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DYNAMIC EFFECTS OF CORPORATE TAXATION IN OPEN ECONOMY*

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Abstract

By exploiting the downward trend of OECD countries profits' taxation rooted into international competition to attract capital, we identify exogenous variations in corporate income taxes. Our SVAR-based evidence reveals that a permanent decline in profits' taxation leads to significant technology improvements which are concentrated in traded industries and generates an expansionary effect on hours which is concentrated in the non-traded sector. While technology dramatically improves in English-speaking and Scandinavian countries, hours significantly increase 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. In line with our estimates, traded technology must display a high elasticity w.r.t. both the domestic and international stock of knowledge in former countries while the weight attached to consumption habits along with wage stickiness shape the expansionary effect on nontradable hours in continental Europe.

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 top statutory corporate income tax (CIT henceforth) rate has been divided by two over the last forty years in industrialized countries, dropping from 48% in 1981 to 35% in 2000 and settling at 25% from 2018 onwards.[1] The gradual and uninterrupted decline in profits' taxation has been driven by the competition between OECD countries to attract capital following the removal of capital controls in the 1980s, see e.g., Devereux et al. [2002], [2008], Egger et al. [2019]. In this work, we explore two questions. Do CIT cuts stimulate economic activity through innovation or a rise in hours or both? Are technology improvements and labor growth uniformly distributed between sectors and across countries? To answer these questions, we exploit the downward trend in corporate taxation which is common to a large set of OECD countries to identify exogenous and permanent variations in profits' taxation. The dynamic effects of an exogenous CIT cut reveal that technology improvements are concentrated within traded industries while the rise in hours originates from 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 and persistently increase only in continental Europe.

Our findings have important economic policy implications. Although the country-split indicates that international differences in real GDP growth are insignificant, technology improvements in tradables are the main driver of the long-run increase in real GDP in English-speaking and Scandinavian countries while the rise in non-traded labor fully explains real GDP growth in continental Europe after a CIT cut. The recent research by Cloyne et al. [2022], [2023] also uncovers the productivity gains driven by a corporate tax cut and contrasts the investment and employment effects between two broad sectors (i.e., goods vs. services) but the analysis is restricted to the U.S. case. Instead, our work provides new insights about the drivers of technology improvements and labor growth brought about by a CIT cut by contrasting the effects between sectors and across countries. To propose a structural interpretation of our estimates, we develop a two-sector open economy setup with endogenous technology decisions. Building on the estimation of key parameters of our model, we find that its ability to account for the evidence rests on a set of elements which characterize the firms' ability to improve technology and also households' preferences.

One major challenge is to identify exogenous variations in corporate taxation, i.e., changes which are exogenous to the state of the economy. While we are using the top statutory CIT rate (which are more likely to be exogenous than effective tax rates) like Akcigit et al. [2022], we cannot exclude that the country-level tax rate is correlated with economic activity. Indeed, we find that country-specific demand shocks predict shocks to

[1] The figures are based on average of top statutory CIT rates in OECD countries. Source: Tax Foundation. Sample: 23 high-income countries, 1981-2023.

the country-level CIT rate. The solution we put forward to ensure that CIT changes are disconnected from country-specific demand shocks is to use the international component of the CIT rate which is driven by tax competition motives. By giving rise to a downward trend in corporate taxation which is common to a large set of OECD countries, the assumption of international tax competition paves the way for the identification of exogenous (and permanent) CIT cuts.

A variation in the international component of the CIT rate might however be an endogenous policy decision. For example, in face of a recession, the home country could decide to lower its CIT rate and such a tax cut might lead neighbor countries to reduce their own profits' taxation. Our identification assumption is based on the fact that the common trend in CIT is only guided by tax competition motives and thus excludes the possibility that the international component of profits' taxation responds to a country-specific CIT cut designed to offset a shock. In accordance with our assumption, we find that our identified shocks to the international component of CIT rates are exogenous to both past and contemporaneous country-specific demand shocks. Granger causality tests also confirm that shocks to the common component of corporate taxation are uncorrelated with aggregate demand shocks which exclude the possibility that the shocks we identify are designed to offset a global recession.

To capture more accurately the degree of international competition faced by each country, we construct a country-specific international tax rate by considering the trade intensity between the home country and its trade partner as a weight. The attractive feature of constructing an import-share-weighted-average of trade partners' CIT rates is that it captures the tax pressure from neighbor countries. This measure is supported by our evidence which reveals that the downward pressure on the home country's CIT rate caused by financial openness is more pronounced when profits' taxation is lower in neighbor countries. One additional important aspect of this tax measure is that it does not contain the country's own CIT rate which strengthens the exogeneity of the international tax rate to the country's economic conditions. To identify exogenous shocks to profits' taxation, we replace the country-level CIT rate with its international measure in the SVAR model.

By using a sample of eleven OECD countries over the period 1973-2017 as the CIT 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), we investigate whether CIT 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 CIT 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 the CIT 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, the effects of the CIT on utilization-adjusted-total factor productivity (TFP) also vary widely across countries due to differences in the ability of industries to transform R&D expenditure into innovation. Differently, international differences in the effects on hours will depend on the extent of wage stickiness which itself depends on the country-specific wage bargaining process. When we apply a clustering analysis based on several dimensions of the wage bargaining organization, we find that continental European countries display the largest degree of wage stickiness. Continental Europe is also characterized by an elasticity of utilization-adjusted-aggregate-TFP w.r.t. the stock of knowledge which is essentially zero while English-speaking and Scandinavian countries display a sizeable elasticity which averages 0.21.

Building on this dichotomy based on wage bargaining institutions and the ability to improve technology, we perform a split-sample analysis and investigate the effects of a CIT shock for two groups of countries: continental European countries on one hand and English-Speaking and Scandinavian countries 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 pronounced and permanent rise in utilization-adjusted-TFP of tradables.

To provide a structural interpretation of our evidence, we propose a new dynamic open economy setup by extending the model with a traded and a non-traded sector developed by Kehoe and Ruhl [2009], Chodorow-Reich et al. [2023], to endogenous technology decisions. Like Corhay et al. [2023] who consider a one-sector closed economy setup, 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). We augment Corhay et al.'s [2023] model in two important ways. First, we consider a two-sector model where the allocation of tangible and intangible assets between traded and non-traded industries depends on their contribution to sectoral output and foreign R&D can (potentially) spillover on domestic technology in both sectors. In addition, 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 CIT 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. Instead, non-traded industries display an elasticity of utilization-adjusted-TFP w.r.t. the stock of knowledge which collapses to zero. Because the CIT cut produces a positive wealth effect which increases consumption in traded goods, traded firms find it optimal to make efficiency gains by increasing the intensity in the use of the stock of ideas to meet a higher demand while curbing higher production costs. Because the stock of knowledge only builds up gradually, the rise in the domestic stock of R&D contributes to technology improvements only in the long-run. By contrast, the bulk of technology improvements in traded industries in the short-run is driven by international R&D spillovers together with the higher intensity in the use of the domestic stock of knowledge.

The ability of the model to account for the positive and significant effect of a CIT cut on hours rests on three important features. First, we have to allow for Greenwood et al. [1988] (GHH henceforth) preferences to eliminate the negative impact of the 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, the gain in utility brought about by an increase in consumption is reduced by the associated (gradual) adjustment in habits. Therefore, 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), the model understates the rise in hours.

The model can also account for the concentration of labor growth within non-traded industries. Intuitively, a higher demand for non-traded goods strongly appreciates their prices over time. Because the elasticity between traded and non-traded goods is low, in line with our estimates, the consumption expenditure share of 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. While wage stickiness ensures a strong positive response of hours to the tax cut in the short-run, the model can generate a persistent increase in hours once we assume that the relative weight of consumption habits is relatively lower in continental Europe which is supported by the evidence reported by Havranek et al. [2017]. The same model with flexible wages and a higher weight of consumption habits 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 evidence about the effects on technology and hours of a permanent CIT cut. In section 3, we develop a two-sector open economy model with tradables and non-tradables and endogenous technology choices. In section 4, we simulate the model and uncover the necessary ingredients to account for our SVAR evidence. Section 5 concludes. The Online Appendix contains more empirical results, conducts robustness checks and details the steps to solve the model.

Related 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, e.g., Mertens and Ravn [2013], Cloyne et al. [2022] use narratively-identified CIT changes which are mainly available for the United States. As stressed by Perotti [2012], 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. 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 the CIT rate which allows for international comparisons. Since the international component of CIT rates is driven by tax competition motives and is not correlated with country-specific (current or prospective) economic activity, our identification approach avoids any potential endogeneity issue. Our exogeneity (F-)test confirms that our identified variations in the international component of CIT are not contaminated by country-specific demand shocks.

Common component approach. Our identification is an adaptation of the ingenious idea by 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. In the same vein and to capture the intensity of competition with neighbors, we construct an import-share-weighted-average of trade partners' CIT rates. While the cointegrating relationship between the country-level and the world TFP lies on the assumption of international technology diffusion, the cointegrating relationship between the country-level and the international CIT rate rests on the assumption of international tax competition; conditional on the removal of capital controls, 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], Akcigit et al. [2022] who consider changes in federal CIT rates which are most likely to be exogenous to economic conditions of an individual U.S. state, we avoid endogeneity by considering a broad (i.e., international) measure of CIT rates relevant to each country whose variations are guided by incentives to attract capital.

Tax competition. While we are interested in the effects of a reduction in profits' taxation, we are aware of the vast literature investigating optimal corporate taxation in an international context, see e.g., Kehoe [1989]. While our and existing evidence, see e.g., Devereux et al. [2008], suggests that financial openness can rationalize the downward trend in CIT, Quadrini and Ríos-Rull [2024] have recently showed that financial globalization which is associated with a larger share of profits generated by multinationals in a country (which belongs to foreigners) can also provide incentives to increase profits taxation as it redistributes income to domestic residents. In contrast to the evidence documented by Chirinko and Wilson [2018] which suggests that the downward trend in CIT across U.S. states is driven by aggregate shocks instead of tax competition, our evidence shows that this conclusion cannot be generalized to OECD countries as identified shocks to the international CIT rate are uncorrelated with past global demand shocks.

Corporate taxation lowers output, investment, labor. Can CIT 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], Cloyne et al. [2022] find that CIT cuts increase investment and real GDP but have no impact on labor in the United States. Using a cross-country empirical analysis, Djankov et al. [2010] detect a negative impact of effective CIT on aggregate investment, FDI, and entrepreneurial activity. Also, their results indicate that corporate taxation is (negatively) 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 CIT leads to a decline in wages for European firms and German firms. Backus et al. [2008] find that CIT can rationalize international differences in capital-output. Suarez Serrato and Zidar [2016] find that a lower CIT attracts firms, which boosts local labor demand and encourages migration to that U.S. state. In addition to providing a structural interpretation of the mechanism through which the CIT shock affects technology, capital and labor decisions at a sectoral level, we contribute to the existing literature by developing a model which reproduces quantitatively the evidence we document.

Corporate taxation lowers innovation. According to the model' predictions by

Jaimovich and Rebelo [2017], CIT rates have negative effects on innovation. Akcigit et al. [2022] empirically show that corporate taxation negatively affects 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 the authors investigate the effects of a CIT cut on technology and rationalize their findings by using a model with endogenous innovation. Like them, we find that a CIT 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. One additional key difference is that the short-run increase in utilization-adjusted-TFP is driven by efficiency gains to meet a higher demand and adoption of foreign innovation. While we corroborate the muted response of labor for English speaking and Scandinavian countries, we find a strong and significant response of hours in continental Europe.

2 Dynamic Effects of Corporate Taxation: Evidence

In this section, we document evidence about the dynamic effects of a CIT cut 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 CIT rates taken from Bachas et al. [2022] who combine data from Vegh and Vuletin [2015], Egger et al. [2019], the Tax Foundation and country-specific sources. We consider a sample of eleven OECD countries which include Australia, Austria, Belgium, France, Germany, Finland, the United Kingdom, Japan, Luxembourg, Sweden, and the United States over the period running from 1973 and 2017 which is the longest period of time for this panel.[2] As explained below, our empirical strategy rests on the existence of a unit-root process in the country-level CIT which has led us to exclude a few OECD countries for which the top statutory CIT was flat over time.[3]

Sectoral data are taken from OECD STAN and EU KLEMS databases. Our dataset includes eleven 1-digit ISIC-rev.3 industries which must be classified as tradables or non-tradables. To conduct this classification, we have calculated the trade openness ratio for each industry by using the World Input Output Dataset. We treat industries as tradables when trade openness is equal or larger than 20%. We thus classify "Agriculture, Hunting, Forestry and Fishing", "Mining and Quarrying", "Total Manufacturing","Transport, Storage and Communication", and "Financial Intermediation" in the traded sector. The

[2]Data for the CIT rate is unavailable before 1973 for Australia and the United Kingdom. Because we are interested in the sectoral effects which leads us to use annual time series, we excluded Canada, Netherlands, Greece, Ireland, Korea, Portugal, and Denmark from the sample due to the absence of data on CIT rates before 1980s.

[3]We have excluded Spain, Norway, and Italy from the sample because the top statutory CIT rate is flat over the period of interest and thus does not display a downward trend.

remaining industries "Electricity, Gas and Water Supply", "Construction", "Wholesale and Retail Trade" and "Community Social and Personal Services", "Hotels and Restaurants" and "Real Estate, Renting and Business Services" are classified as non-tradables. We perform a sensitivity analysis with respect to the classification in Online Appendix C.1 and find that all conclusions hold.

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. We also build intuition about the transmission mechanism by analyzing the movements in 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 $\alpha^{i,k}_{IM}$ of imports from the trade partner k (averaged over 1973-2017).[4] The price of non-traded goods is computed as the ratio of the non-traded value added deflator to the 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 share (LIS henceforth) in sector j averaged over the period 1973-2017.[5] We construct a measure for technological change by adjusting the Solow residual with the capital utilization rate, denoted by $u^{K,j}_{it}$. Once we have constructed the Solow residual for the traded and the non-traded sectors, we construct a measure for technological change denoted by T^j_{it} by adjusting the Solow residual with the capital utilization rate, denoted by $u^{K,j}_{it}$:

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

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-

[4]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.

[5]To construct time series for the capital stock of the traded and the non-traded sector, we have constructed 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 et Yamarik [2002], we split the gross capital stock into traded and non-traded industries by using sectoral value added shares. We have alternatively used the EU KLEMS dataset which provides disaggregated capital stock data (at constant prices) at the 1-digit ISIC-rev.3 level for eleven countries of our sample over different time periods, the longest period being 1973-2017. Our estimates show that our empirical findings for technology improvements are unsensitive to the way the sectoral capital stocks are constructed in the data.

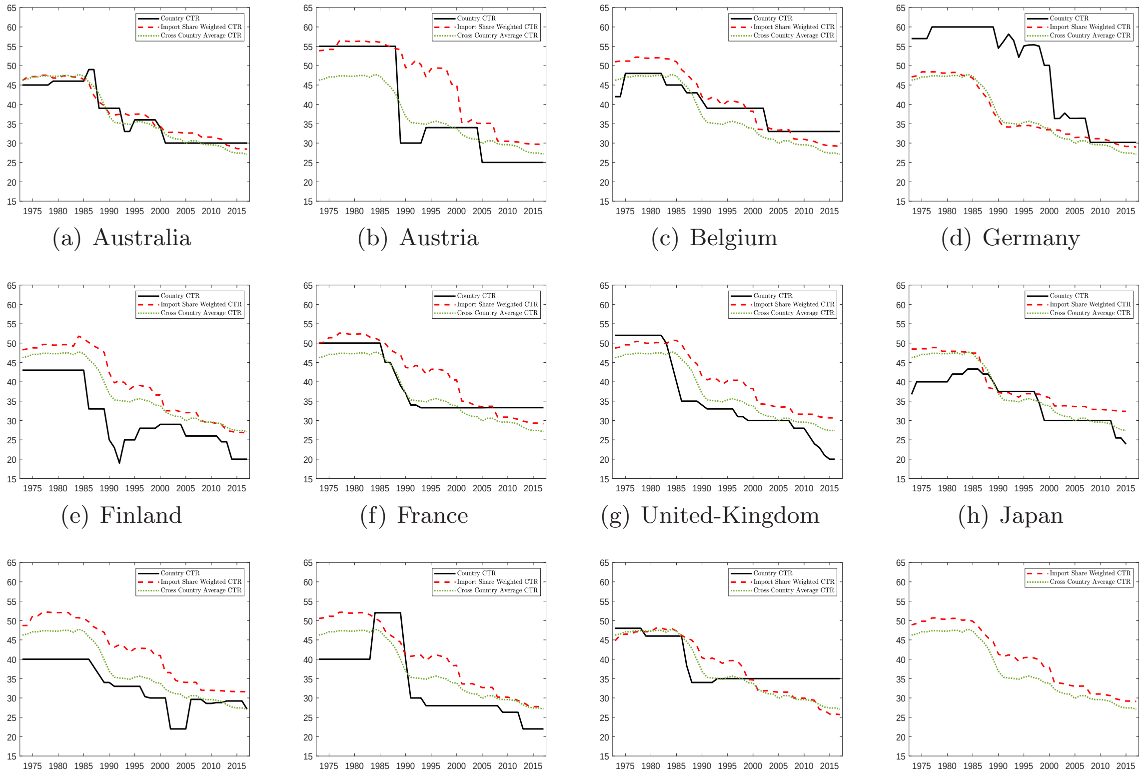
TFP from Huo et al. [2023] and Basu et al. [2006]. Our preferred measure is based on Imbs's [1999] method because it fits our model setup where we consider an endogenous capital utilization rate and the last two measures can only be constructed over a shorter period of time and for a limited number of OECD countries.

2.2 Tax Competition and Exogenous CIT Shocks

One major challenge when analyzing the dynamic effects of a CIT cut is to identify exogenous variations, i.e., tax changes which are not designed to compensate for economic activity fluctuations. Because the government might cut profits' taxation to offset a current (or a future) recession, there is a clear endogeneity issue. To overcome this difficulty, Mertens and Ravn [2013], 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 (mainly the U.S.) 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.

International tax competition and the downward trend in corporate taxation common to OECD countries. Our identification of a permanent shock to the CIT rate lies on the assumption that persistent changes in corporate taxation are not driven by the stage of the business cycle of the country but instead by tax competition motives. Tax competition refers to the process whereby countries compete with each other to attract businesses by offering lower tax rates on profits. This competition can have a permanent effect on CIT because businesses will continue to seek out countries with lower tax rates, leading to a downward pressure on tax rates in other countries. In addition to generating a downward trend in corporate taxation, the willingness to attract capital implies that country-level tax rates share a common component. More specifically, because business capital can cross the border while labor is a much less mobile tax factor, countries have incentives to compete over corporate tax policy in the context of increased economic openness, see e.g., Persson and Tabellini [2002], Egger et al. [2019].

Fig. 1 plots the country-level CIT rate against time in the solid black line for each country of our sample, except Fig. 1(l) which plots the CIT rate for an average OECD economy. As it stands out, corporate taxation displays a downward trend from the end of the seventies or the beginning of the eighties which coincides 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 dotted green line. It is striking to see that domestic CIT rates track well the cross-country



(a) Australia (b) Austria (c) Belgium (d) Germany (e) Finland (f) France (g) United-Kingdom (h) Japan (i) Luxembourg (j) Sweden (k) United States (l) OECD (11)

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

average. Because international tax competition is driven by the removal of capital controls and should be fiercer as countries are more open to capital flows, we should observe a negative relationship between country-level tax rates and financial openness. As a first pass, we plot in Fig. 2 statutory CIT rates (vertical axis) against financial openness (horizontal axis) by using updated time series on assets and liabilities from Lane and Milesi-Ferretti [2007]. The scatter-plot shows that countries-years with more open capital markets tend to have lower CIT rates. While the financial openness indicator in Fig. 2 has the advantage to display a wide cross-country variation, an obvious endogenous relationship with the CIT might arise. To circumvent this issue, in the empirical strategy detailed below, we are using the Chinn-Ito index which measures the intensity of legal restrictions on external accounts.

Financial openness and the race to the bottom: Evidence on tax competition. Our VAR identification is based on the assumption that CIT rates among OECD countries share a common downward trend which is driven by tax competition. While financial openness and capital mobility have caused a race to the bottom, we should observe that the tax setting in the home country depends positively on the level of the tax rates of its trade partners. To capture more accurately the degree of tax pressure faced by each country i, we construct an international tax rate for each country i by considering the trade intensity between the home country and its trade partner $k = 1...10$ within ten countries

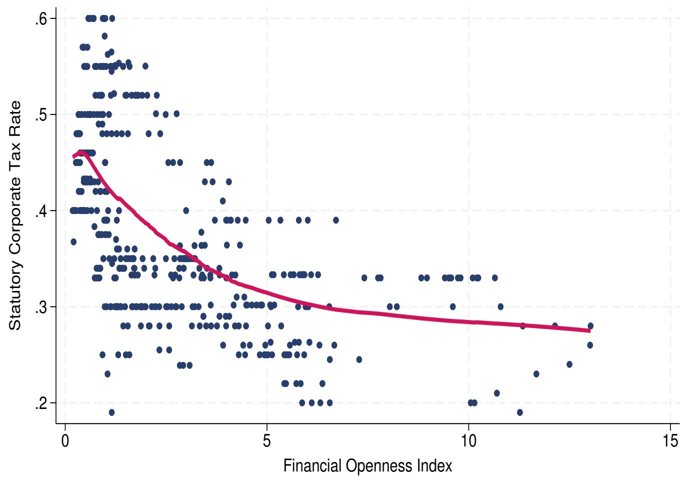


Figure 2: Corporate Tax Rates vs. Financial Openness across Time and Space. Notes We plot the corporate tax rates (vertical axis) against the measure of financial openness. The latter is calculated as the sum of total assets and total liabilities divided by GDP which are taken from Lane and Milesi-Ferretti [2007]. For profits' taxation measure, we use the top statutory CIT rate. We are using a Locally Weighted Scatterplot Smoothing (LOESS) method which is a non-parametric regression technique used for fitting a smooth curve to a scatter-plot of data points. The smoothed values are obtained by running a regression locally (i.e., in the neighborhood of a point) which is also weighted as the central point gets the highest weight. In contrast, polynomial smoothing methods are global in that what happens on the extreme left of a scatter-plot can affect the fitted values on the extreme right. We choose a bandwith of 0.8 meaning that 80% of the data are used in smoothing each point. We exclude Luxembourg from the sample as the financial openness index takes extreme values for this country only. Sample: 10 OECD countries, 1973-2017, annual data.

as a weight:

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

where $\alpha_{IM}^{i,k}$ is the trade (measured by imports) share of the home country i with its trade partner k, the latter having a statutory CIT rate τ_{ikt}. One important feature of the international CIT rate defined in eq. (2) is that it does not contain the country's own CIT. This makes international tax rate exogenous to the country's economic conditions.

To support our assumption, we run the regression of the country-level CIT rate, τ_{it}, on capital openness, κ_{it}, and an interaction term which includes a measure of tax competition, i.e., τ_{it}^{int} (see eq. (2)). The panel data estimations (with t-stat in parenthesis) yield:

$$\tau_{it} = \underset{(14.04)}{0.500} - \underset{(-10.86)}{0.459}\, \kappa_{it} + \underset{(6.83)}{0.815}\, \kappa_{it} \times \tau_{it}^{int} + \nu_{it}. \tag{3}$$

In this analysis, we are using the Chinn-Ito index which measures the country's degree of capital account openness, i.e., κ_{it}.[6] For reasons of space, the complete set of evidence is relegated to Online Appendix D.9. As shown in eq. (3), in accordance with our hypothesis, capital openness has a strong (and statistically significant) negative effect on the home country's CIT rate. While capital openness generates a negative impact on country-level CIT rates, this negative impact should be mitigated when neighbors have high CIT rates. Indeed, the coefficient in front of the interaction term in eq. (3) is positive which indicates that the impact of capital openness on the home country's CIT rate is smaller when trade partners' CIT rates are higher. To put it in a different way, this finding implies that the

[6]The Chinn-Ito index is normalized between zero and one, with higher values indicating that a country is more open to cross-border capital transactions.

home country's CIT rate is positively correlated with profits' taxation of neighbor countries conditional on the ability of capital to move freely across borders. All these conclusions hold even once we control for the country's size, the public debt and the level of unemployment. Following Devereux et al. [2008], because in a model with tax competition all tax rates are jointly determined, we have adopted an instrumental variable approach in Online Appendix D.9 to ensure the robustness of our empirical results. 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 international tax competition has given rise to a downward trend in OECD countries' CIT rates. Conditional on our assumption that changes in the international CIT rate relevant to each country, $d\tau_{it}^{int}$, are independent of demand shocks in the home country, the variations in profits' taxation are exogenous as they are not designed to offset a recession and capture 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 CIT rate with an international measure which reflects the extent of tax competition between countries. Because the corporate tax rate set by trade partners is disconnected from the economic activity of the home country, this measure of tax pressure on the home country's CIT rate is by construction exogenous to the domestic business cycle.

To check that the downward trend in country-level CIT rates is guided by tax competition motives, we have to test formally that there is a common stochastic trend between $\log \tau_{it}$ and $\log \tau_{it}^{int}$ for the eleven OECD countries of our sample. In Online Appendix D.3, we use the panel cointegration test proposed by Westerlund [2007] which shows that there is a cointegration relationship between the logged country-level CIT rate and the logged import-share-weighted-average of trade partners' CIT rates. Because the international CIT is cointegrated with the country-level tax rate, we can estimate a SVAR model where we replace τ_{it} with τ_{it}^{int}. Since the international measure for profits' taxation which captures the intensity of 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 Dupaigne and Fève [2009], we impose long-run restrictions and identify permanent shocks to corporate taxation as shocks that lower permanently the international tax rate τ_{it}^{int}.

SVAR identification. To explore empirically the dynamic effects of a shock to corporate taxation, we estimate the reduced form of a VAR model in panel format on annual data with n observables, i.e., $\hat{X}_{it} = \left[\Delta\tau_{it}^{int}, \hat{V}_{it}\right]$, which includes the variation of the international tax rate ordered first and a set of $n-1$ variables of interest, such as value added, hours and utilization-adjusted-TFP, expressed in rate of growth. All quantities are divided by the working-age population (15-64 years old). The moving average representation of the structural VAR model reads:

$$\hat{X}_{it} = B(L)A_0\varepsilon_{it}, \tag{4}$$

where ε_{it} are the structural shocks we want to identify, A_0 is the matrix that describes the instantaneous effects of structural shocks on observables, and $B(L) = C(L)^{-1}$ 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 the first element of ε_{it}, i.e., structural shocks to international corporate taxation denoted by $\varepsilon_{it}^{\tau^{int}}$, we use the restriction that the unit root in τ_{it}^{int} originates exclusively from tax competition 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, denoting the reduced form innovations by η_{it}, 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 $B(1)\Sigma B(1)'$.

Robustness checks w.r.t. identification. The current methodology adopted in the existing literature to estimate the dynamic effects of CIT shocks is the narrative approach which classifies CIT changes episodes as uncorrelated with macroeconomic fluctuations. In this paper, we adopt a different method where we take advantage of tax competition motives to identify exogenous variations in corporate taxation. First, in Online Appendix D.7, by using narratively-identified shocks to CIT which are only available for the U.S. over the period 1970-2006, see Mertens and Ravn [2013], we contrast estimates when exogenous shocks are narratively identified with our SVAR evidence for this country and over the same period. We find that our SVAR estimates lie within the confidence bounds of the point estimate obtained from the narrative approach.

Second, one might be concerned by the fact that a CIT cut by the domestic country to offset a recession might lead neighbor countries to lower profits' taxation which would undermine our identification as the international tax rate would be endogenous to domestic economic activity. In Online Appendix D.5, we have run Granger causality tests which reveal that shocks to the international tax rate, $\varepsilon_{it}^{\tau^{int}}$, are uncorrelated with domestic business cycle conditions. By contrast, we do find that shocks to country-level CIT rates are correlated with past country-specific demand shocks. In addition, Granger causality tests (see Online Appendix D.9) show that lagged values of our measure of international tax pressure predict the variations in the country-level CIT rate, $d\tau_{it}$, while the other way around is not true. A second potential concern which might bias estimates is that aggregate demand shocks could lead foreign countries to cut CIT rates to offset a global recession and to prevent from a capital outflow the domestic country could mimic its neighbor countries. Reassuringly, the Granger causality test we have run in Online Appendix D.5 reveals that global demand shocks are not predictive of identified shocks to international corporate taxation.

Robustness checks w.r.t. to SVAR method. 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 could have long-lasting effects on the variable of interest). 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 shocks to international corporate taxation which are detailed in Online Appendix D.

First, in Online Appendix D.5, 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 include 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 shocks to τ_{it}^{int}. 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.6, we increase the lags from two to five and find that all of our conclusions stand. Finally, in Online Appendix D.8, we compare the dynamic responses to a CIT shock estimated from the SVAR model where we impose long-run restrictions to identify exogenous variations in the international tax rate with those estimated from Jordà's [2005] local projections. The main objective of this robustness test is to assess whether the long-run restrictions imposed in the VAR model are too restrictive or instead are naturally supported by local projections where we do not impose any structure on the shock or the dynamic responses. We adopt a two-stage least squares (2SLS) method. In the first stage, we regress the country's CIT rate τ_{it} on the measure of international tax competition, τ_{it}^{int}, and appropriate controls and in the second stage, we estimate the dynamic effects of a variation in the instrumented CIT rate, $\bar{\tau}_{it}$, by using the single-equation method. While local projections do not impose the shock to have a long-run effect on variables, we find that exogenous variations in the country's CIT driven by tax competition motives produce the same long-run decline in the country-level CIT rate as in the VAR model. Moreover, all of our conclusions hold.

2.4 Dynamic Effects of Corporate Tax Shocks across Sectors

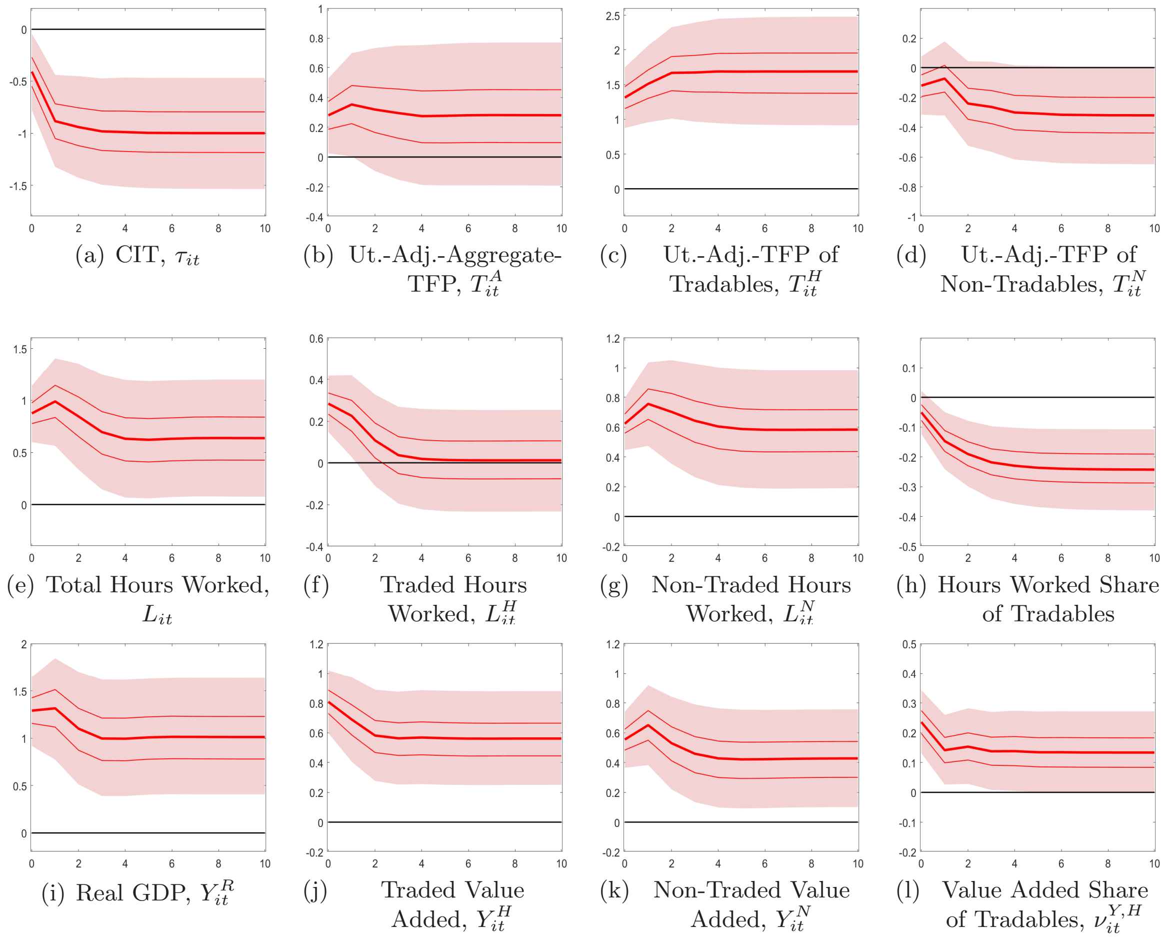
In this section, we analyze the dynamic effects of a permanent corporate tax cut. By reducing the capital cost, a decline in the CIT leads firms to accumulate capital which raises the marginal product of labor and thus has an expansionary effect on hours. Technology should also improve because a CIT cut increases the return on R&D. Higher intangible assets will amplify the positive effect of a permanent corporate tax cut on economic activity caused by the rise in tangible assets and in hours. We explore below the effects on economic activity by focusing on the responses of technology and hours.

The solid red line in Fig. 3 shows the dynamic responses to an exogenous shock to the CIT rate. Shaded areas display the 90% confidence bounds while thin red lines are 68% confidence intervals. The dynamic responses are generated from the estimation of VAR models which include the import-share-weighted-average of trade partners' CIT rates, τ_{it}^{int}, ordered first and a set of variables which are detailed in Online Appendix B. While we replace the country-level CIT 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 of a 1 percentage point permanent decline in the country-level CIT rate, as shown in Fig. 3(a).[7] 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).

Aggregate Effects. The corporate tax cut has an expansionary effect on real GDP, total hours worked, 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 effect of higher labor and technology improvements generate a real GDP growth of 1.3% on impact while real GDP remains permanently 1% higher than its initial steady-state level (see Fig. 3(i)). We find a rise in real GDP for an average OECD economy which is two times larger than what Cloyne et al. [2022] obtain on U.S. data because hours increase sizeably in an average OECD economy while L_{it} remain muted in the United States.

