follow the temporal path given by eq. (181) and (183):

$$\dot{A}(t) = \nu_i \sum_{i=1,3,4} \Phi_A^i e^{\nu_i t}. \tag{205}$$

F.5 Formal Solutions for $Q^K(t)K(t)$ and $Q^Z(t)Z^A(t)$

To determine the dynamics of investment in tangible assets, we first derive the formal solution for the shadow value of the capital stock, $Q^K(t)K(t)$. We thus linearize $Q^K(t)K(t)$ in the neighborhood of the steady-state:

$$Q^K(t)K(t) - P_J^K K = P_J\left(K(t) - K\right) + K\left(Q^K(t) - P_J^K\right), \tag{206}$$

where we used the fact that $Q^K = P_J^K$ in the long-run. Substitute the solutions for $K(t)$ and $Q^K(t)$ along with the dynamic equations for the corporate tax rate and the international stock of knowledge given by eq. (181) and eq. (183):

$$Q^K(t)K(t) - P_J^K K = \sum_{i=1,2,3,6,7} V_i^K D_i e^{\nu_i t}, \tag{207}$$

where $V_i^K = P_J^K \omega_1^i + K\omega_2^i$. Totally differentiating (207) w.r.t. time gives the trajectory for investment in tangible assets along the transitional path:

$$\frac{d(Q^K(t)K(t))}{dt} = \nu_i \sum_{i=1,2,3} V_i^K D_i e^{\nu_i t}. \tag{208}$$

The same logic applies to $Q^Z(t)Z^A(t)$:

$$Q^Z(t)Z^A(t) - P_J^Z Z^A = \sum_{i=1,2,3,6,7} V_i^Z D_i e^{\nu_i t}, \tag{209}$$

where $V_i^Z = P_J^Z \omega_1^i + Z^A\omega_2^i$. Totally differentiating (209) w.r.t. time gives the trajectory for investment in intangible assets along the transitional path:

$$\frac{d(Q^Z(t)Z^A(t))}{dt} = \nu_i \sum_{i=1,2,3} V_i^Z D_i e^{\nu_i t}. \tag{210}$$

Since $N(t) = A(t) - Q^K(t)K(t) - Q^Z(t)Z^A(t)$, we thus have:

$$\dot{N}(t) = \dot{A}(t) - Q^K(\dot{t})K(t) - Q^Z(t)\dot{Z}^A(t), \tag{211}$$

where expressions for the current account, national savings, investment in tangible assets and in intangible assets are given by (196), (205), (208), and (210), respectively.

G Data Description for Calibration

G.1 Non-Tradable Content of GDP and its Demand Components

Table 17 shows the tradable content of GDP, consumption, investment, investment in R&D, government spending, the share of traded hours in total hours, the share of traded capital in aggregate capital stock, the share of traded stock of R&D in the aggregate stock of R&D; the table also shows the corresponding income shares of the input; the table displays the share of exports in GDP, the home content of consumption and investment expenditure in tradables and the home content of government spending, the labor income share in the traded and non-traded sector, the investment-to-GDP ratio, government spending in % of GDP, and R&D investment expenditure in GDP. respectively. Our sample covers the 11 OECD countries displayed by Table 6. The reference period for the calibration of labor variables is 1973-2017 while the reference period for demand components is 1995-2014 due to data availability, as detailed below. When we calibrate the model to a representative economy, we use the last line which shows the (unweighted) average of the corresponding variable.

Aggregate ratios. Columns 18-20 show the investment-to-GDP ratio, ω_J, government spending as a share of GDP, ω_G. To calculate ω_J, we use time series for gross capital formation at current prices and GDP at current prices, both obtained from the OECD National Accounts Database [2017]. Data coverage: 1973-2017 for all countries. To calculate ω_G, we use time series for final consumption expenditure of general government (at current prices) and GDP (at current prices). Source: OECD National Accounts Database [2017]. Data coverage: 1973-2017 for all countries.

We consider a steady-state where trade is initially balanced and we calculate the consumption-to-GDP ratio, ω_C by using the accounting identity between GDP and final expenditure:

$$\omega_C = 1 - \omega_J - \omega_G = 57\%. \tag{212}$$

As displayed by the last line of Table 17, investment expenditure as a share of GDP averages 24%, and government spending as a share of GDP averages 19% (see column 19).

Investment expenditure in intangible assets as a share of GDP. We use data from from Stehrer et al. [2019] (EU KLEMS database). We construct time series for both gross fixed capital formation and capital stock in R&D in the traded and non-traded sectors. Data are available for nine countries for R&D investment and ten countries for the capital stock in R&D over 1995-2017. GFCF in R&D averages 2.7% of GDP, see column 20. By using the fact that total $\omega_J = \omega_J^K + \omega_J^Z$, we can infer investment in tangible assets as a % of GDP, ω_J^K:

$$\omega_J^K = \omega_J - \omega_J^Z = 23.7\% - 2.7\% = 21\%. \tag{213}$$

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Tradable content of GDP demand components. Online Appendix of Cardi and Restout [2023] details the construction of time series for the tradable content of government consumption, G_t^T, tradable content of consumption expenditure, C_t^T, and the tradable content of investment expenditure, J_t^T by using the World Input-Output Databases ([2013], [2016]). Columns 2 to 4 show the tradable content of consumption (i.e., α_C), investment (i.e., α_J), and government spending (i.e., ω_{G^T}), respectively. These demand components have been calculated by adopting the methodology described in Online Appendix F of Cardi and Restout [2023]. Sources: World Input-Output Databases ([2013], [2016]). Data coverage: 1995-2014 except for NOR (2000-2014). The tradable content of consumption, investment and government spending shown in column 2 to 4 of Table 17 averages to 42%, 33% and 17%, respectively.

Non-tradable content of GDP. In the empirical analysis, we use data from EU KLEMS ([2011], [2017]) database to construct time series for sectoral value added over the period running from 1973 to 2017. Since the demand components for non-tradables are computed over 1995-2014 by using the WIOD dataset, to ensure that the value added is equal to the sum of its demand components, we have calculated the non-tradable content of value added as one minus the value in column 1 of Table 17 as follows:

$$\begin{aligned} \omega^{Y,N} &= = \frac{P^N Y^N}{Y}, \\ &= \omega_C \left(1 - \alpha_C\right) + \omega_J \left(1 - \alpha_J\right) + \omega_{G^N} \omega_G = 65\%, \end{aligned} \tag{214}$$

where ω_C and ω_J are consumption- and investment-to-GDP ratios, and ω_G is government spending as a share of GDP, $1-\alpha_C$ and $1-\alpha_J$ are the non-tradable content of consumption and investment expenditure shown in columns 2-4, $\omega_{G^N} = 1-\omega_{G^T}$ where ω_{G^T} is the tradable content of government spending shown in column 5.

Tradable content of investment expenditure. Note that the non-tradable content of GFCF includes the non-tradable content of GFCF in tangible and in intangible assets:

$$\omega_J \left(1 - \alpha_J\right) = \omega_J^K \left(1 - \alpha_J^K\right) + \omega_J^Z \left(1 - \alpha_J^Z\right).$$

From the above equation, we can infer the non-tradable content of investment in tangible assets, $\left(1-\alpha_J^K\right)$:

$$\left(1-\alpha_J^K\right) = \frac{\omega_J\left(1-\alpha_J\right)-\omega_J^Z\left(1-\alpha_J^Z\right)}{\omega_J^K} = 70.5\%, \tag{215}$$

where we used the fact that $\omega_J = 23.7\%$, $\omega_J^K = 21\%$, $\alpha_J^Z = 58.4\%$, $\alpha_J = 33\%$. The tradable content of investment expenditure in tangible assets thus averages 29.5% (see column 3).

Tradable content of hours worked and labor compensation. To calculate the tradable share of labor shown in column 6 and labor compensation shown in column 7, we split the eleven industries into traded and non-traded sectors by adopting the classification detailed in section C.1. Details about data construction for sectoral output and sectoral labor can be found in section A. We calculate the tradable share of labor compensation as the ratio of labor compensation in the non-traded sector (i.e., $W^N L^N$) to overall labor compensation (i.e., WL). Sources: EU KLEMS ([2011], [2017]) and OECD STAN ([2011], [2017]) databases. Data coverage: 1970-2017 for all countries (except Japan: 1973-2015). The tradable content of labor and labor compensation, shown in columns 6-7 of Table 17 both average 37%.

Tradable content of tangible and intangible assets and tradable capital compensation share. To construct time series for traded and non-traded capital stocks, we construct the aggregate capital stock by using the inventory perpetual method and we calculate the traded capital stock by multiplying K_t by the value added share of tradables at nominal prices, i.e., $K_t^H = \omega_t^{Y,H} K_t$. To construct $\alpha_K = \frac{R^{K,H}K^H}{R^K K}$, we assume that $\mu^H \simeq 1$ so that $R^{K,H} = \frac{P^H Y^H - W^H L^H}{K}$. The tradable content of capital and capital compensation, shown in columns 8-9 of Table 17 average 39% and 40%, respectively.

To construct time series for traded and non-traded stocks of R&D, we use data from from Stehrer et al. [2019] (EU KLEMS database). The classification adopted to split the stock of capital in R&D into Z^H and Z^N is identical to that applied to classify value added, see section C.1. According to column 10, the ratio of capital stock of R&D of tradables to the aggregate stock of R&D, Z^H/Z^A, averages 59%.

Home content of consumption and investment expenditure in tradables. Online Appendix of Cardi and Restout [2023] details the construction of time series for the home content of consumption and investment in traded goods by using data taken from WIOD which allows to differentiate between domestic demand for home- and foreign-produced goods. Columns 13 to 14 of Table 17 show the home content of consumption and investment in tradables, denoted by α^H and α_J^H in the model. These shares are obtained from time series calculated by using the formulas derived in Online Appendix F of Cardi and Restout [2023]. Sources: World Input-Output Databases [2013], [2016]. Data coverage: 1995-2014 except for NOR (2000-2014). Column 15 shows the content of government spending in home-produced traded goods. Taking data from the WIOD dataset, time series for ω_{G^H} are constructed by using the formula in Online Appendix F of Cardi and Restout [2023]. Data coverage: 1995-2014 except for NOR (2000-2014). As shown in the last line of columns 13 and 14, the home content of consumption and investment expenditure in traded goods averages to 63% and 44%, respectively, while the share of home-produced traded goods in government spending averages 15%. Since the tradable content of government spending averages 17% (see column 5), the import content of government spending is negligible at 2% only.

Share of exports of final goods in GDP. Since we set initial conditions so that the economy starts with balanced trade, export as a share of GDP, ω_X, shown in column 12 of Table 17 is endogenously determined by the import content of consumption, $1-\alpha^H$, investment expenditure, $1-\alpha_J^H$, and government spending, ω_{G^F}, along with the consumption-to-GDP ratio, ω_C, the investment-to-GDP ratio, ω_J, and government spending as a share of GDP, ω_G. More precisely, dividing the current account equation at the steady-state by GDP, Y, leads to an expression that allows us to calculate the GDP share of exports of final goods and services produced by the home country:

$$\omega_X = \frac{P^H X^H}{Y} = \omega_C \alpha_C\left(1-\alpha^H\right) + \omega_J \alpha_J\left(1-\alpha_J^H\right) + \omega_G \omega_{G^F}, \tag{216}$$

$\omega_{G^F} = 1 - \omega_{G^{N,D}} - \omega_{G^{H,D}}$. The last line of column 12 of Table 17 shows that the export to GDP ratio averages 14%.

Sectoral labor income shares. The labor income share for the traded and non-traded sector, denoted by s_L^H and s_L^N, respectively, are calculated as the ratio of labor compensation of sector j to value added of sector j at current prices. Sources: EU KLEMS ([2011], [2017]) and OECD STAN ([2011], [2017]) databases. Data coverage: 1973-2017 for all countries (except Japan: 1973-2015). As shown in columns 16 and 17 of Table 18, s_L^H and s_L^N averages 0.65 and 0.68, respectively.

Corporate income tax rate. In the empirical analysis, we use the top statutory corporate income tax rates taken from Bachas et al. [2022] for the empirical analysis because as stressed by Akcigit et al. [2022] it is difficult to precisely capture the effective corporate tax burden that is relevant for firms due to the complexity of the corporate tax code. However, for the calibration, top statutory corporate income tax rates are too high as they do not reflect the true profits' taxation, we use the effective tax rates which is an alternative measure provided by Bachas et al. [2022]. Sample: 11 OECD countries, 1973-2017. Column 1 of Table 18 shows that the effective corporate income tax rate, τ, averages 22.5%.

Estimated elasticities. Columns 2 and 3 of Table 18 display estimates of the elasticity of labor supply across sectors, ϵ_L, and the elasticity of capital supply across sectors, ϵ_K. The empirical strategy and pin down these parameters are described in the next two subsections. The elasticity of labor supply across sectors, ϵ_L, shown in column 2 averages 1. This parameter which captures the degree of labor mobility displays a wide cross-country dispersion. The elasticity of capital supply across sectors, ϵ_K, shown in column 3 averages 0.17. In contrast to the degree of mobility of labor, the degree of capital mobility is low in all OECD countries.

Real interest rate, $r^\star$. The real interest rate is computed as the real long-term interest rate which is the nominal interest rate on 10 years government bonds minus the rate of inflation which is the rate of change of the Consumption Price Index (CPI). Sources: OECD Economic Outlook Database [2017] for the long-term interest rate on government bonds and OECD Prices and Purchasing Power Parities Database [2017] for the CPI. Data coverage: 1973-2017. The fourth column of Table 18 shows the value of the real interest rate which averages 2.5% over the period 1973-2017.

Markup. Column 5 displays the markup for the whole economy. To estimate the markup, we adopt the empirical method developed by Roeger [1995] which has been recently extended by Amador and Soares [2017] to allow for imperfectly competitive labor markets in addition to imperfectly competitive goods market. The markup at the aggregate level is estimated for each country by running the regression of the difference between the primal and dual Solow residual in rate of growth on the inverse of the rate of change in the output share of capital income and the rate of change in the labor compensation relative to capital income:

$$\hat{y}_t = \alpha + \beta^K \hat{x}_t^K + \beta^L \hat{x}_t^L + \varepsilon_t^j, \tag{217}$$

where α is a constant, $x_t^K = \left(\hat{P}_t^Q + \hat{Q}_t\right) - \left(\hat{r}_t + \hat{K}_t\right)$ is output growth minus capital income growth, $x_t^L = \left(\hat{W}_t + \hat{L}_t\right) - \left(\hat{R}_t + \hat{K}_t\right)$ is the growth rate of labor compensation minus the rate of growth of capital income, and the dependent variable is the difference between the primal and dual Solow residual in rate of growth:

$$\begin{aligned} \hat{y}_t &= \left(\hat{P}_t^Q + \hat{Q}_t\right) - \theta^L \left(\hat{W}_t + \hat{L}_t\right) \\ &- \theta^M \left(\hat{P}_t^M + \hat{M}_t\right) - \left(1 - \theta^L - \theta^M\right) \left(\hat{R}_t + \hat{K}_t\right). \end{aligned} \tag{218}$$

Variables required to apply the Roeger's method are the following: gross output (at basic current prices), compensation of employees, intermediate inputs at current purchasers prices, and capital services (volume) indices. All these variables are compiled from the EU KLEMS and STAN databases (source: EU KLEMS [2011]), with the exception of the user cost of capital. The capital user cost is calculated as $R_t = P_J(r+\delta_K)$, with P_J is the deflator of gross fixed capital formation, r the real interest rate calculated as the long-term nominal interest rate on government bonds less π_{GDP} the GDP deflator based inflation rate; the rate of depreciation δ_K is set in accordance with the value calculated from consumption of fixed capital taken from the OECD National Account Database [2017]; P_J, i and π_{GDP} were taken from the OECD Annual National Accounts database (Source OECD [2017]). To tackle the potential endogeneity of the regressor and the heteroskedasticity and autocorrelation of the error term when estimating the equation above, we use the correction of Newey and West.

G.2 Estimates of ϵ_L: Empirical Strategy and Estimates

Framework. The economy consists of M distinct sectors, indexed by $j = 0, 1, ..., M$ each producing a different good. Along the lines of Horvath [2000], the aggregate labor index is assumed to take the form:

$$L = \left[\int_0^M \left(\vartheta^j\right)^{-\frac{1}{\epsilon^L}} \left(L^j\right)^{\frac{\epsilon^L+1}{\epsilon^L}} dj\right]^{\frac{\epsilon^L}{\epsilon^L+1}}. \tag{219}$$

Optimal labor supply L^j to sector j is

$$L^j = \vartheta^j \left(\frac{W^j}{W}\right)^{\epsilon^L} L. \tag{220}$$

Each sector consists of a large number of identical firms which use labor, L^j, and physical capital, K^j, according to a constant returns to scale technology described by a CES production function. The representative firm faces two cost components: a capital rental cost equal to R^j, and a wage rate equal to W^j, respectively. Since each sector is assumed to be perfectly competitive, the representative firm chooses capital and labor by taking prices as given. The demand for labor and capital read as follows:

$$s_L^j \frac{P^j Y^j}{L^j} = W^j, \tag{221a}$$

$$\left(1 - s_L^j\right) \frac{P^j Y^j}{K^j} = R^j. \tag{221b}$$

Inserting labor demand (221a) into labor supply to sector j (220) and solving leads the share of sector j in aggregate labor:

$$\frac{L^j}{L} = \left(\vartheta^j\right)^{\frac{1}{\epsilon^L+1}} \left(\frac{s_L^j P^j Y^j}{\int_0^M s_L^j P^j Y^j dj}\right)^{\frac{\epsilon^L}{\epsilon^L+1}}, \tag{222}$$

where we used the fact that the aggregate wage rate can be rewritten as follows:

$$W = \frac{\int_0^M s_L^j P^j Y^j dj}{L}. \tag{223}$$

We denote by β^j the fraction of labor's share of value added accumulating to labor in sector j:

$$\beta^j = \frac{s_L^j P^j Y^j}{\sum_{j=1}^M s_L^j P^j Y^j}. \tag{224}$$

Using (224), the labor share in sector j (222) can be rewritten as follows:

$$\frac{L^j}{L} = \left(\vartheta^j\right)^{\frac{1}{\epsilon^L+1}} \left(\beta^j\right)^{\frac{\epsilon^L}{\epsilon^L+1}}. \tag{225}$$

Introducing a time subscript and taking logarithm, eq. (225) reads as:

$$\ln\left(\frac{L^j}{L}\right)_t = \frac{1}{\epsilon^L+1} \ln \vartheta^j + \frac{\epsilon^L}{\epsilon^L+1} \ln \beta_t^j. \tag{226}$$

Table 17: Ratios to Calibrate the Two-Sector Model

Countries	Tradable share					Input share						Home share				LIS		Aggregate ratios		
	GDP	Cons.	Inv.	R&D inv.	Gov.	L^H/L	α_L	K^H/K	α_K	Z^H/Z^A	α_Z	X^H	C^H	I^H	G^H	LIS^H	LIS^N	I^K/Y	G/Y	I^Z/Y
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
AUS	0.38	0.42	n.a.	n.a.	0.46	0.35	0.36	0.39	0.45	n.a.	n.a.	0.09	0.76	0.49	0.17	0.58	0.67	0.27	0.18	n.a.
AUT	0.36	0.44	0.38	0.60	0.09	0.39	0.38	0.38	0.38	0.54	0.60	0.17	0.56	0.42	0.11	0.68	0.68	0.25	0.18	0.024
BEL	0.35	0.47	n.a.	n.a.	0.03	0.35	0.36	0.37	0.38	0.55	n.a.	0.21	0.44	0.20	0.22	0.66	0.68	0.23	0.22	n.a.
DEU	0.37	0.47	0.35	0.71	0.06	0.33	0.34	0.38	0.31	0.74	0.71	0.14	0.69	0.43	0.09	0.75	0.64	0.23	0.20	0.026
FIN	0.34	0.43	0.20	0.63	0.19	0.39	0.42	0.39	0.49	0.64	0.63	0.12	0.67	0.41	0.17	0.64	0.74	0.25	0.20	0.037
FRA	0.29	0.43	0.20	0.56	0.02	0.33	0.32	0.34	0.32	0.56	0.56	0.10	0.71	0.46	0.22	0.72	0.69	0.23	0.22	0.024
GBR	0.35	0.42	0.29	0.38	0.19	0.39	0.37	0.39	0.44	0.51	0.38	0.12	0.66	0.42	0.19	0.69	0.74	0.20	0.20	0.020
JPN	0.33	0.34	0.23	0.75	0.39	0.41	0.39	0.42	0.43	0.75	0.75	0.04	0.85	0.82	0.16	0.59	0.66	0.30	0.16	0.033
LUX	0.36	0.45	0.33	0.38	0.05	0.35	0.34	0.33	0.47	0.34	0.38	0.29	0.18	0.16	0.15	0.57	0.60	0.21	0.15	0.006
SWE	0.33	0.44	0.33	0.69	0.03	0.34	0.39	0.40	0.43	0.67	0.69	0.15	0.63	0.38	0.06	0.67	0.74	0.24	0.25	0.046
USA	0.33	0.31	0.36	0.56	0.37	0.41	0.39	0.48	0.33	0.57	0.56	0.06	0.83	0.68	0.16	0.61	0.62	0.22	0.16	0.030
OECD	0.35	0.42	0.29	0.58	0.17	0.37	0.37	0.39	0.40	0.59	0.58	0.14	0.63	0.44	0.15	0.65	0.68	0.24	0.19	0.027

Notes: Columns 1-5 show the value added share of tradables, the tradable content of consumption, investment in tangible assets, investment in intangible assets, and government expenditure (in % of GDP). Columns 6-11 shows hours worked share of tradables, L^H/L, the tradable content of labor compensation, α_L, the ratio of traded capital to aggregate capital stock, K^H/K, the tradable content of capital income, α_K, the ratio of stock of R&D of tradables in the aggregate stock of R&D, Z^H/Z^A, and the tradable content of income on intangible assets, α_Z. Column 12 gives the ratio of exports of final goods and services to GDP; columns 13 and 14 show the home share of consumption and investment expenditure in tradables and column 15 shows the content of government spending in home-produced traded goods; columns 16 and 17 displays the labor income share in the traded and the non-traded sector; I^K/Y is the investment-to-GDP ratio, G/Y is government spending as a share of GDP; I^Z/Y is the share of investment in R&D in GDP.