Sectoral technology effects. While aggregate technology significantly improves (by 0.3%) on impact only (at a 90% threshold), the adjustment is quite distinct when we differentiate the technology effects between the traded and the non-traded sector. As shown in Fig. 3(c), a corporate tax cut leads to a sizeable (and statistically significant) technology improvement which is concentrated in the traded sector as T_{it}^{H} rises by almost 1.7% in

[7] To normalize the shock so that the responses show the effects after a permanent CIT 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 how 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 CIT rate.



(a) CIT, τ_{it} (b) Ut.-Adj.-Aggregate-TFP, T_{it}^{A} (c) Ut.-Adj.-TFP of Tradables, T_{it}^{H} (d) Ut.-Adj.-TFP of Non-Tradables, T_{it}^{N}

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

(i) Real GDP, Y_{it}^{R} (j) Traded Value Added, Y_{it}^{H} (k) Non-Traded Value Added, Y_{it}^{N} (l) Value Added Share of Tradables, $\nu_{it}^{Y,H}$

Figure 3: Dynamic Effects of a Corporate Tax Shock in OECD Countries ($N = 11$). Notes: Ut-adj-TFP means Utilization-Adjusted-TFP. The solid red line shows the response of aggregate and sectoral variables to an exogenous decline in the CIT rate by 1 percentage point in the long-run. Red shaded areas indicate the 90 percent confidence bounds and the thin red lines indicate the 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.

the long-run. In contrast, utilization-adjusted-TFP of non-tradables remains essentially unchanged as the response is not statistically significant (see Fig. 3(d)). 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 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 68% threshold. As we shall see in the next subsection, 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. Although the contribution of the reallocation of labor toward the non-traded sector to the rise in L^N is negligible on impact, the contribution amounts to more than one-third after three years as the shift of labor only builds up gradually. While labor growth mostly originates from non-traded industries, 56% of real GDP growth is driven by the rise in traded value added, the traded sector accounting for 35% of GDP only. The large contribution of Y_{it}^H to the rise in real GDP is brought about by technology improvements concentrated in the traded sector which raise the value added share of tradables at constant prices by 0.2 ppt of real GDP in the long-run (see Fig. 3(l)).

2.5 Dynamic Effects of Corporate Tax Shocks across Countries

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 to ensure the accuracy of SVAR estimates.

Country-split. To split the sample into two sub-groups, we use two dimensions. The first dimension is related to the ability to improve technology, i.e., to transform R&D into innovation. In Online Appendix G.6, we rank countries in accordance with the elasticity of utilization-adjusted-aggregate-TFP w.r.t. the domestic stock of knowledge we estimate for one country at a time. The country-split is clear-cut as two groups of countries naturally emerge. For continental Europe, which includes Austria, Belgium, France and Germany, the elasticity of utilization-adjusted-TFP is essentially zero for both tradables and non-tradables. In contrast, the elasticity amounts to 0.50 for tradables and 0.05 for non-tradables in English-speaking and Scandinavian countries. While we name the latter group of economies English-speaking and Scandinavian countries for convenience, because it comprises Australia, the U.K, the U.S., Finland, Sweden, it also includes Japan and Luxembourg. Whereas the latter country displays a low elasticity of technology w.r.t. the stock of knowledge, Luxembourg is also characterized by the greatest technology improvement after a permanent corporate tax cut, see Online Appendix C.7 where we estimate the effects of a reduction in profits' taxation on utilization-adjusted-TFP (and the aggregate wage rate) for one country at a time. Therefore, we decided to classify this economy in the second group.[8]

The second dimension is related to the degree of wage flexibility. We have estimated the dynamic effects of a corporate tax cut on the aggregate wage rate for one country at a time, see Online Appendix C.7. We find that wages are unresponsive to the corporate tax shock in continental European countries which include Austria, Belgium, France and Germany. In contrast, the wage rate significantly increases after a reduction in corporate taxation

[8]As a first pass, as detailed in Online Appendix C.7, we have estimated the effects of a corporate tax cut on technology for one country at a time. Except for Luxembourg, the dynamic effects of a corporate tax cut on utilization-adjusted-TFP are consistent with our estimates of the elasticity of technology w.r.t. the stock of knowledge. In particular, the effects of a corporate tax cut on utilization-adjusted-TFP remain insignificant in these four economies. In contrast, in the rest of the sample, technology significantly increases.

in English-speaking and Scandinavian countries (including Japan and Luxembourg). To further support these evidence which might display a lack of accuracy because the VAR analysis is conducted at a country level, we have conducted an analysis aimed at identifying clusters. As detailed in Online Appendix C.4, to identify these two clusters, we adopt 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 relative 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 relative higher wage flexibility.

In sum, our evidence provides a clear-cut country-split based on two dimensions which include the ability to improve technology and the relative wage rigidity. As mentioned above, continental Europe displays a low elasticity of technology w.r.t. the stock of knowledge and a higher degree of wage stickiness while the second group of countries named English-speaking and Scandinavian countries for convenience displays a greater ability to improve technology and a higher degree of wage flexibility.

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 solid blue line and continental European countries on the other displayed by the dashed red lines. Shaded areas are 68% confidence bounds. As can be seen in Fig. 4(a), the adjustment of the country-level CIT rate to international tax pressure is similar between the two groups of countries. In contrast, the adjustment in wages and in technology is distinct between the two sub-samples. As displayed by the dashed red line in Fig. 4(c), a CIT cut has a significant and persistent effect on total hours in continental European countries while the aggregate wage rate remains mostly unresponsive to the shock (see Fig. 4(b)). By contrast, Fig. 4(d) reveals that technology remains essentially unchanged after a permanent corporate tax cut in continental Europe while utilization-adjusted-aggregate-TFP permanently increases by 0.7% in the long-run in English-speaking and Scandinavian countries (see the blue line).

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 on R&D between the two groups of countries and find that both investment in intangible assets and the stock of capital in R&D significantly increase but only in the

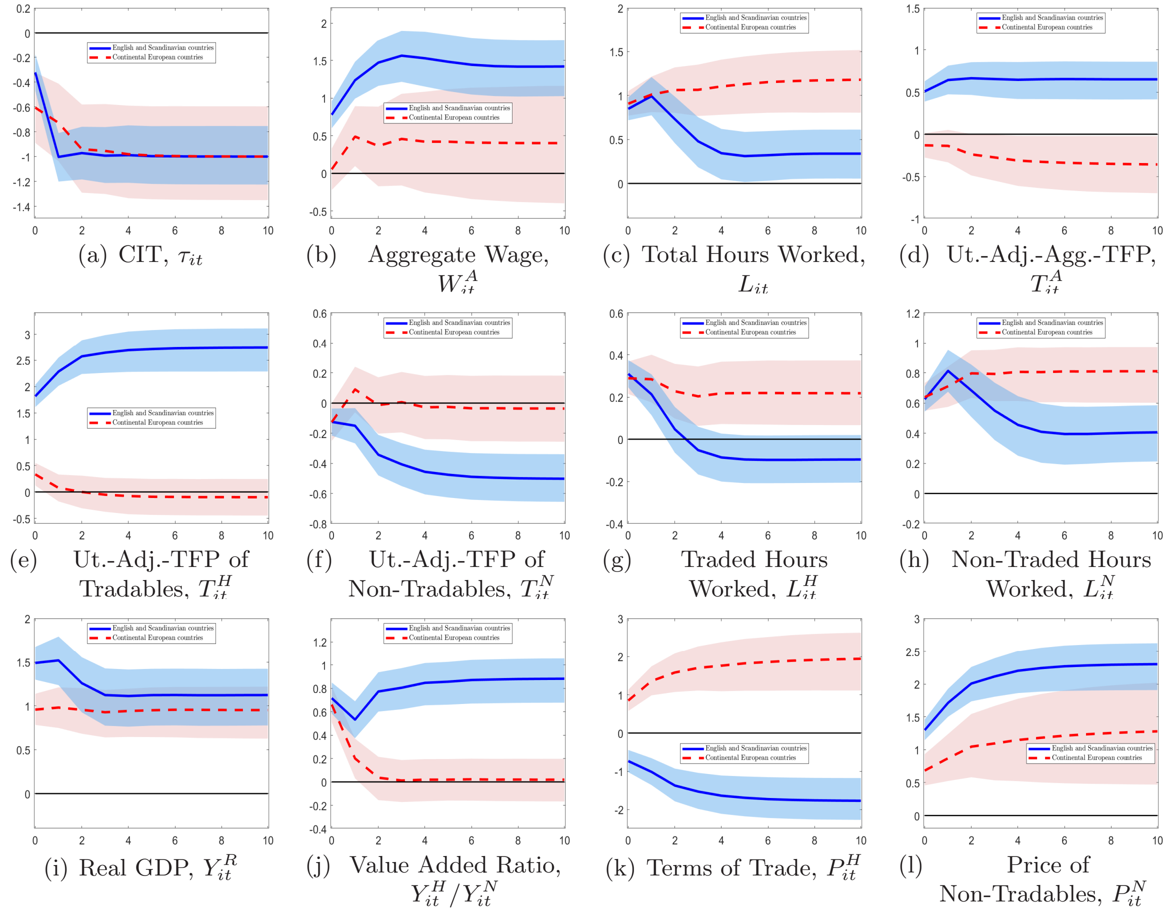


Figure 4: Dynamic Effects of a CIT Shock: Country-Split. Notes: We investigate the effects of an exogenous decline in CIT by 1 percentage point in the long-run for two groups of countries. The solid blue line with diamonds shows the responses of English-speaking and Scandinavian countries while the dashed red line displays the responses of continental European countries. Shaded areas indicate the 68 percent confidence bounds based on bootstrap sampling. Continental Europe is a group of countries with a lower ability to improve technology and a higher wage stickiness while English-speaking and Scandinavian countries include economies with a higher ability to improve technology and where wages display relatively more flexibility than in the former group. Horizontal axes indicate years. Vertical axes measure percentage deviation from trend. Sample: 7 vs. 4 OECD countries, 1973-2017, annual data.

traded sector in English-speaking and Scandinavian countries. By contrast R&D remains unresponsive to the CIT shock in continental Europe. While in the latter group of countries, technology is unchanged in both sectors, hours 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. While real GDP growth does not display some significant differences between the two sub-samples, see Fig. 4(i), the contribution of sectors is quite distinct between the two clusters. More specifically, as displayed by Fig. 4(j), technology improvements in traded industries raise permanently traded relative to non-traded value added in English-speaking and Scandinavian countries. This gives rise to an excess supply in the traded goods market leading to a depreciation in the terms of trade, see Fig. 4(k), which further boosts the demand for home-produced traded goods; 66% of real GDP growth originates from the rise in Y_{it}^H on average over a 10-year horizon. In contrast, in continental Europe, the non-traded sector drives 66% of real GDP growth. Fig. 4(l) reveals that the price of non-tradables appreciates as a result of the excess demand in the non-traded goods market. Because the price-elasticity of the demand for non-traded goods is low (i.e., much smaller than one as corroborated by our own estimates), the appreciation in the relative price of non-traded goods raises the consumption share of non-tradables and provides incentive to shift labor toward the non-traded sector.

International differences in real GDP growth. Because we estimate the response of real GDP to a permanent decline in the top statutory CIT which is normalized to 1 percentage point in the long-run, we have computed the long-run semi-elasticity of real GDP w.r.t. the CIT rate by calculating the present value of the cumulative rate of change in real GDP, $Y_{R,it}$, to the present value of the cumulative change in τ_{it} over a 10-year horizon, i.e., $X_t^{\text{tax}} = \frac{\int_0^t d\log Y_{R,s} e^{-rs} ds}{\int_0^t d\tau_s e^{-rs} ds}$ with $t = 10$, where r is the real interest rate. By using data relevant to each group of countries, we find a long-run semi-elasticity of real GDP w.r.t. the CIT of 1.2 and 1.3 for continental Europe and English-speaking and Scandinavian countries, respectively. Whereas the discrepancy is not statistically significant, the factor and the sector driving real GDP growth vary between the two groups. Almost 70% of the long-run increase in real GDP is driven by technology improvements in the traded sector in English-speaking and Scandinavian countries while labor growth in the non-traded sector remains the main driver of real GDP growth in continental Europe.

Further checks: Dividend policy and profit-sharing rules. Because we find that hours do 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 hiring more workers, see Online Appendix C.5. We find that the response of the ratio of dividends to gross operating surplus is muted for both groups of countries; therefore the dividend policy does not drive international differences in technology improvements or in labor growth.

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 with an infinite horizon which is populated by a constant number of identical households and firms, both having perfect foresight. Like Kehoe and Ruhl [2009], 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. For reasons of space, we present the model below and relegate household's first-order conditions together with the solution method to Online Appendix 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:

$$C(t) = \left[\varphi^{\frac{1}{\phi}} \left(C^T(t)\right)^{\frac{\phi-1}{\phi}} + (1-\varphi)^{\frac{1}{\phi}} \left(C^N(t)\right)^{\frac{\phi-1}{\phi}}\right]^{\frac{\phi}{\phi-1}}, \tag{5}$$

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, $C^F(t)$:

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

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 chooses the allocation of total hours, $L(t)$, between sectors. Like Horvath [2000], we generate imperfect mobility of labor across sectors by assuming that traded (i.e., $L^H(t)$) and non-traded (i.e., $L^N(t)$)

hours are imperfect substitutes:

$$L(t) = \left[\vartheta_L^{-1/\epsilon_L}\left(L^H(t)\right)^{\frac{\epsilon_L+1}{\epsilon_L}} + (1-\vartheta_L)^{-1/\epsilon_L}\left(L^N(t)\right)^{\frac{\epsilon_L+1}{\epsilon_L}}\right]^{\frac{\epsilon_L}{\epsilon_L+1}}, \tag{7}$$

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. When $\epsilon_L \to \infty$, the case of perfect labor mobility obtains.

Supply of tangible and intangible assets across sectors. The aggregate stock of tangible (intangible) assets is denoted by $K(t)$ ($Z^A(t)$). We allow for imperfect capital mobility by assuming that traded $K^H(t)$ and non-traded $K^N(t)$ capital stock are imperfect substitutes:

$$K(t) = \left[\vartheta_K^{-1/\epsilon_K}\left(K^H(t)\right)^{\frac{\epsilon_K+1}{\epsilon_K}} + (1-\vartheta_K)^{-1/\epsilon_K}\left(K^N(t)\right)^{\frac{\epsilon_K+1}{\epsilon}}\right]^{\frac{\epsilon_K}{\epsilon_K+1}}, \tag{8}$$

where $0 < \vartheta_K < 1$ is the weight of traded capital and ϵ_K 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:

$$Z^A(t) = \left[\vartheta_Z^{-1/\epsilon_Z}\left(Z^H(t)\right)^{\frac{\epsilon_Z+1}{\epsilon_Z}} + (1-\vartheta_Z)^{-1/\epsilon_Z}\left(Z^N(t)\right)^{\frac{\epsilon_Z+1}{\epsilon}}\right]^{\frac{\epsilon_Z}{\epsilon_Z+1}}, \tag{9}$$

where $0 < \vartheta_Z < 1$ is the weight of traded intangible assets and ϵ_Z 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 $\beta > 0$, households derive utility from their consumption, $C(t)$, and experience disutility from working and maximize the following objective function:

$$\mathcal{U} = \int_0^\infty \Lambda\left(C(t), S(t), L(t)\right) e^{-\beta t}\mathrm{d}t. \tag{10}$$

We consider a 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:

$$\Lambda\left(C, S, L\right) \equiv \frac{X^{1-\sigma}-1}{1-\sigma}, \quad X\left(C, S, L\right) \equiv CS^{-\gamma_S} - \frac{\sigma_L}{1+\sigma_L}\gamma_L L^{\frac{1+\sigma_L}{\sigma_L}}, \tag{11}$$

where $\sigma_L > 0$ is the Frisch elasticity of labor supply, $\sigma > 0$ parametrizes the curvature of the utility function, S is the household's reference stock and $\gamma_S \geq 0$ is the weight attached to relative consumption since $CS^{-\gamma_S} \equiv C^{1-\gamma_S}\left(C/S\right)^{\gamma_S}$. 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 where the reference stock $S(t)$ is determined by the past consumption of others, see Carroll et al. [1997]. Each household takes the reference stock as given 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 habits collapse to the values prevailing for each individual. In eq. (12), the reference stock is thus formed as an exponentially declining weighted average of past economy-wide average levels of consumption:

$$S(t) = \delta_S \int_{-\infty}^{t} C(\tau)\, e^{-\delta_S (t-\tau)} \mathrm{d}\tau, \qquad \delta_S > 0, \tag{12}$$

where the parameter $\delta_S > 0$ indexes the relative weight of recent consumption in determining the reference stock $S(t)$. Differentiating eq. (12) with respect to time gives the law of motion of the stock of habits:[9]

$$\dot{S}(t) = \delta_S \left[C(t) - S(t) \right]. \tag{13}$$

Capital and technology utilization rates. We assume that 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 and the technology utilization rates (i.e., $u^{K,j}(t)$ and $u^{Z,j}(t)$) 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:

$$C^{K,j}(t) = \xi_1^j \left(u^{K,j}(t) - 1 \right) + \frac{\xi_2^j}{2} \left(u^{K,j}(t) - 1 \right)^2, \tag{14a}$$

$$C^{Z,j}(t) = \chi_1^j \left(u^{Z,j}(t) - 1 \right) + \frac{\chi_2^j}{2} \left(u^{Z,j}(t) - 1 \right)^2, \tag{14b}$$

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 $\mathrm{Tax}(t)$, households' flow budget constraint states that real disposable income can be saved by accumulating traded bonds, $\dot{N}(t)$, 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:

$$\begin{aligned} &\dot{N}(t) + P_C(t)C(t) + \sum_{V=K,Z} P_J^V(t) J^V(t) + \sum_{j=H,N} P^j(t) \left(C^{K,j}(t) \nu^{K,j}(t) K(t) + C^{Z,j}(t) \nu^{Z,j}(t) Z^A(t) \right) \\ &= r^\star N(t) + W(t)L(t) + R^K(t)K(t) \sum_{j=H,N} \alpha_K^j(t) u^{K,j} + R^Z(t) Z^A(t) \sum_{j=H,N} \alpha_Z^j(t) u^{Z,j} - \mathrm{Tax}(t), \end{aligned} \tag{15}$$

[9]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.

where P_C and P_J^V (with $V = K, Z$) are price indices for consumption and investment goods; we denote the share of sectoral tangible (intangible) assets in the aggregate stock of capital (knowledge) by $\nu^{K,j}(t) = K^j(t)/K(t)$ ($\nu^{Z,j}(t) = Z^j(t)/Z^A(t)$), and the compensation share of sector $j = H, N$ by $\alpha_K^j(t) = \frac{R^{K,j}(t)K^j(t)}{R^K(t)K(t)}$ ($\alpha_Z^j(t) = \frac{R^{Z,j}(t)Z^j(t)}{R^Z(t)Z^A(t)}$) 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, $J^{K,T}(t)$, and the non-traded good, $J^{K,N}(t)$, by means of a CES technology:

$$J^K(t) = \left[\iota^{\frac{1}{\phi_K}} \left(J^{K,T}(t)\right)^{\frac{\phi_K-1}{\phi_K}} + (1-\iota)^{\frac{1}{\phi_K}} \left(J^{K,N}(t)\right)^{\frac{\phi_K-1}{\phi_K}}\right]^{\frac{\phi_K}{\phi_K-1}}, \tag{16}$$

where $0 < \iota < 1$ 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 $J^{K,T}(t)$ is defined as a CES aggregator of home-produced traded inputs, $J^{K,H}(t)$, and foreign-produced traded inputs, $J^{K,F}(t)$:

$$J^{K,T}(t) = \left[\left(\iota^H\right)^{\frac{1}{\rho_K}} \left(J^{K,H}(t)\right)^{\frac{\rho_K-1}{\rho_K}} + \left(1-\iota^H\right)^{\frac{1}{\rho_K}} \left(J^{K,F}(t)\right)^{\frac{\rho_K-1}{\rho_K}}\right]^{\frac{\rho_K}{\rho_K-1}}, \tag{17}$$

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.

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

$$J^K(t) = I^K(t) + \frac{\kappa}{2}\left(\frac{I^K(t)}{K(t)} - \delta_K\right)^2 K(t), \tag{18}$$

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:

$$\dot{K}(t) = I^K(t) - \delta_K K(t). \tag{19}$$

Investment in intangible assets. The intangible good is produced using inputs of the home-produced traded good, $J^{Z,H}(t)$, and the non-traded good, $J^{Z,N}(t)$:

$$J^Z(t) = \left[\iota_Z^{\frac{1}{\phi_Z}} \left(J^{Z,H}(t)\right)^{\frac{\phi_Z-1}{\phi_Z}} + (1-\iota_Z)^{\frac{1}{\phi_Z}} \left(J^{Z,N}(t)\right)^{\frac{\phi_Z-1}{\phi_Z}}\right]^{\frac{\phi_Z}{\phi_Z-1}}, \tag{20}$$

where $0 < \iota_Z < 1$ is the weight of the intangible traded input 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:

$$\dot{Z}^A(t) = I^Z(t) - \delta_Z Z^A(t), \tag{21}$$

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 is also subject to adjustment costs whose magnitude is governed by $\zeta > 0$:

$$J^Z(t) = I^Z(t) + \frac{\zeta}{2}\left(\frac{I^Z(t)}{Z^A(t)} - \delta_Z\right)^2 Z^A(t), \tag{22}$$

where $J^Z(t)$ stands for total investment in intangible assets.

Reallocation incentives. A permanent CIT 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 $C(t)$, they allocate consumption expenditure to traded and non-traded goods:

$$1 - \alpha_C(t) = \frac{P^N(t)C^N(t)}{P_C(t)C(t)} = (1-\varphi)\left(\frac{P^N(t)}{P_C(t)}\right)^{1-\phi}, \tag{23}$$

where $1 - \alpha_C(t)$ is the share of consumption expenditure allocated to non-traded goods. Because technology improvements are concentrated within traded industries, a CIT cut gives rise to an excess supply in the traded goods market and an excess demand in the non-traded goods market. According to (23), an appreciation in non-traded goods prices, $P^N(t)$, increases $1 - \alpha_C(t)$ as long as $\phi < 1$, as evidence suggests. This assumption ensures that a CIT cut has a strong expansionary effect on $L^N(t)$, 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, the final output is made up of an aggregate of differentiated varieties which are produced by a large number of imperfectly competitive intermediate good firms. We drop the time index below when it causes no confusion.

Final Good Firms. The final 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 intermediate goods:

$$Y^j = \left[\int_0^1 \left(X_i^j\right)^{\frac{\omega^j - 1}{\omega^j}} \mathrm{d}i\right]^{\frac{\omega^j}{\omega^j - 1}}, \tag{24}$$

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: $X_i^j = \left(P_i^j/P^j\right)^{-\omega^j} Y^j$ 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. We add a tilde below when assets are inclusive of the intensity in the use of capital or ideas. Within each sector j, there are firms producing differentiated goods. Each intermediate good producer rents labor services from households, $L^j(t)$, along with services from tangible assets, $\tilde{K}_i^j(t)$, and intangible assets, $\tilde{Z}^j(t)$, to produce an intermediate good:

$$X_i^j(t) = T^j(t)\left(L_i^j(t)\right)^{\theta^j}\left(\tilde{K}_i^j(t)\right)^{1-\theta^j}, \tag{25}$$

where $T^j(t)$ stands for utilization-adjusted-TFP in sector j and θ^j is the labor income share in sector j. Because technology improvements are brought about by the domestic stock of intangible assets, $\tilde{Z}_t^j$, rented from households, the technology of production described by eq. (25) displays returns to scale potentially larger than one. In line with the assumption by Buera and Oberfield [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. Formally, the stock of ideas Z_t^j has a domestic component $\tilde{Z}_t^j$ and an international component denoted by $Z^{W,j}(t)$:

$$\mathsf{Z}^j(t) = \left(\tilde{Z}_i^j(t)\right)^{\theta_Z^j} \left(Z^{W,j}(t)\right)^{1-\theta_Z^j}, \tag{26}$$

where θ_Z^j captures the domestic content of the stock of knowledge in sector j. Both the domestic (i.e., $\tilde{Z}^j(t)$) and the international stock of ideas (i.e., $Z^{W,j}(t)$) are sector-specific and produce differentiated effects on utilization-adjusted-TFP in sector j:[10]

$$T^j(t) = \left(\tilde{Z}_i^j(t)\right)^{\nu_Z^j\theta_Z^j} \left(Z^{W,j}(t)\right)^{\nu_Z^{W,j}\left(1-\theta_Z^j\right)}, \tag{27}$$

where $\nu_Z^j \geq 0$ ($\nu_Z^{W,j} \geq 0$) is a parameter which determines the ability of sector j to transform domestic (international) intangible assets into innovation.

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. Intermediate good producers choose prices along with hours, tangible assets and intangible assets:

$$\Pi_i^j(t) \equiv (1-\tau)\,\mathrm{NOS}_i^j(t) - \left(R^{K,j}(t) - \delta_K\right)\tilde{K}_i^j(t) - R^{Z,j}(t)\tilde{Z}_i^j(t) - P^j(t)F^j, \tag{28}$$

where $\mathrm{NOS}_i^j(t) = P_i^j(t)X_i^j(t) - W^j(t)L_i^j(t) - \delta_K\tilde{K}_i^j(t)$ is the net operating surplus and 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 read (see Online Appendix E.2):

$$P_i^j\theta^j\frac{X_i^j}{L_i^j} = \mu^j W^j, \tag{29a}$$

$$P_i^j\left(1-\theta^j\right)\frac{X_i^j}{\tilde{K}_i^j} = \mu^j\left[\left(\frac{R^{K,j}-\delta_K}{1-\tau}\right) + \delta_K\right], \tag{29b}$$

$$(1-\tau)\,P_i^j\nu_Z^j\theta_Z^j\frac{X_i^j}{\tilde{Z}_i^j} = \mu^j R^{Z,j}, \tag{29c}$$

[10] Cai et al. [2022] detect some spillovers 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) on utilization-adjusted-TFP of non-tradables (tradables), we didnot detect any spillovers across sectors as the coefficients are not statistically significant. However, knowledge spillover can occur between industries of the same broad sector.

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 $\frac{\partial X_i^j}{\partial \tilde{Z}_i^j} = \nu_Z^j \theta_Z^j \frac{X_i^j}{\tilde{Z}_i^j}$.

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., $\Pi_i^j(t) = 0$. Inserting first-order conditions (29a)-(29c) into profit (28), and setting to zero implies that $(1-\tau) P_i^j X_i^j \left[1 - \frac{1+\nu_Z^j \theta_Z^j}{\mu^j}\right] - P_i^j F^j = 0$. We require the markup to be larger than the degree of increasing returns to scale, i.e.,

$$1 + \nu_Z^j \theta_Z^j < \mu^j, \tag{30}$$

so that the excess of after-tax value added over the payment of factors of production 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., $P_i^j = P^j$ and they produce the same quantity, i.e., $X_i^j = X^j = Y^j$. We denote output net of fixed costs by $O^j = Y^j - F^j$ which reads as follows $O^j = Y^j \left[1 - (1-\tau)\left(1 - \frac{1+\nu_Z^j \theta_Z^j}{\mu^j}\right)\right]$ where use has been made of the free entry condition.

3.3 Model Closure and Equilibrium

Government. Government expenditure, G, on non-traded and traded goods, i.e., $G \equiv P^N G^N + G^T$ where G^T includes home and imported goods, i.e., $G^T = P^H G^H + G^F$, is financed by raising lump-sum taxes in addition to corporate taxes levied on firms' profits:

$$P^N(t) G^N + P^H(t) G^H + G^F = \text{Tax}(t) + \sum_{j=H,N} \tau(t) \text{NOS}^j(t). \tag{31}$$

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

$$O^N(t) = C^N(t) + G^N(t) + \sum_{V=K,Z} \left(J^{V,N}(t) + C^{V,N}(t) V^N(t)\right), \tag{32a}$$

$$O^H(t) = C^H(t) + G^H(t) + X^H(t) + \sum_{V=K,Z} \left(J^{V,H}(t) + C^{V,H}(t) V^H(t)\right), \tag{32b}$$

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

$$X^H(t) = \varphi_X \left(P^H(t)\right)^{-\phi_X}, \tag{33}$$

where $\varphi_X > 0$ is a scaling parameter, and ϕ_X is the price-elasticity of exports. Using (29a)-(29c) and market clearing conditions (32), the current account equation (15) can be rewritten as a function of the trade balance:

$$\dot{N}(t) = r^\star N(t) + P^H(t) X^H(t) - M^F(t), \tag{34}$$

where $M^F = C^F + G^F + J^{K,F}$ stands for imports of consumption and capital goods.

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

$$d\tau(t) = d\tau + x_T e^{-\xi_T t}, \tag{35}$$

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 CIT rate closes the gap with its long-run level and thus captures the persistence of the tax shock.

Model solution. The adjustment of the open economy toward the steady-state is described by a dynamic system which comprises seven equations which 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 CIT rate, $\tau(t)$, and the sector-specific-international stock of knowledge, $Z^{W,j}(t)$. The law of motion of the international stock of knowledge will be specified in the next section. In line with our estimates which show that a shock to the international CIT rate increases $Z^{W,H}(t)$, we assume that domestic (traded) firms freely benefit from the progression of the stock of knowledge. As we shall see, this element is an important driver of technology improvements for tradables. The solution method to solve the continuous time model is detailed in Online Appendix E.4 and F.

4 Quantitative Analysis

In this section, we take the model to the data. For this purpose we solve the model numerically.[11] Therefore, first we discuss parameter values before turning to the effects of a permanent CIT cut.

4.1 Calibration

Calibration strategy. At the steady-state, the capital and the technology utilization rates, $u^{K,j}$ and $u^{Z,j}$, collapse to one so that $\tilde{K}^j = K^j$ and $\tilde{Z}^j = Z^j$. 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 Online Appendix G.1. Our reference period for the calibration is 1973-2017. Because we (first) calibrate the reference model to a representative OECD economy, we take unweighted average values of ratios and parameters which are summarized in Table 1. 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.

[11]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].

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 hours worked share of tradables of $L^H/L = 36\%$, a weight of traded tangible and intangible assets 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 $\omega_J^Z = 2.7\%$, 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. At the steady-state, parameters related to capital ξ_1^j, and technology, χ_1^j, adjustment cost functions are set to be equal to $R^{K,j}/P^j$ and $R^{Z,j}/P^j$, respectively, with $j = H, N$.

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 1, 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 1, 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%.

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.7. This finding is in line with the evidence documented by Bems [2008]. We also find that the tradable content of investment expenditure in R&D is stable over time at 58%. Therefore, in the calibration, we choose a value of one for the elasticity of substitution ϕ_K (ϕ_Z) between traded and non-traded investment inputs in tangible (intangible) assets.

We have estimated empirically the degree of labor mobility between sectors, ϵ_L, for one country at a time, see Online Appendix G.2. In line with the average of our estimates, we choose a value of 1 for ϵ_L (see column 16 of Table 1) which collapses to the value estimated by Horvath [2000] on U.S. data over 1948-1985. We have also estimated the degree of capital mobility across sectors, see Online Appendix G.3. Building on our estimates, we choose a degree of mobility of tangible (ϵ_K) and intangible assets (ϵ_Z) across sectors of 0.17 (see column 17 of Table 1).

Building on our panel data estimates, see Online Appendix G.4, the elasticity of substitution ϕ between traded and non-traded goods is set to 0.45 (see column 15 of Table 1). 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 pin down the values of parameters ν_Z^j and $\nu_Z^{W,j}$ (see eq. (27)) which determine the ability of sectors to transform intangible assets into innovation, we have to estimate values for the elasticity of technology w.r.t. the domestic and international stock of ideas. For this purpose, we run the regression of utilization-adjusted-TFP in sector j on the domestic stock of R&D of the corresponding sector and the international stock of R&D defined as an import-share-weighted-average of the stock of R&D relevant to 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 estimates 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, for non-tradables we set $\nu_Z^N = \nu_Z^{W,N} = 0$, see columns 19 and 21 of Table 1. As shown in eq. (27), the elasticity of technology w.r.t. to Z^j (i.e., $\nu_Z^j \theta_Z^j$) and w.r.t. $Z^{W,j}$ (i.e., $\nu_Z^{W,j}\left(1-\theta_Z^j\right)$) are a function of the domestic component of technology captured by θ_Z^j; to extract the common component across countries for home technology, $1-\theta_Z^j$, we have recourse to a principal component analysis applied to utilization-adjusted-TFP in sector $j = H, N$; 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 22-23 of Table 1). By combining estimated values for the elasticity of technology for tradables and θ_Z^H, we can pin down $\nu_Z^H = 0.52$ $(= 0.292/0.56)$, and $\nu_Z^{W,H} = 0.24$ $(= 0.104/0.44)$, see columns 18 and 20 of Table 1.

Finally, we have estimated the markup for the whole economy by adopting the empirical strategy by Amador and Soares [2017] which is an adaptation of the approach pioneered by Roeger [1995]. We choose a value for the markup of 1.35, see column 27 of Table 1.

Nine parameters are taken from external research works. We choose $\sigma = 1$ so that the intertemporal elasticity of substitution for consumption collapses to one. In line with the estimates documented by Peterman [2016], we set the Frisch elasticity of labor supply σ_L to 3. Building on the estimates documented by Havranek et al. [2017], we choose a value for the weight attached to consumption habits, γ_S, of 0.7. Like Carroll et al. [1997], we choose a depreciation rate for the stock of consumption habits, δ_S, of 0.2.

We choose a value for κ which captures the magnitude of capital adjustment costs so that the elasticity of I^K/K w.r.t. Tobin's q, i.e., Q^K/P_J^K, is equal to the value implied by estimates in Eberly et al. [2008]. The resulting value of κ is equal to 17. 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., $\rho = \rho_K = 3$. Assuming that all countries have the same elasticities, since

Table 1: Data to Calibrate the Two Open Economy Sector Model, 1973-2017

Tradable share					Home share				LIS		Input ratios		
O^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	0.14	0.65	0.68	0.36	0.38	0.59
Elasticities									Aggregate ratios			Markup	i.r.
ϕ	ϵ_L	ϵ_K	ν_Z^H	ν_Z^N	$\nu_Z^{W,H}$	$\nu_Z^{W,N}$	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 15-23 show the values of 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_Z^H (ν_Z^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 $\nu_Z^{W,H}$ ($\nu_Z^{W,N}$) 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 CPI.

the price-elasticity of exports is a weighted average of ρ and ρ_K, we set $\phi_X = 3$.

Setting the dynamics for the endogenous response of domestic CIT. We identify a shock to the international component of CIT, τ_{it}^{int}, and then estimate the endogenous response of the domestic CIT rate, $\tau(t)$. To reproduce the dynamics of $\tau(t)$ we estimate empirically, we normalize the steady-state variation in the domestic CIT rate to 1 percentage point (i.e., $d\tau = -0.01$) and set $x_T = 0.35$ together with $\xi_T = 0.9$ in eq. (35).

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 (exclusively in the traded sector) and because all trade partners also lower their tax rate and improve technology (on average), domestic firms in the home country can take advantage of a higher stock of ideas. The adjustment of the sector-specific-international stock of ideas, $Z^{W,j}(t)$, toward its long-run (higher) level, $Z^{W,j}$, expressed in deviation relative to the initial steady-state is governed by the following continuous time process:

$$dZ^{W,j}(t) = dZ^{W,j} + x_Z^j e^{-\xi_Z^j t}, \tag{36}$$

where $dZ^{W,j}$ stands for the permanent increase in the international stock of knowledge relevant to sector $j = H, N$, and $x_Z^j > 0$, $\xi_Z^j > 0$ parameterize the change on impact in $Z^{W,j}(t)$ and the speed of adjustment, respectively. Because traded industries are exposed to foreign innovation and since $\nu_Z^{W,H} > 0$ (while $\nu_Z^{W,N} \simeq 0$), the traded sector can take advantage of international R&D spillovers. As there is no knowledge spillovers across sectors, the dynamics of the world TFP relevant to traded industries, $T^{W,H}(t)$, just collapses to the dynamics of utilization-adjusted-TFP of tradables for a representative OECD economy.[12] Building on the response of $T^H(t)$, we can infer the dynamics of utilization-adjusted-world-TFP of

[12] We have estimated the response of utilization-adjusted-world-TFP of tradables, $T^{W,H}(t)$, defined as an import-share-weighted-average of traded TFPs of trade partners of the home country, to a CIT cut

tradables, $T^{W,H}(t)$, and calibrate the dynamics of $Z^{W,H}(t)$. We choose a value for x_Z^H of -0.0157 and a value of 0.9 for ξ_Z^H in eq. (36) to reproduce the dynamics of $Z^{W,H}(t)$.

Capital and technology utilization adjustment costs. We set the adjustment cost in the capital utilization rate, ξ_2^j, to 0.2 in both sectors so as to account for our estimated responses of $u^{K,j}(t)$ after a permanent CIT cut. While we can estimate empirically the response of $u^{K,j}(t)$, we cannot observe the adjustment in the intensity $u^{Z,j}(t)$ in the use of the stock of ideas in the data but we can infer indirectly the adjustment cost in the technology utilization rate χ_2^j. Because the stock of ideas builds up only gradually, $Z^j(t)$ contributes to the technology improvement in sector j mainly in the long-run. In the short-run, increases in utilization-adjusted-TFP are driven by the combined effect of the diffusion of the international stock of knowledge and the capacity of firms to increase overall production efficiency to meet higher demand. Cardi and Restout [2023] show that the capacity of firms to increase overall production efficiency to meet higher demand depends on firms' characteristics such as the intensity of production in capital. In line with this finding, technology improvements are found to be concentrated in the traded sector which is made up of capital intensive industries. This observation is especially true for English-speaking and Scandinavian countries where utilization-adjusted-TFP of tradables dramatically increases and the differential in the capital income share between tradables and non-tradables exceeds 6 percentage points of value added. We choose $\chi_2^H = 0.0001$ as this value allows the model to account for the technology improvement in the traded sector given the elasticity ν_2^H and the strength of international R&D spillovers captured by the combined effect of $\nu_Z^{W,H}$ and $dZ^{W,H}(t)$. Because technology is essentially unchanged in the non-traded sector, we let χ_2^N tend toward infinity.

4.2 Decomposition of Model's Performance

In this subsection, we quantify the role of each model's ingredient in driving the effects of a CIT cut on technology and hours. We show that the ability of the model to account for the effects of a CIT cut we estimate empirically depends on the firms' ability to improve technology and the specification of household's preferences.

Our baseline model comprises two sets of elements. The first set of element is related to endogenous technology decisions which include three dimensions. First, households invest in R&D giving rise to a stock of ideas $Z^A(t)$ which is allocated to sectors in accordance with its contribution to the marginal revenue product of sector $j = H, N$. As stressed above, the change in stock of knowledge $Z^j(t)$ in sector j contributes to productivity increases only in the long-run. Second, we allow for an endogenous intensity in the use of the stock of intangible assets (i.e., $\chi_2^H < \infty$). Third, (traded) firms are supposed to take

and find that its response (although less pronounced) is not statistically different from the response of utilization-adjusted-TFP of tradables of an average OECD economy.

advantage of international R&D spillovers (i.e., $\nu^{W,H} > 0$). The second set of elements is related to preferences which have two important 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 (i.e., $\gamma_S > 0$). As shown below, the model reproduces well the evidence only once we consider the aforementioned ingredients.

In Table 2, 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. In columns 5-7 and 12-14, we consider three variants of the baseline model by abstracting from consumption habits. Columns 7 and 14 ('No R&D') display results for a restricted version of our model which collapses to the Kehoe and Rhul [2009] (KR henceforth) model with GHH preferences. In this restricted model, we assume that the production of sectoral goods does not depend on intangible assets (i.e., $\nu_Z^j = \nu_Z^{W,j} = 0$). 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., $\nu_Z^H > 0$) but we assume that the adjustment costs of the technology utilization rate $u^{Z,H}(t)$ are prohibitive (i.e., we set $\chi_2^H \to \infty$) so that $u^{Z,H}(t) = 1$ and international R&D spillovers are shut down (i.e., $\nu_Z^{W,H} = 0$). Columns 5 and 12 ('Tech') show a variant of the baseline model with endogenous technology decisions but where consumption habits are shut down (i.e., we set $\gamma_S = 0$). 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, see Online Appendix I.1 for details about preferences' specification. 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., $\chi_2^H \to \infty$) and abstract from international R&D spillovers (i.e., we set $\nu_Z^{W,H} = 0$).

Table 2 reports impact and long-run effects on selected variables; while panel A focuses on total hours, $L(t)$, traded and non-traded hours, $L^H(t)$ and $L^N(t)$, the hours worked share of tradables, $\nu^{L,H}(t)$, panel B shows results for utilization-adjusted-aggregate-TFP, $T^A(t)$, and utilization-adjusted-TFP of tradables, $T^H(t)$. Panel C shows effects on real GDP, $O_R(t)$, and in the real value added share of tradables, $d\nu^{O,H}(t)$. To shed some light on the transmission mechanism, we consider in panel D the responses of non-traded goods' prices and the terms of trade, $P^N(t)$ and $P^H(t)$, while panel E displays the effects on households' consumption, $C(t)$, and total investment in tangible and intangible assets including capital installation costs, $P_J(t)J(t) = P_J^K(t)J^K(t) + P_J^Z(t)J^Z(t)$.

Shock to CIT. Across all model's variants, we consider a permanent decline in the CIT rate τ by 1 percentage point while τ declines by -0.65 ppt on impact, close to our estimates.

First ingredient: Investment in R&D. In columns 7 and 14 of Table 2, we report

Table 2: Impact and Long-Run Effects of a Permanent CIT Cut by 1 ppt

	VAR ($t=0$)	Impact ($t=0$) Theoretical Responses						VAR ($t=10$)	Long-run ($t=10$) Theoretical Responses					
	Data	Benchmark		Shimer	GHH (no habits)			Data	Benchmark		Shimer	GHH (no habits)		
		Tech	No tech	Tech	Tech	No tech	No R&D		Tech	No tech	Tech	Tech	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	0.90	0.24	0.43	0.92	0.35	0.21	0.59	0.66	0.48	0.42	2.01	0.72	0.55
H-hours, $dL^H(t)$	0.28	0.20	-0.01	-0.01	0.03	-0.02	0.02	0.01	0.11	0.06	0.03	0.56	0.11	0.14
N-hours, $dL^N(t)$	0.62	0.69	0.26	0.44	0.89	0.37	0.19	0.58	0.55	0.42	0.39	1.45	0.61	0.41
Hours share of H, $d\nu^{L,H}(t)$	-0.05	-0.06	-0.09	-0.14	-0.25	-0.10	-0.04	-0.21	-0.08	-0.08	-0.09	-0.09	-0.08	-0.02
B. Technology														
Agg. ut-adj.TFP, $dT^A(t)$	0.43	0.32	0.00	0.24	0.23	0.00	0.00	0.45	0.46	0.05	0.42	0.58	0.06	0.00
Ut-adj-TFP of H, $dT^H(t)$	1.31	1.01	0.00	0.78	0.72	0.00	0.00	1.68	1.46	0.16	1.37	1.85	0.19	0.00
C. Real GDP														
Real GDP, $dO_R(t)$	1.37	0.98	0.08	0.51	0.77	0.14	0.04	0.99	1.16	0.45	0.90	2.47	0.65	0.42
VA share of H, $d\nu^{O,H}(t)$	0.29	0.19	-0.06	0.07	-0.09	-0.10	-0.04	0.19	0.32	0.01	0.29	0.37	-0.01	-0.02
D. Relative Prices														
N-prices, $\hat{P}^N(t)$	1.05	0.97	0.55	1.51	1.68	0.57	0.28	1.85	1.54	0.52	1.60	1.27	0.33	0.06
H-prices, $\hat{P}^H(t)$	-0.17	-0.29	0.17	0.03	-0.12	0.12	0.08	-0.59	-0.39	-0.03	-0.31	-0.82	-0.14	-0.05
E. Cons. and Inv.														
Consumption $dC(t)$	0.51	0.43	-0.05	0.33	0.83	0.07	-0.10	0.60	0.50	0.12	0.35	1.41	0.29	0.09
Investment, $dJ(t)$	0.90	0.35	0.21	0.29	0.04	0.03	0.00	0.63	0.41	0.29	0.37	0.28	0.15	0.09

Notes: Impact ($t = 0$) and long-run ($t = 10$) effects of a permanent decline in the CIT 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 including 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 (i.e., the terms of trade). Panel E shows the responses of consumption and investment, both expressed in percentage point of GDP. Investment covers both tangible and intangible assets and includes installation costs. In columns 1 and 8, we show impact and ten-year-horizon responses we estimate empirically in the VAR model. In columns 2 and 9, we show responses for the baseline model with GHH preferences, consumption habits, and technology endogenous technology utilization rate, international R&D spillovers. In columns 3 and 10, we consider the same model as in columns 2 and 9 except that we shut down the technology endogenous technology utilization rate and international R&D spillovers. In columns 4 and 11, we consider the baseline model with Shimer [2009] preferences. In columns 5 and 12, we consider the baseline model without consumption habits. Columns 6 and 13 consider the baseline model with consumption habits and shut down the endogenous technology utilization rate and international R&D spillovers. Columns 7 and 14 show the predictions of a model shutting down abstracting from R&D, i.e., we set $\nu_Z^j = \nu_Z^{W,j} = 0$ so that the production function collapses to: $Y^j = \left(L_i^j(t)\right)^{\theta^j} \left(\tilde{K}_i^j(t)\right)^{1-\theta^j}$.

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 shut down the technology channel by setting $\nu_Z^j = \nu_Z^{W,j} = 0$ and by letting $\chi_2^H \to \infty$ so that $u^{Z,H} = 1$. Because the return on innovation is zero, households do not invest in R&D activity so that the utilization-adjusted-TFP remains unchanged as can be seen in panel B, in contradiction with our evidence. Without technology improvements, sectoral wages do not increase enough to generate the increase in hours we estimate empirically; more specifically, total hours worked rise by 0.21% on impact which is more than four times smaller than what we estimate empirically (i.e., 0.91%, see panel A in column 1).

Second ingredient: Endogenous technology utilization rate and international R&D spillovers. In columns 6 and 13 of Table 2, we assume that the production of sectoral goods is intensive in intangible assets (i.e., we set $\nu_Z^H = 0.52$), but we shut down the intensity in the use of the stock of innovation, i.e., we let $\chi_2^H \to \infty$, so that $u^{Z,H} = 1$, and impose $\nu_Z^{W,H} = 0$ 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, utilization-adjusted-aggregate-TFP remains unchanged on impact. While the stock of ideas can shift across sectors, high mobility costs of ideas between sectors imply that the stock of knowledge in sector j, i.e., Z^j, does not vary. Therefore, allowing for endogenous innovation is not sufficient to generate the magnitude of technology improvements we estimate empirically (see panel B of column 1). It is only once the stock of ideas has built up that productivity gains amount to 0.19% 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 (see panel E). Because technology remains unchanged in the short-run, the model cannot account for the adjustment in hours on impact (0.35% vs. 0.91% in the data, see panel A in columns 6 and 1, respectively).

Third ingredient: Consumption habits. In columns 5 and 12 of Table 2, 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 (11). 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., $\nu_Z^{W,H} > 0$, the model with endogenous technology decisions can generate a rise in utilization-adjusted-TFP of tradables of 0.72% and an increase in utilization-adjusted-aggregate-TFP of 0.23%. The rise in the international stock of R&D improves the technology of tradables by 0.6% on its own. The remaining fraction of the rise in $T^H(t)$ is driven by the increased intensity in the use of the stock of intangible assets, $u^{Z,H}(t)$, as it is optimal for traded firms to raise productivity to meet a higher demand for home-produced traded goods (because χ_2^H is low). Technology improvement in the traded sector raises significantly traded value added, $O^H(t)$, and depreciates the terms of trade by -0.12% close to the VAR evidence (-0.17%).

By pushing up the aggregate wage, technology improvements provide a strong incentive to increase labor supply. As shown in panel A, the model generates a rise in total hours by 0.92% on impact (see column 5) which squares well with our estimated impact response for total hours by 0.91% (see column 1). However, contrasting the long-run response of hours of 2.01% (see column 12) with the rise in hours estimated empirically over a ten-year horizon which stands at 0.59%, the model considerably overestimates the positive impact of a CIT cut on labor supply. In contrast, by allowing for consumption habits, the baseline model (see column 9) generates an increase in total hours which is three times smaller (i.e., by 0.66%) and thus squares well with what we estimate empirically (i.e., 0.59%, see column 8).

More specifically, the model abstracting from consumption habits (see column 12) generates a rise in household's consumption by 1.41 ppt of GDP (see panel E) while in the data, we find a rise of 0.60 ppt only (see column 8). Consumption habits are crucial to account for the effects of a CIT cut on hours as they mitigate the rise in consumption and amplify the rise in leisure. Intuitively, the expected higher level of habits lowers the utility gain from an increase in consumption which encourages households to consume less goods and more leisure. By curbing the rise in labor supply, allowing for consumption habits improves model's performance.

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 we estimate empirically. 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 panel A (columns 4 and 11), assuming Shimer [2009] preferences leads the model to produce a rise in hours slightly larger than 40% which substantially understates the rise in total hours we estimate empirically (0.91% at $t = 0$ and 0.59% at $t = 10$ in the data).[13]

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 spillovers immediately improves technology of tradables by 1.01% which leads to a rise in utilization-adjusted-

[13] Because consumption habits mitigate the wealth effect when considering Shimer [2009] preferences, we are keeping this feature to contrast the effects on hours. If we shut down habits, hours merely increase on impact.

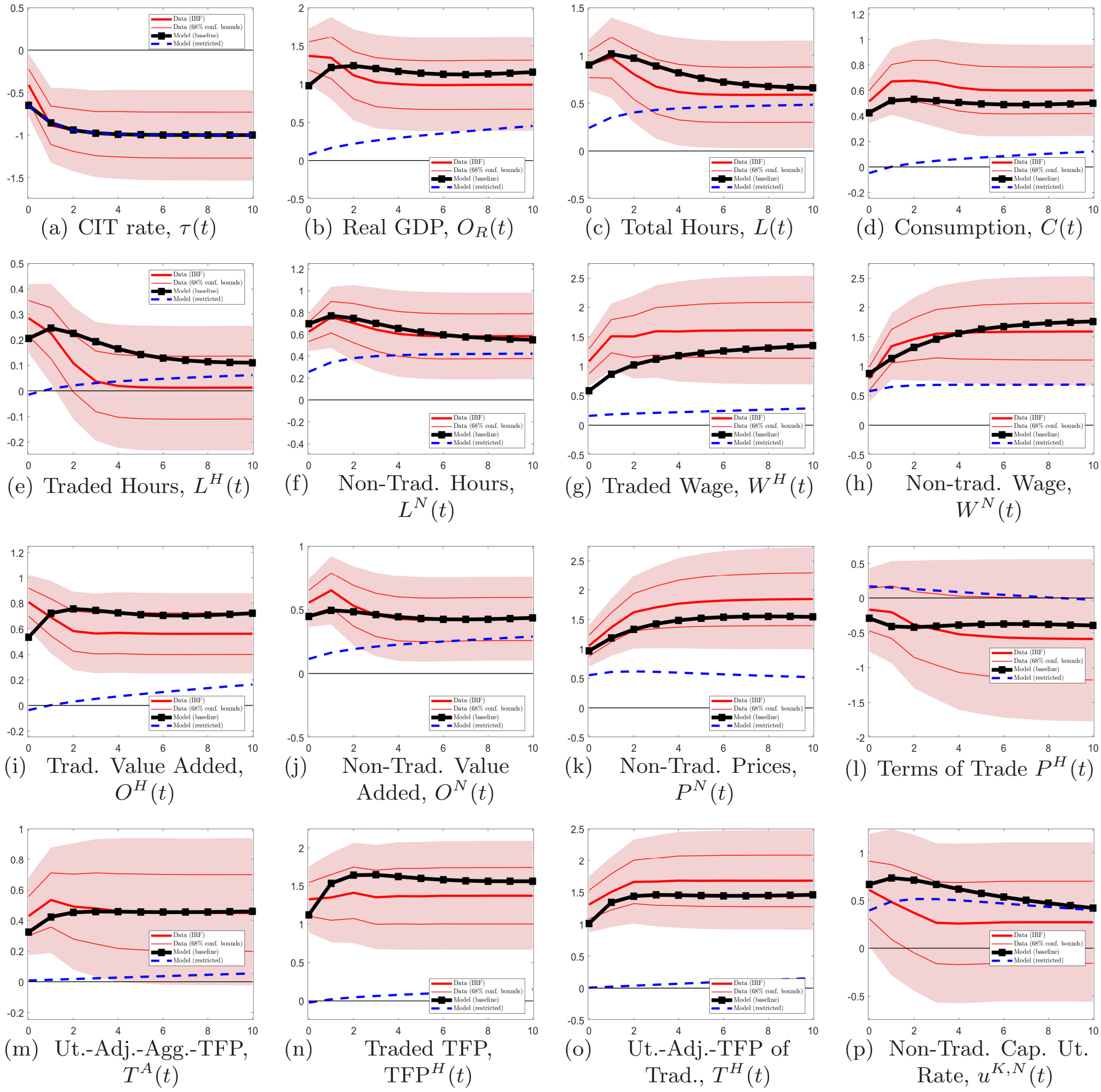
aggregate-TFP of 0.32% close to our empirical estimate (0.43%). By stimulating wages, technology improvements have a positive impact on labor supply which raises hours by 0.90% (see column 2), a magnitude which collapses to what we estimate empirically (0.91%, see column 1). While the specification of GHH preferences removes the negative impact of the wealth effect on hours, allowing for consumption habits curb the increase in consumption in the short- and especially in the long-run (0.50 ppt in the model vs. 0.60 ppt of GDP in the data, see panel E) 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 (see column 9) and 0.59% in the data.

Reallocation of productive resources in a two-sector open economy setup. According to our evidence, a CIT cut lowers the hours worked share of tradables (by reallocating hours toward the non-traded sector) and increases the value added share of tradables. Our two-sector open economy model can account for the sectoral composition effects of a reduction in profits' taxation only once we consider the baseline model. By producing a positive wealth effect (through higher wages and a larger return on tangible and intangible assets), a CIT cut encourages households to consume more traded and non-traded goods. The excess demand for non-traded goods appreciates non-traded goods' prices by 0.97% on impact (1.05% in the data) and by 1.54% in the long-run (1.85% in the data), see panel D. Because the elasticity of substitution between traded and non-traded goods (i.e., ϕ) is smaller than one, as shown in the last row of panel A, hours are reallocated toward the non-traded traded as reflected into a decline in the hours worked share of tradables on impact (by -0.06 ppt) and in the long-run (by -0.08 ppt).

Because technology improvements are concentrated within traded industries, the value added share of tradables increases in line with the evidence (see the last line of panel C). An excess supply shows up on the home-produced traded goods market which depreciates the terms of trade by -0.29% on impact (-0.17% in the data) and -0.39% in the long-run (-0.59% in the data), see the last line of panel D. Because home- and foreign-produced-traded goods are high substitutes (i.e., $\rho = \rho_K = \phi_X = 3$), 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 (even if the shift of labor is already hampered by labor mobility costs).

4.3 Dynamic Effects of a Permanent CIT Cut

While in Table 2, 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 red lines) dynamic responses with the shaded area (thin red lines) indicating the 90% (68%) confidence bounds. We also contrast theoretical responses from the baseline



(a) CIT rate, $\tau(t)$ (b) Real GDP, $O_R(t)$ (c) Total Hours, $L(t)$ (d) Consumption, $C(t)$

(e) Traded Hours, $L^H(t)$ (f) Non-Trad. Hours, $L^N(t)$ (g) Traded Wage, $W^H(t)$ (h) Non-trad. Wage, $W^N(t)$

(i) Trad. Value Added, $O^H(t)$ (j) Non-Trad. Value Added, $O^N(t)$ (k) Non-Trad. Prices, $P^N(t)$ (l) Terms of Trade $P^H(t)$

(m) Ut.-Adj.-Agg.-TFP, $T^A(t)$ (n) Traded TFP, $\text{TFP}^H(t)$ (o) Ut.-Adj.-TFP of Trad., $T^H(t)$ (p) Non-Trad. Cap. Ut. Rate, $u^{K,N}(t)$

Figure 5: Theoretical vs. Empirical Responses Following a 1 ppt Permanent CIT Cut. Notes: Ut-adj-TFP means utilization-adjusted-TFP; Cap. Ut. means capital utilization; Agg. means aggregate; Trad. means tradables. The solid red line displays point estimate from the VAR model with shaded areas (thin lines) indicating 90% (68%) confidence bounds; the thick solid black line with squares displays model predictions in the baseline scenario; the dashed blue line shows the predictions of a restricted version of the baseline model where we shut down the endogenous intensity in the use of the stock of knowledge (by setting $\chi_2^j \to \infty$) and we abstract from the impact of international R&D spillovers on domestic technology (by setting $\nu_Z^{W,j} = 0$).

model with the predictions of a restricted model shown in dashed blue lines which imposes prohibitive technology utilization adjustment costs in both sectors (i.e., $\chi_2^j \to \infty$) so that $u^{Z,j} = 1$ and assumes that the international stock of ideas does not spillover on domestic technology, i.e., we set $\nu_Z^{W,j} = 0$. We consider the same CIT cut for the baseline model and its restricted version, see Fig. 5(a).

Dynamics. As shown in the first row of Fig. 5, the baseline model reproduces well the expansionary effect of a permanent CIT cut on real GDP, total hours and consumption while the same model abstracting from both an endogenous technology utilization rate in the traded sector and international R&D spillovers fails to account for the evidence. The reason for this 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 builds up only gradually. Because productivity gains are insignificant, as shown in Fig. 5(g) and Fig. 5(h), the CIT cut has a mitigated impact on traded and non-traded wages which in turn results in small (and insufficient) increases in $L^H(t)$ and $L^N(t)$, as displayed by Fig. 5(e) and Fig. 5(f).

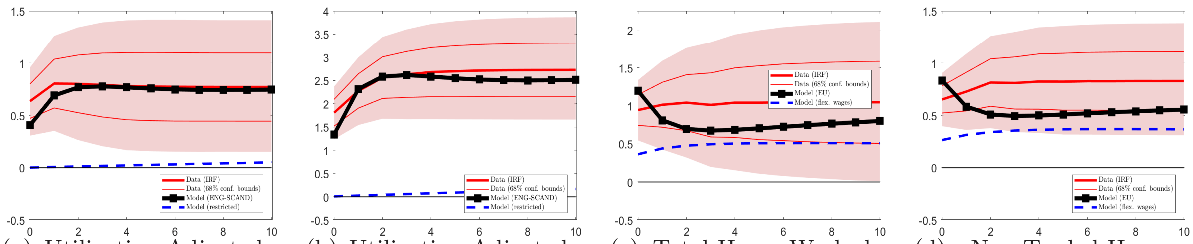
In contrast, the baseline model can generate a rise in total hours by 0.9% on impact as traded firms increase the intensity in the use of the stock of ideas on impact before gradually increasing the stock of knowledge. In addition, traded firms benefit from international R&D spillovers which further 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 households to supply more labor, the significant technology improvement in the traded sector produces an increase in traded value added (see Fig. 5(i)) and in real GDP which is in line with the evidence. While traded value added growth is driven by productivity gains and to a lesser extent by higher traded hours in the short-run, Fig. 5(j) shows that the tax cut has also an expansionary effect on non-traded value added which is mainly driven by higher labor and the increase in the capital utilization rate (see Fig. 5(p)).

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, as shown in the black line, the enhancement of the wealth effect through higher productivity gains leads the baseline model to reproduce well the dynamics of consumption. Because technology is essentially unchanged in the non-traded sector while C^N increases, non-traded goods prices appreciate over time. While the baseline model reproduces well the gradual appreciation in $P^N(t)$, the restricted model considerably understates its dynamics by under-predicting the rise in overall consumption. As shown in the black line in Fig. 5(l), by increasing traded value added, the baseline model generates an excess supply of home-produced traded goods which depreciates the terms of trade. Because productivity gains are insignificant in the short-run, the restricted model gives rise to a terms of trade appreciation instead of a depreciation as can be seen in the dashed blue lines in Fig. 5(l).

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. both the domestic and the international stock of knowledge. Building on our estimates, we set η_Z^H and $\eta_Z^{W,H}$ to 0.62 and 0.51, respectively. The second sub-sample is made up of four OECD countries which are characterized by sticky wages, low international R&D spillovers (i.e., $\eta_Z^{W,H} = 0.135$), and an elasticity of technology of tradables w.r.t. to the domestic stock of knowledge which collapses to zero. In accordance with the estimates documented by Havranek [2017] which reveal that the relative weight of habits is much smaller in Europe, we choose a

Eng. speak. and Scand. countries | Continental European countries



(a) Utilization-Adjusted-Aggregate-TFP, $T^A(t)$

(b) Utilization-Adjusted-Traded-TFP, $T^H(t)$

(c) Total Hours Worked, $L(t)$

(d) Non-Traded Hours Worked, $L(t)$

Figure 6: Theoretical vs. Empirical Responses Following a 1 ppt Permanent CIT Cut: English-speaking and Scandinavian countries vs. continental European countries. Notes: The solid red line displays point estimate from the VAR model with shaded areas (thin lines) indicating 90% (68%) confidence bounds. For English-speaking and Scandinavian countries, see Fig. 6(a)-6(b), the thick solid black line with squares displays model predictions in the baseline scenario. The dashed blue line shows the predictions of a restricted version of the baseline model where we shut down the endogenous intensity in the use of the stock of knowledge (by setting $\chi_2^j \to \infty$) and we abstract from the impact of international R&D spillovers on domestic technology (by setting $\nu_Z^{W,j} = 0$). For continental Europe, see Fig. 6(c)-6(d), the solid black lines with squares show the predictions of a baseline model where we consider sticky wages and the weight to habits, γ_S, collapses to 0.05. The dashed blue lines show the predictions of a model with flexible wages and $\gamma_S = 0.7$.

value for γ_S of 0.05 in line with micro-estimates. This value allows the model to avoid under-estimating the rise in consumption and give rise to a persistent increase in hours in the long-run. We provide more details about the calibration to the data in the Online Appendix I.3. Note that for both groups of countries, we have updated the set of seventeen parameters plus initial conditions which must be endogenously calibrated to match the ratios we estimate for both groups of countries.

Fig. 6 contrasts the baseline model's predictions (shown in black line with squares) with empirical responses. The solid red line displays point estimate from the VAR model with shaded areas (thin lines) indicating 90% (68%) confidence bounds. The thick solid black line with squares in Fig. 6(a)-6(b) displays model's predictions for English-speaking and Scandinavian countries when the technology channel operates while the dashed blue line shows the predictions of a restricted version of the baseline model where we shut down the endogenous intensity in the use of the stock of knowledge (by setting $\chi_2^j \to \infty$) and we abstract from the impact of international R&D spillovers on domestic technology (by setting $\nu_Z^{W,j} = 0$) for comparison purposes.

For continental Europe, Fig. 6(c) and Fig. 6(d) show the predictions of the model with flexible wages and a weight of habits of $\gamma_S = 0.7$ (shown in dashed blue lines) which are contrasted with the predictions obtained in the (reference) model with sticky wages and a low weight of consumption habits $\gamma_S = 0.05$ (shown in black lines with squares). To generate sticky wages (see Online Appendix H for details), we assume that households stand ready to supply labor services to employment agencies in the traded and the non-traded sector which differentiate these labor services and then aggregate them to sell them to intermediate good producers within each sector $j = H, N$. Households receive an income in exchange for labor services and also rent tangible and intangible assets to domestic

Table 3: Impact and Long-Run Effects of a CIT Cut: English-speaking and Scandinavian countries vs. Continental European countries

	Eng. and Scand. countries				Cont. Europ. countries							
	$t = 0$		$t = 10$		$t = 0$				$t = 10$			
	VAR	Model	VAR	Model	VAR	Model			VAR	Model		
	Data	Flex. W	Data	Flex. W	Data	Rigid W & Hab	Rigid W	Flex. W	Data	Rigid W & Hab	Rigid W	Flex. W
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
A. Corporate Tax												
Corp. Inc. Tax, $d\tau(t)$	-0.32	-0.32	-1.00	-1.00	-0.60	-0.60	-0.60	-0.60	-1.00	-1.00	-1.00	-1.00
B. Hours												
Total hours, $dL(t)$	0.93	1.07	0.30	0.75	0.95	1.20	0.85	0.36	1.05	0.80	0.50	0.51
Non-traded hours, $dL^N(t)$	0.62	0.90	0.40	0.70	0.65	0.83	0.56	0.26	0.83	0.55	0.36	0.37
C. Technology Improvement												
Agg. ut-adj.TFP, $dT^A(t)$	0.64	0.41	0.77	0.75	0.04	0.11	0.11	0.11	-0.07	0.14	0.14	0.14
Ut-adj-TFP of trad., $dT^H(t)$	1.81	1.34	2.73	2.51	0.33	0.32	0.32	0.32	-0.12	0.41	0.41	0.41
D. Consumption												
Consumption, $dC(t)$	0.78	0.71	0.58	0.87	0.41	0.52	0.26	0.01	0.74	0.32	0.13	0.13

Notes: The Table show the impact ($t = 0$) and long-run ($t = 10$) effects of a 1 ppt permanent decline in CIT by differentiating the effects between English-speaking and Scandinavian countries vs. Continental European countries. Panels A,B,C,D show the deviation in percentage relative to steady-state. Panel B shows the effects on total and non-traded hours while panel C displays the responses of aggregate and traded utilization-adjusted-TFP. Panel D displays the response of consumption. 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 5-12, we calibrate the model to the group of countries made up of continental European economies. We consider three variants. Columns 8 and 12 shows results when we consider flexible wages. In columns 6-7 and 10-11, we extend the baseline model to wage stickiness. While in columns 7 and 11 we set the weight attached to habits, γ_S, to 0.7, in columns 6 and 10, we set γ_S to 0.05.

firms. Like Chodorow-Reich et al. [2023], we assume Rotemberg type 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:

$$\Theta^j\left(\pi_i^{W,j}(t)\right) \equiv \frac{\phi_W^j}{2}\left(\pi_i^{W,j}(t)\right)^2 W^j(t)L^j(t), \tag{37}$$

where $\pi_i^{W,j}(t) = \dot{W}_i^j(t)/W_i^j(t)$ is the wage inflation rate and $\phi_W^j > 0$ determines the degree of wage stickiness in employment agency i 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 a value for the elasticity of substitution between labor varieties ϵ_W^j of 10 which is a value commonly chosen in the literature and set $\phi_W^j = 10$ as the time frequency is annual in our model.

While in Online Appendix I.3 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 3 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 and 9 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 and $\gamma_S = 0.05$ displayed by columns 6 and 10. To quantify the role of habits and sticky wages, respectively, in driving the effects on hours, we show the predictions of the same model with sticky wages but a higher weight of habits $\gamma_S = 0.7$ in columns 7 and 11, and we show the predictions of the model with flexible wages and $\gamma_S = 0.7$ in columns 8 and 12.

Technology improvements. We start with technology improvements shown in panel C of Table 3. 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 for the group of English-speaking and Scandinavian countries. The ability of the model to generate a large increase in productivity rests on three key factors. First, the technology of production displays a high ability to transform R&D into innovation, i.e., both ν_Z^j and $\nu_Z^{W,j}$ take high values in accordance with our estimates. The second and third key elements are low adjustment costs in the intensity in the use of $Z^j(t)$ and international R&D spillovers. An endogenous $u^{Z,j}(t)$ contributes 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 account 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 modest at 4% at $t = 10$. As displayed by Fig. 6(a) and Fig. 6(b), it is only once we allow for $\chi_2^H < \infty$ and $\nu_Z^{W,H} > 0$ that the model can account for the magnitude of technology improvements.

Hours worked. Despite the fact that technology merely improves in continental European countries, hours worked increase significantly in the data by 0.95% on impact and 1.05% in the long-run as can be seen in columns 5 and 9 of panel B. The performance of the model in reproducing the effects of a CIT cut on hours rests on two key features. First, wage stickiness is essential to produce the increase in hours we find in the data but only in the short-run. 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, wages paid by intermediate good producers are merely modified in the short-run while the marginal revenue product of labor increases (due to the appreciation in P^N in the non-traded sector and international R&D spillovers in the traded sector), which provides high incentives to increase hours. As shown in column 7, the model with sticky wages generates a rise in hours by 0.85% on impact while the same model with flexible wages leads to an increase in $L(t)$ by 0.36% only (see column 8). However, contrasting columns 11 and 12 reveal that the sticky wages channel is not operative in the long-run. The second key driver of the model performance is a small weight of consumption habits in utility. As shown in column 10, a reduction in γ_S from 0.7 to 0.05 dramatically amplifies the rise in hours in the long-run from 0.50% (see column 11) to 0.80%. Intuitively, as γ_S takes lower values, households have more incentives to increase consumption in goods and to a lesser extent in leisure. Because the disutility from labor is lower, the CIT cut generates a persistent increase in hours in the long-run. As can be seen in Fig. 6(c)-6(d), the model with flexible wages and $\gamma_S = 0.7$ displayed by dashed blue lines considerably understates the expansionary effect of a corporate tax cut on hours, both in the short- and in the long-run while the baseline model displayed by black lines can account for the sizeable and persistent increase in hours.