Table 18: Corporate income tax rate, interest rate, elasticities, markup

Countries	Corp. tax rate	Mobility		Interest	Markup
	τ	ϵ_L	ϵ_K	r	μ^A
	(1)	(2)	(3)	(4)	(5)
AUS	0.32	0.47	0.07	0.028	1.24
AUT	0.15	1.38	0.18	0.029	1.29
BEL	0.26	0.61	0.23	0.031	1.20
DEU	0.13	0.97	0.04	0.022	1.29
FIN	0.18	0.41	0.11	0.024	1.29
FRA	0.30	1.38	0.09	0.031	1.32
GBR	0.22	0.55	0.06	0.023	1.77
JPN	0.33	0.96	0.60	0.017	1.32
LUX	0.21	0.02	0.00	0.018	1.18
SWE	0.17	0.53	0.00	0.029	1.55
USA	0.21	2.78	0.14	0.025	1.18
OECD	0.225	1.00	0.17	0.025	1.33

Notes: τ is the effective corporate income tax rate; ϵ_L is the elasticity of labor supply across sectors; ϵ_K is the elasticity of capital supply across sectors; column 4 shows the real interest rate is the real long-term interest rate calculated as the nominal interest rate on 10 years government bonds minus the rate of inflation which is the rate of change of the Consumption Price Index. Column 5 displays the markup for the whole economy.

Totally differentiating (226), denoting the rate of growth of the variable with a hat, including country fixed effects captured by country dummies, f_i, sector dummies, f_j, and common macroeconomic shocks by year dummies, f_t, leads to:

$$\hat{L}^j_{it} - \hat{L}_{it} = f_i + f_t + \gamma_i \hat{\beta}^j_{it} + \nu^j_{it}, \tag{227}$$

where

$$\hat{L}_{it} = \sum_{j=1}^{M} \beta^j_{i,t-1} \hat{L}^j_{i,t}. \tag{228}$$

and

$$\beta^j_{it} = \frac{s^j_{L,i} P^j Y^j_{it}}{\sum_{j=1}^{M} s^j_{L,i} P^j_{it} Y^j_{it}}, \tag{229}$$

where $s^j_{L,i}$ is the labor income share in sector j in country i which is averaged over 1970-2017. Y^j is value added.

Elasticity of labor supply across sectors. We use panel data to estimate (227) where $\gamma_i = \frac{\epsilon^L_i}{\epsilon^L_i+1}$ and β^j_{it} is given by (224). The LHS term of (227) is calculated as the difference between changes (in percentage) in hours worked in sector j, $\hat{L}^j_{i,t}$, and in total hours worked, $\hat{L}_{i,t}$. The RHS term β^j corresponds to the fraction of labor's share of value added accumulating to labor in sector j. Denoting by $P^j_t Y^j_t$ value added at current prices in sector $j = H, N$ at time t, β^j_t is computed as $\frac{s^j_L P^j_t Y^j_t}{\sum_{j=H}^{N} s^j_L P^j_t Y^j_t}$ where s^j_L is the LIS in sector $j = H, N$ defined as the ratio of the compensation of employees to value added in the jth sector, averaged over the period 1970-2017. Because hours worked are aggregated by means of a CES function, percentage change in total hours worked, $\hat{L}_{i,t}$, is calculated as a weighted average of sectoral hours worked percentage changes, i.e., $\hat{L}_t = \sum_{j=H}^{N} \beta^j_{t-1} \hat{L}^j_t$. The parameter we are interested in, say the degree of substitutability of hours worked across sectors, is given by $\epsilon^L_i = \gamma_i/(1-\gamma_i)$. In the regressions that follow, the parameter γ_i is assumed to be different across countries when estimating ϵ^L_i for each economy ($\gamma_i \neq \gamma_{i'}$ for $i \neq i'$).

To construct $\hat{L}^j$ and $\hat{\beta}^j$ we combine raw data on hours worked L^j, nominal value added $P^j Y^j$ and labor compensation $W^j L^j$. All required data are taken from the EU KLEMS ([2011], [2017]). The sample includes the 11 OECD countries mentioned above over the period 1974-2017 (except for Japan: 1974-2015).

Table 19 reports empirical estimates that are consistent with $\epsilon_L > 0$. All values are statistically significant at 10% except for Luxembourg. Abstracting from the estimated

Table 19: Estimates of Elasticity of Labor Supply across Sectors (ϵ_L)

Country	Elasticity of labor supply across Sectors (ϵ_L)
AUS	0.472^a (3.89)
AUT	1.376^a (2.97)
BEL	0.611^a (3.74)
DEU	0.969^a (3.52)
FIN	0.410^a (4.58)
FRA	1.378^a (3.08)
GBR	0.549^a (4.01)
JPN	0.961^a (3.79)
LUX	0.018 (0.49)
SWE	0.530^a (4.62)
USA	2.780^b (2.11)
Countries	11
Observations	940
Data coverage	1974-2017
Country fixed effects	yes
Time dummies	yes
Time trend	no

Notes: ^{a}, ^{b} and ^{c} denote significance at 1%, 5% and 10% levels. Heteroskedasticity and autocorrelation consistent t-statistics are reported in parentheses.

value for Luxembourg which is not statistically significant, we find an average value of one, as reported in last line of column 2 of Table 18. Overall, we find that ϵ_L ranges from a low of 0.41 for Finland to a high of 2.78 for the United States.

G.3 Estimates of ϵ_K: Empirical Strategy and Estimates

Framework. The economy consists of M distinct sectors, indexed by $j = 0, 1, ..., M$ each producing a different good. Along the lines of Horvath [2000], the aggregate capital index is assumed to take the form:

$$K = \left[\int_0^M \left(\vartheta_K^j\right)^{-\frac{1}{\epsilon^K}} \left(K^j\right)^{\frac{\epsilon^K+1}{\epsilon^K}} dj\right]^{\frac{\epsilon^K}{\epsilon^K+1}}. \tag{230}$$

Optimal capital supply K^j to sector j reads:

$$K^j = \vartheta_K^j \left(\frac{R^j}{R^K}\right)^{\epsilon^K} K. \tag{231}$$

The demand for labor and capital are described by:

$$s_L^j \frac{P^j Y^j}{L^j} = W^j, \tag{232a}$$

$$\left(1 - s_L^j\right) \frac{P^j Y^j}{K^j} = R^j. \tag{232b}$$

Inserting labor demand (232a) into capital supply to sector j (231) and solving leads the share of sector j in aggregate labor:

$$\frac{K^j}{K} = \left(\vartheta_K^j\right)^{\frac{1}{\epsilon^K+1}} \left(\frac{\left(1 - s_L^j\right) P^j Y^j}{\int_0^M \left(1 - s_L^j\right) P^j Y^j dj}\right)^{\frac{\epsilon^K}{\epsilon^K+1}}, \tag{233}$$

where we have used the fact that aggregate capital rental rate reads:

$$R^K = \frac{\int_0^M \left(1 - s_L^j\right) P^j Y^j dj}{K}. \tag{234}$$

We denote by $\beta^{K,j}$ the ratio of capital income in sector j to overall capital income:

$$\beta^{K,j} = \frac{\left(1 - s_L^j\right) P^j Y^j}{\sum_{j=1}^M \left(1 - s_L^j\right) P^j Y^j}. \tag{235}$$

Using (235), the share of capital in sector j (233) can be rewritten as follows:

$$\frac{K^j}{K} = \left(\vartheta_K^j\right)^{\frac{1}{1+\epsilon^K}} \left(\beta^{K,j}\right)^{\frac{\epsilon^K}{\epsilon^K+1}}. \tag{236}$$

Introducing a time subscript and taking logarithm, eq. (236) reads as:

$$\ln\left(\frac{K^j}{K}\right)_t = \frac{1}{\epsilon^K + 1}\ln \vartheta_K^j + \frac{\epsilon^K}{\epsilon^K + 1}\ln \beta_t^{K,j}. \tag{237}$$

We denote the rate of growth of the variable with a hat. We totally differentiate (237) and include country fixed effects captured by country dummies, g_i, sector dummies, g_j, and common macroeconomic shocks captured by year dummies, g_t:

$$\hat{K}_{it}^j - \hat{K}_{it} = g_i + g_t + g_j + \gamma_i^K \hat{\beta}_{it}^{K,j} + \nu_{it}^{K,j}, \tag{238}$$

We use panel data to estimate (238). We run the regression of the percentage change in the share of capital in sector j on the percentage change in the capital income share of sector j relative to the aggregate economy. Intuitively, when the demand for capital rises in sector j, $\beta^{K,j}$ increases which provides incentives for households to shift capital toward this sector. To calculate $\beta_{it}^{K,j}$ for sector j, in country i at time t, we proceed as follows:

$$\hat{K}_{it} = \sum_{j=1}^M \beta_{i,t-1}^{K,j} \hat{K}_{i,t}^j. \tag{239}$$

and

$$\beta_{it}^{K,j} = \frac{\left(1 - s_{L,i}^j\right) P_{it}^j Y_{it}^j}{\sum_{j=1}^M \left(1 - s_{L,i}^j\right) P_{it}^j Y_{it}^j}, \tag{240}$$

where $\left(1 - s_{L,i}^j\right)$ is the capital income share in sector j in country i which is averaged over 1970-2017. Y^j is value added and P^j is the value added deflator.