5 Conclusion

In this paper, we propose a new identification of exogenous and permanent shocks to profits taxation based on the downward trend of statutory CIT rates which is common to a large set of OECD countries. Because the downward trend is driven by tax pressure from neighbor countries, we construct an import-share-weighted-average of trade partners' CIT rates to better reflect the intensity of tax competition between countries to attract capital. Since this measure is cointegrated with the country-level CIT rate and is exogenous to the country-specific economic activity, we replace the country-level CIT rate with its international component when estimating the SVAR model in panel format on annual data.

We find that a permanent decline in the CIT rate has a strong expansionary effect on utilization-adjusted-TFP 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 CIT cut by 1 percentage point once we consider the following elements. While the elasticities of productivity w.r.t. the domestic and the international stock of knowledge must be large (i.e., 0.29 and 0.11, respectively) in accordance with our empirical estimates, traded firms must also use more intensively the existing stock of intangible assets to meet a higher demand for their product (and avoid an increase in production costs). The additional key element is to let the stock of ideas from abroad spillover on the domestic traded firms' technology.

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.

When we split the sample of countries into two sub-samples, our SVAR evidence shows that a lower CIT has sizeable effects 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 sizeably and persistently in this group of countries and labor growth is concentrated within non-traded industries. Building on our model's predictions, the distinct technology effects across the two groups of countries we estimate empirically after a CIT 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, thus explaining the large technology improvements in the latter group. Because of wage stickiness and a relative low weight of consumption habits in household's preferences, continental European countries experience a significant increase in hours even in the absence of technology improvements.

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A Data Description for Empirical Analysis

Source: Corporate income taxation (CIT) for the introduction. To have the most recent and harmonized data for the top statutory CIT rate, we use data from the Tax Foundation `https://taxfoundation.org/data/all/global/corporate-tax-rates-by-country-2023/` for the figures we mention in the first paragraph of the Introduction. Sample: 23 high-income countries, 1981-2023. Countries: Australia, Austria, Belgium, Canada, Switzerland, Germany, Denmark, Spain, Finland, France, United Kingdom of Great Britain and Northern Ireland, Greece, Ireland, Iceland, Italy, Japan, Luxembourg, Netherlands, Norway, New Zealand, Portugal, Sweden, United States of America.

Source: CIT for the empirical analysis. We use the top statutory CIT rates taken from Bachas et al. [2022] as they start earlier than the aforementioned data. This dataset combines data from Vegh and Vuletin [2015], Egger et al. [2019], the Tax Foundation and country-specific sources. Countries: eleven OECD countries which include Australia (AUS), Austria (AUT), Belgium (BEL), France (FRA), Germany (DEU), Finland (FIN), the United Kingdom (GBR), Japan (JPN), Luxembourg (LUX), Sweden (SWE), and the United States (USA).

Source: Sectoral data: 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 data for AUT, BEL, DEU, FIN, FRA, GBR, JPN, LUX, SWE et USA. For Australia, sectoral data are taken from the Structural Analysis (STAN) database provided by the OECD ([2011], [2017]). For both EU KLEMS and OECD STAN databases, the March 2011 release provides data for eleven 1-digit ISIC-rev.3 industries over the period 1970-2007 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 detailed in section C.1. We map the ISIC-rev.4 classification into the ISIC-rev.3 classification in accordance with the concordance Table 4. 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, time 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 4: 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

All quantities are divided by the working-age population (15-64 years old) taken from OECD ALFS Database. The definition of aggregate and sectoral variables are as follows (mnemonics are in parentheses):

- Aggregate variables: real GDP ($Y_{R,it}$) is the sum of traded and non-traded value added at constant prices. Total hours worked (L_{it}) is the sum of traded and non-traded hours worked.
- Time series for sectoral value added in current VA (constant, VA_QI) prices are constructed by adding value added in current (constant) prices for all sub-industries k in sector $j = H, N$, i.e., $P^j_{it} Y^j_{it} = \sum_k P^j_{k,it} Y^j_{k,it}$ ($\bar{P}^j_{it} Y^j_{it} = \sum_k \bar{P}^j_{k,it} Y^j_{k,it}$ where the bar indicates that prices P^j are those of the base year), from which we construct price indices (or sectoral value added deflators), P^j_{it}.

Table 5: 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.

- Time series for traded hours worked (L_{it}^H), non-traded hours worked (L_{it}^N) correspond to hours worked by persons engaged in sector j. Sectoral hours worked (H_EMP) are constructed by adding hours worked for all sub-industries k in sector $j = H, N$.
- The hours worked share of sector j, L_{it}^j/L_{it}, is the ratio of hours worked in sector j to total hours worked.
- The labor income share (LIS) in sector j, $s_{L,it}^j = \left(\frac{W^j L^j}{P^j Y^j}\right)_{it}$, is constructed as the ratio of labor compensation (LAB) which is the total of compensation of employees and compensation of self-employed in sector $j = H, N$ 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., $Y_{it}^j/Y_{R,it}$ for $j = H, N$
- Utilization-adjusted-total-factor-productivity, T_{it}^j, is constructed as the Solow residual from constant-price domestic currency series of value added, the labor income share, hours, and sectoral capital stock in sector $j = H, N$. To have a consistent measure of technological change, we adjust the Solow residual with the time series for the capital utilization rate which have been constructed by adapting the methodology proposed by Imbs [1999]. We describe its construction later below.
- The 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].
- The sectoral nominal wage is calculated as the ratio of the labor compensation in sector $j = H, N$ to total hours worked by persons engaged in that sector. Nominal wages are divided to foreign price, i.e., $W_{it}^j/P_{it}^{H,\star}$;
- The foreign-produced traded goods price index, $P_{it}^{H,\star}$, relevant to home country i is constructed as a geometric weighted average of the traded value added deflator of twenty trade partners of the corresponding country i, the weight being equal to the share of imports from the trade partner k.
- Non-traded goods prices, $P_{it}^N/P_{it}^{H,\star}$ are constructed as the ratio of the non-traded value added deflator to to the foreign-produced traded goods price index, $P_{it}^{H,\star}$, relevant to home country i. The sectoral value added deflator P_{it}^j for sector $j = H, N$ is calculated by dividing the value added at current prices by the value added at constant prices in sector j.
- Terms of trade, $\text{TOT}_{it} = P_{it}^H/P_{it}^{H,\star}$, are computed as the ratio of the traded value added deflator of the home country i, P_{it}^H, to the foreign-produced traded goods price index, $P_{it}^{H,\star}$, relevant to home country i.

Construction of time series for the sectoral capital stock, K_{it}^j. To construct the time 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_{it}, we adopt the perpetual inventory approach. The inputs necessary to construct the capital stock series are i) the capital stock at the beginning of the investment series, $K_{i,1973}$, ii) a value for the constant depreciation rate, $\delta_{K,i}$, iii) the real gross capital formation series, I_{it}. Real gross capital formation is obtained from OECD National Accounts Database [2017] (data in millions of national currency, constant prices). We drop the time index below when it does not cause confusion. We construct the series for the capital stock using the law of motion for capital in the model:

$$K_{t+1} = I_t + (1 - \delta_K) K_t. \tag{38}$$

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:

$$\frac{1}{45}\sum_{t=1973}^{2017} \frac{\delta_K P_{J,t} K_t}{Y_t} = \frac{CFC}{Y}, \tag{39}$$

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:

$$K_{1973} = \frac{I_{1973}}{g_I + \delta_K}, \tag{40}$$

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 (38), (39) and (40) 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 (38), where $t = 1974, ..., 2017$, (39), and (40). 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 Kingdom: 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]), OECD ([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]):

$$u_t^{K,j} = \left[\frac{\left(1 - s_{L,t}^j\right)}{\delta_K \phi_K} \frac{P_t Y_{R,t}}{P_{J,t} K_t}\right]^{\frac{1}{\phi_K}}, \tag{41}$$

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:

$$\begin{aligned} \hat{Z}_t^j &= \hat{\text{TFP}}_t^j - \left(1 - s_L^j\right)\hat{u}_t^{K,j}, \\ \ln Z_t^j - \ln \bar{Z}_t^j &= \left(\ln \text{TFP}_t^j - \ln \bar{\text{TFP}}_t^j\right) - \left(1 - s_L^j\right)\left(\ln u_t^{K,j} - \ln \bar{u}_t^{K,j}\right). \end{aligned} \tag{42}$$

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 $\ln Z_t^j$:

$$\ln Z_t^j = \left(\ln Z_t^j - \ln \bar{Z}_t^j\right) + \ln \bar{Z}_t^j. \tag{43}$$

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:

$$C(L)\hat{X}_{it} = \eta_{it}, \tag{44}$$

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 (44) 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 $\varepsilon_{it} = [\varepsilon^{\tau}_{it}, \varepsilon^{V}_{it}]$ is related to the vector of reduced form residuals η_{it} through:

$$\eta_{it} = A_0 \varepsilon_{it}, \tag{45}$$

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:

$$\hat{X}_{it} = B(L) A_0 \varepsilon_{it}, \tag{46}$$

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 permanent shocks to (international) corporate taxation, ε^{τ}_{it}, we use the restriction that the unit root in the international measure of corporate taxation originates exclusively from tax competition motives 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 forms of a VAR model by panel OLS regression with country fixed effects. The baseline VAR model includes the international corporate tax rate τ^{int}_{it} and a vector of variables such as real GDP, Y_{it}, total hours worked, L_{it}, utilization-adjusted-aggregate-TFP, T^{A}_{it}. We also consider additional VAR specifications to estimate the sectoral effects:

- Aggregate level: $\hat{x}^{agg}_{it} = [\Delta\tau^{int}_{it}, \hat{Y}_{it}, \hat{L}_{it}, \hat{T}^{A}_{it}]$; to estimate the effects on consumtion C_{it} and investment I_{it}: $\hat{x}^{cons}_{it} = [\Delta\tau^{int}_{it}, \hat{Y}_{it}, \hat{C}_{it}, \hat{I}_{it}]$;
- Sectoral level: $\hat{x}^{sec}_{it} = [\Delta\tau^{int}_{it}, \hat{Y^j}_{it}, \hat{L^j}_{it}]$ for $j = H, N$;
- Technology: $\hat{x}^{tech}_{it} = [\Delta\tau^{int}_{it}, \hat{T^H}_{it}, \hat{T^N}_{it}]$ for $j = H, N$;
- Sectoral composition and labor reallocation: $\hat{x}^{share}_{it} = [\Delta\tau^{int}_{it}, Y^{H}_{it}\hat{/}Y_{it}, L^{H}_{it}\hat{/}L_{it}]$ for $j = H, N$;
- Labor income shares: $\hat{x}^{LIS}_{it} = [\Delta\tau^{int}_{it}, \hat{LIST}_{it}, \hat{LISN}_{it}]$ for $j = H, N$;
- R&D (stock of knowledge and investment in R&D): $\hat{x}^{rd}_{it} = [\Delta\tau^{int}_{it}, \hat{Z^j}_{it}, \hat{T^j}_{it}]$ for $j = H, N$ R&D capital stock. $[\Delta\tau^{int}_{it}, \hat{I^{Z,H}}_{it}, \hat{I^{Z,j}}_{it}]$ where $I^{Z,j}$ is for R&D investment;
- Sectoral wages: $\hat{x}^{w}_{it} = [\Delta\tau^{int}_{it}, \hat{W}^{H}_{it} - \hat{P}^{H,\star}_{it}, \hat{W}^{N}_{it} - \hat{P}^{H,\star}_{it}]$ for $j = H, N$;

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

Because we consider alternative VAR models, the fact that identified corporate income tax shocks display substantial differences across VAR specifications might be a concern. To check if estimating different specifications of the VAR model could be an issue, we have calculated simple correlations between structural shocks to the international corporate income tax. The first row of Table 6 is the most interesting as it shows the correlation between structural tax shocks whose identification is based on the first VAR model with aggregate macroeconomic variables and those identified on the basis of alternative VAR models which includes sectoral variables. The correlation

Table 6: Correlation Matrix between Structural Tax Shocks across VAR models

VAR models	Correlations				
	VAR agg. (1)	VAR sec-H (2)	VAR sec-N (3)	VAR tech (4)	VAR sec-comp (5)
Aggregate	1.000	0.969	0.968	0.883	0.907
Sectoral Level - Traded variables		1.000	0.909	0.901	0.954
Sectoral Level - Non-Traded variables			1.000	0.876	0.889
Technology				1.000	0.934
Sectoral composition and lab. reallocation					1.0000

Notes: The first column of the Table indicates the VAR model while columns 1 through 5 show the correlation between structural tax shocks across VAR models.

varies from a low of 0.883 for the VAR model which includes only utilization-adjusted-TFP to a high of 0.969 for the VAR model which includes sectoral value added and sectoral hours worked. Overall, given the high value of correlation between structural tax shocks across VAR models, the potential discrepancy in the estimated responses caused by slight differences in estimated structural tax shocks should be very small, if any.

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 a 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 by using two dimensions, including the elasticity of technology w.r.t. the stock of knowledge and the degree of age rigidity. With regards to the second dimension, we consider a first group of countries where wages are flexible and a second group of countries where wages are less flexible. 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 identify two clusters by using the 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 taken from the World Input-Output Database. 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", 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. 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 shock to CIT 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 database, 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	Classification				
	code	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 the international corporate tax rate which lowers the country-level corporate tax rate by 1% in the long-run on selected variables shown in Fig. 3 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, 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.

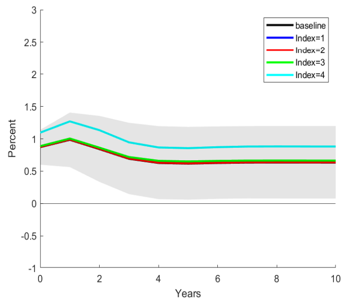
In each panel, the shaded area corresponds to the 90% confidence bounds for the baseline. The first row of Fig. 7 contrasts the responses of total, traded and non-traded hours worked. The second row of Fig. 7 displays the responses of utilization-adjusted-TFP for the whole economy, the traded sector 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.

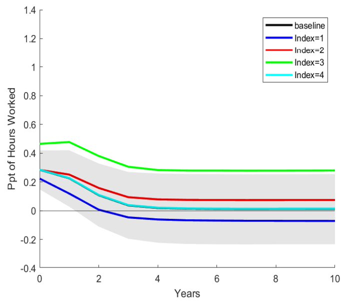
Alternative responses are fairly close to those estimated for the baseline classification as they lie within the confidence interval (for the baseline classification) for all the selected horizons. In conclusion, our main findings hold and remain unsensitive to the classification of one specific industry 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

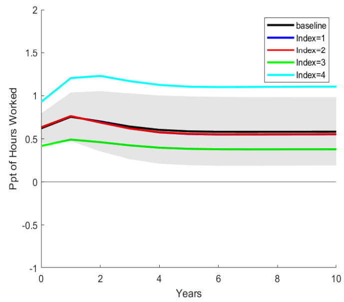
Our dataset covers eleven industries which are classified as tradables or non-tradables. The traded sector is made up of five industries and the non-traded sector of six industries. In this subsection, we conduct our empirical analysis at a more disaggregate level. The objective is twofold. First, we investigate whether all industries classified as tradables or non-tradables



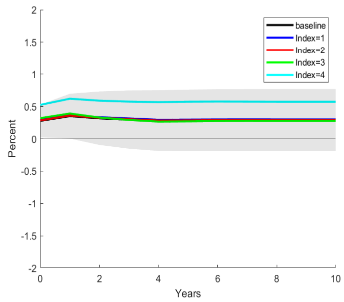
(a) Total Hours Worked, L_{it}



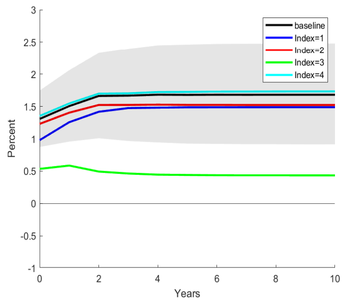
(b) Traded Hours Worked, L_{it}^{H}



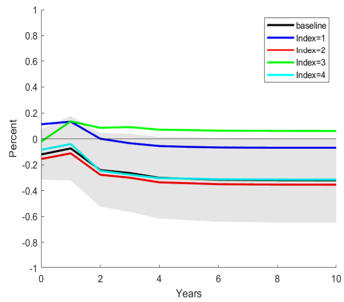
(c) Non-Traded Hours Worked, L_{it}^{N}



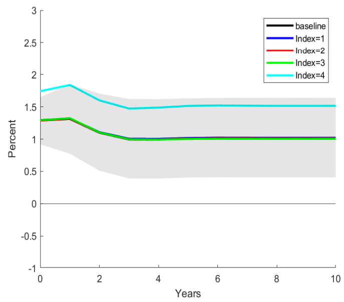
(d) Utilization-Adjusted-Aggregate-TFP, T_{it}^{A}



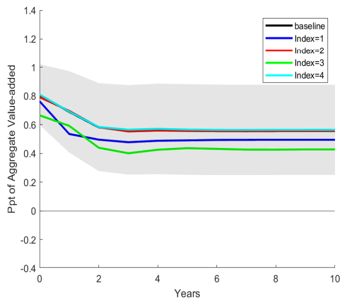
(e) Utilization-Adjusted-TFP of Tradables, T_{it}^{H}



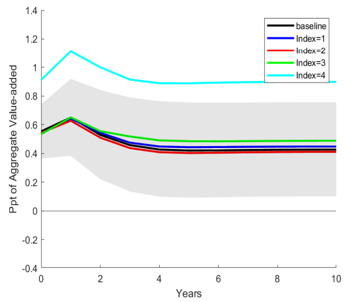
(f) Utilization-Adjusted-TFP of Non-Tradables, T_{it}^{N}



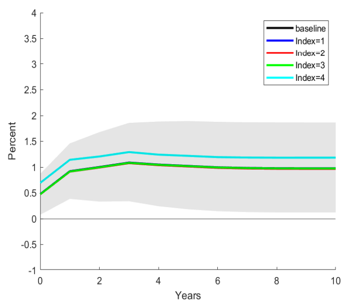
(g) Real GDP, $Y_{R,it}$



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



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



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

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.

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 CIT shock by adopting the 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 CIT rate, by estimating a VAR model which includes the import-share-weighted-average corporate income tax rate, τ_{it}^{int}, value added in industry k, hours worked in industry k, (all quantities are divided by the working age population and all variables are in rate of growth except for the tax rate which is in variation); we consider a second specification where we consider the import-share-weighted-average corporate income tax rate, τ_{it}^{int}, TFP in industry k pertaining to the traded sector, TFP in industry k pertaining to the non-traded sector. 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: $\ln L_t^{k,j} - \ln L^{k,j} \simeq \frac{dL_t^{k,j}}{L^{k,j}} = \hat{L}_t^{k,j}$ 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:

$$\begin{aligned}
\hat{L}_t^j &= \sum_{k\in j} \frac{W^{k,j}L^{k,j}}{W^j L^j}\hat{L}_t^{k,j}, \\
\frac{W^j L^j}{WL}\hat{L}_t^j &= \sum_{k\in j} \frac{W^{k,j}L^{k,j}}{WL}\hat{L}_t^j, \\
\alpha^{L,j}\hat{L}_t^j &= \sum_{k\in j} \alpha^{L,k,j}\hat{L}_t^{k,j}, \qquad (47)
\end{aligned}$$

where $\sum_j \sum_k \alpha^{L,k,j} = 1$. 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 $\alpha^{L,k,j} = \frac{W^{k,j}L^{k,j}}{W^j L^j}$ averaged over 1973-2017. In multiplying $\hat{L}_t^{k,j}$ by $\alpha^{L,k,j}$, 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:

$$\begin{aligned}
\text{TFP}_t^{k,j} &= \sum_{k\in j} \frac{P^{k,j}Y^{k,j}}{P^j Y^j}\hat{\text{TFP}}_t^{k,j}, \\
\text{TFP}_t^j &= \sum_{k\in j} \frac{P^{k,j}Y^{k,j}}{P^j Y^j}\hat{\text{TFP}}_t^{k,j}, \\
\text{TFP}_t^j &= \sum_{k\in j} \omega^{Y,k,j}\hat{\text{TFP}}_t^{k,j}, \qquad (48)
\end{aligned}$$

where $\omega^{Y,k,j} = \frac{P^{k,j}Y^{k,j}}{P^j Y^j}$ 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 'Agriculture' 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 do not 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

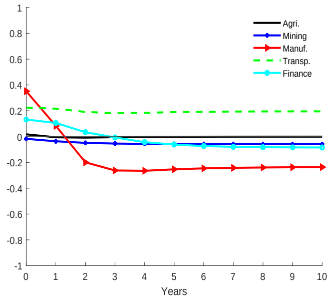
In this subsection, we conduct a robustness check with respect to the measure of utilization-adjusted TFP. We replace the measure of utilization-adjusted-TFP based on the Solow residual adjusted with the capital utilization rate obtained by applying the Imbs method with three alternative measures: i) 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 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 are 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.

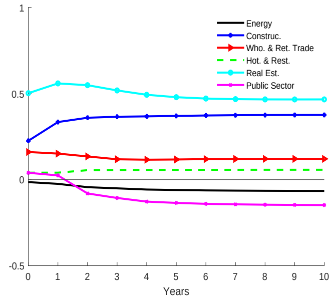
C.4 Wage Flexibility vs. Wage Rigidity: Hierarchical Cluster Tree Method

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.

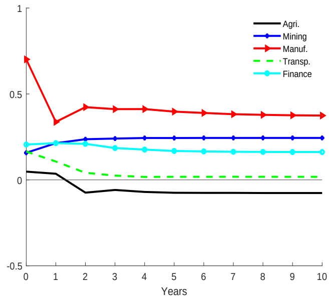
However, factors underlying wage rigidity are not necessarily related to employment rigidity like firing costs. Dickens et al. [2007] show that unionization and collective bargaining coverage at the country level are positively related to wage rigidity. Du Caju et al. [2012] find empirically that wages 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



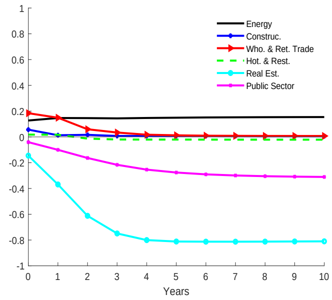
(a) Traded Hours Worked, L_{it}^{H}



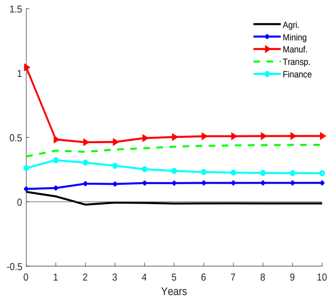
(b) Non-Traded Hours Worked, L_{it}^{N}



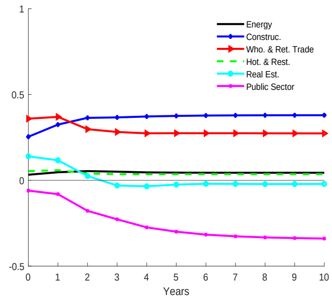
(c) Utilization-Adjusted-TFP of Tradables, T_{it}^{H}



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

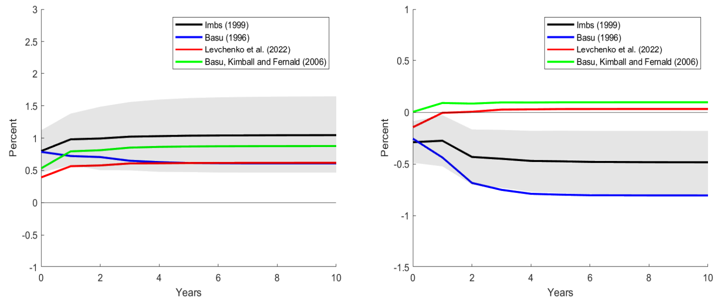


(e) Traded Value Added, Y_{it}^{H}



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

Figure 8: Dynamic Effects of Corporate Tax Shocks at an Industry Level. Notes: 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 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. 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^H_{it} (b) Utilization-Adjusted-TFP of Non-Tradables, T^N_{it}

Figure 9: Effects Corporate Tax Shocks on Technology: Robustness Check w.r.t. Alternative Technology MeasuresNotes: 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].

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 (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 which 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. For example, Finland and Sweden have very low heights which means that these two countries are very similar in terms of wage rigidity. The height captures the extent of dissimilarity between two counties. For example, Japan and the US are characterized by a low wage rigidity but they display more dissimilarities than Scandinavian countries.

In line with responses for one country at a time, the hierarchical tree shows that continental European countries display a similar degree of wage stickiness while other countries display relatively more wage flexibility. This visualization techniques shows that continental European countries are more distant to Finland and Sweden than they are from Australia, Luxembourg and the UK and they are even more distant to the U.S. and Japan.

Our clustering analysis reveals that continental European countries (Austria, Belgium, Germany, and France) form a cluster which is characterized by a higher degree of wage rigidity relative to the other clusters made up of English-speaking and Scandinavian countries

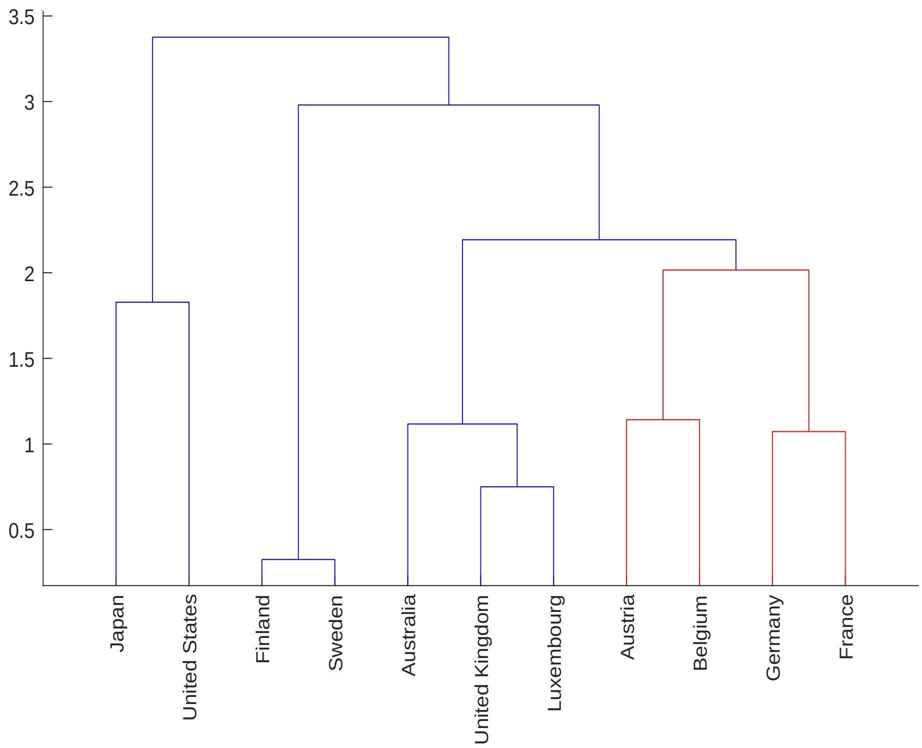


Figure 10: Clustering of Countries Based on Hierarchical Cluster Tree Method: Notes In Fig. 10, We adopt a hierarchical cluster tree method to cluster countries by using four labor market indicators: union density rate, adjusted bargaining coverage rate, the predominant level at which wage bargaining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

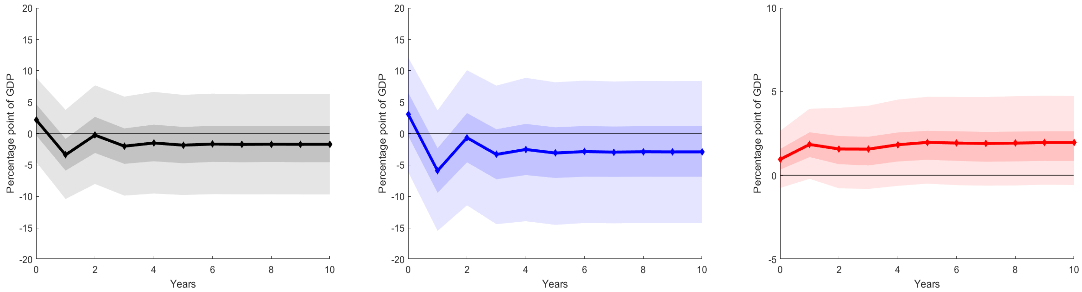
plus Japan and Luxembourg.

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 doe not increase persistently in the long-run in English-speaking and Scandinavian 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 from 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 by the black line with diamonds. The response is not significant and thus we can conclude that the change in the dividend policy plays no role in driving our results. 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 and thus they cannot explain insignificant long-run



(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..

labor effects and are consistent with the high and significant technology improvements we detect empirically. 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

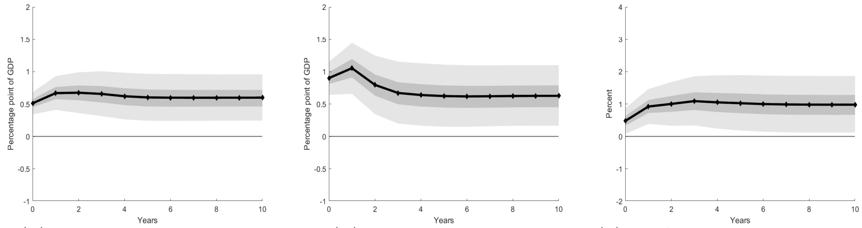
C.6 Additional Empirical Results: Effects on R&D

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.

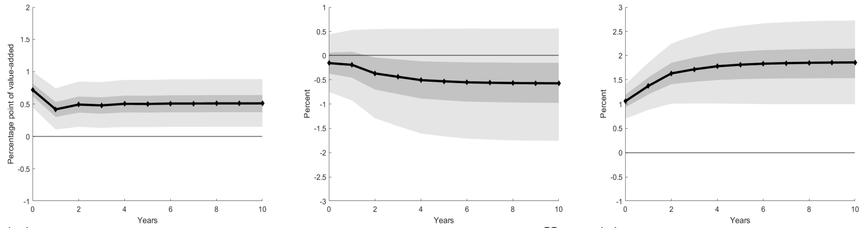
Aggregate Effects for $N = 11$ Countries. in Fig. 12, we show results for consumption, investment, the aggregate wage together with the terms of trade and non-traded-goods prices.

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: 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

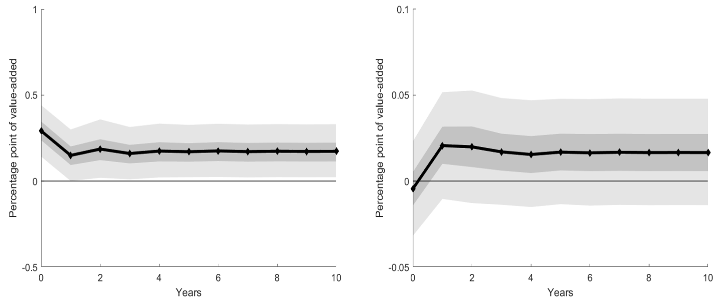


(a) Consumption, C_{it} (b) Investment, I_{it} (c) Aggregate Wage Rate, W_{it}

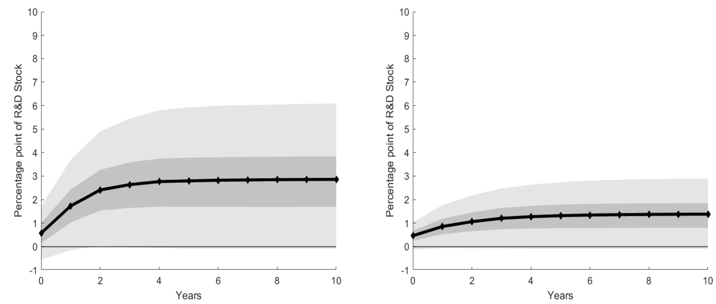


(d) Ratio of Traded to Non-Traded Value Added, $(Y^H/Y^N)_{it}$ (e) Terms of Trade, P_{it}^H (f) Non-Traded Goods Prices, P_{it}^N

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.



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

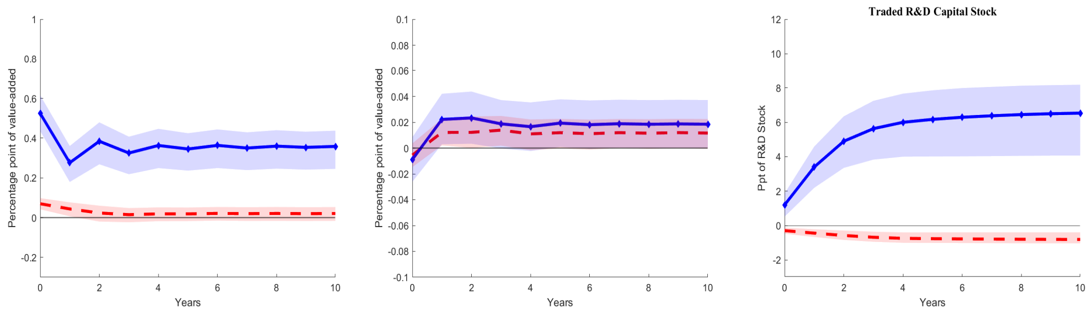


(c) R&D Stock in Tradables, $\mathcal{Z}_{it}^H$ (d) R&D Stock in Non-Tradables, $\mathcal{Z}_{it}^N$

Figure 13: Dynamic Effects of a Corporate Tax Shock in OECD Countries ($N = 9, 10$) 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.

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



(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, 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.

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 (ordered first in the VAR model) is the cross-country average; in doing this, we ensure that each country faces the same shock. We base our country split on two dimensions which include the extent of wage stickiness and the ability of firms to transform R&D into innovation. In this subsection, we document a set of empirical findings which support our country-split. More specifically, we estimate the responses of the wage rate and technology to a shock to the international corporate tax rate in order to assess the extent of technology improvement and wage flexibility after a corporate income tax cut.

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).

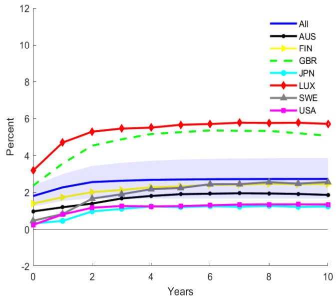
Dynamic effects of corporate tax cut on aggregate wages at country level. Fig. 16 shows the dynamic responses of the aggregate wage rate for each sub-sample. The first column shows results for English-speaking and Scandinavian countries while the second column shows results for continental European countries. 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

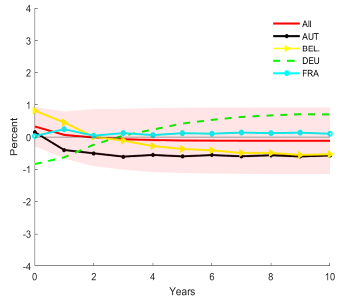
The estimates documented by Kaymak and Schott [2023] indicate that between 30% to 60% of the observed decline in labor income shares should be driven by the fall in corporate taxation due to the shift of the market share from labor- to capital-intensive industries. In contrast to us, the authors concentrate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

English-speaking and Scandinavian countries

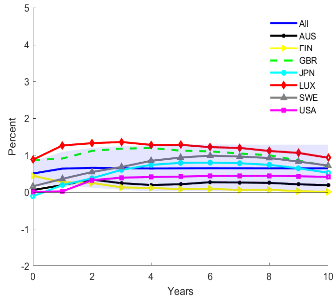
Continental European countries



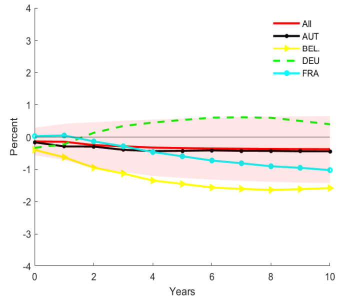
(a) Utilization-Adjusted-TFP of Tradables, T_{it}^{H}



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



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

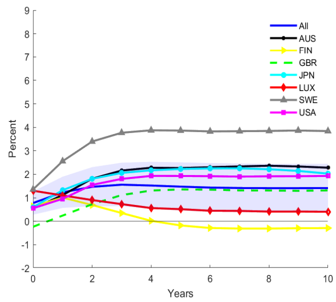


(d) Utilization-Adjusted-Aggregate-TFP, T_{it}^{H}

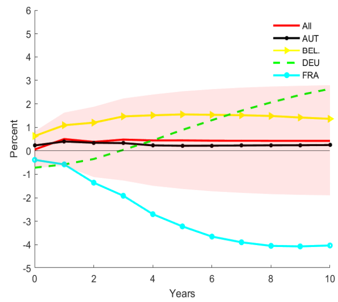
Figure 15: Dynamic Effects of a Corporate Tax Shock on Technology: International Differences. Notes: The blue line in Fig. 15(a) and Fig. 15(c) shows the point estimate from the VAR model estimated in panel data for the sub-sample made up of English-speaking and Scandinavian countries. Other colored 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.

English-speaking and Scandinavian countries

Continental European countries

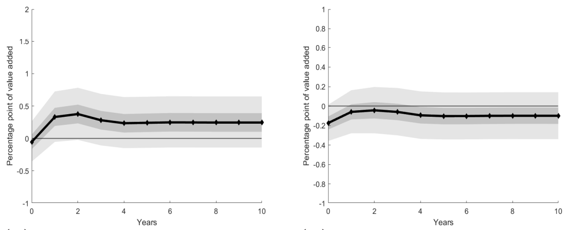


(a) Aggregate Wage Rate, W_{it}^{A}



(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.

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 (CIT) 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.

Because we based our identification of exogenous shocks to corporate taxation on the existence of a downward trend in profits' taxation which is driven by tax competition motives, in subsection D.9, we document a set of evidence which supports our assumption. We run the regression of country-level corporate tax rates on financial openness and an interaction term including the international corporate tax rate which captures the tax pressure coming from neighbor countries.

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 demand shocks might contaminate the identification of permanent CIT shocks. In subsection D.5, we run an exogeneity test which confirms that the shock to corporate taxation we identify are not contaminated by persistent demand shocks. Granger causality tests also confirm that past (country-specific or global) demand shocks are not predictive of the shocks to the international tax rate we identify. In subsection D.6, 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.7, we compare our results with the effects estimated from narratively-identified shocks.

In subsection D.8, we compare the dynamic effects estimated from the SVAR where we impose long-run restrictions with those estimated from local projections with the shock being only the change in the international tax rate. The objective of this robustness check is to assess whether the conditions we impose in the SVAR are restrictive or not.

In subsection D.9, we run Granger causality tests which show that the variations in the international tax rate are uncorrelated with past aggregate or country-specific business cycle conditions.

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

Column 1 of Table 11 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}. Column 2 shows the correlation between the country-level corporate income tax rate, τ_{it}, and the cross-country average tax rate, $\bar{\tau}_{t}^{int}$.

Frequency of CIT cuts In Fig. 18, we plot the number of CIT cuts per year for our sample of eleven OECD countries. The number of CIT tax cuts averages 1.65 per year. Because it is smaller than two, it means that on average, only one country lowers its CIT rate. While this empirical finding suggests that there is no international coordination on average during the period 1973-2017, Fig. 18 reveals that during the period 1988-1991 where

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

Parameters	Correlation between τ and τ^{int}	
	$\text{corr}(\tau_{it}, \bar{\tau}_{it}^{int})$	$\text{corr}(\tau_{it}, \tau_{t}^{int})$
	(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 import-share-weighted-average tax rates of trade partners of the home country, τ_{it}^{int}. Column 2 shows the correlation between the country-level corporate income tax rate, τ_{it}, and the cross-country average tax rate, $\bar{\tau}_{t}^{int}$. The last row of the table 'OECD (11)' shows the country average.

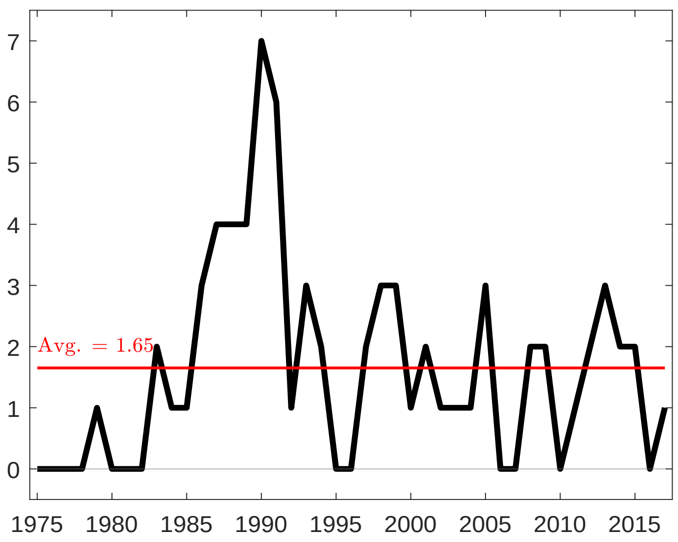


Figure 18: Number of CIT cuts per year in OECD countries over 1973-2017 Notes In Fig. 18, we plot the number of CIT cuts per year for our sample of eleven OECD countries. Sample: 11 OECD countries, 1973-2017, annual data, top statutory CIT rates.

European countries have opened their financial account to foreign investors, the number of CIT cuts have significantly increased to four in 1988-1989 and culminated to 7 in 1990. It is worth mentioning the variations in corporate taxation are concentrated over the period running from 1988 to 1991. This period corresponds to the complete removal of barriers to capital mobility in Europe and this period is not associated with a recession (which occurs in 1993).

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.[14]

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.

[14] 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	-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^H	-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^H	-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^H_{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^H	-2.330	0.010	4.478	1.000	1.405	0.920	132.277	0.000
$P^H/P^{H,\star}$	-3.125	0.001	0.383	0.649	-2.527	0.006	79.136	0.000
$P^N/P^{H,\star}$	-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^H	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^H/Y^N	-0.057	0.477	2.350	0.991	1.031	0.849	98.278	0.000
Y^H/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
$W/P^{H,\star}$	-3.792	0.000	3.136	0.999	-0.079	0.468	126.272	0.000
W^H/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^H_{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

In this subsection, we check the existence of a common stochastic trend by running a cointegration test. First, as shown in the first two rows of the Table 12 where we test the null hypothesis of a unit root in panel data, the panel unit root hypothesis cannot be rejected for the country-level corporate tax rates, and for the import-share-weighted-average of trade partners' CIT rates. Therefore τ_{it} and τ_{it}^{int} display a unit root process and these time series are both I(1). Since the international tax rate is integrated of order one, it paves the way for the identification of a permanent shock. Whereas τ_{it}^{int} is disconnected from domestic economic activity which implies that variations in the international tax rate are exogenous to country-specific demand shocks, for the international tax rate to be a valid instrument, i.e., for τ_{it} to be replaced with τ_{it}^{int}, both variables must be cointegrated.

To test the hypothesis that the country-level CIT rate, τ_{it}, and its international counterpart, i.e., τ_{it}^{int}, share a unique common trend which can be interpreted as changes in the CIT rate driven by international tax competition motives, we estimate the cointegration relationship between the two time series, i.e., the country-level and the international tax rate. We run the Westerlund [2007] panel cointegration test. 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 the log country-level CIT and the log international CIT rate.

Table 13: Westerlund ECM panel cointegration tests for country CIT rate and import-share-weighted-average CIT of trade partners

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.

D.4 Downward Trend in Profits' Taxation: Tax Competition and Financial Openness

Our SVAR identification is based on the assumption that increased capital mobility triggered by financial openness has given rise to international tax competition which has produced a common downward trend in corporate taxation among OECD countries. In addition, tax setting in the home country will depend on the level of the corporate 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 use a more sophisticated capital openness index which is the Chinn-Ito index (KAOPEN) [15] To test our assumptions, we run the regression of corporate tax rates on capital openness and a measure of the intensity of tax competition:

$$\tau_{it} = \beta_i + \beta_1 \kappa_{it} + \beta_2 \kappa_{it} \times \tau_{it}^{int} + \beta_3 X_{it} + \nu_{it}, \tag{49}$$

where β_i captures country fixed effects, τ_{it} is the statutory CIT rate for country i at year t, κ_{it} is the capital openness index and X_{it} includes the control variables such as the country size, the public-debt-to-GDP ratio and the unemployment rate.

By noting that:

$$\frac{\partial \tau_{it}}{\partial \kappa_{it}} = \beta_1 + \beta_2 \times \tau_{it}^{int}, \tag{50a}$$

$$\frac{\partial \tau_{it}}{\partial \tau_{it}^{int}} = \beta_2 \times \kappa_{it}, \tag{50b}$$

eq. (49) tests the following predictions:

- First prediction: capital mobility originating from financial openness puts downward pressure on corporate taxation; we expect $\beta_1 > 0$.
- Second prediction: the downward pressure on profits' taxation caused by capital mobility originating from financial openness is more pronounced when neighbor countries (i.e., trade partners) have set low corporate tax rates; we expect $\beta_2 \times \tau_{it}^{int} \geq 0$.
- Third prediction: corporate taxation of the home country is positively correlated with that of neighbor countries (i.e., trade partners) conditional on the removal of capital controls and this positive correlation is increasing with financial openness; we expect $\beta_2 \times \kappa_{it} \geq 0$.

Note that the third prediction collapses to the second prediction and is just a way to reformulate the prediction.

Table 14 displays the results of the regression specified in eq. 49. As shown in the first row which displays the impact of capital openness, the variable has a significant and

[15] 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].

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.[16] For example, higher unemployment tends to provide some incentives to cut corporate tax rates but the effect is not statistically significant.

In eq. 49, 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 which are denoted by $\bar{\tau}_{it}^{int}$. The result for this IV regression is shown in column 4 of the Table 14. The sign and the size of the coefficients are consistent with the baseline regression.

Table 14: 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

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

D.5 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 investigate whether the identified shocks are really CIT shocks is to test whether non-tax 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 identi-

[16]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.

fication 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 for 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 15. 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 in 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.

Table 15: 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

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:

$$\varepsilon_{it}^{\tau^{int}} = d_i + \varepsilon_{it}^{G} + \varepsilon_{it}^{R} + \varepsilon_{it}^{T} + v_{it}, \tag{51}$$

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. (51), 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 17: Granger Causality Panel Tests

	Test Statistic	p-value
$\varepsilon_{it}^{D} \nrightarrow \varepsilon_{it}^{\tau}$	3.129	0.04
$\varepsilon_{it}^{D} \nrightarrow \varepsilon_{it}^{\tau^{int}}$	2.199	0.11
$\varepsilon_{it}^{D,W} \nrightarrow \varepsilon_{it}^{\tau}$	0.675	0.51
$\varepsilon_{it}^{D,W} \nrightarrow \varepsilon_{it}^{\tau^{int}}$	0.966	0.38

Notes: the null hypothesis that X_{it} it does not Granger-cause Z_{it} ($X_{it} \nrightarrow Z_{it}^{int}$) is rejected if p-value ≤ 0.05 at a 5% significance level.

The results of panel data estimations are presented in Table 16. 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 $\varepsilon_{it}^{\tau^{int}}$. 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: $\varepsilon_{it}^{\tau^{int}}$
ε_{it}^{G}	0.47 (.028)
ε_{it}^{R}	0.79 (.039)
ε_{it}^{T}	-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_{it}^{τ} it on fixed effects and current and four lags of government spending shocks (ϵ_{it}^{G}), monetary shocks (ϵ_{it}^{R}) and tax shocks (ϵ_{it}^{T}). The null hypothesis is that all of the coefficients on explanatory variables are jointly equal to zero. If p-value ≥ 0.05 at a 5% significance level, the variables are not significant in explaining the identified corporate tax shock $\varepsilon_{it}^{\tau^{int}}$.

Granger causality tests. One major challenge is to identify changes in corporate taxation which are exogenous to business cycle conditions. For example, in face of a recession, the home country could decide to lower its CIT rate which in turn would bias estimates. While we are using the top statutory CIT rate, we cannot exclude that the country-level tax rate is correlated with economic activity. We are using Granger causality tests below to test whether shocks to the country-level CIT rate, ε_{it}^{τ}, are uncorrelated with past country-specific demand shocks. For this purpose, we estimate the following specification:

$$\varepsilon_{i,t}^{\tau} = \alpha_i + \alpha_t + \mu(L)\, \epsilon_{i,t-1}^{D} + \gamma(L)\, \varepsilon_{i,t-1}^{\tau} + \eta_{i,t}, \tag{52}$$

To identify demand shocks ϵ_{it}^{D}, we adopt the Blanchard and Quah [1989] SVAR identification approach and estimate a VAR model which includes the rate of growth of real GDP, $\hat{Y}_{R,it}$, and the unemployment rate, u_{it}. We assume that supply shocks have a permanent effect on real GDP while demand shocks, $\epsilon_{i,t}^{D}$, have only a temporary impact. The Granger-causality test result is shown in the first row Table 17. Each entry displays the F-statistic for a joint significance test of the coefficients $\mu(L)$, with p-values shown in the last column. We do find that past demand shocks are predictive of country-level tax changes. By contrast, as shown in the second row, we find that shocks to the international tax rate, $\varepsilon_{it}^{\tau^{int}}$, are uncorrelated with past country-specific demand shocks, ϵ_{it}^{D}.

The third and fourth row of Table 17 display Granger causality tests for aggregate demand shocks, $\epsilon_{it}^{D,W}$. To identify aggregate demand shocks, we estimate a VAR model which includes foreign real GDP (constructed as an import share weighted average of trade partners' real GDP), $Y_{R,it}^{W}$, which enters the VAR model in rate of growth and the foreign unemployment rate (constructed as an import share weighted average of trade partners' unemployment rate), u_{it}^{W}. The last two rows of Table 17 reveal that shocks to country-level and shocks to the international tax rate, i.e., ε_{it}^{τ} $\varepsilon_{it}^{\tau^{int}}$, are exogenous to past aggregate demand shocks, $\epsilon_{it}^{D,W}$.

D.6 The Number of Lags

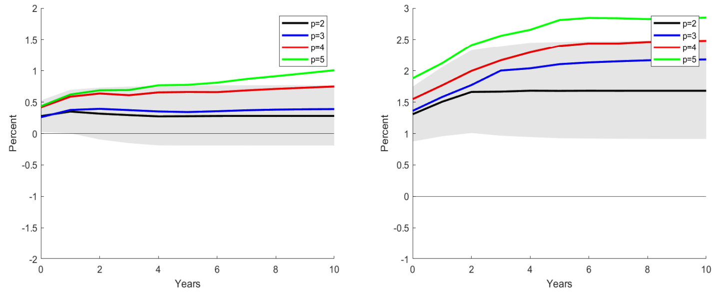
Chari et al. [2008] recommend to increase the number of lags to avoid the identification of a permanent shock by means of the estimation of a VAR model with long-run restrictions being contaminated by persistent demand shocks. De Graeve and Westermark [2013] find that raising the number of lags may be a viable strategy to achieve identification when 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. 19 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.

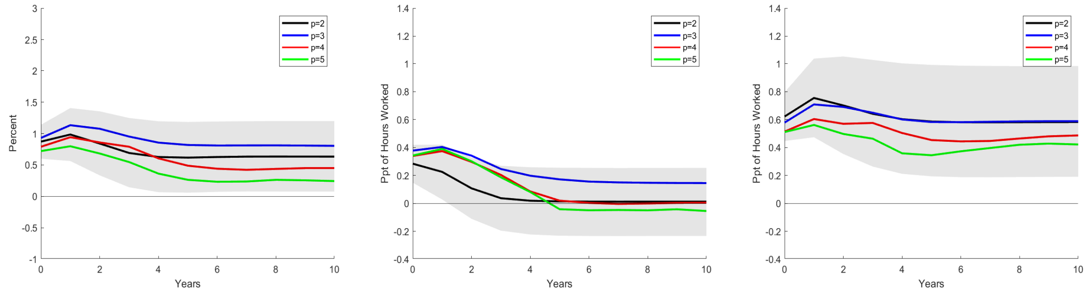
D.7 SVAR Identification vs. Narratively-Identified Corporate Income Tax Shocks: The United States Case

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 three versions of the VAR model: the first version identifies corporate income tax shocks by using the narrative measure, the second version by using the cross-country average tax rate and the third by using the import-share-weighted-average CIT rate. Fig. 20 shows the effects on real GDP, consumption, and investment.

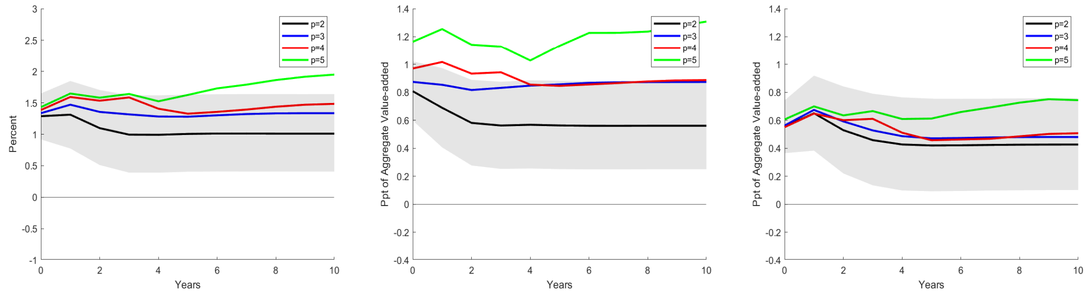
The impulse response functions for real GDP and consumption are close to the results of Mertens and Ravn [2013]. GDP per capita increases by around 0.6 percent, and the rise in consumption is equivalent to a 0.5 percent point rise in GDP per capita. The cross-country average corporate tax rate gives 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



(a) Utilization-Adjusted-Aggregate-TFP (b) Utilization-Adjusted-TFP of Tradables (c) Utilization-Adjusted TFP of Non-Tradables

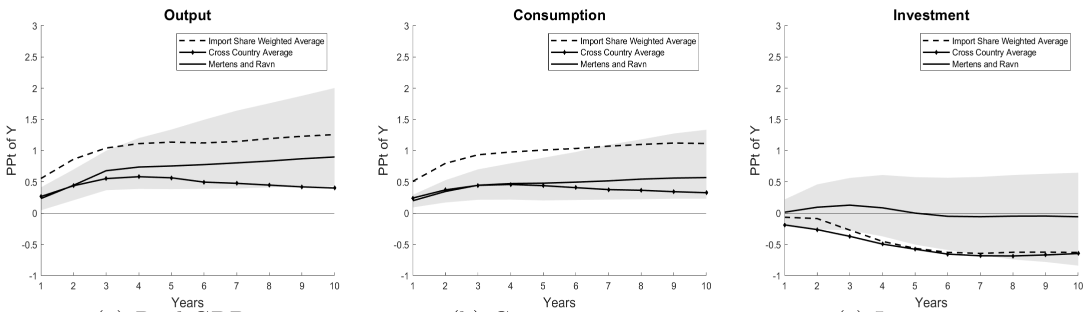


(d) Total Hours Worked (e) Traded Hours Worked (f) Non-Traded Hours Worked



(g) Real GDP (h) Traded Value Added (i) Non-Traded Value Added

Figure 19: 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.



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

Figure 20: 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.

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 discrepancy in the estimated effects caused by an exogenous variation in the international tax rate and the responses brought about by narratively-identified-CIT-shocks may stem from the fact that the narrative measure considers only significant events related long-run growth and ideologic motives while the international measure we are using in the main text captures the variations in the tax rate driven by tax competition motives.

D.8 Dynamic Effects of a CIT Shock: VAR vs. Local Projections

In this subsection, we conduct a robustness check by contrasting the dynamic effects of an exogenous variation in the CIT rate which are estimated from a VAR model with those estimated by using local projections. The advantage of the VAR methodology over local projections is that it produces smoother responses. The advantage of local projections over the VAR method is that it imposes less restrictions and in particular it does not impose the shock to have long-run effect on variables.

In the main text, we estimate a panel SVAR which includes the international tax rate in variation and a set of macroeconomic variables in rate of growth such as value added at constant prices, hours worked, utilization-adjusted TFP, and we assume that tax shocks are shocks which lower permanently the international tax rate as the result of tax competition while the other country-level variables included in the VAR model are assumed to have no long-run effects on the international tax rate. Next we generate dynamic responses to the tax shock from the VAR model.

The main objective of our robustness test is to assess whether the long-run restrictions imposed in the VAR model are too restrictive or instead are naturally supported by local projections where we do not impose any structure on the shock or the dynamic responses. To conduct a robustness check, we adopt a two-stage least squares (2SLS) method. We denote the logarithm with a low case letter. In the first step, we instrument the country-level CIT by using the import-share-weighted-average of trade partners' CIT rates, i.e., we run the following regression in panel format:

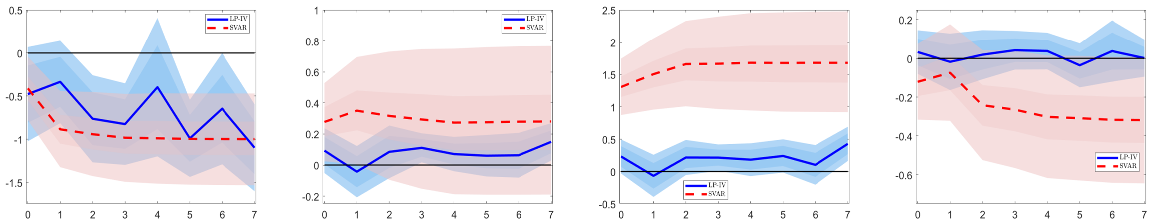
$$d\tau_{i,t} = \alpha_i + \beta d\tau_{i,t}^{int} + \sum_{s=1}^{2} \lambda_s d\tau_{i,t-s} + \sum_{s=1}^{2} \theta_s d\tau_{i,t-s}^{int} + \sum_{s=1}^{2} \alpha_s \Delta x_{i,t-s} + \varepsilon_{i,t}, \tag{53}$$

where $d\tau_{i,t} \equiv \tau_{i,t} - \tau_{i,t-1}$, $d\tau_{i,t}^{int} \equiv \tau_{i,t}^{int} - \tau_{i,t-1}^{int}$ and $\Delta y_{i,t} \equiv x_{i,t} - x_{i,t-1}$ with $x_{i,t}$ is the variable of interest in log. Denoting the instrumented CIT obtained from the first step by $\bar{\tau}_{it}$, in the second step, we estimate the dynamic effects of a variation in the country's CIT exclusively driven by tax competition motives which ensures that the change in $\bar{\tau}_{it}$ is not guided by the desire of the government to offset a current recession. We estimate the dynamic effects by using the local projection method which simply requires estimation of a series of regressions for each horizon h for each variable of interest on the CIT shock (i.e., $d\bar{\tau}_{i,t}$):

$$dx_{i,t+h} = \alpha_{i,h} + \beta_{i,h} t + \psi_h (L) z_{i,t-1} + \gamma_h d\bar{\tau}_{i,t} + \eta_{i,t+h}, \tag{54}$$

where x is the logarithm of the variable of interest, β_h measures the response of variable x at horizon $h = 0, 1, 2..10$, $\alpha_{i,h}$ are country fixed effects; z is a vector of control variables (i.e., past values of τ_{it}^{int} and of the variable of interest), $\psi_h (L)$ is a polynomial (of order two) in the lag operator. The coefficient γ_h gives the response of x at time $t + h$ to the CIT shock at time t. We compute heteroskedasticity and autocorrelation robust standard errors based on Newey-West. Eq. (54) can be estimated separately for each horizon h by OLS. Variations in $\bar{\tau}_{i,t}$ reflect changes in the country-level CIT rate which are guided by tax competition motives only and thus are disconnected from the (current and future) domestic economic activity.

Results. Fig. 21 contrasts the dynamic effects of a shock to the international tax rate estimated from a SVAR with those estimated from local projections (by adopting the two-step method). The dashed red line shows the response of aggregate and sectoral variables to an exogenous decline in CIT by 1 percentage point in the long-run which is obtained

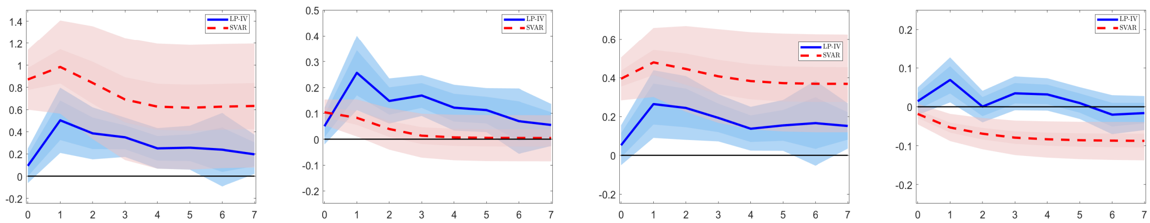


(a) Corporate Income Tax, τ_{it}

(b) Utilization-Adjusted-Aggregate-TFP, Z_{it}^{A}

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

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

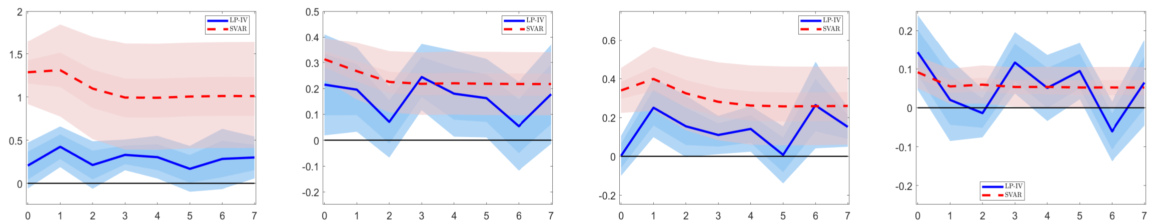


(e) Total Hours Worked, L_{it}

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

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

(h) Hours Worked Share of Tradables



(i) Real GDP, Y_{it}^{R}

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

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

(l) Value Added Share of Tradables

Figure 21: Dynamic Effects of a Corporate Tax Shock in OECD Countries ($N = 11$): Local Projections vs. SVAR Notes: The solid red 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 which is obtained from the estimation of a VAR model, see section B.2. Light red shaded areas indicate the 90 percent confidence bounds from the SVAR estimate. The solid blue line shows results when we adopt a one-step approach, like Ramey and Zubairy [2018], with the shock being simply given by the change int he international tax rate, with the set of controls that includes lagged measures of the international tax rate and the dependent variables. Shaded areas in light blue indicate the 90 percent confidence bounds associated with the point estimate from local projections. Vertical axes measure deviation from trend in percentage. Horizontal axes indicate years. Sample: 11 OECD countries, 1973-2017, annual data.

from the estimation of a VAR model, see section B.2 for the VAR specifications. Light red shaded areas indicate the 90 percent confidence bounds associated with the SVAR estimate. The solid blue line shows results when we adopt the 2SLS approach, with the shock being given by the change in the CIT instrumented by the international tax rate, with the set of controls that includes lagged measures of the international tax rate and the dependent variables. Shaded areas in light blue indicate the 90 percent confidence bounds associated with the point estimate from local projections.

First, without any imposing any restrictions, the single-equation method shows that a change in the instrumented CIT rate which captures the extent of the tax pressure on the domestic country coming from its trade partners produces a long-run decline in the country-level CIT rate which is significant at 90%. The dynamic response of CIT obtained from local projections collapses to the response obtained in the VAR. Second, a change in the instrumented CIT gives rise to very similar results to SVAR evidence, although we can notice some differences. First, all of our conclusions hold. Whether we use LP or SVAR, we find that a drop in the CIT rate driven by tax competition motives generates an increase in hours which is concentrated in the non-traded sector and a technology improvement concentrated in the traded sector. Second, the dynamic effects are not statistically different except for technology improvements in the traded sector which are understated with local projections. We believe that this result comes from the fact that we don't estimate directly the dynamic effect of a variation in τ_{it}^{int} on utilization-adjusted-TFP of tradables. When we do it, the dynamic effect from LP and SVAR on $T^H(t)$ are not distinct. Intuitively, when we use the change in τ_{it}^{int}, we consider the decline in CIT rates of trade partners which encourage them to increase the stock of ideas which has an impact on domestic technology in tradables, $T^H(t)$, through international R&D spillovers which play a key role in driving the dynamics of the utilization-adjusted-TFP of tradables. Third, overall, whether we use LP with the shock being the instrumented change in the CIT rate capturing tax competition motives or we adopt a SVAR methodology where the shock is identified by assuming that tax shocks are shocks which lower permanently the international corporate tax rate in the long-run leads to the same results qualitatively and quantitatively.

D.9 More Robustness Checks about the Exogeneity of the CIT Cuts

Our SVAR identification of exogenous variations in CIT rates lies on the existence of a downward trend in CIT rates which is common to a large set of OECD countries. Such downward trend is driven by tax competition motives following the removal of capital controls. While in section D.5, we have run an exogeneity test and Granger causality tests which reveal that identified shocks to the international tax rate $\varepsilon_{it}^{\tau^{int}}$ are not contaminated by persistent country-specific demand shocks (such as shocks to government spending, tax revenues and monetary policy) or correlated with past country-specific or global demand shocks, we also run additional Granger causality tests below which involve row time series to ensure that aggregate (i.e., global) or county-specific macroeconomic conditions are not predictive of variations in the international tax rate. Reassuringly, Granger causality tests below show that the variations in the international tax rate are uncorrelated with past aggregate or country-specific business cycle conditions.

Are country-level business cycle conditions predictive of variations in the international tax rate? Let us assume that the home country experiences a recession at time t and decides to cut its CIT rate in face of a current recession. We could hypothesize that trade partners coordinate to fight back and cut their own CIT rates at time t. According to our identification assumption, trade partners do not update their CIT rate following a variation in the CIT rate by the home country when the latter adjusts the tax rate to offset a recession. The reason is that we assume that countries react to a change in the neighbor country's CIT rate only if this variation is aimed at improving the long-run economic performance or is guided by ideological changes related to political party. In others words, countries perfectly understand that the home country's CIT adjustments are actions to manage demand, stimulate production, offset a debt crisis, or fund spending decisions. In constructing our measure of the international tax rate which captures the tax pressure from neighbor countries, we are able to avoid any potential endogeneity caused by

Table 18: Panel Granger Causality Tests

	Test Statistic	p-value
$\tau_{it}^{int} \nrightarrow \tau_{it}$	3.75	0.02
$\tau_{it} \nrightarrow \tau_{it}^{int}$	2.593	0.08
GDP $\nrightarrow \tau_{it}^{int}$	0.470	0.63
Hours $\nrightarrow \tau_{it}^{int}$	0.029	0.97
TFP $\nrightarrow \tau_{it}^{int}$	0.415	0.66
Gov Spend. $\nrightarrow \tau_{it}^{int}$	0.329	0.72
Tax Rev. $\nrightarrow \tau_{it}^{int}$	0.569	0.57
Public Debt $\nrightarrow \tau_{it}^{int}$	0.878	0.42
World GDP $\nrightarrow \tau_{it}^{int}$	1.633	0.20

Notes: the null hypothesis that X_{it} it does not Granger-cause Z_{it} ($X_{it} \nrightarrow Z_{it}^{int}$) is rejected if p-value ≤ 0.05 at a 5% significance level. We include two lags of both Z_{it} and X_{it} in each pairwise Granger causality test. The World output, $Y_{R,it}^{\star}$, is the import-share-weighted-average of trade partners's real GDP, i.e. $Y_{R,it}^{\star} = \Sigma_{k\neq i}^{10} \alpha_{IM}^{i,k} Y_{R,ikt}$, where $\alpha_{IM}^{i,k}$ is the trade (measured by imports) share of the home country i with its trade partner k, the latter having a real GDP $Y_{R,ikt}$.

the domestic economic activity. More specifically, exogenous actions for corporate taxation are guided by tax competition motives which is captured by the downward trend of the common component of profits' taxation.

To test our hypothesis formally, we perform Granger causality tests in panel format by estimating the following specification:

$$d\tau_{i,t}^{int} = \alpha_i + \mu(L)\, d\log x_{i,t-1} + \gamma(L)\, d\tau_{i,t-1}^{int} + \eta_{i,t}, \tag{55}$$

where α_i are country fixed effects, τ_{it}^{int} is the international tax rate (defined as the import-share weighted average of trade partners' CIT rates), x is a vector of predictive variables, $\mu(L)$ and $\gamma(L)$ are a polynomial (of order two) in the lag operator.

We test if the variations in the international tax rate are predictable by past movements in a range of variables capturing economic and fiscal conditions, including real GDP, total hours worked, utilization-adjusted-aggregate-TFP, government purchases, net tax revenues, tax collections, public debt, and world real GDP (defined as the import-share-weighted average of real GDP of trade partners). Each predictor variable is tested one at a time, and we include two lags of both the predictor and the international tax rate. We carry out these tests using an annual panel dataset of 11 OECD countries from 1973 to 2017. Data on macroeconomic indicators are primarily taken from the OECD Economic Outlook database.

The Granger-causality test results are shown in Table 18, where each entry displays the F-stat for a joint significance test of the coefficients $\mu(L)$, with p-values given in brackets. In accordance with our identification assumption, we find that the domestic CIT rate is indeed correlated with past values of the international tax rate (see the first row) while the international tax rate is not correlated with past values of the domestic CIT rate (see the second row). These two empirical findings corroborate our assumption that the variations in CIT rates are driven by tax competition motives giving rise to a downward trend. As shown in the third row of Table 18, country-specific economic activity does not cause any variation in the international CIT rate which ensures that our instrument is exogenous.