Data: Source and Construction. We take capital stock series from the EU KLEMS [2011] and [2017] databases which provide disaggregated capital stock data (at constant prices) at the 1-digit ISIC-rev.3 level for up to 11 industries. To construct $\hat{K}_{it}^j$ and $\hat{\beta}_{it}^{K,j}$ we combine raw data on capital stock K^j, nominal value added $P^j Y^j$ and labor compensation $W^j L^j$ to calculate $1 - s_L^j$.

Degree of capital mobility across sectors. We use panel data to estimate eq. (238) where $\gamma_i^K = \frac{\epsilon_{K,i}}{\epsilon_{K,i}+1}$ and $\beta_{it}^{K,j}$ is given by (240). Table 20 reports empirical estimates that are consistent with $\epsilon_K > 0$. We average positive values for ϵ_K and exclude negative values as they are inconsistent. We find an average value for ϵ_K of 0.17, as reported in last line of column 3 of Table 18. The values are low for all countries of the sample which suggests high capital mobility costs across sectors in OECD countries.

Table 20: Elasticity of Capital Supply across Sectors (ϵ_K)

Country	Elasticity of capital supply across Sectors (ϵ_K)
AUS	0.069 (1.14)
AUT	0.179^c (1.70)
BEL	0.235^c (1.69)
DEU	0.042 (0.63)
FIN	0.108^b (2.45)
FRA	0.093 (1.10)
GBR	0.062 (1.21)
JPN	0.599^a (4.50)
LUX	−0.039 (−1.16)
SWE	−0.035 (−0.53)
USA	0.140 (1.48)
Countries	11
Observations	758
Data coverage	1974-2017
Country fixed effects	yes
Time dummies	yes
Time trend	no

Notes: ^{a}, ^{b} and ^{c} denote significance at 1%, 5% and 10% levels. Heteroskedasticity and autocorrelation consistent t-statistics are reported in parentheses.

G.4 Elasticity of Substitution in Consumption between Traded and Non-Traded Goods, ϕ

Derivation of the testable equation. To estimate the elasticity of substitution in consumption, ϕ, between traded and non-traded goods, we derive a testable equation by rearranging the demand for non-traded goods, i.e., $C_t^N = (1-\varphi)\left(\frac{P_t^N}{P_{C,t}}\right)^{-\phi} C_t$, since time series for consumption in non-traded goods are too short. More specifically, we derive an expression for the non-tradable content of consumption expenditure by using the market clearing condition for non-tradables and construct time series for $1-\alpha_{C,t}$ by using time series for non-traded value added and demand components of GDP while keeping the non-tradable content of investment and government expenditure fixed, in line with the evidence documented by Bems [2008] for the share of non-traded goods in investment and building on our own evidence for the non-tradable content of government spending. After verifying that the (logged) share of non-tradables and the (logged) ratio of non-traded prices to the consumption price index are both integrated of order one and cointegrated, we run the regression by adding country and time fixed effects together and including a country-specific time trend and estimate the coefficient by using a Fully Modified OLS estimator.

Multiplying both sides of $C_t^N = (1-\varphi)\left(\frac{P_t^N}{P_{C,t}}\right)^{-\phi} C_t$ by P^N/P_C leads to the non-tradable content of consumption expenditure:

$$1-\alpha_{C,t} = \frac{P_t^N C_t^N}{P_{C,t} C_t} = (1-\varphi)\left(\frac{P_t^N}{P_{C,t}}\right)^{1-\phi}. \tag{241}$$

Because time series for non-traded consumption display a short time horizon for most of the countries of our sample while data for sectoral value added and GDP demand components are available for all of the countries of our sample over the period running from 1970 to 2017, we construct time series for the share of non-tradables by using the market clearing condition for non-tradables:

$$\frac{P_t^N C_t^N}{P_{C,t} C_t} = \frac{1}{\omega_{C,t}}\left[\frac{P_t^N Y_t^N}{Y_t} - (1-\alpha_J)\,\omega_{J,t} - \omega_{G^N}\omega_{G,t}\right]. \tag{242}$$

Table 21: Elasticity of Substitution between Tradables and Non-Tradables (ϕ)

	eq. (243)
Whole Sample	0.446^{a} (5.56)
Countries	11
Observations	492
Data coverage	1973-2017
Country fixed effects	yes
Time dummies	yes
Time trend	yes

Notes: ^{a}, ^{b} and ^{c} denote significance at 1%, 5% and 10% levels. Heteroskedasticity and autocorrelation consistent t-statistics are reported in parentheses.

Since the time horizon is too short at a disaggregated level (for I^j and G^j) for most of the countries, we draw on the evidence documented by Bems [2008] which reveals that $1-\alpha^J = \frac{P^N J^N}{P^J J}$ is constant over time; we further assume that $\frac{P^N G^N}{G} = \omega_{G^N}$ is constant as well in line with our evidence. We thus recover time series for the share of non-tradables by using time series for the non-traded value added at current prices, $P_t^N Y_t^N$, GDP at current prices, Y_t, consumption expenditure, gross fixed capital formation, I_t, government spending, G_t while keeping the non-tradable content of investment and government expenditure, $1-\alpha_J$, and ω_{G^N}, fixed.

Empirical strategy. Once we have constructed time series for $1-\alpha_{C,t} = \frac{P_t^N C_t^N}{P_{C,t} C_t}$ by using (241), we take the logarithm of both sides of (241) and run the regression of the logged share of non-tradables on the logged ratio of non-traded prices to the consumption price index:

$$\ln\left(1-\alpha_{C,it}\right) = f_i + f_t + \alpha_i\ .t + (1-\phi)\ln\left(P^N/P_C\right)_{it} + \mu_{it}, \tag{243}$$

where f_i captures the country fixed effects, f_t are time dummies, and μ_{it} are the i.i.d. error terms. Because parameter φ in (241) may display a trend over time, we add country-specific trends, as captured by $\alpha_i t$. It is worth mentioning that P^N is the value added deflator of non-tradables.

Data source and construction. Data for non-traded value added at current prices, $P_t^N Y_t^N$ and GDP at current prices, Y_t, are taken from EU KLEMS ([2011], [2017]) database (data coverage: 1973-2017 for all countries, except for Japan: 1973-2015). To construct time series for consumption, investment and government expenditure as a percentage of nominal GDP, i.e., $\omega_{C,t}$, $\omega_{J,t}$ and $\omega_{G,t}$, respectively, we use data at current prices obtained from the OECD Economic Outlook [2017] Database (data coverage: 1973-2017). Sources, construction and data coverage of time series for the share of non-tradables in investment $(1-\alpha_J)$ and in government spending (ω_{G^N}) are described in depth above; P^N is the value added deflator of non-tradables. Data are taken from EU KLEMS ([2011], [2017]) and OECD STAN ([2011], [2017]) databases (data coverage: 1973-2017 for all countries, except for Japan: 1973-2017). Finally, data for the consumer price index $P_{C,t}$ are obtained from the OECD Prices and Purchasing Power Parities [2017] database (data coverage: 1973-2017).

Results. Since both sides of (243) display trends, we ran unit root and then cointegration tests. Having verified that these two assumptions are empirically supported, we estimate the cointegrating relationships by using the fully modified OLS (FMOLS) procedure for cointegrated panel proposed by Pedroni [2000], [2001]. FMOLS estimate of (243) is reported in Table 21. We find a value for the elasticity of substitution between traded and non-traded goods in consumption of 0.44 which collaspes to the estimated value documented by Stockman and Tesar [1995].

G.5 Elasticity of Utilization-Adjusted-TFP w.r.t. the Stock of R&D

We measure technology by adjusting the Solow residual with the intensity in the use of capital. We assume that the stock of ideas Z^j_t gives rise to utilization-adjusted-TFP. Both sectors, i.e., traded and non-traded industries can benefit from the domestic stock of ideas but also from international knowledge. We assume that the stock of ideas Z^j_t is made up of a domestic Z^j_t (we ignore the technology utilization rate) and an international stock of knowledge $Z^W(t)$:

$$\mathsf{Z}^j(t) = \left(Z^j_i(t)\right)^{\theta^j_Z} \left(Z^W(t)\right)^{1-\theta^j_Z}, \tag{244}$$

where θ^j_Z captures the domestic content of the stock of knowledge accessible to domestic firms in sector j. While the stock of knowledge gives rise to technology improvements, we assume that the domestic and the international stock of knowledge produces differentiated effects on utilization-adjusted-TFP in sector j:

$$\mathcal{T}^j_t = \left(Z^j_i(t)\right)^{\nu^j \theta^j_Z} \left(Z^W(t)\right)^{\nu^{W,j}\left(1-\theta^j_Z\right)}, \tag{245}$$

where ν^j ($\nu^{W,j}$) is the elasticity of technology w.r.t. the domestic (international) stock of knowledge. Our objective is to estimate this parameter at a sector level to calibrate our model.

We take the log of (245), add an error term and run the regression of logged utilization-adjusted-TFP in sector j on the logged stock of R&D in country i and the logged international stock of R&D. We run the regression by using cointegration in panel format on annual data:

$$\ln \mathrm{T}^j_{it} = \alpha_i + \alpha_t + \beta_i t + \gamma^j \ln Z^j_{it} + \gamma^{W,j} \ln Z^W_{it} + \eta_{it}, \tag{246}$$

where we include country fixed effects and country-specific linear time trend and we estimate $\gamma^j = \nu^j \theta^j_Z$. Because θ^j_Z is the domestic component of country-level-utilization-adjusted-TFP we obtain from the principal component analysis, we can infer $\nu^j = \frac{\gamma^j}{\theta^j_Z}$.

We use data from from Stehrer et al. [2019] (EU KLEMS database). We construct time series for the capital stock in R&D in the traded and non-traded sectors. Data are available for ten countries for the capital stock in R&D over 1995-2017 at a sectoral level. Table 22 provides information about the sample. Data are available for all countries over 1995-2017 except Australia. Data are available over a shorter time horizon for Japan (1995-2015) and Sweden (1995-2016).

We construct time series for the international stock of knowledge $Z^{W,j}_{it}$ as the geometric average of the stock of R&D in sector j of the (ten) trade partners of the corresponding country i, the weight being equal to the share $\alpha^{M,k}_i$ of imports from the trade partner k (averaged over 1973-2017). We assume international R&D spillovers but abstract from inter-sectoral R&D spillovers. This assumption implies that utilization-adjusted-TFP of sector $j = H, N$ will be affected by the stock of R&D of this sector j and the international stock of R&D defined an import-share-weighted-average of stock of R&D in sector j of trade partners of the home country i.

By adopting a principal component analysis, we have estimated the common component of utilization-adjusted-TFP. Results are reported in Tale 23. The world component of traded technology amounts to 43.7% which implies that $\theta^H_Z = 56.3\%$ for tradables. The world component of non-traded technology is lower and stands at 37.5% which implies that $\theta^N_Z = 62.5\%$ for non-tradables.