To sum up, our empirical findings shown in the first three rows of Table 18 reveals that the tax pressure from trade partners determines the CIT setting behavior of the home country. While the tax pressure from abroad influences the behavior of the home country in setting its CIT rate, the other way around is not true. In addition, country-specific developments do not influence the CIT setting behavior of trade partners which corroborates the fact that our instrument is exogenous to domestic economic activity.

Does the international tax rate display an endogeneity with the international business cycle? While so far we have shown that CIT rates are driven by the common component which is not affected by the domestic economic activity, we have to test that the international tax rate is uncorrelated with contemporaneous fiscal developments in the domestic country and is also uncorrelated with the international business cycle. A world demand shock causing a recession might lead foreign countries to lower CIT rates to offset the negative impact of the recession on economic activity. According to our assumption, the decline in the import-share-weighted-average of CIT rates of trade partners, τ_{it}^{int}, will lead the home country to lower its own CIT rate, τ_{it}. Because the world recession might cause a domestic recession, the tax pressure from abroad will produce an indirect endogenity between the country-level CIT rate and the domestic recession. To test if our identification could be undermined by this chain of events, we test whether a change in world GDP (defined an import-share-weighted-average of real GDP of trade partners of the domestic country) Granger-causes the international tax rate. As shown in the last row of Table 18, the international tax rate is exogenous to the international business cycle.

In addition, reassuringly, past economic or fiscal developments appear to be uncorrelated with the variations in the international tax rate, which supports the idea that they are indeed exogenous to contemporaneous business cycles. More specifically, we find that the variations in the international tax rate are not predicted by lagged hours, or lagged utilization-adjusted-aggregate-TFP. We don't find that lagged changes in government spending or in public debt or tax revenues are predictive of the common component of corporate taxation changes.

To conclude, the Granger causality tests shown in Table 18 reveal that i) the tax pressure from abroad Granger-causes the CIT setting behavior in the home country, ii) a change in the country-specific CIT rate, for example to offset a recession, does not cause a variation in the tax rate of trade partners, iii) the domestic economic activity or domestic fiscal developments do not cause a variation in the international tax rate, iv) a world demand shock does not cause a change in the international component of OECD countries' CIT rates.

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, endogenous terms of trade, and accumulation of capital and ideas. 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 [1997].

Households accumulate both physical and intangible capital stocks in the economy and rent them 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, $J^{K,N}$. As for consumption, input of the traded good to produce tangible investment goods is a composite of home-produced traded goods, $J^{K,H}$, 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 and the stock of ideas, the optimal allocation of labor, tangible and intangible assets between sectors 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:

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

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, $C^F(t)$:

$$C^T(t) = \left[\left(\varphi^H\right)^{\frac{1}{\rho}} \left(C^H(t)\right)^{\frac{\rho-1}{\rho}} + \left(1-\varphi^H\right)^{\frac{1}{\rho}} \left(C^F(t)\right)^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}}, \tag{57}$$

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:

$$P_C = \left[\varphi \left(P^T\right)^{1-\phi} + (1-\varphi)\left(P^N\right)^{1-\phi}\right]^{\frac{1}{1-\phi}}, \tag{58}$$

where the price index for traded goods is:

$$P^T = \left[\varphi_H \left(P^H\right)^{1-\rho} + (1-\varphi_H)\right]^{\frac{1}{1-\rho}}. \tag{59}$$

Given the consumption-based price index (58), the representative household has the following demand of traded and non-traded goods:

$$C^T = \varphi \left(\frac{P^T}{P_C}\right)^{-\phi} C, \tag{60a}$$

$$C^N = (1-\varphi) \left(\frac{P^N}{P_C}\right)^{-\phi} C. \tag{60b}$$

Given the price indices (58) and (59), the representative household has the following demand of home-produced traded goods and foreign-produced traded goods:

$$C^H = \varphi \left(\frac{P^T}{P_C}\right)^{-\phi} \varphi_H \left(\frac{P^H}{P^T}\right)^{-\rho} C, \tag{61a}$$

$$C^F = \varphi \left(\frac{P^T}{P_C}\right)^{-\phi} (1-\varphi_H) \left(\frac{1}{P_T}\right)^{-\rho} C. \tag{61b}$$

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:

$$\hat{P}_C = \alpha_C \hat{P}^T + (1-\alpha_C) \hat{P}^N, \tag{62a}$$

$$\hat{P}^T = \alpha_H \hat{P}^H, \tag{62b}$$

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:

$$\alpha_C = \varphi \left(\frac{P^T}{P_C}\right)^{1-\phi}, \tag{63a}$$

$$1-\alpha_C = (1-\varphi) \left(\frac{P^N}{P_C}\right)^{1-\phi}, \tag{63b}$$

$$\alpha^H = \varphi_H \left(\frac{P^H}{P^T}\right)^{1-\rho}, \tag{63c}$$

$$1-\alpha^H = (1-\varphi_H) \left(\frac{1}{P^T}\right)^{1-\rho}. \tag{63d}$$

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]:

$$L(t) = \left[\vartheta_L^{-1/\epsilon_L} \left(L^H(t)\right)^{\frac{\epsilon_L+1}{\epsilon_L}} + (1-\vartheta_L)^{-1/\epsilon_L} \left(L^N(t)\right)^{\frac{\epsilon_L+1}{\epsilon_L}}\right]^{\frac{\epsilon_L}{\epsilon_L+1}}, \tag{64}$$

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 (64), is:

$$W = \left[\vartheta_L \left(W^H\right)^{\epsilon_L+1} + (1-\vartheta_L) \left(W^N\right)^{\epsilon_L+1}\right]^{\frac{1}{\epsilon_L+1}}, \tag{65}$$

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:

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

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

$$\hat{W} = \alpha_L \hat{W}^H + (1 - \alpha_L) \hat{W}^N, \tag{67}$$

where α_L is the tradable content of labor compensation:

$$\alpha_L = \vartheta_L \left(\frac{W^H}{W}\right)^{1+\epsilon_L}, \quad 1 - \alpha_L = (1 - \vartheta_L) \left(\frac{W^N}{W}\right)^{1+\epsilon_L}, \tag{68}$$

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:

$$K(t) = \left[\vartheta_K^{-1/\epsilon_K} \left(K^H(t)\right)^{\frac{\epsilon_K+1}{\epsilon_K}} + (1 - \vartheta_K)^{-1/\epsilon_K} \left(K^N(t)\right)^{\frac{\epsilon_K+1}{\epsilon}}\right]^{\frac{\epsilon_K}{\epsilon_K+1}}, \tag{69}$$

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 (69) is:

$$R^K = \left[\vartheta_K \left(R^{K,H}\right)^{\epsilon_K+1} + (1 - \vartheta_K) \left(R^{K,N}\right)^{\epsilon_K+1}\right]^{\frac{1}{\epsilon_K+1}}, \tag{70}$$

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 capital rental rate, the allocation of aggregate capital stock to the traded and the non-traded sector reads:

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

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:

$$\hat{R}^K = \alpha_K \hat{R}^{K,H} + (1 - \alpha_K) \hat{R}^{K,N}, \tag{72}$$

where α_K is the tradable content of capital return:

$$\alpha_K = \vartheta_K \left(\frac{R^{K,H}}{R^K}\right)^{1+\epsilon_K}, \quad 1 - \alpha_K = (1 - \vartheta_K) \left(\frac{R^{K,N}}{R^K}\right)^{1+\epsilon_K}. \tag{73}$$

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:

$$Z^A(t) = \left[\vartheta_Z^{-1/\epsilon_Z} \left(Z^H(t)\right)^{\frac{\epsilon_Z+1}{\epsilon_Z}} + (1 - \vartheta_Z)^{-1/\epsilon_Z} \left(Z^N(t)\right)^{\frac{\epsilon_Z+1}{\epsilon}}\right]^{\frac{\epsilon_Z}{\epsilon_Z+1}}, \tag{74}$$

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:

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

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:

$$\hat{R}^Z = \alpha_Z \hat{R}^{Z,H} + (1 - \alpha_Z) \hat{R}^{Z,N}, \tag{76}$$

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

$$\alpha_Z = \vartheta_Z \left(\frac{R^{Z,H}}{R^Z}\right)^{1+\epsilon_Z}, \quad 1-\alpha_Z = (1-\vartheta_Z)\left(\frac{R^{Z,N}}{R^Z}\right)^{1+\epsilon_Z}. \tag{77}$$

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:

$$\mathcal{U} = \int_0^\infty \Lambda\left(C(t), S(t), L(t)\right) e^{-\beta t} \mathrm{d}t, \tag{78}$$

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

$$\Lambda\left(C, S, L\right) \equiv \frac{X^{1-\sigma}-1}{1-\sigma}, \quad X\left(C, S, L\right) \equiv CS^{-\gamma_S} - \frac{\sigma_L}{1+\sigma_L}\gamma_L L^{\frac{1+\sigma_L}{\sigma_L}}, \tag{79}$$

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:

$$S(t) = \delta_S \int_{-\infty}^t C\left(\tau\right) e^{-\delta_S (t-\tau)} \mathrm{d}\tau, \qquad \delta_S > 0. \tag{80}$$

where the parameter δ_S indexes the relative weight of recent consumption in determining the reference stock $S(t)$. Differentiating equation (80) with respect to time gives the law of motion of the stock of habits:

$$\dot{S}(t) = \delta_S \left[C(t) - S(t)\right]. \tag{81}$$

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:

$$U\left(C(t), S(t)\right) = C(t)^{\gamma_S} \left(\frac{C(t)}{S(t)}\right)^{1-\gamma_S}. \tag{82}$$

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. (79)):

$$X_C = S^{-\gamma_S}, \tag{83a}$$
$$X_{CC} = 0, \tag{83b}$$
$$X_S = -C\gamma_S S^{-(\gamma_S+1)} < 0, \tag{83c}$$
$$X_{SS} = \gamma_S\left(\gamma_S+1\right) CS^{-(\gamma_S+2)} > 0, \tag{83d}$$
$$X_{SC} = -\gamma_S S^{-(\gamma_S+1)} < 0, \tag{83e}$$
$$X_L = -\gamma_L L^{\frac{1}{\sigma_L}} < 0, \tag{83f}$$
$$X_{LL} = -\frac{\gamma_L}{\sigma_L} L^{\frac{1}{\sigma_L}-1} < 0, \tag{83g}$$

and the partial derivatives of $\Lambda = \Lambda((C,S,L)$ (see eq. (79)):

$$\Lambda_C = X^{-\sigma} X_C > 0, \tag{84a}$$

$$\Lambda_{CC} = -\sigma X^{-(\sigma+1)} \left(X_C\right)^2 < 0, \tag{84b}$$

$$\Lambda_S = X^{-\sigma} X_S < 0, \tag{84c}$$

$$\Lambda_{SS} = -\sigma X^{-(\sigma+1)} \left(X_S\right)^2 + X^{-\sigma} X_{SS}, \tag{84d}$$

$$\Lambda_{SC} = -\sigma X^{-(\sigma+1)} X_S X_C + X^{-\sigma} X_{SC}, \tag{84e}$$

$$\Lambda_L = X^{-\sigma} X_L, \tag{84f}$$

$$\Lambda_{LL} = -\sigma X^{-(\sigma+1)} \left(X_L\right)^2 + X^{-\sigma} X_{LL} < 0, \tag{84g}$$

$$\Lambda_{CL} = -\sigma X^{-(\sigma+1)} X_C X_L > 0, \tag{84h}$$

$$\Lambda_{SL} = -\sigma X^{-(\sigma+1)} X_S X_L < 0, \tag{84i}$$

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:

$$C^{K,j}(t) = \xi_1^j \left(u^{K,j}(t) - 1\right) + \frac{\xi_2^j}{2} \left(u^{K,j}(t) - 1\right)^2, \tag{85a}$$

$$C^{Z,j}(t) = \chi_1^j \left(u^{Z,j}(t) - 1\right) + \frac{\chi_2^j}{2} \left(u^{Z,j}(t) - 1\right)^2, \tag{85b}$$

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 $\text{Tax}(t)$, 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:

$$\begin{aligned}
&\dot{N}(t) + P_C(t)C(t) + \sum_{V=K,Z} P_J^V(t) J^V t) + \sum_{j=H,N} P^j(t) \left(C^{K,j}(t)\nu^{K,j}(t)K(t) + C^{Z,j}(t)\nu^{Z,j}(t)Z^A(t)\right) \\
&= r^\star N(t) + W(t)L(t) + R^K(t)K(t) \sum_{j=H,N} \alpha_K^j(t) u^{K,j} + R^Z(t)Z^A(t) \sum_{j=H,N} \alpha_Z^j(t) u^{Z,j} - \text{Tax}(t),
\end{aligned} \tag{86}$$

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, $J^{K,T}(t)$, and the non-traded good, $J^{K,N}(t)$, by means of a CES technology:

$$J^K(t) = \left[\iota^{\frac{1}{\phi_K}} \left(J^{K,T}(t)\right)^{\frac{\phi_K - 1}{\phi_K}} + (1-\iota)^{\frac{1}{\phi_K}} \left(J^{K,N}(t)\right)^{\frac{\phi_K - 1}{\phi_K}}\right]^{\frac{\phi_K}{\phi_K - 1}}, \tag{87}$$

where $0 < \iota < 1$ 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 $J^{K,T}(t)$ is defined as a CES aggregator of home-produced traded inputs, $J^{K,H}(t)$, and foreign-produced traded inputs, $J^{K,F}(t)$:

$$J^{K,T}(t) = \left[\left(\iota^H\right)^{\frac{1}{\rho_K}} \left(J^{K,H}(t)\right)^{\frac{\rho_K - 1}{\rho_K}} + \left(1-\iota^H\right)^{\frac{1}{\rho_K}} \left(J^{K,F}(t)\right)^{\frac{\rho_K - 1}{\rho_K}}\right]^{\frac{\rho_K}{\rho_K - 1}}, \tag{88}$$

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:

$$J^K(t) = I^K(t) + \frac{\kappa}{2}\left(\frac{I^K(t)}{K(t)} - \delta_K\right)^2 K(t), \tag{89}$$

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

$$\frac{\partial J^K(t)}{\partial I^K(t)} = 1 + \kappa\left(\frac{I^K(t)}{K(t)} - \delta_K\right), \tag{90a}$$

$$\frac{\partial J^K(t)}{\partial K(t)} = -\frac{\kappa}{2}\left(\frac{I^K(t)}{K(t)} - \delta_K\right)\left(\frac{I^K(t)}{K(t)} + \delta_K\right). \tag{90b}$$

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:

$$\dot{K}(t) = I^K(t) - \delta_K K(t). \tag{91}$$

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:

$$P_J^K = \left[\iota\left(P_J^T\right)^{1-\phi_K} + (1-\iota)\left(P^N\right)^{1-\phi_K}\right]^{\frac{1}{1-\phi_K}}, \tag{92}$$

where the price index for traded goods is:

$$P_J^T = \left[\iota^H\left(P^H\right)^{1-\rho_K} + \left(1-\iota^H\right)\right]^{\frac{1}{1-\rho_K}}. \tag{93}$$

Given the investment-based price index (92), we can derive the demand for inputs of the traded good and the non-traded good:

$$J^{K,T} = \iota^H\left(\frac{P_J^T}{P_J^K}\right)^{-\phi_K} J^K, \tag{94a}$$

$$J^{K,N} = \left(1-\iota^H\right)\left(\frac{P^N}{P_J^K}\right)^{-\phi_K} J^K. \tag{94b}$$

Given the price indices (92) and (93), we can derive the demand for inputs of home-produced traded goods and foreign-produced traded goods:

$$J^{K,H} = \iota\left(\frac{P_J^T}{P_J^K}\right)^{-\phi_K} \iota^H\left(\frac{P^H}{P_J^T}\right)^{-\rho_K} J^K, \tag{95a}$$

$$J^{K,F} = \iota\left(\frac{P_J^T}{P_J^K}\right)^{-\phi_K} \left(1-\iota^H\right)\left(\frac{1}{P_J^T}\right)^{-\rho_K} J^K. \tag{95b}$$

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:

$$\hat{P}_J^K = \alpha_J^K \hat{P}^T + \left(1 - \alpha_J^K\right) \hat{P}^N, \tag{96a}$$

$$\hat{P}_J^T = \alpha_J^H \hat{P}^H, \tag{96b}$$

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:

$$\alpha_J^K = \iota \left(\frac{P_J^T}{P_J}\right)^{1-\phi_K}, \tag{97a}$$

$$1 - \alpha_J^K = (1-\iota) \left(\frac{P^N}{P_J}\right)^{1-\phi_K}, \tag{97b}$$

$$\alpha_J^H = \iota^H \left(\frac{P^H}{P_J^T}\right)^{1-\rho_K}, \tag{97c}$$

$$1 - \alpha_J^H = \left(1 - \iota^H\right) \left(\frac{1}{P_J^T}\right)^{1-\rho_K}. \tag{97d}$$

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:

$$J^Z(t) = \left[\iota_Z^{\frac{1}{\phi_Z}} \left(J^{Z,H}(t)\right)^{\frac{\phi_Z - 1}{\phi_Z}} + (1-\iota_Z)^{\frac{1}{\phi_Z}} \left(J^{Z,N}(t)\right)^{\frac{\phi_Z - 1}{\phi_Z}}\right]^{\frac{\phi_Z}{\phi_Z - 1}}, \tag{98}$$

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 (98) is:

$$P_J^Z = \left[\iota_Z \left(P^H\right)^{1-\phi_Z} + (1-\iota_Z) \left(P^N\right)^{1-\phi_Z}\right]^{\frac{1}{1-\phi_Z}}. \tag{99}$$

Given the knowledge investment-based price index (99), we can derive the demand for inputs of the traded good and the non-traded good:

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

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

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:

$$\hat{P}_J^Z = \alpha_J^Z \hat{P}^H + \left(1 - \alpha_J^Z\right) \hat{P}^N, \tag{101}$$

where

$$\alpha_J^Z = \frac{P^H J^{Z,H}}{P_J^Z J^Z} = \iota_Z \left(\frac{P^H}{P_J^Z}\right)^{1-\phi_Z}. \tag{102}$$

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

$$\dot{Z}^A(t) = I^Z(t) - \delta_Z Z^A(t), \tag{103}$$

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:

$$J^Z(t) = I^Z(t) + \frac{\zeta}{2} \left(\frac{I^Z(t)}{Z^A(t)} - \delta_Z\right)^2 Z^A(t), \tag{104}$$

with partial derivatives

$$\frac{\partial J^Z(t)}{\partial I^Z(t)} = 1 + \zeta\left(\frac{I^Z(t)}{Z^A(t)} - \delta_Z\right), \tag{105a}$$

$$\frac{\partial J^Z(t)}{\partial Z^A(t)} = -\frac{\zeta}{2}\left(\frac{I^Z(t)}{Z^A(t)} - \delta_Z\right)\left(\frac{I^Z(t)}{Z^A(t)} + \delta_Z\right). \tag{105b}$$

First-order conditions. Households choose consumption, worked hours, capital and technology utilization rates, investment in tangible and intangible assets by maximizing lifetime utility (78) subject to (86), (91) and (103). Denoting the co-state variables associated with the flow budget constraint (86), the physical capital accumulation equation (91) (i.e., $\dot{K}(t) = I(t) - \delta_K K(t)$), and the accumulation equation of ideas (103) by λ, $Q^{K,\prime}$, and $Q^{Z,\prime}$ respectively, the first-order conditions characterizing the representative household's optimal plans are described by

$$\Lambda_C\left(C(t), S(t), L(t)\right) = \bar{\lambda} P_C(t), \tag{106a}$$

$$-\Lambda_L\left(C(t), S(t), L(t)\right) = \bar{\lambda} W(t), \tag{106b}$$

$$Q^K(t) = P_J^K(t)\left[1 + \kappa\left(\frac{I^K(t)}{K(t)} - \delta_K\right)\right], \tag{106c}$$

$$Q^Z(t) = P_J^Z(t)\left[1 + \zeta\left(\frac{I^Z(t)}{Z^A(t)} - \delta_Z\right)\right], \tag{106d}$$

$$\frac{R^{K,j}(t)}{P^j(t)} = \xi_1^j + \xi_2^j\left(u^{K,j}(t) - 1\right), \quad j = H, N, \tag{106e}$$

$$\frac{R^{Z,j}(t)}{P^j(t)} = \chi_1^j + \chi_2^j\left(u^{Z,j}(t) - 1\right), \quad j = H, N, \tag{106f}$$

$$\dot{\lambda}(t) = \lambda\left(\beta - r^\star\right), \tag{106g}$$

$$\begin{aligned}\dot{Q}^K(t) = \left(r^\star + \delta_K\right) Q^K(t) - \Bigg\{ & \sum_{j=H,N} \alpha_K^j(t) u^{K,j}(t) R^K(t) \\ & - \sum_{j=H,N} P^j(t) C^{K,j}(t) \nu^{K,j}(t) - P_J^K(t)\frac{\partial J^K(t)}{\partial K(t)}\Bigg\},\end{aligned} \tag{106h}$$

$$\begin{aligned}\dot{Q}^Z(t) = \left(r^\star + \delta_Z\right) Q^Z(t) - \Bigg\{ & \sum_{j=H,N} \alpha_Z^j(t) u^{Z,j}(t) R^Z(t) \\ & - \sum_{j=H,N} P^j(t) C^{Z,j}(t) \nu^{Z,j}(t) - P_J^Z(t)\frac{\partial J^Z(t)}{\partial Z^A(t)}\Bigg\},\end{aligned} \tag{106i}$$

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 (106h) and (106i), 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.

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:

$$Y^j = \left[\int_0^1 \left(X_i^j\right)^{\frac{\omega^j - 1}{\omega^j}} \mathrm{d}i\right]^{\frac{\omega^j}{\omega^j - 1}}, \tag{107}$$

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.

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 in this sector j, respectively, the profit the final good producer reads (the subscript F refers to final good):

$$\Pi_F^j = P^j \left[\int_0^1 \left(X_i^j \right)^{\frac{\omega^j - 1}{\omega^j}} \mathrm{d}i \right]^{\frac{\omega^j}{\omega^j - 1}} - \int_0^1 P_i^j X_i^j \mathrm{d}i. \tag{108}$$

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

$$X_i^j = \left(\frac{P_i^j}{P^j} \right)^{-\omega^j} Y^j, \tag{109}$$

and the price of the final output is given by:

$$P^j = \left(\int_0^1 \left(P_i^j \right)^{1-\omega^j} \mathrm{d}i \right)^{\frac{1}{1-\omega^j}}, \tag{110}$$

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. (109), the price-elasticity of the demand for output of the ith variety within sector j is:

$$-\frac{\partial X_i^j}{\partial P_i^j} \frac{P_i^j}{X_i^j} = \omega^j. \tag{111}$$

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 $\tilde{Z}_i^j(t)$, to produce a final good according to a technology of production which displays increasing returns to scale:

$$X^j(t) = T^j(t) \left(L_i^j(t) \right)^{\theta^j} \left(\tilde{K}_i^j(t) \right)^{1-\theta^j}, \tag{112}$$

where $T^j(t)$ is utilization-adjusted-TFP in sector j. The firms have access to a stock of ideas $\mathsf{Z}^j(t)$ which 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 $Z^{W,j}(t)$:

$$\mathsf{Z}^j(t) = \left(\tilde{Z}_i^j(t) \right)^{\theta_Z^j} \left(Z^{W,j}(t) \right)^{1-\theta_Z^j}, \tag{113}$$

where θ_Z^j captures the domestic content of the stock of knowledge accessible to domestic firms in sector j. Both the domestic (i.e., $\tilde{Z}^j(t)$) and the international stock of ideas (i.e., $Z^{W,j}(t)$) are sector-specific and produce differentiated effects on utilization-adjusted-TFP in sector j:

$$T^j(t) = \left(\tilde{Z}_i^j(t) \right)^{\nu_Z^j \theta_Z^j} \left(Z^{W,j}(t) \right)^{\nu_Z^{W,j} \left(1-\theta_Z^j\right)}, \tag{114}$$

where $\nu_Z^j \geq 0$ ($\nu_Z^{W,j} \geq 0$) is a parameter which determines the ability of sector j to transform domestic (international) R&D into innovation.

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:

$$\max_{L_i^j(t), \tilde{K}_i^j(t), \tilde{Z}_i^j(t)} \Pi_i^j(t) \tag{115}$$

where

$$\Pi_i^j(t) \equiv (1-\tau)\left[P_i^j(t)X_i^j(t) - W^j(t)L_i^j(t) - \delta_K \tilde{K}_i^j(t)\right] - \left(R^{K,j}(t)-\delta_K\right)\tilde{K}_i^j(t) - R^{Z,j}(t)\tilde{Z}_i^j(t) - P^j F^j, \tag{116}$$

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:

$$\mathcal{L}_i^j = \Pi_i^j(t) + \eta_i^j\left[X_i^j(t) - \left(P_i^j\right)^{-\omega^j}\left(P^j\right)^{\omega^j} Y^j\right]. \tag{117}$$

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:

$$\left[(1-\tau)P_i^j + \eta_i^j\right]\frac{\partial F^j(.)}{\partial L_i^j} = (1-\tau)W^j, \tag{118a}$$

$$\left[(1-\tau)P_i^j + \eta_i^j\right)\frac{\partial F^j(.)}{\partial \tilde{K}_i^j} = \left(R^{K,j}-\delta_K\right) + \delta_K(1-\tau), \tag{118b}$$

$$\left[(1-\tau)P_i^j + \eta_i^j\right]\frac{\partial F^j(.)}{\partial \tilde{Z}_i^j} = R^{Z,j}, \tag{118c}$$

$$(1-\tau)X_i^j = -\eta_i^j\omega^j\left(P_i^j\right)^{-\omega^j-1}\left(P^j\right)^{\omega^j} Y^j, \tag{118d}$$

Using $X_i^j = \left(\frac{P_i^j}{P^j}\right)^{-\omega^j} Y^j$, eq. (118d) can be rewritten as follows:

$$\eta_i^j = -\frac{(1-\tau)P_i^j}{\omega^j}. \tag{119}$$

Denoting the markup charged by intermediate good producers by $\mu^j = \frac{\omega^j}{\omega^j-1} > 1$, and inserting (119) into (118a)-(118c), first-order conditions can be rewritten as follows:

$$P_i^j\theta^j\frac{X_i^j}{L_i^j} = \mu^j W^j, \tag{120a}$$

$$P_i^j\left(1-\theta^j\right)\frac{X_i^j}{\tilde{K}_i^j} = \mu^j\left[\left(\frac{R^{K,j}-\delta_K}{1-\tau}\right) + \delta_K\right], \tag{120b}$$

$$(1-\tau)P_i^j\nu_Z^j\theta_Z^j\frac{X_i^j}{\tilde{Z}_i^j} = \mu^j R^{Z,j}, \tag{120c}$$

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 $\frac{\partial X_i^j}{\partial \tilde{Z}_i^j} = \nu_Z^j\theta_Z^j\frac{X_i^j}{\tilde{Z}_i^j}$.

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 $\mathrm{NOS}_i^j(t) = P_i^j(t)X_i^j(t) - W^j(t)L_i^j(t) - \delta_K\tilde{K}_i^j(t)$. Rewriting first-order conditions (120a)-(120c)

$$\frac{P_i^j}{\mu^j}\theta^j X_i^j = W^j L_i^j, \tag{121a}$$

$$\frac{P_i^j}{\mu^j}\left(1-\theta^j\right)X_i^j = \left[\left(\frac{R^{K,j}-\delta_K}{1-\tau}\right) + \delta_K\right]\tilde{K}_i^j, \tag{121b}$$

$$(1-\tau)\frac{P_i^j}{\mu^j}\nu_Z^j\theta_Z^j X_i^j = \mu^j R^{Z,j}\tilde{Z}_i^j. \tag{121c}$$

Inserting (121a)-(121c) into profit leads to:

$$
\begin{aligned}
& P_i^j X_i^j - (1-\tau) W^j L_i^j (1-\tau) \left[\frac{R^K - \delta_K}{1-\tau} + \delta_K \right] \tilde{K}_i^j - R^Z \tilde{Z}_i^j - P^j F^j = 0, \\
= \; & P_i^j X_i^j - (1-\tau) \frac{P_i^j}{\mu^j} \theta^j X_i^j - (1-\tau) \frac{P_i^j}{\mu^j} \left(1-\theta^j\right) X_i^j - (1-\tau) \frac{P_i^j}{\mu^j} \nu_Z^j \theta_Z^j X_i^j - P^j F^j = 0, \\
& (1-\tau) P_i^j X_i^j \left[1 - \frac{\theta^j + \left(1-\theta^j\right) + \nu_Z^j \theta_Z^j}{\mu^j} \right] - P_i^j F^j = 0, \\
& (1-\tau) P_i^j X_i^j \left[1 - \frac{1 + \nu_Z^j \theta_Z^j}{\mu^j} \right] - P_i^j F^j = 0.
\end{aligned}
\tag{122}
$$

Because the firm must pay (time-invariant) fixed costs F^j, to ensure that profits cannot be negative, we require the markup denoted by μ^j to be larger than the degree of increasing returns to scale caused the contribution of the stock of intangible assets to the production of the i-th variety of the intermediate good:

$$
\mu^j > 1 + \nu^j \theta_Z^j, \tag{123}
$$

so that the excess of value added over the payment of factors of production 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., $P_i^j = P^j$ and they produce the same quantity, i.e., $X_i^j = X^j = Y^j$. Eq. (122) implies that after-tax value added covers the payment of after-tax labor services, 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:

$$
(1-\tau) P^j Y^j = (1-\tau) W^j L^j + \left(R^{K,j} - \tau\delta_K\right) \tilde{K}^j + R^{Z,j} \tilde{Z}^j + P^j F^j. \tag{124}
$$

Output Net of Fixed Costs

We denote output net of fixed costs by $O^j = Y^j - F^j$. By using the free entry condition (122), i.e., $P_i^j F^j = (1-\tau) P^j Y^j \left[1 - \frac{1+\nu_Z^j \theta_Z^j}{\mu^j}\right]$, value added in sector j net of fixed cost reads as follows:

$$
\begin{aligned}
O^j &= Y^j - F^j, \\
&= Y^j \left[1 - (1-\tau) \left(1 - \frac{1 + \nu_Z^j \theta_Z^j}{\mu^j} \right) \right].
\end{aligned}
\tag{125}
$$

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

$$
\begin{aligned}
(1-\tau) P^j Y^j - P^j F^j &= (1-\tau) \left[W^j L^j + \delta_K \tilde{K}_i^j \right] + \left[R^{K,j} - \delta_K \right] \tilde{K}^j + R^{Z,j} \tilde{Z}^j, \\
P^j Y^j - P^j \frac{F^j}{1-\tau} &= W^j L^j + \left[\frac{R^{K,j} - \delta_K}{1-\tau} + \delta_K \right] \tilde{K}^j + \frac{R^{Z,j} \tilde{Z}^j}{1-\tau}.
\end{aligned}
\tag{126}
$$

Unit Cost for Producing

As shall be useful, we derive the unit cost for producing in sector j. Dividing the demand for labor (120a) by the demand for capital (120b), and next dividing the demand for demand for tangible assets (120b) by the demand for intangible assets (120c), and finally the demand for labor (120a) by the demand for intangible assets (120c), we get:

$$
\frac{1-\theta^j}{\theta^j} \frac{L^j}{\tilde{K}^j} = \frac{R^{K,j} - \tau\delta_K}{W^j (1-\tau)}, \tag{127a}
$$

$$
\frac{1-\theta^j}{\nu_Z^j \theta_Z^j} \frac{\tilde{Z}^j}{\tilde{K}^j} = \frac{R^{K,j} - \tau\delta_K}{R^{Z,j}}, \tag{127b}
$$

$$
\frac{\nu_Z^j \theta_Z^j}{\theta^j} \frac{L^j}{\tilde{Z}^j} = \frac{R^{Z,j}}{W^j (1-\tau)}. \tag{127c}
$$

Making use of eq. (127a) and (127b) to eliminate L^j and $\tilde{Z}^j$ from the Cobb-Douglas production function (112)-(113) and solving for $\tilde{K}^j$, and next making use of eq. (127a) and (127c) to eliminate $\tilde{K}^j$ and $\tilde{Z}^j$ from the Cobb-Douglas production function (112)-(113) and solving for L^j, and finally making use of eq. (127b) and (127c) to eliminate $\tilde{K}^j$ and L^j from the Cobb-Douglas production function (112)-(113) and solving for $\tilde{Z}^j$ leads to the conditional demand for capital stock, for labor, and for intangible assets:

$$\left(\tilde{K}^j\right)^{1+\nu_Z^j\theta_Z^j} = \frac{Y^j}{(Z^{W,j})^{(1-\theta_Z^j)\nu_Z^{W,j}}} \left(\frac{1-\theta^j}{\theta^j}\right)^{\theta^j} \left(\frac{1-\theta^j}{\nu_Z^j\theta_Z^j}\right)^{\nu_Z^j\theta_Z^j} \frac{\left(R^{Z,j}\right)^{\nu_Z^j\theta_Z^j}\left(W^j(1-\tau)\right)^{\theta^j}}{\left(R^{K,j}-\tau\delta_K\right)^{\theta^j+\nu_Z^j\theta_Z^j}}, \tag{128a}$$

$$\left(L^j\right)^{1+\nu_Z^j\theta_Z^j} = \frac{Y^j}{(Z^{W,j})^{(1-\theta_Z^j)\nu_Z^{W,j}}} \left(\frac{\theta^j}{1-\theta^j}\right)^{1-\theta^j} \left(\frac{\theta^j}{\nu_Z^j\theta_Z^j}\right)^{\nu_Z^j\theta_Z^j} \frac{\left(R^{Z,j}\right)^{\nu_Z^j\theta_Z^j}\left(R^{K,j}-\tau\delta_K\right)^{1-\theta^j}}{\left(W^j(1-\tau)\right)^{(1-\theta^j)+\nu_Z^j\theta_Z^j}}, \tag{128b}$$

$$\left(\tilde{Z}^j\right)^{1+\nu_Z^j\theta_Z^j} = \frac{Y^j}{(Z^{W,j})^{(1-\theta_Z^j)\nu_Z^{W,j}}} \frac{\nu_Z^j\theta_Z^j}{\left(1-\theta^j\right)^{1-\theta^j}\left(\theta^j\right)^{\theta^j}} \frac{\left(W^j(1-\tau)\right)^{\theta^j}\left(R^{K,j}-\tau\delta_K\right)^{1-\theta^j}}{R^{Z,j}}. \tag{128c}$$

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

$$C^j = (1-\tau)\,W^j L^j + \left[R^{K,j}-\tau\delta_K\right]\tilde{K}^j + R^{Z,j}\tilde{Z}^j. \tag{129}$$

Inserting conditional demand for inputs (128a)-(128c) into total cost (129), 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:

$$C^j = \left[\frac{Y^j}{(Z^{W,j})^{(1-\theta_Z^j)\nu_Z^{W,j}}}\right]^{\frac{1}{1+\nu_Z^j\theta_Z^j}} \left(M^j\right)^{\frac{1}{1+\nu_Z^j\theta_Z^j}} \left(1+\nu_Z^j\theta_Z^j\right) \tag{130}$$

where we set

$$M^j = \left(\Psi^j\right)^{-1}\left(W^j(1-\tau)\right)^{\theta^j}\left(R^{K,j}-\tau\delta_K\right)^{1-\theta^j}\left(R^{Z,j}\right)^{\nu_Z^j\theta_Z^j}, \tag{131}$$

where

$$\Psi^j = \left(\theta^j\right)^{\theta^j}\left(1-\theta^j\right)^{1-\theta^j}\left(\nu_Z^j\theta_Z^j\right)^{\nu_Z^j\theta_Z^j}. \tag{132}$$

By using (126) and the definition of total costs (129)) which implies that $(1-\tau)\,P^jY^j - P^jF^j = C^j$ 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. (125)), 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 $Y^j\left(1+\nu_Z^j\theta_Z^j\right)$ which leads to

$$\begin{aligned} c^j &= \frac{C^j}{(1-\tau)\,Y^j\left(1+\nu_Z^j\theta_Z^j\right)}, \\ &= \left(Y^j\right)^{-\frac{\nu_Z^j\theta_Z^j}{1+\nu_Z^j\theta_Z^j}}\left[\frac{M^{j,\prime}}{(Z^{W,j})^{(1-\theta_Z^j)\nu_Z^{W,j}}}\right]^{\frac{1}{1+\nu_Z^j\theta_Z^j}}, \end{aligned} \tag{133}$$

where $M^{j,\prime} \equiv \frac{M^j}{1-\tau}$

$$M^{j,\prime} = \left(\Psi^j\right)^{-1}\left(W^j\right)^{\theta^j}\left(\frac{R^{K,j}-\delta_K}{1-\tau}+\delta_K\right)^{1-\theta^j}\left(\frac{R^{Z,j}}{1-\tau}\right)^{\nu_Z^j\theta_Z^j}. \tag{134}$$

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

$$\frac{P^j}{\mu^j} = c^j. \tag{135}$$

E.3 Solving the Model

Consumption and Labor. Totally differentiating first-order conditions for consumption (106a) and labor (106b) leads to:

$$\frac{\Lambda_{CC}}{\Lambda_C}dC + \frac{\Lambda_{CL}}{\Lambda_C}dL = \frac{d\bar{\lambda}}{\bar{\lambda}} - \frac{\Lambda_{CS}}{\Lambda_C}dS + \frac{\alpha_C\alpha^H}{P^H}dP^H + \frac{1-\alpha_C}{P^N}dP^N, \tag{136a}$$

$$\frac{\Lambda_{LC}}{\Lambda_L}dC + \frac{\Lambda_{LL}}{\Lambda_L}dL = \frac{d\bar{\lambda}}{\bar{\lambda}} + \frac{dW}{W} - \frac{\Lambda_{LS}}{\Lambda_L}dS. \tag{136b}$$

Eqs. (136a)-(136b) can be solved for consumption and hours:

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

Note that plugging $\frac{X^{-\sigma}}{P_C} = \bar{\lambda}$ into eq. (106b) 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 (137) into (60b), (61a)-(61b), allows us to solve for C^g (with $g = H, N, F$)

$$C^g = C^g\left(\bar{\lambda}, P^N, P^H, W^H, W^N\right), \tag{138}$$

where we used the fact that

$$\begin{aligned}
\hat{C}^N &= -\phi\alpha_C\hat{P}^N + \phi\alpha_C\alpha^H\hat{P}^H + \hat{C}, && (139a)\\
\hat{C}^H &= -\left[\rho\left(1-\alpha^H\right) + \phi\left(1-\alpha_C\right)\alpha^H\right]\hat{P}^H + \left(1-\alpha_C\right)\phi\hat{P}^N + \hat{C}, && (139b)\\
\hat{C}^F &= \alpha^H\left[\rho - \phi\left(1-\alpha_C\right)\right]\hat{P}^H + \left(1-\alpha_C\right)\phi\hat{P}^N + \hat{C}. && (139c)
\end{aligned}$$

Labor supply to sector $j = H, N$. Inserting first the solution for labor (137) into (66) allows us to solve for L^j (with $j = H, N$):

$$L^j = L^j\left(\bar{\lambda}, P^N, P^H, W^H, W^N\right), \tag{140}$$

with partial derivatives given by:

$$\begin{aligned}
\hat{L}^H &= \epsilon_L\left(1-\alpha_L\right)\hat{W}^H - \left(1-\alpha_L\right)\epsilon_L\hat{W}^N + \hat{L}, && (141a)\\
\hat{L}^N &= \epsilon_L\alpha_L\hat{W}^N - \alpha_L\epsilon_L\hat{W}^H + \hat{L}. && (141b)
\end{aligned}$$

Capital supply to sector $j = H, N$. The decision to allocate capital between to the traded and the non-traded sectors (71) allows us to solve for K^H and K^N:

$$K^j = K^j\left(K, R^{K,H}, R^{K,N}\right), \tag{142}$$

with partial derivatives given by:

$$\begin{aligned}
\hat{K}^H &= \epsilon_K\left(1-\alpha_K\right)\hat{R}^{K,H} - \left(1-\alpha_K\right)\epsilon_K\hat{R}^{K,N} + \hat{K}, && (143a)\\
\hat{K}^N &= \epsilon_K\alpha_K\hat{R}^{K,N} - \alpha_K\epsilon_K\hat{R}^{K,H} + \hat{K}. && (143b)
\end{aligned}$$

Supply of ideas to sector $j = H, N$. The decision to allocate intangible assets between the traded and the non-traded sectors (75) allows us to solve for Z^H and Z^N:

$$Z^j = Z^j\left(Z^A, R^{Z,H}, R^{Z,N}\right), \tag{144}$$

with partial derivatives given by:

$$\begin{aligned}
\hat{Z}^H &= \epsilon_Z\left(1-\alpha_Z\right)\hat{R}^{Z,H} - \left(1-\alpha_Z\right)\epsilon_Z\hat{R}^{Z,N} + \hat{Z}^A, && (145a)\\
\hat{Z}^N &= \epsilon_Z\alpha_Z\hat{R}^{Z,N} - \alpha_Z\epsilon_Z\hat{R}^{Z,H} + \hat{Z}^A. && (145b)
\end{aligned}$$

Sectoral Wages and Sectoral Rental Rates for Tangible and Intangible Assets

First-order conditions from firm's profit maximization are for sector $j = H, N$:

$$\frac{P^j}{\mu^j}\theta^j \left(u^{Z,j}Z^j\right)^{\nu_Z^j\theta_Z^j} \left(Z^{W,j}\right)^{\nu_Z^{W,j}\left(1-\theta_Z^j\right)} \left(L^j\right)^{\theta^j-1} \left(u^{K,j}K^j\right)^{1-\theta^j} = W^j, \tag{146a}$$

$$\frac{P^j}{\mu^j}\left(1-\theta^j\right) \left(u^{Z,j}Z^j\right)^{\nu_Z^j\theta_Z^j} \left(Z^{W,j}\right)^{\nu_Z^{W,j}\left(1-\theta_Z^j\right)} \left(L^j\right)^{\theta^j} \left(u^{K,j}K^j\right)^{-\theta^j} = R^{K,j}, \tag{146b}$$

$$\frac{P^j}{\mu^j}\nu_Z^j\theta_Z^j \left(u^{Z,j}Z^j\right)^{\left(\nu_Z^j\theta_Z^j-1\right)} \left(Z^{W,j}\right)^{\nu_Z^{W,j}\left(1-\theta_Z^j\right)} \left(L^j\right)^{\theta^j} \left(u^{K,j}K^j\right)^{1-\theta^j} = R^{Z,j}. \tag{146c}$$

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

$$\begin{aligned} &-\left[\left(1-\theta^j\right)\hat{L}^j + \hat{W}^j\right] + \left(1-\theta^j\right)\left(\hat{u}^{K,j} + \hat{K}^j\right) + \nu_Z^j\theta_Z^j\left(\hat{u}^{Z,j} + \hat{Z}^j\right) \\ &\qquad = -\hat{P}^j - \nu_Z^{W,j}\left(1-\theta_Z^j\right)\hat{Z}^W, \end{aligned} \tag{147a}$$

$$\begin{aligned} &\theta^j\hat{L}^j - \left[\theta^j\left(\hat{u}^{K,j} + \hat{K}^j\right) + \hat{R}^{K,j}\right] + \nu_Z^j\theta_Z^j\left(\hat{u}^{Z,j} + \hat{Z}^j\right) = \frac{R^{K,j}-\delta_K}{\left(1-\tau\right)\left(R^{K,j}-\tau\delta_K\right)}d\tau \\ &\qquad -\hat{P}^j - \nu_Z^{W,j}\left(1-\theta_Z^j\right)\hat{Z}^W, \end{aligned} \tag{147b}$$

$$\begin{aligned} &\theta^j\hat{L}^j + \left(1-\theta^j\right)\left(\hat{u}^{K,j} + \hat{K}^j\right) - \left[\left(1-\nu_Z^j\theta_Z^j\right)\left(\hat{u}^{Z,j} + \hat{Z}^j\right) + \hat{R}^{Z,j}\right] = \frac{d\tau}{1-\tau} - \hat{P}^j \\ &\qquad -\nu_Z^{W,j}\left(1-\theta_Z^j\right)\hat{Z}^W, \end{aligned} \tag{147c}$$

where we used the fact that

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

to get (147b).

Inserting intermediate solutions for L^j, K^j, Z^j described by (140), (142), (144), respectively, and invoking the theorem of implicit functions leads to:

$$W^j, R^{K,j}, R^{Z,j}\left(P^j, K, Z^A, u^{K,j}, u^{Z,j}, \tau, Z^{W,j}\right). \tag{148}$$

Plugging back (148) into (140), (142), (144) leads to solutions for L^j, K^j, Z^j; inserting these solutions into the production function (112)-(113) allows us to solve for Y^j; thus intermediate solutions read:

$$L^j, K^j, Z^j, Y^j\left(P^j, K, Z^A, u^{K,j}, u^{Z,j}, \tau, Z^{W,j}\right). \tag{149}$$

Solutions to capital and technology utilization rates in sector $j = H, N$.

Inserting first the marginal revenue product of capital (146b) into the optimal decision for the capital utilization rate

$$\begin{aligned} \frac{R^{K,j}(t)}{P^j(t)} &= \xi_1^j + \xi_2^j\left(u^{K,j}(t)-1\right), \\ &= \frac{\delta_K\tau}{P^j(t)} + \frac{(1-\tau)}{\mu^j}\left(1-\theta^j\right)\left(u^{Z,j}(t)Z^j(t)\right)^{\nu_Z^j\theta_Z^j}\left(Z^{W,j}(t)\right)^{\nu_Z^{W,j}\left(1-\theta_Z^j\right)}\left(L^j(t)\right)^{\theta^j} \\ &\times \left(u^{K,j}(t)K^j(t)\right)^{-\theta^j}. \end{aligned} \tag{150}$$

Inserting first the marginal revenue product of ideas (146c) into the optimal decision for the technology utilization rate

$$\begin{aligned} \frac{R^{Z,j}(t)}{P^j(t)} &= \chi_1^j + \chi_2^j\left(u^{Z,j}(t)-1\right), \\ &= \frac{(1-\tau)}{\mu^j}\nu_Z^j\theta_Z^j\left(u^{Z,j}(t)Z^j(t)\right)^{\left(\nu_Z^j\theta_Z^j-1\right)}\left(Z^{W,j}(t)\right)^{\nu_Z^{W,j}\left(1-\theta_Z^j\right)}\left(L^j(t)\right)^{\theta^j}\left(u^{K,j}(t)K^j(t)\right)^{1-\theta^j}. \end{aligned} \tag{151}$$

Totally differentiating (150) leads to:

$$\begin{aligned}
& \left[\frac{\xi_2^j}{\xi_1^j - \frac{\delta_K \tau}{P^j}} + \theta^j\right] \hat{u}^{K,j} - \theta^j \hat{L}^j + \theta^j \hat{K}^j - \nu_Z^j \theta_Z^j \left(\hat{u}^{Z,j} + \hat{Z}^j\right) \\
= & \frac{R^{K,j} - \delta_K}{(1-\tau)\left(R^{K,j} - \tau \delta_K\right)} d\tau + \nu_Z^{W,j} \left(1 - \theta_Z^j\right) \hat{Z}^W,
\end{aligned} \quad (152)$$

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 (151) leads to:

$$\begin{aligned}
& \left[\frac{\chi_2^j}{\chi_1^j} + \left(1 - \nu_Z^j \theta_Z^j\right)\right] \hat{u}^{Z,j} - \theta^j \hat{L}^j - \left(1 - \theta^j\right) \left(\hat{u}^{K,j} + \hat{K}^j\right) + \left(1 - \nu_Z^j \theta_Z^j\right) \hat{Z}^j \\
= & -\frac{d\tau}{(1-\tau)} + \nu_Z^{W,j} \left(1 - \theta_Z^j\right) \hat{Z}^W.
\end{aligned} \quad (153)$$

Inserting (148)-(149) into (152) and (153) and invoking the implicit function theorem leads to:

$$u^{K,j}, u^{Z,j} \left(P^j, K, Z^A, Z^{W,j}, \tau\right). \quad (154)$$

Plugging (154) into (148) and (149) leads to

$$W^j, R^{K,j}, R^{Z,j}, L^j, K^j, Y^j \left(P^j, K, Z^A, Z^{W,j}, \tau\right). \quad (155)$$

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

Eq. (106c) can be solved for the investment rate:

$$\frac{I^K}{K} = v^K \left(\frac{Q^K}{P_J^K \left(P^H, P^N\right)}\right) + \delta_K, \quad (156)$$

where

$$v^K(.) = \frac{1}{\kappa} \left(\frac{Q^K}{P_J^K} - 1\right), \quad (157)$$

with

$$v_{Q^K}^K = \frac{\partial v^K(.)}{\partial Q^K} = \frac{1}{\kappa} \frac{1}{P_J^K} > 0, \quad (158a)$$

$$v_{P^H}^K = \frac{\partial v^K(.)}{\partial P^H} = -\frac{1}{\kappa} \frac{Q^K}{P_J^K} \frac{\alpha_J \alpha_J^H}{P^H} < 0, \quad (158b)$$

$$v_{P^N} = \frac{\partial v^K(.)}{\partial P^N} = -\frac{1}{\kappa} \frac{Q^K}{P_J^K} \frac{(1 - \alpha_J)}{P^N} < 0. \quad (158c)$$

Inserting (156) into (106c), investment including capital installation costs can be rewritten as follows:

$$\begin{aligned}
J^K &= K \left[\frac{I^K}{K} + \frac{\kappa}{2} \left(\frac{I^K}{K} - \delta_K\right)^2\right], \\
&= K \left[v^K(.) + \delta_K + \frac{\kappa}{2} \left(v^K(.)\right)^2\right].
\end{aligned} \quad (159)$$

Eq. (159) can be solved for investment including capital installation costs:

$$J^K = J^K \left(K, Q^K, P^N, P^H\right), \quad (160)$$

where

$$J_K = \frac{\partial J^K}{\partial K} = \frac{J}{K}, \tag{161a}$$

$$J_X^K = \frac{\partial J^K}{\partial X} = \kappa v_X \left(1 + \kappa v^K (.)\right) > 0, \tag{161b}$$

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

Substituting (160) into (94b), (95a), and (95b) allows us to solve for the demand of non-traded, home-produced traded, and foreign inputs:

$$J^{K,g} = J^{K,g}\left(K, Q^K, P^N, P^H\right), \quad g = F, H, N, \tag{162}$$

with partial derivatives given by

$$\begin{aligned}
\hat{J}^{K,N} &= -\alpha_J \phi_J \hat{P}^N + \phi_J \alpha_J \alpha_J^H \hat{P}^H + \hat{J}^K, && (163a)\\
\hat{J}^{K,H} &= -\left[\rho_K\left(1-\alpha_J^H\right) + \alpha_J^H \phi_J \left(1-\alpha_J\right)\right]\hat{P}^H + \phi_J\left(1-\alpha_J\right)\hat{P}^N + \hat{J}^K, && (163b)\\
\hat{J}^{K,F} &= \alpha_J^H\left[\rho_K - \phi_J\left(1-\alpha_J\right)\right]\hat{P}^H + \phi_J\left(1-\alpha_J\right)\hat{P}^N + \hat{J}^K, && (163c)
\end{aligned}$$

where

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

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

From eq. (106d), 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

$$v^Z(.) = \frac{1}{\zeta}\left(\frac{Q^Z}{P_J^Z} - 1\right) \tag{164}$$

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:

$$J^Z = J^Z\left(Z^A, Q^Z, P^N, P^H\right). \tag{165}$$

Inserting first (165) into (100a)-(100b), we can solve for investment in traded and non-traded R&D:

$$J^{Z,H}, J^{Z,N}\left(Z^A, Q^Z, P^N, P^H\right). \tag{166}$$

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

$$O'^H = C^H + G^H + J^{K,H} + J^{Z,H} + X^H + C^{K,H}K^H + C^{Z,H}Z^H, \tag{167a}$$

$$O^N = C^N + G^N + J^{K,N} + J^{Z,N} + C^{K,N}K^N + C^{Z,N}Z^N. \tag{167b}$$

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

$$P^H, P^N\left(K, Q^K, Z^A, Q^Z, Z^{W,j}, \tau\right). \tag{168}$$

Plugging back these solutions (168) into (154), (155) leads to:

$$u^{K,j}, W^j, R^{K,j}, R^{Z,j}, L^j, K^j, Y^j\left(K, Q^K, Z^A, Q^Z, Z^{W,j}, \tau\right). \tag{169}$$

Inserting solutions for sectoral prices (168) into intermediate solutions for investment in tangible (162) and intangible assets (166) and consumption (138) in goods $g = H, N, F$, leads to:

$$C^g, J^{K,g}, J^{Z,g}\left(K, Q^K, Z^A, Q^Z, Z^{W,j}, \tau\right), \qquad g = H, N, F. \tag{170}$$

E.4 Dynamics

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

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

$$-\delta_K K(t) - \frac{\kappa}{2}\left(\frac{I(t)}{K(t)} - \delta_K\right)^2 K(t), \quad (171a)$$

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

$$\left. - \sum_{j=H,N} P^j(t) C^{K,j}(t) \nu^{K,j}(t) - P_J(t) \frac{\partial J(t)}{\partial K(t)} \right\}, \quad (171b)$$

$$\dot{Z}^A(t) = v^Z\left(K(t), Q^K(t), Z^A(t), Q^Z(t), \tau(t), Z^{W,j}(t)\right) Z^A(t), \quad (171c)$$

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

$$\left. - \sum_{j=H,N} P^j(t) C^{K,j}(t) \nu^{K,j}(t) - P_J^Z(t) \frac{\partial J^Z(t)}{\partial Z^A(t)} \right], \quad (171d)$$

$$\dot{S}(t) = \delta_S \left(C(t) - S(t)\right), \quad (171e)$$

$$d\tau(t) = x_T e^{-\xi_T t}, \quad (171f)$$

$$dZ^{W,j}(t) = x_Z^j e^{-\xi_Z^j t}, \quad (171g)$$

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

The dynamic system can be written in a compact form:

$$\dot{K}(t) = \Upsilon\left(K(t), Q^K(t), Z^A(t), Q^Z(t), S(t), \tau(t), Z^{W,j}(t)\right), \quad (172a)$$

$$\dot{Q}^K(t) = \Sigma\left(K(t), Q^K(t), Z^A(t), Q^Z(t), S(t), \tau(t), Z^{W,j}(t)\right), \quad (172b)$$

$$\dot{Z}^A(t) = \Pi\left(K(t), Q^K(t), Z^A(t), Q^Z(t), S(t), \tau(t), Z^{W,j}(t)\right), \quad (172c)$$

$$\dot{Q}^Z(t) = \Gamma\left(K(t), Q^K(t), Z^A(t), Q^Z(t), S(t), \tau(t), Z^{W,j}(t)\right), \quad (172d)$$

$$\dot{S}(t) = \Theta\left(K(t), Q^K(t), Z^A(t), Q^Z(t), S(t), \tau(t), Z^{W,j}(t)\right), \quad (172e)$$

$$\dot{\tau}(t) = -\xi_T\left(\tau(t) - \tau\right), \quad (172f)$$

$$\dot{Z}^{W,j}(t) = -\xi_Z^j\left(Z^{W,j}(t) - Z^{W,j}\right), \quad (172g)$$

where $j = H, N$.

We linearize (172a)-(172g) around the steady-state:

$$\begin{pmatrix} \dot{K}(t) \\ \dot{Q}^K(t) \\ \dot{Z}^A(t) \\ \dot{Q}^Z(t) \\ \dot{S}(t) \\ \dot{\tau}(t) \\ \dot{Z}^{W,j}(t) \end{pmatrix} = \begin{pmatrix} \Upsilon_K & \Upsilon_{Q^K} & \Upsilon_{Z^A} & \Upsilon_{Q^Z} & \Upsilon_S & \Upsilon_\tau & \Upsilon_{Z^{W,j}} \\ \Sigma_K & \Sigma_{Q^K} & \Sigma_{Z^A} & \Sigma_{Q^Z} & \Sigma_S & \Sigma_\tau & \Sigma_{Z^{W,j}} \\ \Pi_K & \Pi_{Q^K} & \Pi_{Z^A} & \Pi_{Q^Z} & \Pi_S & \Pi_\tau & \Pi_{Z^{W,j}} \\ \Gamma_K & \Gamma_{Q^K} & \Gamma_{Z^A} & \Gamma_{Q^Z} & \Gamma_S & \Gamma_\tau & \Gamma_{Z^{W,j}} \\ \Theta_K & \Theta_{Q^K} & \Theta_{Z^A} & \Theta_{Q^Z} & \Theta_S & \Theta_\tau & \Theta_{Z^{W,j}} \\ 0 & 0 & 0 & 0 & 0 & -\xi_T & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & -\xi_Z^j \end{pmatrix} \begin{pmatrix} dK(t) \\ dQ^K(t) \\ dZ^A(t) \\ dQ^Z(t) \\ dS(t) \\ d\tau(t) \\ dZ^{W,j}(t) \end{pmatrix}. \quad (173)$$

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., $K(0)=K_0$, $Z^A(0)=Z_0^A$, $S(0)=S_0$, $\tau(0)=\tau_0$, $Z^{W,j}(0)=Z_0^{W,j}$. Convergent solutions toward the stable manifold read:

$$dK(t) = D_1 e^{\nu_1 t} + D_2 e^{\nu_2 t} + D_3 e^{\nu_3 t} + \omega_1^6 D_6 e^{\nu_6 t} + \omega_1^7 D_7 e^{\nu_7 t}, \tag{174a}$$

$$dQ^K(t) = \omega_2^1 D_1 e^{\nu_1 t} + \omega_2^2 D_2 e^{\nu_2 t} + \omega_2^3 D_3 e^{\nu_3 t} + \omega_2^6 D_6 e^{\nu_6 t} + \omega_2^7 D_7 e^{\nu_7 t}, \tag{174b}$$

$$dZ^A(t) = \omega_3^1 D_1 e^{\nu_1 t} + \omega_3^2 D_2 e^{\nu_2 t} + \omega_3^3 D_3 e^{\nu_3 t} + \omega_3^6 D_6 e^{\nu_6 t} + \omega_3^7 D_7 e^{\nu_7 t}, \tag{174c}$$

$$dQ^Z(t) = \omega_4^1 D_1 e^{\nu_1 t} + \omega_4^2 D_2 e^{\nu_2 t} + \omega_4^3 D_3 e^{\nu_3 t} + \omega_4^6 D_6 e^{\nu_6 t} + \omega_4^7 D_7 e^{\nu_7 t}, \tag{174d}$$

$$dS(t) = \omega_5^1 D_1 e^{\nu_1 t} + \omega_5^2 D_2 e^{\nu_2 t} + \omega_5^3 D_3 e^{\nu_3 t} + \omega_5^6 D_6 e^{\nu_6 t} + \omega_5^7 D_7 e^{\nu_7 t}, \tag{174e}$$

$$d\tau(t) = D_6 e^{\nu_6 t}, \tag{174f}$$

$$dZ^{W,j}(t) = D_7 e^{\nu_7 t}, \tag{174g}$$

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

Setting $t = 0$ into the solutions for the stock of capital, (174a), the stock of knowledge, (174c), and the stock of consumption habits, (174e), 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:

$$\begin{pmatrix} 1 & 1 & 1 \\ \omega_3^1 & \omega_3^2 & \omega_3^3 \\ \omega_5^1 & \omega_5^2 & \omega_5^3 \end{pmatrix} \begin{pmatrix} D_1 \\ D_2 \\ D_3 \end{pmatrix} = \begin{pmatrix} \Psi_1 \\ \Psi_2 \\ \Psi_3 \end{pmatrix}, \tag{175}$$

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

To find eigenvectors ω_k^6, we solve

$$\begin{pmatrix} \Upsilon_K - \nu_6 & \Upsilon_{Q^K} & \Upsilon_{Z^A} & \Upsilon_{Q^Z} & \Upsilon_S \\ \Sigma_K & \Sigma_{Q^K} - \nu_6 & \Sigma_{Z^A} & \Sigma_{Q^Z} & \Sigma_S \\ \Pi_K & \Pi_{Q^K} & \Pi_{Z^A} - \nu_6 & \Pi_{Q^Z} & \Pi_S \\ \Gamma_K & \Gamma_{Q^K} & \Gamma_{Z^A} & \Gamma_{Q^Z} - \nu_6 & \Gamma_S \\ \Theta_K & \Theta_{Q^K} & \Theta_{Z^A} & \Theta_{Q^Z} & \Theta_S - \nu_6 \end{pmatrix} \begin{pmatrix} \omega_1^6 \\ \omega_2^6 \\ \omega_3^6 \\ \omega_4^6 \\ \omega_5^6 \end{pmatrix} = \begin{pmatrix} -\Upsilon_\tau \\ -\Sigma_\tau \\ -\Pi_\tau \\ -\Gamma_\tau \\ -\Theta_\tau \end{pmatrix} \tag{176}$$

and to find eigenvectors ω_k^7, we solve:

$$\begin{pmatrix} \Upsilon_K - \nu_7 & \Upsilon_{Q^K} & \Upsilon_{Z^A} & \Upsilon_{Q^Z} & \Upsilon_S \\ \Sigma_K & \Sigma_{Q^K} - \nu_7 & \Sigma_{Z^A} & \Sigma_{Q^Z} & \Sigma_S \\ \Pi_K & \Pi_{Q^K} & \Pi_{Z^A} - \nu_7 & \Pi_{Q^Z} & \Pi_S \\ \Gamma_K & \Gamma_{Q^K} & \Gamma_{Z^A} & \Gamma_{Q^Z} - \nu_7 & \Gamma_S \\ \Theta_K & \Theta_{Q^K} & \Theta_{Z^A} & \Theta_{Q^Z} & \Theta_S - \nu_7 \end{pmatrix} \begin{pmatrix} \omega_1^7 \\ \omega_2^7 \\ \omega_3^7 \\ \omega_4^7 \\ \omega_5^7 \end{pmatrix} = \begin{pmatrix} -\Upsilon_{Z^{W,j}} \\ -\Sigma_{Z^{W,j}} \\ -\Pi_{Z^{W,j}} \\ -\Gamma_{Z^{W,j}} \\ -\Theta_{Z^{W,j}} \end{pmatrix} \tag{177}$$

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:

$$R^{K,j,\prime} = \frac{R^{K,j} - \delta_K}{1-\tau} + \delta_K, \tag{178a}$$

$$R^{Z,j,\prime} = \frac{R^{Z,j}}{1-\tau}. \tag{178b}$$

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

$$P_C C = P^H C^H + C^F + P^N C^N, \tag{179a}$$

$$P_J^K J^K = P^H J^{K,H} + J^{K,F} + P^N J^{K,N}, \tag{179b}$$

$$P_J^Z J^Z = P^H J^{Z,H} + P^N J^{Z,N}, \tag{179c}$$

$$T = G = P^H G^H + G^F + P^N G^N, \tag{179d}$$

$$P^j Y^j \left(\frac{1 + \nu_Z^j \theta_Z^j}{\mu^j} \right) = \left(W^j L^j + R^{K,j,\prime} \tilde{K}^j + R^{Z,j,\prime} \tilde{Z}^j \right). \tag{179e}$$

where (179e) follows from Euler theorem and free entry condition which implies

$$\frac{P^j F^j}{1-\tau} = P^j Y^j \left[1 - \frac{1+\nu_Z^j \theta_Z^j}{\mu^j}\right], \tag{180a}$$

$$O^j \equiv Y^j - F^j = P^j Y^j \left(\frac{1+\nu_Z^j \theta_Z^j}{\mu^j}\right) = W^j L^j + R^{K,j,\prime} \tilde{K}^j + R^{Z,j,\prime} \tilde{Z}^j. \tag{180b}$$

Using (179e), inserting (179a)-(179c) into (86) and invoking market clearing conditions for non-traded goods (167b) and home-produced traded goods (167a) yields:

$$\begin{aligned}\dot{N} &= r^\star N + P^H \left(Y^H - C^H - G^H - J^{K,H} - J^{Z,H} - C^{K,H} K^H - C^{Z,H} Z^H\right) - \left(C^F + J^{K,F} + G^F\right), \\ &= r^\star N + P^H X^H - M^F, \end{aligned} \tag{181}$$

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

$$M^F = C^F + G^F + J^{K,F}. \tag{182}$$

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 (181), inserting solutions (174a)-(174g), integrating over $(0,t)$, solving, invoking the transversality condition leads to the stable convergent path for the stock of net foreign assets:

$$dN(t) = \frac{E_1 D_1}{\nu_1 - r^\star} e^{\nu_1 t} + \frac{E_2 D_2}{\nu_2 - r^\star} e^{\nu_2 t} + \frac{E_3 D_3}{\nu_3 - r^\star} e^{\nu_3 t} + \frac{E_6 D_6}{\nu_6 - r^\star} e^{\nu_6 t} + \frac{E_7 D_7}{\nu_7 - r^\star} e^{\nu_7 t}, \tag{183}$$

and the intertemporal solvency condition

$$dN + \frac{E_1 D_1}{\nu_1 - r^\star} + \frac{E_2 D_2}{\nu_2 - r^\star} + \frac{E_3 D_3}{\nu_3 - r^\star} + \frac{E_6 D_6}{\nu_6 - r^\star} + \frac{E_7 D_7}{\nu_7 - r^\star}, \tag{184}$$

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

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:

$$d\tau(t) = d\tau + x_T e^{-\xi_T t}, \tag{185}$$

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 (185) w.r.t. time leads to:

$$\dot{\tau}(t) = -\xi_T d\tau(t), \tag{186}$$

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 increases the absorption capacity of international ideas or symmetrically reduces 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 $Z^{W,j}$ evolves according to the following dynamic equation:

$$dZ^{W,j}(t) = dZ^{W,j} + x_Z e^{-\xi_Z^j t} \tag{187}$$

where $dZ^{W,j}(t) = Z^{W,j} - Z_0^{W,j}$; x_Z^j parametrizes the variation of the international stock of knowledge on impact; xi_Z^j 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 (187) in percentage deviation relative to the initial steady-state by dividing both sides by the initial level of the international stock of knowledge (which is normalized to one):

$$\hat{Z}^W(t) = \hat{Z}^{W,j} + x_Z^j e^{-\xi_Z^j t}, \tag{188}$$

where $\hat{Z}^{W,j}(\infty) = \hat{Z}^{W,j}$ with $\hat{Z}^{W,j}$ the steady-state (permanent) change in percentage in the international stock of knowledge. Differentiating (187) w.r.t. time leads to:

$$\dot{Z}^{W,j}(t) = -\xi_Z^j dZ^{W,j}(t), \tag{189}$$

where $dZ^{W,j}(t) = Z^{W,j}(t) - Z^{W,j}$ 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 (172a)-(172g), the linearized system can be written in a matrix form:

$$\begin{pmatrix} \dot{K}(t) \\ \dot{Q}^K(t) \\ \dot{Z}^A(t) \\ \dot{Q}^Z(t) \\ \dot{S}(t) \\ \dot{\tau}(t) \\ \dot{Z}^{W,j}(t) \end{pmatrix} = \begin{pmatrix} \Upsilon_K & \Upsilon_{Q^K} & \Upsilon_{Z^A} & \Upsilon_{Q^Z} & \Upsilon_S & \Upsilon_\tau & \Upsilon_{Z^{W,j}} \\ \Sigma_K & \Sigma_{Q^K} & \Sigma_{Z^A} & \Sigma_{Q^Z} & \Sigma_{Z^A} & \Sigma_\tau & \Sigma_{Z^{W,j}} \\ \Pi_K & \Pi_{Q^K} & \Pi_{Z^A} & \Pi_{Q^Z} & \Pi_S & \Pi_\tau & \Pi_{Z^{W,j}} \\ \Gamma_K & \Gamma_{Q^K} & \Gamma_{Z^A} & \Gamma_{Q^Z} & \Gamma_S & \Gamma_\tau & \Gamma_{Z^{W,j}} \\ \Theta_K & \Theta_{Q^K} & \Theta_{Z^A} & \Theta_{Q^Z} & \Theta_S & \Theta_\tau & \Theta_{Z^{W,j}} \\ 0 & 0 & 0 & 0 & 0 & -\xi_T & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & -\xi_Z^j \end{pmatrix} \begin{pmatrix} dK(t) \\ dQ^K(t) \\ dZ^A(t) \\ dQ^Z(t) \\ dS(t) \\ d\tau(t) \\ dZ^{W,j}(t) \end{pmatrix}. \tag{190}$$

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., $K(0) = K_0$, $Z^A(0) = Z_0^A$, $S(0) = S_0$, $\tau(0) = \tau_0$, $Z^{W,j}(0) = Z_0^{W,j}$.