Table 24 shows estimation results from the regression of eq. (246) in panel format by considering the whole sample (first row, N=10 countries) and for the country split by considering flexible-wage-countries (N=6) vs. rigid-wage-countries (N=4).

Whole sample, $N = 10$. For the whole sample, we find a value for the elasticity of utilization-adjusted-TFP of tradables w.r.t. the domestic stock of R&D of tradables of $\gamma^H = 0.292$ and a value for the elasticity of utilization-adjusted-TFP of tradables w.r.t. the international stock of R&D of tradables of $\gamma^{W,H} = 0.104$. For the non-traded sector, none of the estimated values are statistically significant so that $\gamma^N = \gamma^{W,N} = 0$.

Table 22: Stock of Capital (KLEMS) and Stock of R&D (KLEMS) at Industry Level: Data Availability

	data on K from KLEMS	data on stock R&D
AUS	1973-2007	no data
AUT	1976-2017	1995-2017
BEL	1995-2017	1995-2017
DEU	1991-2017	1995-2017
FIN	1973-2017	1995-2017
FRA	1978-2017	1995-2017
GBR	1973-2017	1995-2017
JPN	1973-2015	1995-2015
LUX	1995-2017	1995-2017
SWE	1993-2016	1995-2016
USA	1973-2016	1995-2017

Table 23: The Share of Variance of TFP Growth Attributable to World TFP Growth (in %)

	Total Variance	Variance World	Contribution in %	
			World	Country-level
	(1)	(2)	(3)	(4)
Agg. Technology	0.0023	0.0009	38.60	61.40
H-Technology	0.0072	0.0031	43.69	56.31
N-Technology	0.0021	0.0008	37.49	62.51

Notes: We run a principal component analysis to extract the common component to all country-level-adjusted-aggregate-TFP growth that we interpret as the world component. In columns 1 and 2, we show the variance of the rate of growth of country-level-adjusted-TFP and its common component, respectively. The figure in columns 3-4 denotes the fraction of the variance of country-level TFP growth attributable to the world component and country-specific component, respectively.

Table 24: Elasticities of Utilization-Adjusted-TFP w.r.t. the Stock of Domestic ($\hat{\gamma}_i^j$) R&D and the Stock of International R&D ($\hat{\gamma}_i^{Wj}$) for the Whole Sample and the Country-Split

	Aggregate Economy		Sector H		Sector N	
	$\hat{\gamma}_i^j$	$\hat{\gamma}_i^{Wj}$	$\hat{\gamma}_i^j$	$\hat{\gamma}_i^{Wj}$	$\hat{\gamma}_i^j$	$\hat{\gamma}_i^{Wj}$
Whole Sample	-0.031^a	0.016	0.292^a	0.104^a	-0.007	0.012
	(3.33)	(0.55)	(8.10)	(5.39)	(-0.14)	(1.12)
Flex. wage N=6	0.110^a	0.043^a	0.506^a	0.134^a	0.024^b	0.044^a
	(7.94)	(2.62)	(11.89)	(4.62)	(2.50)	(4.83)
Rigid. wage N=4	-0.241^a	-0.023^b	-0.030^c	0.059^a	-0.053^a	-0.036^a
	(-4.46)	(2.34)	(-1.74)	(2.87)	(-3.29)	(-4.14)
Countries	10	10	10	10	10	10
Observations	226	226	226	226	226	226
Data coverage	1995-2017	1995-2017	1995-2017	1995-2017	1995-2017	1995-2017
Country fixed effects	yes	yes	yes	yes	yes	yes
Time dummies	no	no	no	no	no	no
Time trend	yes	yes	yes	yes	yes	yes

Notes: [a], [b] and [c] denote significance at 1%, 5% and 10% levels. Heteroskedasticity and autocorrelation consistent t-statistics are reported in parentheses. Denoting utilization-adjusted-TFP in sector j by $\mathcal{Z}_{it}^j$ and domestic and international stocks of R&D by Z_{it}^j and Z_{it}^{Wj} respectively, we run the regression of utilization adjusted TFP on the stocks of domestic and international R&D at constant prices in sector j in panel format on annual data:

$$\ln \mathrm{T}_{it}^j = \alpha_i + \alpha_t + \beta_i t + \gamma^j \ln Z_{it}^j + \gamma^{W,j} \ln Z_{it}^W + \eta_{it},$$

where we include country fixed effects and country-specific linear time trend. We construct the international stock of knowledge as a geometric weighted average of trade partners' stock of R&D at constant prices for country i, i.e., $Z_{it}^W = \Pi_{k=1}^{10} \left(Z_{kt}\right)^{\alpha_{ik}^M}$ where α_k^M is the share of imports of home country i from the trade partner k. Sample: 10 OECD countries, 1973-2017, annual data.

By using the domestic component $\theta_Z^H = 0.567$ of the stock of knowledge accessible to domestic firms in the traded sector, we find an effect of the stock of R&D Z_{it}^H on technology

Table 25: Elasticities of Utilization-Adjusted-TFP w.r.t. the Stock of Domestic ($\hat{\gamma}_i^j$) R&D and the Stock of International R&D ($\hat{\gamma}_i^{Wj}$) for English-Speaking and Scandinavian Countries

	Sector H		Sector N	
	$\hat{\gamma}_i^j$	$\hat{\gamma}_i^{Wj}$	$\hat{\gamma}_i^j$	$\hat{\gamma}_i^{Wj}$
FIN	0.239^a (10.04)	0.161^a (4.02)	0.135^a (3.27)	0.043^c (1.89)
GBR	0.818^b (2.08)	0.115 (0.73)	0.023 (0.69)	0.025 (1.41)
JPN	0.066 (0.49)	0.555^a (7.01)	0.260^a (5.42)	0.276^a (6.07)
LUX	0.044^a (3.56)	−0.076 (−0.71)	0.024^a (3.13)	-0.117^a (−3.00)
SWE	0.337^a (4.28)	0.061 (0.60)	−0.165 (−1.38)	−0.001 (−0.03)
USA	1.533^a (8.67)	−0.012 (−0.34)	-0.133^a (−5.00)	0.039^a (5.48)
Countries	6	6	6	6
Observations	134	134	134	134
Data coverage	1995-2017	1995-2017	1995-2017	1995-2017
Country fixed effects	yes	yes	yes	yes
Time dummies	no	no	no	no
Time trend	yes	yes	yes	yes

Notes: ^{a}, ^{b} and ^{c} denote significance at 1%, 5% and 10% levels. Heteroskedasticity and autocorrelation consistent t-statistics are reported in parentheses. Denoting utilization-adjusted-TFP in sector j by $\mathcal{Z}_{it}^j$ and domestic and international stocks of R&D by Z_{it}^j and Z_{it}^{Wj} respectively, we run the regression of utilization adjusted TFP on the stocks of domestic and international R&D at constant prices in sector j in panel format on annual data:

$$\ln \mathrm{T}_{it}^j = \alpha_i + \alpha_t + \beta_i t + \gamma^j \ln Z_{it}^j + \gamma^{W,j} \ln Z_{it}^W + \eta_{it},$$

where we include country fixed effects and country-specific linear time trend. We construct the international stock of knowledge as a geometric weighted average of trade partners' stock of R&D at constant prices for country i, i.e., $Z_{it}^W = \Pi_{k=1}^{10} \left(Z_{kt}\right)^{\alpha_{ik}^M}$ where α_k^M is the share of imports of home country i from the trade partner k. Sample: 6 OECD countries, 1973-2017, annual data.

Table 26: Elasticities of Utilization-Adjusted-TFP w.r.t. the Stock of Domestic ($\hat{\gamma}_i^j$) R&D and the Stock of International R&D ($\hat{\gamma}_i^{Wj}$) for Continental European Countries

	Sector H		Sector N	
	$\hat{\gamma}_i^j$	$\hat{\gamma}_i^{Wj}$	$\hat{\gamma}_i^j$	$\hat{\gamma}_i^{Wj}$
AUT	-0.071	0.051	-0.053	-0.055^a
	(-0.46)	(1.35)	(-0.36)	(-4.44)
BEL	0.389^a	0.076^c	-0.139^a	0.049^a
	(3.53)	(1.67)	(-4.48)	(2.69)
DEU	0.351^b	0.030	-0.105^a	-0.070^a
	(2.14)	(0.93)	(-3.24)	(-3.83)
FRA	-0.790^a	0.079^c	0.085	-0.068^a
	(-8.70)	(1.79)	(1.49)	(-2.71)
Countries	4	4	4	4
Observations	92	92	92	92
Data coverage	1995-2017	1995-2017	1995-2017	1995-2017
Country fixed effects	yes	yes	yes	yes
Time dummies	no	no	no	no
Time trend	yes	yes	yes	yes

Notes: ^{a}, ^{b} and ^{c} denote significance at 1%, 5% and 10% levels. Heteroskedasticity and autocorrelation consistent t-statistics are reported in parentheses. Denoting utilization-adjusted-TFP in sector j by $\mathcal{Z}_{it}^j$ and domestic and international stocks of R&D by Z_{it}^j and Z_{it}^{Wj} respectively, we run the regression of utilization adjusted TFP on the stocks of domestic and international R&D at constant prices in sector j in panel format on annual data:

$$\ln \mathrm{T}_{it}^j = \alpha_i + \alpha_t + \beta_i t + \gamma^j \ln Z_{it}^j + \gamma^{W,j} \ln Z_{it}^W + \eta_{it},$$

where we include country fixed effects and country-specific linear time trend. We construct the international stock of knowledge as a geometric weighted average of trade partners' stock of R&D at constant prices for country i, i.e., $Z_{it}^W = \Pi_{k=1}^{10} \left(Z_{kt}\right)^{\alpha_{ik}^M}$ where α_k^M is the share of imports of home country i from the trade partner k. Sample: 6 OECD countries, 1973-2017, annual data.

T_{it}^H of $\nu^H = \frac{0.292}{0.563} = 0.519$. Using the international component of traded technology, i.e., $1 - \theta_Z^H = 0.437$, we find an effect of the stock of R&D Z_{it}^H on technology T_{it}^H of $\nu^{W,H} = \frac{0.104}{0.437} = 0.238$. The same logic applies to the non-traded sector. Because estimates values are not statistically significant, we have $\nu^N = \nu^{W,N} = 0$.

Flexible-wage countries, $N = 6$. For the group of countries with more flexible wages, the second row of Table 24 shows that the elasticity of utilization-adjusted-TFP of tradables w.r.t. the domestic stock of R&D of tradables amounts to $\gamma^H = 0.506$ and a value for the elasticity of utilization-adjusted-TFP of tradables w.r.t. the international stock of R&D of tradables of $\gamma^{W,H} = 0.134$. By using the domestic and international components of utilization-adjusted-TFP of tradables, we find an estimated effect of the domestic stock of knowledge on utilization-adjusted-TFP of tradables of $\nu^H = \frac{\gamma^H}{\theta_Z^H} = \frac{0.506}{0.563} = 0.899$ and an estimated effect of the international stock of knowledge on T^H of $\nu^{W,H} = \frac{0.134}{0.437} = 0.307$.

For the non-traded sector, we have $\gamma^N = 0.024$ and $\gamma^{W,N} = 0.044$. which leads to an estimated effect of the domestic stock of knowledge on utilization-adjusted-TFP of non-tradables of $\nu^N = \frac{\gamma^N}{\theta_Z^N} = \frac{0.024}{0.625} = 0.038$ and an estimated effect of the international stock of knowledge on T^N of $\nu^{W,N} = \frac{0.044}{0.375} = 0.118$.

Rigid-wage countries, $N = 4$. For this group of countries, only the international stock of knowledge has a consistent and statistically significant effect on utilization-adjusted-TFP of tradables. More specifically, we have $\gamma^H = \gamma^N = \gamma^{W,N} = 0$ while $\gamma^{W,H} = 0.059$ which leads to an estimated effect of the international stock of knowledge $Z^{W,H}$ on utilization-adjusted-TFP of tradables of $\nu^{W,H} = \frac{\gamma^{W,H}}{1-\theta_Z^H} = \frac{0.059}{0.437} = 0.135$.

G.6 Investment Share of Tradables

If we aggregate investment in tangible and in intangible assets, the optimal share of investment expenditure spent on traded inputs reads:

$$\alpha_J = \iota \left(\frac{P^T}{P_J}\right)^{1-\phi_J}, \tag{247}$$

where ϕ_J is the elasticity of substitution between traded and non-traded investment inputs. If we restrict our attention of the investment in R&D, the optimal share of investment in intangible assets spent on traded goods reads (see section E.1):

$$\alpha_J^Z = \frac{P^H J^{Z,H}}{P_Z J^Z} = \iota_Z \left(\frac{P^H}{P_Z}\right)^{1-\phi_Z}, \tag{248}$$

where ϕ_Z is the elasticity of substitution between traded and non-traded R&D investment inputs. If we restrict attention to tangible assets, the optimal share of investment in tangible assets spent on traded goods reads (see section E.1):

$$\alpha_J^K = \alpha_J^K = \iota \left(\frac{P_K^T}{P_J}\right)^{1-\phi_K}, \tag{249}$$

where ϕ_K is the elasticity of substitution between traded and non-traded investment inputs.

To calibrate our model, we have to choose values for parameters ϕ_K and ϕ_Z. We have time series for GFCF which includes both investment in tangible and in intangible assets. In Fig. 20(a), we plot the tradable content of investment expenditure when we use WIOD to construct the time series for GFCF at a sectoral level. The blue line shows the country average (across 11 OECD countries). The tradable content of investment expenditure averages 32% and this share is stable over time, although there is a slight decline from 33% in 1995 to 30% in 2014. To further check the stability of the tradable share of investment expenditure, we have constructed time series for α_J by using two alternative sources, i.e., OECD and EU KLEMS. The OECD classification is based on assets classification (for example dwellings, machinery, ...) while the classification by EU KLEMS is a classification by industry, i.e., it shows the investment per industry. While the classifications are completely different, we find an average of 0.41 for OECD, 0.33 for EU KLEMS and 0.32 for WOID. Because the classification is based on investment by industry for EU KLEMS and WIOD, it is reassuring that the figures are very close. While the mean for OECD time series is higher, Fig. 20(c) shows that the tradable content of investment expenditure is stale over time. We detect a slight gradual decline in α_J in Fig. 20(d).

In Fig. 20(b), we plot the tradable share of investment in R&D. As it stands out, α_J^Z is stable over time. Since the tradable content of total investment expenditure (i.e., α_J) and the tradable content of investment in R&D (i.e., α_J^Z) are both stable over time, the tradable content of investment in physical capital (i.e., α_J^K) must also be constant over time by construction. In the calibration, we choose a value of one for the elasticity of substitution ϕ_K between traded and non-traded investment inputs in tangible assets, and a value of one for the elasticity of substitution ϕ_Z between traded and non-traded investment inputs in intangible assets.

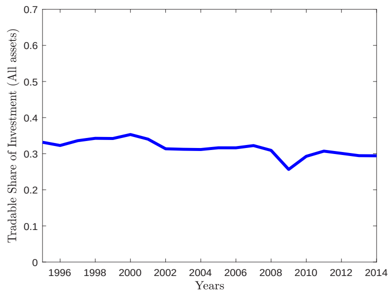
H Numerical Analysis for the Country-Split Analysis

In this section, we provide more information about the calibration of the model to the data when we consider sub-samples and we also show more numerical results.

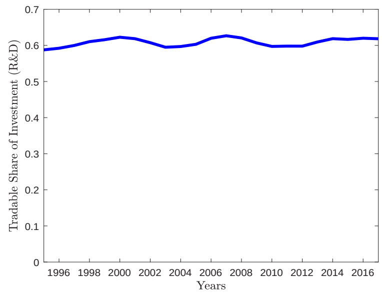
H.1 Calibration of the Model to the Data

At the steady-state, capital utilization rates, $u^{K,j}$, collapse to one so that $\tilde{K}^j = K^j$. To calibrate the reference model, we have estimated a set of ratios and parameters for the the two groups of OECD economies in our dataset, see Table 27. Our reference period for the calibration is 1973-2017.

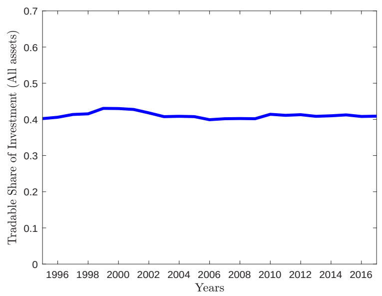
For the first sub-sample which is made-up of English-speaking and Scandinavian countries (including Japan and Luxembourg), like for a representative OECD economy, we have to choose values for 43 parameters which include i) 17 parameters which are endogenously calibrated to match ratios, ii) 15 parameters takes directly from our data or that we estimate empirically, and iii) 11 parameters which are taken from external research works. The first and the third row of the Table 27 shows the values of main parameters for our calibration for English-speaking and Scandinavian countries.



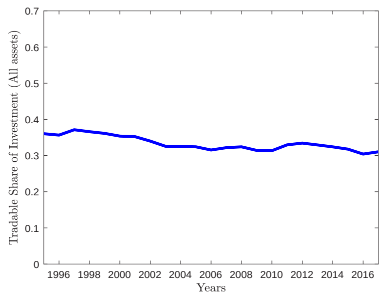
(a) Tradable Share of GFCF (Source: WIOD)



(b) Tradable Share of Investment in R&D (Source: EU KLEMS)



(c) Tradable Share of GFCF (Source: OECD)



(d) Tradable Share of GFCF (Source: EU KLEMS)

Figure 20: The Investment Share in Tradables (995-2017) for 11 OECD Countries. Notes: In Fig. 20(a), 20(c), 20(d), the blue line shows the share of investment expenditure spent on tradables by using three different sources: WIOD, OECD, EU KLEMS, respectively. Fig. 20(b) plots the tradable content of R&D investment expenditure by using one unique source: EU KLEMS. Sample for both figures: 11 OECD countries, 1995-2017.

English-speaking and Scandinavian countries, $N = 7$. Parameters including φ, ι, ι_Z, φ^H, ι^H, ϑ_L, ϑ_K, ϑ_Z, δ_K, δ_Z, G, G^N, G^H must be set to target a tradable content of consumption and investment expenditure in tangible and intangible assets of $\alpha_C = 40\%$, $\alpha_J^K = 29\%$, $\alpha_J^Z = 57\%$, respectively, a home content of consumption and investment (in physical capital) expenditure in tradables of $\alpha^H = 66\%$ and $\alpha_J^H = 48\%$, respectively, a weight of labor supply of $L^H/L = 37\%$, a weight of tangible and intangible assets supply to the traded sector of $K^H/K = 40\%$ and $Z^H/Z^A = 58\%$, respectively, an investment share of GDP in physical capital and in R&D of $\omega_J^K = 20.5\%$ and $\omega_J^K = 2.9\%$, respectively, a ratio of government spending to GDP of $\omega_G = 18.7\%$ $(= G/Y)$, a tradable and home-tradable share of government spending of $\omega_{G^T} = 24\%$ $(= 1-(P^N G^N/G))$, and $\omega_{G^H} = 15\%$ $(= P^H G^H/G)$, and we choose initial conditions so as trade is balanced, i.e., $\upsilon_{NX} = \frac{NX}{P^H Y^H} = 0$ with $NX = P^H X^H - C^F - I^F - G^F$. Because $u^{K,j} = u^{Z,j} = 1$ at the steady-state, four parameters related to capital ξ_1^H, ξ_1^N, and technology, χ_1^H, χ_1^N, adjustment cost functions are set to be equal to $R^{K,H}/P^H$, $R^{K,N}/P^N$, $R^{Z,H}/P^H$, $R^{Z,N}/P^N$, respectively.

Fifteen parameters are assigned values which are taken directly or estimated from our own data. We choose the model period to be one year. In accordance with column 28 of Table 2, the world interest rate, $r^\star$, which is equal to the subjective time discount rate, β, is set to 2.3%. In line with mean values shown in columns 10 and 11 of Table 2, the shares of labor income in traded and non-traded value added, θ^H and θ^N, are set to 0.62 and 0.68, respectively, which leads to an aggregate LIS of 65%.

Building on our panel data estimates for the elasticity of labor supply across sectors, ϵ, we choose a value of 0.95 for this parameter which collapses to the country average of our estimates for the group $N = 7$. We have also estimated the degree of mobility of capital between sectors, ϵ_K, and choose a value of 0.21 which collapses to the country average of our estimates. Due to a lack of data, we cannot estimate the degree of mobility of intangible assets between sectors, ϵ_Z, and and choose a value for this parameter which collapses the degree of mobility of capital, i.e., $\epsilon_Z = \epsilon_K = 0.21$. Because the elasticity of substitution ϕ between traded and non-traded goods cannot be estimated accurately for one country at a time, we set ϕ to 0.45 (see column 13 of Table 2), since this value corresponds to our panel data estimates.

To determine values for the elasticity of technology w.r.t. the domestic and international stock of ideas, we run the regression of utilization-adjusted-TFP in sector j on the domestic stock of R&D in the corresponding sector and the international stock of R&D defined as an import-share-weighted-average of the stock of R&D in sector j of the ten trade partners of the home country. The elasticity of utilization-adjusted-TFP w.r.t the domestic stock of knowledge γ^j that we estimate is determined by the domestic content of technology (i.e., θ^j_Z) and the parameter η^j, i.e., $\gamma^j = \theta^j_Z \eta^j$. By using the fact that $\theta^H_Z = 0.57$, and since $\gamma^H = 0.51$, we should set $\eta^H = 0.89$. However, this value would require to increase the markup value above 1.51 because the differential between the markup μ^H and the degree of increasing returns to scale $1 + \theta^H_Z \eta^H$ must be positive. We decided to take a different route and keep μ^H unchanged at 1.35 in accordance with our estimates and thus we set $\eta^H = 0.62$ so that $\mu^H = 1.35 > 1.349 = 1 + \theta^H_Z \eta^H$. The elasticity of utilization-adjusted-traded-TFP w.r.t the international stock of knowledge $\gamma^{W,H}$ that we estimate is determined by the content of technology which is common across countries (measured by $1 - \theta^H_Z$) and the parameter $\eta^{W,H}$, i.e., $\gamma^{W,H} = \left(1 - \theta^H_Z\right) \eta^{W,H}$. While our panel data estimate yields a value of 0.13, see section G.5, two countries (Luxembourg and the United States) have negative values which are not statistically significant. When we ignore these values, we find an estimated value for the elasticity $\gamma^{W,H}$ of 0.22. By using the fact that $1 - \theta^H_Z = 0.43$, we thus choose a value of 0.51 for $\eta^{W,H}$. When we turn to the non-traded sector, as shown in Table 24, the estimates of the elasticity γ^N and $\gamma^{W,N}$ are small at 0.024 and 0.044 which would lead values for η^N and $\eta^{W,N}$ of 0.04 and 0.12, respectively. Such values would produce a technology improvement in the non-traded sector which is at odds with the SVAR evidence which reveals that the response of utilization-adjusted-TFP of non-tradables is not statistically significant. Therefore, we choose to set $\nu^N = \nu^{W,N} = 0$.

Eleven parameters are taken from external research works. These values are identical to those chosen for a representative OECD economy.

Setting the dynamics for endogenous response of domestic corporate income tax and international R&D spillover. We have to choose values for three parameters in eq. (38) to reproduce the dynamics from the VAR model for $\tau(t)$. First, we normalize the steady-state variation in the domestic corporate income tax rate to 1 percentage point, i.e., $d\tau = 0.01$. We choose a value of 0.68 for $x_T = d\tau(0) - d\tau$ and a value of 0.9 for ξ_T so as to reproduce the estimated response of τ from the VAR model. To reproduce the dynamics of the international diffusion of innovation, we choose the same parameters as in the main text.

Capital utilization adjustment costs. We set the magnitude of the adjustment cost in the capital utilization rate, i.e., ξ^j_2, so as to account for empirical responses of $u^{K,j}(t)$ after a permanent decline in corporate taxation. We let $\xi^H_2 \to \infty$ because the adjustment of $u^{K,H}(t)$ is not significant and we choose a value of $\xi^N_2 = 0.2$ to account for the increase in the intensity in the use of the capital stock in the non-traded sector.

Continental European countries, $N = 4$. Parameters including φ, ι, ι_Z, φ^H, ι^H, ϑ_L, ϑ_K, ϑ_Z, δ_K, δ_Z, G, G^N, G^H must be set to target a tradable content of consumption and investment expenditure in tangible and intangible assets of $\alpha_C = 45\%$, $\alpha^K_J = 31\%$, $\alpha^Z_J = 62\%$, respectively, a home content of consumption and investment (in physical capital) expenditure in tradables of $\alpha^H = 60\%$ and $\alpha^H_J = 38\%$, respectively, a weight of labor supply of $L^H/L = 34\%$, a weight of tangible and intangible assets supply to the traded sector of $K^H/K = 36\%$ and $Z^H/Z^A = 60\%$, respectively, an investment share of GDP in physical capital and in R&D of $\omega^K_J = 20.7\%$ and $\omega^K_J = 2.5\%$, respectively, a ratio of government spending to GDP of $\omega_G = 20.7\%$ $(= G/Y)$, a tradable and home-tradable share of government spending of $\omega_{G^T} = 5\%$ $(= 1 - (P^N G^N/G))$, and $\omega_{G^H} = 3\%$ $(= P^H G^H/G)$, and we choose initial conditions so as trade is balanced, i.e., $\upsilon_{NX} = \frac{NX}{P^H Y^H} = 0$ with $NX = P^H X^H - C^F - I^F - G^F$. Because $u^{K,j} = u^{Z,j} = 1$ at the steady-state, four parameters related to capital ξ^H_1, ξ^N_1, and technology, χ^H_1, χ^N_1, adjustment cost functions are set to be equal to adjustment cost functions are set to be equal to $R^{K,H}/P^H$, $R^{K,N}/P^N$, $R^{Z,H}/P^H$, $R^{Z,N}/P^N$, respectively.

Fifteen parameters are assigned values which are taken directly or estimated from our own data. We choose the model period to be one year. In accordance with column 28 of Table 2, the world interest rate, $r^\star$, which is equal to the subjective time

Table 27: Data to Calibrate the Two Open Economy Sector Model (73-17) to Two Sub-Samples: English-speaking and Scandinavian Countries vs. Continental European Countries

Sub-sample	Tradable share					Home share				LIS		Input ratios		
	Y^H	C^T	$I^{K,T}$	$I^{Z,H}$	G^T	X^H	C^H	$I^{K,H}$	G^H	θ^H	θ^N	L^H/L	K^H/K	Z^H/Z^A
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Eng. & Scand.	0.35	0.40	0.29	0.57	0.24	0.13	0.66	0.48	0.23	0.62	0.68	0.37	0.40	0.58
Cont. Europe	0.34	0.45	0.31	0.62	0.05	0.16	0.60	0.38	0.03	0.70	0.67	0.34	0.36	0.60
Sub-sample	Elasticities									Aggregate ratios			Markup	i.r.
	ϕ	ϵ_L	ϵ_K	ν^H	ν^N	$\nu^{W,H}$	$\nu^{W,N}$	θ^H_Z	θ^N_Z	I^K/Y	I^Z/Y	G/Y	μ	r
	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)
Eng. & Scand.	0.45	0.95	0.21	0.62	0.00	0.51	0.00	0.56	0.63	0.21	0.029	0.19	1.35	0.023
Cont. Europe	0.45	1.08	0.17	0.00	0.00	0.24	0.00	0.56	0.63	0.21	0.025	0.21	1.35	0.028

Notes: Columns 1-5 show the GDP share of tradables, the tradable content of consumption expenditure, the tradable content of investment expenditure in tangible and intangible assets, the tradable content of government expenditure. Column 6 gives the ratio of exports of final goods and services to GDP; columns 7 and 8 show the home share of consumption and investment expenditure in tradables and column 9 shows the content of government spending in home-produced traded goods; columns 10-11 show the labor income shares for tradables and non-tradables. Columns 12-15 display the hours worked share of tradables, the ratio of traded capital stock to the aggregate physical capital stock and the ratio of the stock of R&D of tradables to the aggregate stock of R&D. Columns show elasticities we have estimated empirically. ϕ is the elasticity of substitution between traded and non-traded goods in consumption; ϵ_L is the elasticity of labor supply across sectors; ϵ_K is the elasticity of capital supply across sectors; θ^H_Z (θ^N_Z) is the domestic component of traded (non-traded) technology and ν^H (ν^N) pins down the elasticity of the domestic component of technology w.r.t. the domestic stock of ideas in the traded (non-traded) sector while $\nu^{W,H}$ ($\nu^{W,N}$) captures the elasticity of the international component of traded (non-traded) technology w.r.t. to the international stock of ideas of trade partners in the traded (non-traded) sector. I^K/Y is the investment-to-GDP ratio for tangible assets and I^Z/Y is the investment-to-GDP ratio for tangible assets and G/Y is government spending as a share of GDP. μ is the markup for the whole economy. The interest rate is measured by the real long-term interest rate calculated as the nominal interest rate on 10 years government bonds minus the rate of inflation which is the rate of change of the Consumption Price Index.

discount rate, β, is set to 2.8%. In line with mean values shown in columns 10 and 11 of Table 2, the shares of labor income in traded and non-traded value added, θ^H and θ^N, are set to 0.70 and 0.67, respectively, which leads to an aggregate LIS of 68%.

Building on our panel data estimates for the elasticity of labor supply across sectors, ϵ, we choose a value of 1.08 for this parameter which collapses to the country average of our estimates. We have also estimated the degree of mobility of capital between sectors, ϵ_K, and choose a value of 0.14 which collapses to the country average of our estimates. Due to a lack of data, we cannot estimate the degree of mobility of intangible assets between sectors, ϵ_Z, and and choose a value for this parameter which collapses the degree of mobility of capital, i.e., $\epsilon_Z = \epsilon_K = 0.14$. We keep ϕ unchanged at 0.45 (see column 13 of Table 2), since this value corresponds to our panel data estimates.

We have estimated empirically the elasticity of technology w.r.t. the domestic and international stock of ideas for continental European countries. By using the fact that $\theta_Z^H = 0.57$, our estimates suggest that $\eta^{W,H} = 0.13$. We set $\eta^H = 0.001$ because the estimated is slightly negative and thus inconsistent. For the non-traded sector, we set $\eta^N = \eta^{W,N} = 0$ in line with our estimates.

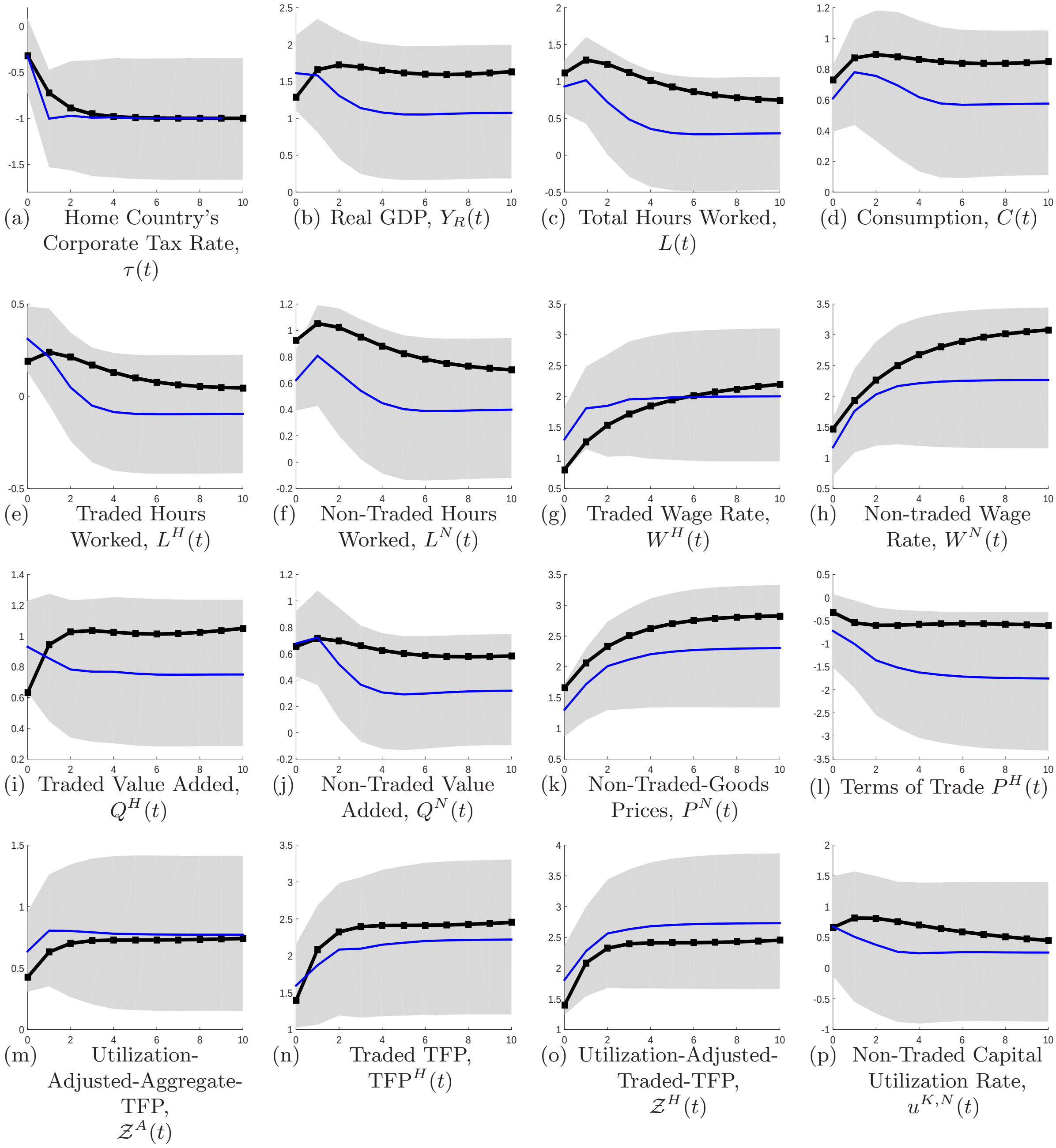
Eleven parameters are taken from external research works. These values are identical to those chosen for a representative OECD economy.

Setting the dynamics for endogenous response of domestic corporate income tax and international R&D spillover. We have to choose values for three parameters in eq. (38) to reproduce the dynamics from the VAR model for $\tau(t)$. First, we normalize the steady-state variation in the domestic corporate income tax rate to 1 percentage point, i.e., $d\tau = 0.01$. We choose a value of 0.2 for $x_T = d\tau(0) - d\tau$ and a value of 0.3 for ξ_T so as to reproduce the estimated response of τ from the VAR model. To reproduce the dynamics of the international diffusion of innovation, we choose the same parameters as in the main text.

Capital and technology utilization adjustment costs. We set the magnitude of the adjustment cost in the capital utilization rate, i.e., ξ_2^j, so as to account for empirical responses of $u^{K,j}(t)$ after a permanent decline in corporate taxation. We choose $\xi_2^H = 0.1$ and $\xi_2^N = 0.15$ so as to account for the increase in the intensity in the use of the capital stock in the traded and and non-traded sector. We choose a value for the parameter χ_2^H of 0.01 and $\chi_2^N \to \infty$. Because $\nu^H = \nu^N = 0$, these parameters have no impact.

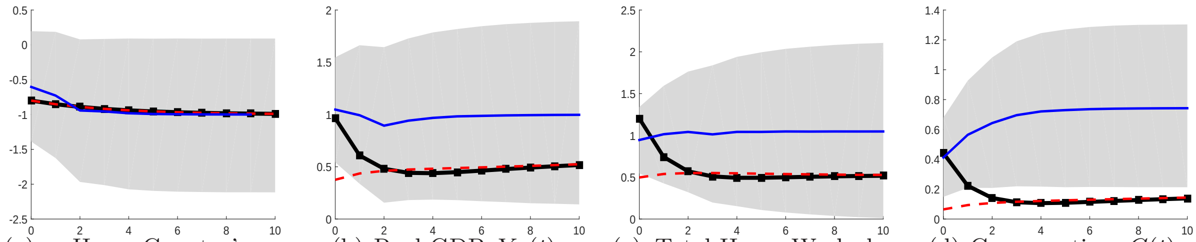
H.2 Additional Numerical Results

For reasons of space, in the main text, we focus on a limited set of variables. In this Appendix, we provide more numerical results. Fig. 21 shows numerical results for the group of countries made up of English-speaking and Scandinavian economies. The black line with squares show model's predictions while the blue line displays the point estimate from the estimation of the SVAR model. Fig. 22 shows numerical results for the flexible wage model (dashed red lines) and the sticky wage model (black lines with squares).



(a) Home Country's Corporate Tax Rate, $\tau(t)$
(b) Real GDP, $Y_R(t)$
(c) Total Hours Worked, $L(t)$
(d) Consumption, $C(t)$
(e) Traded Hours Worked, $L^H(t)$
(f) Non-Traded Hours Worked, $L^N(t)$
(g) Traded Wage Rate, $W^H(t)$
(h) Non-traded Wage Rate, $W^N(t)$
(i) Traded Value Added, $Q^H(t)$
(j) Non-Traded Value Added, $Q^N(t)$
(k) Non-Traded-Goods Prices, $P^N(t)$
(l) Terms of Trade $P^H(t)$
(m) Utilization-Adjusted-Aggregate-TFP, $\mathcal{Z}^A(t)$
(n) Traded TFP, $\text{TFP}^H(t)$
(o) Utilization-Adjusted-Traded-TFP, $\mathcal{Z}^H(t)$
(p) Non-Traded Capital Utilization Rate, $u^{K,N}(t)$

Figure 21: Theoretical vs. Empirical Responses Following a 1 ppt Permanent Corporate Tax Cut: English-speaking and Scandinavian Countries. Notes: The solid blue line which displays point estimate from the VAR model with shaded areas indicating 90% confidence bounds; the thick solid black line with squares displays model predictions in the baseline scenario.

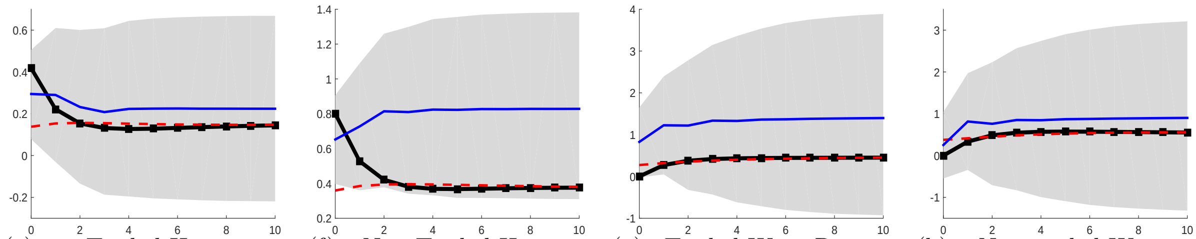


(a) Home Country's Corporate Tax Rate, $\tau(t)$

(b) Real GDP, $Y_R(t)$

(c) Total Hours Worked, $L(t)$

(d) Consumption, $C(t)$

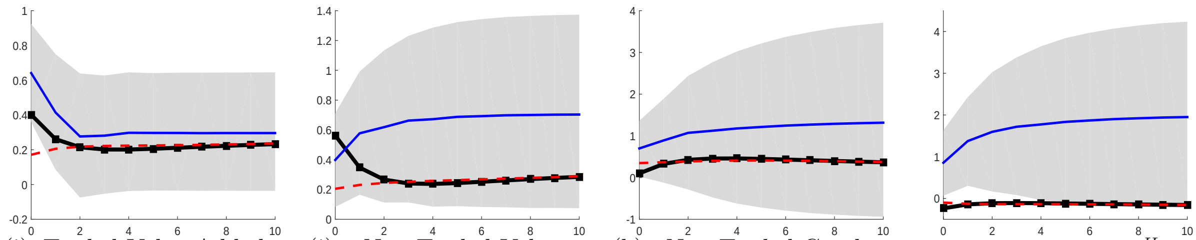


(e) Traded Hours Worked, $L^H(t)$

(f) Non-Traded Hours Worked, $L^N(t)$

(g) Traded Wage Rate, $W^H(t)$

(h) Non-traded Wage Rate, $W^N(t)$

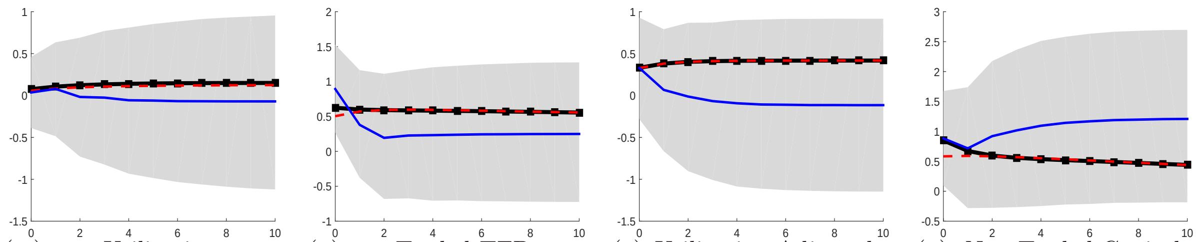


(i) Traded Value Added, $Q^H(t)$

(j) Non-Traded Value Added, $Q^N(t)$

(k) Non-Traded-Goods Prices, $P^N(t)$

(l) Terms of Trade $P^H(t)$



(m) Utilization-Adjusted-aggregate-TFP, $\mathcal{Z}^A(t)$

(n) Traded TFP, $\text{TFP}^H(t)$

(o) Utilization-Adjusted-Traded-TFP, $\mathcal{Z}^H(t)$

(p) Non-Traded Capital Utilization Rate, $u^{K,N}(t)$

Figure 22: Theoretical vs. Empirical Responses Following a 1 ppt Permanent Corporate Tax Cut: Technology. Notes: The solid blue line which displays point estimate from the VAR model with shaded areas indicating 90% confidence bounds; the thick solid black line with squares displays model predictions in the baseline scenario where we consider sticky wages in the traded and the non-traded sector. The dashed red lines shows the model's predictions when we assume that wages are flexible.

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