Convergent solutions toward the stable manifold read:

$$dK(t) = D_1 e^{\nu_1 t} + D_2 e^{\nu_2 t} + D_3 e^{\nu_3 t} + \omega_1^6 D_6 e^{\nu_6 t} + \omega_1^7 D_7 e^{\nu_7 t}, \tag{191a}$$

$$dQ^K(t) = \omega_2^1 D_1 e^{\nu_1 t} + \omega_2^2 D_2 e^{\nu_2 t} + \omega_2^3 D_3 e^{\nu_3 t} + \omega_2^6 D_6 e^{\nu_6 t} + \omega_2^7 D_7 e^{\nu_7 t}, \tag{191b}$$

$$dZ^A(t) = \omega_3^1 D_1 e^{\nu_1 t} + \omega_3^2 D_2 e^{\nu_2 t} + \omega_3^3 D_3 e^{\nu_3 t} + \omega_3^6 D_6 e^{\nu_6 t} + \omega_3^7 D_7 e^{\nu_7 t}, \tag{191c}$$

$$dQ^Z(t) = \omega_4^1 D_1 e^{\nu_1 t} + \omega_4^2 D_2 e^{\nu_2 t} + \omega_4^3 D_3 e^{\nu_3 t} + \omega_4^6 D_6 e^{\nu_6 t} + \omega_4^7 D_7 e^{\nu_7 t}, \tag{191d}$$

$$dS(t) = \omega_5^1 D_1 e^{\nu_1 t} + \omega_5^2 D_2 e^{\nu_2 t} + \omega_5^3 D_3 e^{\nu_3 t} + \omega_5^6 D_6 e^{\nu_6 t} + \omega_5^7 D_7 e^{\nu_7 t}, \tag{191e}$$

$$d\tau(t) = D_6 e^{\nu_6 t}, \tag{191f}$$

$$dZ^{W,j}(t) = D_7 e^{\nu_7 t}, \tag{191g}$$

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

$$\begin{pmatrix} 1 & 1 & 1 \\ \omega_3^1 & \omega_3^2 & \omega_3^3 \\ \omega_5^1 & \omega_5^2 & \omega_5^3 \end{pmatrix} \begin{pmatrix} D_1 \\ D_2 \\ D_3 \end{pmatrix} = \begin{pmatrix} K_0 - K - \omega_1^6 D_6 - \omega_1^7 D_7 \\ Z_0^A - Z^A - \omega_3^6 D_6 - \omega_3^7 D_7 \\ S_0 - S - \omega_5^6 D_6 - \omega_5^7 D_7 \end{pmatrix}. \tag{192}$$

The three equations can be jointly solved for the three arbitrary constants D_1, D_2, D_3 associated with the three negative eigenvalues $\nu_1 < 0$, $\nu_2 < 0$, $\nu_3 < 0$.

It is straightforward to solve for the arbitrary constants D_6 and D_7: by setting $t = 0$ into (191f)-(191g):

$$\tau(0) - \tau = \tau_0 - \tau = D_6 = x_T, \tag{193a}$$

$$Z^{W,j}(0) - Z^{W,j} = Z_0^{W,j} - Z^{W,j} = D_7 = x_Z^j. \tag{193b}$$

F.3 Formal Solution for the Stock of Non Human Wealth, $A(t)$

Saving equation. 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 (106h) and intangible capital (106i), inserting the accumulation equations for tangible assets (91), intangible assets (103), and for traded bonds (86), yields the accumulation equation for the stock of financial wealth or the dynamic equation for private savings:

$$\dot{A}(t) = r^\star A(t) + \sum_{j=H,N} W^j(t)L^j(t) - \text{Tax}(t) - P_C(t)C(t), \tag{194}$$

where we assume that the government levies lump-sum taxes, $\text{Tax}(t)$, in addition to fiscal revenues from corporate income taxation to finance purchases of foreign-produced and home-produced traded goods and non-traded goods, i.e., $G^F + P^H(t)G^H + P^N(t)G^N = \text{Tax}(t) + \sum_{j=H,N} \tau(t)\text{NOS}^j(t)$, 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:

$$P_J J^K = P_J^K \frac{\partial J^K}{\partial I^K} I^K + P_J^K \frac{\partial J^K}{\partial K} K, \tag{195a}$$

$$P_J^Z J^Z = P_J \frac{\partial J^Z}{\partial I^Z} I^Z + P_J^Z \frac{\partial J^Z}{\partial Z^A} Z^A, \tag{195b}$$

where $\frac{\partial J^K}{\partial I^K} = Q^K$ and $\frac{\partial J^Z}{\partial I^Z} = Q^Z$.

Solution for the stock of non-human wealth. To determine the formal solution for the stock of non-human wealth, we first linearize (194) in the neighborhood of the steady-state

$$\dot{A}(t) = r^\star \left(A(t) - \tilde{A}\right) + \sum_X \Lambda_X \left(X(t) - \tilde{X}\right), \tag{196}$$

where $X = K, Q^K, Z^A, Q^Z, S, \tau, Z^{W,j}$, 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 $Z^{W,j}$, which are described by (191a) and (191g), remembering that $D_4 = D_5 = 0$, integrating over $(0, t)$, solving, invoking the transversality condition leads to the stable convergent path for the stock of non financial wealth:

$$dA(t) = \frac{F_1 D_1}{\nu_1 - r^\star} e^{\nu_1 t} + \frac{F_2 D_2}{\nu_2 - r^\star} e^{\nu_2 t} + \frac{F_3 D_3}{\nu_3 - r^\star} e^{\nu_3 t} + \frac{F_6 D_6}{\nu_6 - r^\star} e^{\nu_6 t} + \frac{F_7 D_7}{\nu_7 - r^\star} e^{\nu_7 t}, \tag{197}$$

and the intertemporal solvency condition

$$dA + \frac{F_1 D_1}{\nu_1 - r^\star} + \frac{F_2 D_2}{\nu_2 - r^\star} + \frac{F_3 D_3}{\nu_3 - r^\star} + \frac{F_6 D_6}{\nu_6 - r^\star} + \frac{F_7 D_7}{\nu_7 - r^\star}, \tag{198}$$

where $\nu_1, \nu_2, \nu_3, \nu_6, \nu_7 < 0$, $F_i = \Delta_K + \Delta_{Q^K} \omega_2^i + \Delta_{Z^A} \omega_3^i + \Delta_{Q^Z} \omega_4^i + \Delta_S \omega_5^i$ for $i = 1, 2, 3$, $F_6 = \Delta_K \omega_1^6 + \Delta_{Q^K} \omega_2^6 + \Delta_{Z^A} \omega_3^6 + \Delta_{Q^Z} \omega_4^6 + \Delta_S \omega_5^6 + \Delta_\tau$, $F_7 = \Delta_K \omega_1^7 + \Delta_{Q^K} \omega_2^7 + \Delta_{Z^A} \omega_3^7 + \Delta_{Q^Z} \omega_4^7 + \Delta_S \omega_5^7 + \Delta_{Z^{W,j}}$.

F.4 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:

$$Q^K(t)K(t) - P_J^K K = P_J \left(K(t) - K\right) + K \left(Q^K(t) - P_J^K\right), \tag{199}$$

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. (185) and eq. (187):

$$Q^K(t)K(t) - P_J^K K = \sum_{i=1,2,3,6,7} V_i^K D_i e^{\nu_i t}, \tag{200}$$

where $V_i^K = P_J^K \omega_1^i + K \omega_2^i$. Totally differentiating (200) w.r.t. time gives the trajectory for investment in tangible assets along the transitional path:

$$\frac{d(Q^K(t)K(t))}{dt} = \nu_i \sum_{i=1,2,3} V_i^K D_i e^{\nu_i t}. \tag{201}$$

The same logic applies to $Q^Z(t)Z^A(t)$:

$$Q^Z(t)Z^A(t) - P_J^Z Z^A = \sum_{i=1,2,3,6,7} V_i^Z D_i e^{\nu_i t}, \tag{202}$$

where $V_i^Z = P_J^Z \omega_1^i + Z^A \omega_2^i$. Totally differentiating (202) w.r.t. time gives the trajectory for investment in intangible assets along the transitional path:

$$\frac{d(Q^Z(t)Z^A(t))}{dt} = \nu_i \sum_{i=1,2,3} V_i^Z D_i e^{\nu_i t}. \tag{203}$$

Current account is equal to savings minus investment in tangible and intangible assets. Since $N(t) = A(t) - Q^K(t)K(t) - Q^Z(t)Z^A(t)$, we thus have:

$$\dot{N}(t) = \dot{A}(t) - \frac{d\left(Q^K(t)K(t)\right)}{dt} - \frac{dQ^Z(t)Z^A(t)}{dt}, \tag{204}$$

where expressions for the current account, national savings, investment in tangible assets and in intangible assets are given by (183), (197), (201), and (203), respectively.

G Data Description for Calibration

G.1 Non-Tradable Content of GDP and its Demand Components

Table 19 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 5. 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 of the Table of Table 19 which shows the (unweighed) 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:

$$\omega_C = 1 - \omega_J - \omega_G = 57\%. \tag{205}$$

As displayed by the last line of Table 19, 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:

$$\omega_J^K = \omega_J - \omega_J^Z = 23.7\% - 2.7\% = 21\%. \tag{206}$$

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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 19 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 GDP share of non-tradables as follows:

$$\begin{aligned}\omega^{Y,N} &= = \frac{P^N Y^N}{Y}, \\ &= \omega_C (1-\alpha_C) + \omega_J (1-\alpha_J) + \omega_{G^N}\omega_G = 65\%, \end{aligned} \tag{207}$$

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. Column 1 of Table 19 shows the GDP share of tradables calculated as one minus the value shown in eq. (207).

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:

$$\omega_J (1-\alpha_J) = \omega_J^K \left(1-\alpha_J^K\right) + \omega_J^Z \left(1-\alpha_J^Z\right).$$

From the above equation, we can infer the non-tradable content of investment in tangible assets, $\left(1-\alpha_J^K\right)$:

$$\left(1-\alpha_J^K\right) = \frac{\omega_J (1-\alpha_J) - \omega_J^Z \left(1-\alpha_J^Z\right)}{\omega_J^K} = 70.5\%, \tag{208}$$

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 of Table 19).

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 19 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 19 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 19 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, exports as a share of GDP, ω_X, shown in column 12 of Table 19 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:

$$\omega_X = \frac{P^H X^H}{Y} = \omega_C \alpha_C \left(1-\alpha^H\right) + \omega_J \alpha_J \left(1-\alpha_J^H\right) + \omega_G \omega_{G^F}, \tag{209}$$

$\omega_{G^F} = 1 - \omega_{G^{N,D}} - \omega_{G^{H,D}}$. The last line of column 12 of Table 19 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 20, 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 20 shows that the effective corporate income tax rate, τ, averages 22.5%.

Estimated elasticities. Columns 2 and 3 of Table 20 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 to pin down these parameters is described below 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 20 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:

$$\hat{y}_t = \alpha + \beta^K \hat{x}_t^K + \beta^L \hat{x}_t^L + \varepsilon_t^j, \tag{210}$$

where α is a constant, $x_t^K = \left(\hat{P}_t^Q + \hat{Q}_t\right) - \left(\hat{R}_t^K + \hat{K}_t\right)$ is output growth minus capital income growth, $x_t^L = \left(\hat{W}_t + \hat{L}_t\right) - \left(\hat{R}_t^K + \hat{K}_t\right)$ 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:

$$\begin{aligned}\hat{y}_t &= \left(\hat{P}_t^Q + \hat{Q}_t\right) - \theta^L \left(\hat{W}_t + \hat{L}_t\right) \\ &- \theta^M \left(\hat{P}_t^M + \hat{M}_t\right) - \left(1 - \theta^L - \theta^M\right)\left(\hat{R}_t^K + \hat{K}_t\right).\end{aligned} \tag{211}$$

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. The time series for these variables are constructed from the EU KLEMS and STAN databases, 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:

$$L = \left[\int_0^M \left(\vartheta^j\right)^{-\frac{1}{\epsilon^L}} \left(L^j\right)^{\frac{\epsilon^L+1}{\epsilon^L}} dj\right]^{\frac{\epsilon^L}{\epsilon^L+1}}. \tag{212}$$

Optimal labor supply L^j to sector j is

$$L^j = \vartheta^j \left(\frac{W^j}{W}\right)^{\epsilon^L} L. \tag{213}$$

For simplicity purposes, we assume that goods market are perfectly competitive. 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:

$$s_L^j \frac{P^j Y^j}{L^j} = W^j, \tag{214a}$$

$$\left(1 - s_L^j\right) \frac{P^j Y^j}{K^j} = R^j. \tag{214b}$$

Inserting labor demand (214a) into labor supply to sector j (213) and solving leads the share of sector j in aggregate labor:

$$\frac{L^j}{L} = \left(\vartheta^j\right)^{\frac{1}{\epsilon^L+1}} \left(\frac{s_L^j P^j Y^j}{\int_0^M s_L^j P^j Y^j dj}\right)^{\frac{\epsilon^L}{\epsilon^L+1}}, \tag{215}$$

Table 19: Ratios to Calibrate the Two-Sector Model

Countries	Tradable share					Input share						Home share				LIS		Aggregate ratios		
	GDP	Cons.	K-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/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/Y is the investment-to-GDP ratio which includes investment in tangible and intangible assets, G/Y is government spending as a share of GDP; I^Z/Y is the share of investment in R&D in GDP.

Table 20: 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.

where we used the fact that the aggregate wage rate can be rewritten as follows:

$$W = \frac{\int_0^M s_L^j P^j Y^j dj}{L}. \tag{216}$$

We denote by β^j the fraction of labor's share of value added accumulating to labor in sector j:

$$\beta^j = \frac{s_L^j P^j Y^j}{\sum_{j=1}^M s_L^j P^j Y^j}. \tag{217}$$

Using (217), the labor share in sector j (215) can be rewritten as follows:

$$\frac{L^j}{L} = \left(\vartheta^j\right)^{\frac{1}{\epsilon^L+1}} \left(\beta^j\right)^{\frac{\epsilon^L}{\epsilon^L+1}}. \tag{218}$$

Introducing a time subscript and taking logarithm, eq. (218) reads as:

$$\ln\left(\frac{L^j}{L}\right)_t = \frac{1}{\epsilon^L+1}\ln\vartheta^j + \frac{\epsilon^L}{\epsilon^L+1}\ln\beta_t^j. \tag{219}$$

Totally differentiating (219), 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:

$$\hat{L}_{it}^j - \hat{L}_{it} = f_i + f_t + \gamma_i \hat{\beta}_{it}^j + \nu_{it}^j, \tag{220}$$

where

$$\hat{L}_{it} = \sum_{j=1}^M \beta_{i,t-1}^j \hat{L}_{i,t}^j. \tag{221}$$

and

$$\beta_{it}^j = \frac{s_{L,i}^j P^j Y_{it}^j}{\sum_{j=1}^M s_{L,i}^j P_{it}^j Y_{it}^j}, \tag{222}$$

where $s_{L,i}^j$ is the labor income share in sector j in country i which is averaged over 1973-2017. Y^j is value added.

Elasticity of labor supply across sectors. We use panel data to estimate (220) where $\gamma_i = \frac{\epsilon_i^L}{\epsilon_i^L+1}$ and β_{it}^j is given by (217). The LHS term of (220) is calculated as the difference between changes (in percentage) in hours worked in sector j, $\hat{L}_{i,t}^j$, and in total

Table 21: Estimates of Elasticity of Labor Supply across Sectors (ϵ_L), 1973-2017

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.

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 $P_t^j Y_t^j$ value added at current prices in sector $j = H, N$ at time t, β_t^j is computed as $\frac{s_L^j P_t^j Y_t^j}{\sum_{j=H}^N s_L^j P_t^j Y_t^j}$ where s_L^j 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 1973-2017. 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., $\hat{L}_t = \sum_{j=H}^N \beta_{t-1}^j \hat{L}_t^j$. The parameter we are interested in, say the degree of substitutability of hours worked across sectors, is given by $\epsilon_i^L = \gamma_i/(1-\gamma_i)$. In the regressions that follow, the parameter γ_i is assumed to be different across countries when estimating ϵ_i^L 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 and OECD STAN. The sample includes the 11 OECD countries mentioned above over the period 1974-2017 (except for Japan: 1974-2015).

Table 21 reports empirical estimates which are consistent with $\epsilon_L > 0$. All values are statistically significant at 10% except for Luxembourg. Abstracting from the estimated 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 20. 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:

$$K = \left[\int_0^M \left(\vartheta_K^j\right)^{-\frac{1}{\epsilon^K}} \left(K^j\right)^{\frac{\epsilon^K+1}{\epsilon^K}} dj\right]^{\frac{\epsilon^K}{\epsilon^K+1}}. \tag{223}$$

Optimal capital supply K^j to sector j reads:

$$K^j = \vartheta_K^j \left(\frac{R^j}{R^K}\right)^{\epsilon^K} K. \tag{224}$$

The demand for labor and capital are described by:

$$s_L^j \frac{P^j Y^j}{L^j} = W^j, \tag{225a}$$

$$\left(1 - s_L^j\right) \frac{P^j Y^j}{K^j} = R^j. \tag{225b}$$

Inserting labor demand (225a) into capital supply to sector j (224) and solving leads the share of sector j in aggregate labor:

$$\frac{K^j}{K} = \left(\vartheta_K^j\right)^{\frac{1}{\epsilon^K+1}} \left(\frac{\left(1 - s_L^j\right) P^j Y^j}{\int_0^M \left(1 - s_L^j\right) P^j Y^j dj}\right)^{\frac{\epsilon^K}{\epsilon^K+1}}, \tag{226}$$

where we have used the fact that aggregate capital rental rate reads:

$$R^K = \frac{\int_0^M \left(1 - s_L^j\right) P^j Y^j dj}{K}. \tag{227}$$

We denote by $\beta^{K,j}$ the ratio of capital income in sector j to overall capital income:

$$\beta^{K,j} = \frac{\left(1 - s_L^j\right) P^j Y^j}{\sum_{j=1}^M \left(1 - s_L^j\right) P^j Y^j}. \tag{228}$$

Using (228), the share of capital in sector j (226) can be rewritten as follows:

$$\frac{K^j}{K} = \left(\vartheta_K^j\right)^{\frac{1}{1+\epsilon^K}} \left(\beta^{K,j}\right)^{\frac{\epsilon^K}{\epsilon^K+1}}. \tag{229}$$

Introducing a time subscript and taking logarithm, eq. (229) reads as:

$$\ln\left(\frac{K^j}{K}\right)_t = \frac{1}{\epsilon^K+1} \ln \vartheta_K^j + \frac{\epsilon^K}{\epsilon^K+1} \ln \beta_t^{K,j}. \tag{230}$$

We denote the rate of growth of the variable with a hat. We totally differentiate (230) and include country fixed effects captured by country dummies, g_i, and common macroeconomic shocks captured by year dummies, g_t:

$$\hat{K}_{it}^j - \hat{K}_{it} = g_i + g_t + \gamma_i^K \hat{\beta}_{it}^{K,j} + \nu_{it}^{K,j}. \tag{231}$$

We use panel data to estimate (231). 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:

$$\hat{K}_{it} = \sum_{j=1}^M \beta_{i,t-1}^{K,j} \hat{K}_{i,t}^j. \tag{232}$$

and

$$\beta_{it}^{K,j} = \frac{\left(1 - s_{L,i}^j\right) P_{it}^j Y_{it}^j}{\sum_{j=1}^M \left(1 - s_{L,i}^j\right) P_{it}^j Y_{it}^j}, \tag{233}$$

Table 22: Elasticity of Capital Supply across Sectors (ϵ_K), 1973-2017

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.

where $\left(1 - s^j_{L,i}\right)$ is the capital income share in sector j in country i which is averaged over 1973-2017. 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] databases which provide disaggregated capital stock data (at constant prices) at the 1-digit ISIC-rev.3 level for up to 11 industries. See column 1 of Table 24 as the time period varies across countries. To construct $\hat{K}^j_{it}$ and $\hat{\beta}^{K,j}_{it}$ we combine raw data on capital stock K^j, nominal value added P^jY^j and labor compensation W^jL^j to calculate $1 - s^j_L$.

Degree of capital mobility across sectors. We use panel data to estimate eq. (231) where $\gamma^K_i = \frac{\epsilon_{K,i}}{\epsilon_{K,i}+1}$ and $\beta^{K,j}_{it}$ is given by (233). Table 22 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 20. The values are low for all countries of the sample which suggests high capital mobility costs across sectors in OECD countries.

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., $C^N_t = (1-\varphi)\left(\frac{P^N_t}{P_{C,t}}\right)^{-\phi} C_t$, 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:

$$1-\alpha_{C,t} = \frac{P_t^N C_t^N}{P_{C,t} C_t} = (1-\varphi)\left(\frac{P_t^N}{P_{C,t}}\right)^{1-\phi}. \tag{234}$$

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 1973 to 2017, we construct time series for the share of non-tradables by using the market clearing condition for non-tradables:

$$\frac{P_t^N C_t^N}{P_{C,t} C_t} = \frac{1}{\omega_{C,t}}\left[\frac{P_t^N Y_t^N}{Y_t} - (1-\alpha_J)\,\omega_{J,t} - \omega_{G^N}\omega_{G,t}\right]. \tag{235}$$

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 (234), we take the logarithm of both sides of (234) and run the regression of the logged share of non-tradables on the logged ratio of non-traded prices to the consumption price index:

$$\ln(1-\alpha_{C,it}) = f_i + f_t + \alpha_i\ .t + (1-\phi)\ln\left(P^N/P_C\right)_{it} + \mu_{it}, \tag{236}$$

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 (234) 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]), OECD [2011], [2017] databases (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 (236) 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 (236) is reported in Table 23. We find a value for the elasticity of substitution between traded and non-traded goods in consumption of 0.45 which almost collapses to the estimated value of 0.44 documented by Stockman and Tesar [1995] and commonly chosen by the open economy macroeconomics literature.

Table 23: Elasticity of Substitution between Tradables and Non-Tradables (ϕ)

	eq. (236)
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.

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 $\mathsf{Z}^j(t)$ is made up of a domestic $Z^j(t)$ (we ignore the technology utilization rate) and an international stock of knowledge $Z^{W,j}(t)$:

$$\mathsf{Z}^j(t) = \left(Z^j_i(t)\right)^{\theta^j_Z} \left(Z^{W,j}(t)\right)^{1-\theta^j_Z}, \tag{237}$$

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:

$$\mathcal{T}^j_t = \left(Z^j_i(t)\right)^{\nu^j_Z \theta^j_Z} \left(Z^{W,j}(t)\right)^{\nu^{W,j}_Z\left(1-\theta^j_Z\right)}, \tag{238}$$

where ν^j_Z ($\nu^{W,j}_Z$) 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 (238), 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:

$$\ln \mathrm{T}^j_{it} = \alpha_i + \beta_i t + \gamma^j \ln Z^j_{it} + \gamma^{W,j} \ln Z^{W,j}_{it} + \eta_{it}, \tag{239}$$

where we include country fixed effects and country-specific linear time trend and we estimate $\gamma^j = \nu^j_Z \theta^j_Z$ and $\gamma^{W,j} = \nu^{W,j}_Z \left(1-\theta^j_Z\right)$. Because θ^j_Z is the domestic component of country-level-utilization-adjusted-TFP we obtain from the principal component analysis, we can infer $\nu^j_Z = \frac{\gamma^j}{\theta^j_Z}$ and $\nu^{W,j}_Z = \frac{\gamma^{W,j}}{1-\theta^j_Z}$.

We use data 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 24 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 $Z^{W,j}_{it}$ relevant to sector $j = H, N$, 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 25. The world component of traded technology amounts to 43.7% which implies that $\theta_Z^H = 56.3\%$ for tradables. The world component of non-traded technology is lower and stands at 37.5% which implies that $\theta_Z^N = 62.5\%$ for non-tradables.

Table 26 shows estimation results from the regression of eq. (239) 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).

Table 24: Stock of Capital (KLEMS) and Stock of R&D (KLEMS) at Industry Level: Data Availability

	data on K from KLEMS (1)	data on stock R&D (2)
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 25: The Share of Variance of TFP Growth Attributable to World TFP Growth (in %)

	Total Variance (1)	Variance World (2)	Contribution in % World (3)	Country-level (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.

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 $\gamma^N = \gamma^{W,N} = 0$.

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 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 $\nu_Z^{W,H} = \frac{0.104}{0.437} = 0.238$. The same logic applies to the non-traded sector. Because estimates values are not statistically significant, we have $\nu_Z^N = \nu_Z^{W,N} = 0$.

English-speaking and Scandinavian countries, $N = 6$. For English-speaking and Scandinavian countries, the second row of Table 26 shows that the elasticity of utilization-

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 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 (3.33)	0.016 (0.55)	0.292^a (8.10)	0.104^a (5.39)	−0.007 (−0.14)	0.012 (1.12)
Flex. wage N=6	0.110^a (7.94)	0.043^a (2.62)	0.506^a (11.89)	0.134^a (4.62)	0.024^b (2.50)	0.044^a (4.83)
Rigid. wage N=4	-0.241^a (−4.46)	-0.023^b (2.34)	-0.030^c (−1.74)	0.059^a (2.87)	-0.053^a (−3.29)	-0.036^a (−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 $Z_{it}^{W,j}$ 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:

$$\ln \mathrm{T}_{it}^j = \alpha_i + \beta_i t + \gamma^j \ln Z_{it}^j + \gamma^{W,j} \ln Z_{it}^{W,j} + \eta_{it},$$

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., $Z_{it}^{W,j} = \Pi_{k=1}^{10}\left(Z_{kt}^j\right)^{\alpha_{ik}^M}$ 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.

Table 27: 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 ($\hat{\gamma}_i^{W,j}$) for English-Speaking and Scandinavian Countries

	Sector H		Sector N	
	$\hat{\gamma}_i^j$	$\hat{\gamma}_i^{W,j}$	$\hat{\gamma}_i^j$	$\hat{\gamma}_i^{W,j}$
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:

$$\ln \mathrm{T}_{it}^j = \alpha_i + \beta_i t + \gamma^j \ln Z_{it}^j + \gamma^{W,j} \ln Z_{it}^{W,j} + \eta_{it},$$

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., $Z_{it}^{W,j} = \Pi_{k=1}^{10}\left(Z_{kt}^j\right)^{\alpha_{ik}^M}$ 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 28: 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 ($\hat{\gamma}_i^{W,j}$) for Continental European Countries

	Sector H		Sector N	
	$\hat{\gamma}_i^j$	$\hat{\gamma}_i^{W,j}$	$\hat{\gamma}_i^j$	$\hat{\gamma}_i^{W,j}$
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 $Z_{it}^{W,j}$ 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:

$$\ln \mathrm{T}_{it}^j = \alpha_i + \beta_i t + \gamma^j \ln Z_{it}^j + \gamma^{W,j} \ln Z_{it}^{W,j} + \eta_{it},$$

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., $Z_{it}^{W,j} = \Pi_{k=1}^{10} \left(Z_{kt}^j\right)^{\alpha_{ik}^M}$ 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.

adjusted-TFP of tradables w.r.t. the domestic stock of R&D of tradables amounts to $\gamma^H = 0.506$ and the elasticity of utilization-adjusted-TFP of tradables w.r.t. the international stock of R&D of tradables amounts to $\gamma^{W,H} = 0.134$. 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 the domestic component of utilization-adjusted-TFP of tradables of $\nu_Z^H = \frac{\gamma^H}{\theta_Z^H} = \frac{0.506}{0.563} = 0.899$ and an estimated effect of the international stock of knowledge on the international component of T^H of $\nu_Z^{W,H} = \frac{0.134}{0.437} = 0.307$.

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 the domestic component of utilization-adjusted-TFP of non-tradables of $\nu_Z^N = \frac{\gamma^N}{\theta_Z^N} = \frac{0.024}{0.625} = 0.038$ and an estimated effect of the international stock of knowledge on the international component of T^N of $\nu_Z^{W,N} = \frac{0.044}{0.375} = 0.118$.

Continental European 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 the international component of utilization-adjusted-TFP of tradables of $\nu_Z^{W,H} = \frac{\gamma^{W,H}}{1-\theta_Z^H} = \frac{0.059}{0.437} = 0.135$.

G.6 Elasticity of Utilization-Adjusted-TFP w.r.t. the Stock of R&D and the Country-Split

Ranking of elasticities of utilization-adjusted-TFP w.r.t. the stock of domestic R&D. Because technology is made up of a domestic and an international component with weights θ_Z^j and $1 - \theta_Z^j$, respectively, i.e.,

$$T^j(t) = \left(T^{c,j}(t)\right)^{\theta_Z^j} \left(T^{W,j}(t)\right)^{1-\theta_Z^j} \tag{240}$$

where the domestic component of technology, $T^{c,j}(t)$, is influenced by the domestic stock of knowledge $Z^j(t)$:

$$T^{c,j}(t) = \left(Z^j(t)\right)^{\nu_Z^j} \quad (241)$$

where ν_Z^j is the elasticity of $T^{c,j}(t)$ w.r.t. $Z^j(t)$, and the international component of technology, $T^{W,j}(t)$, is influenced by the international stock of knowledge $Z^{W,j}(t)$ relevant to sector $j = H, N$:

$$T^{W,j}(t) = \left(Z^{W,j}(t)\right)^{\nu_Z^{W,j}}. \quad (242)$$

To ease the discussion below where we focus on the elasticity of technology w.r.t. the domestic stock of knowledge, as long as it does not cause confusion, we set:

$$\gamma^j = \nu_Z^j \theta_Z^j. \quad (243)$$

In Table 29, we rank countries in accordance with the inferred value for the elasticity of aggregate utilization-adjusted-TFP w.r.t. to the domestic stock of knowledge. Because aggregate technology is a weighted average of sectoral technologies, in column 1, we have computed the aggregate elasticity γ^A as a weighted average of elasticities in the traded and the non-traded sectors, i.e., $\gamma^A = \nu^{Y,H}\gamma^H + \left(1 - \nu^{Y,H}\right)\gamma^N$. In computing the aggregate elasticity, we set the value for the sectoral elasticity to zero when the estimated value is not statistically significant at a standard threshold of 10%. We have computed the t-stat for γ^A by calculating the ratio $\gamma^A/Var\left(\gamma^A\right)$ where we apply the delta-method to compute the variance of the aggregate elasticity, i.e., $Var\left(\gamma^A\right) = \left(\nu^{Y,H}\right)^2 Var\left(\gamma^H\right) + \left(\nu^{Y,H}\right)^2 Var\left(\gamma^N\right)$.

Country-split. The ranking of OECD countries according to the elasticity of technology w.r.t the stock of knowledge, γ^A, reveals that continental European countries display a low elasticity (-0.03) while English-speaking and Scandinavian countries together with Japan display a relatively higher elasticity of utilization-adjusted-TFP w.r.t. the stock of R&D (0.21 on average). The estimated values for the elasticity are consistent with the responses of utilization-adjusted-TFP to a tax cut displayed by Fig. 15(c)-15(d) except for Luxembourg for which we find a low elasticity of technology w.r.t. the stock of knowledge while the response of utilization-adjusted-TFP is the highest. To be consistent with empirical responses, we split our sample by considering a group of continental European countries (including Austria, Belgium, France, Germany) and a group of English-speaking and Scandinavian countries which include the UK and the US, Finland and Sweden, plus Japan. We also include Luxembourg in the latter group because our evidence reveals the productivity gains much more pronounced than the former group and the degree of wage stickiness is also relatively lower.

As displayed by the first of the last three rows of the table where we calculate the mean of our estimates for the ten OECD countries of our sample (since Australia has not data for R&D activity by economic activity), the elasticity of technology w.r.t. the stock of knowledge is essentially zero for the non-traded sector, 0.29 for the traded sector and 0.11 at an aggregate level. The estimates display a wide heterogeneity across countries. For continental Europe, the elasticity of utilization-adjusted-TFP is essentially zero in the traded and the non-traded sector while the elasticity amounts to 0.50 for tradables and 0.05 for non-tradables in English-speaking and Scandinavian countries. It is worth mentioning that cross-country average of estimated values for tradables and non-tradables, $\gamma^H = 0.5$ and $\gamma^N = 0.05$, are very close to the estimated value for the whole group 'English-speaking and Scandinavian countries, $\gamma^H = 0.506$ and $\gamma^N = 0.024$, see Table 26.

G.7 Investment Share of Tradables

In this subsection, we document evidence which supports our choice of setting $\phi_K = \phi_Z = 1$ by showing that the investment share of tradables is stable over time for our set of OECD countries.

If we aggregate investment in tangible and in intangible assets, the optimal share of investment expenditure spent on traded inputs reads:

$$\alpha_J = \iota \left(\frac{P^T}{P_J}\right)^{1-\phi_J}, \quad (244)$$

Table 29: Country-Split Based on the Ranking of Elasticities of Utilization-Adjusted-TFP w.r.t. the Stock of Domestic R&D

	Aggregate Elasticity	Tradables	Non-Tradables	$\nu^{N,N}$
	(1)	(2)	(3)	(4)
FRA	-0.25 (-5.23)	-0.79 (-8.70)	0.00 (1.49	0.62
AUT	0.00 (0.00)	0.00 (-0.46)	0.00 (-0.36)	0.64
LUX	0.03 (1.05)	0.35 (2.14)	-0.10 (-3.24)	0.62
BEL	0.05 (1.15)	0.39 (3.53)	-0.14 (-4.48)	0.58
DEU	0.07 (1.52)	0.34 (4.28)	0.00 (-1.38)	0.68
SWE	0.12 (2.06)	0.82 (2.08)	0.00 (0.69)	0.61
JPN	0.16 (2.64)	0.00 (0.49)	0.26 (5.42)	0.61
FIN	0.18 (4.73)	0.04 (3.56)	0.02 (3.13)	0.55
GBR	0.32 (6.84)	1.53 (8.67)	-0.13 (-5.00)	0.63
USA	0.42 (6.85)	0.24 (10.04)	0.13 (3.27)	0.67
OECD-10	0.11	0.29	0.00	0.62
Low	-0.03	-0.01	-0.06	0.64
High	0.21	0.50	0.05	0.61

Notes: Columns 2 and 3 display estimates of the elasticity of utilization-adjusted with respect to the stock of R&D for tradales and non-tradables, respectively. Column 4 shows the value added share of non-tradable (at current prices) denoted by $\nu^{Y,N}$. The figures shown in column 1 are a weighted average of estimates for tradables and non-tradables, i.e., $\gamma^A = \nu^{Y,H}\gamma^H + \nu^{Y,N}\gamma^N$. Because we calculate the aggregate elasticity γ^A as a weighted average of sectoral elasticities, we have calculated the t-stat by using the delta-method; applying this method implies that $Var\left(\gamma^A\right) = \left(\nu^{Y,H}\right)^2 Var\left(\gamma^H\right) + \left(\nu^{Y,H}\right)^2 Var\left(\gamma^N\right)$. While OECD-10 displays the mean for the 10 OECD countries, 'Low' gives the mean for the four continental European countries (Austria, Belgium, France, and Germany) while 'High' gives the mean for English-Speaking (the UK and the US) and Scandinavian countries (Finland, Sweden) plus Japan and Luxembourg.

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):

$$\alpha_J^Z = \frac{P^H J^{Z,H}}{P_J^Z J^Z} = \iota_Z \left(\frac{P^H}{P_J^Z}\right)^{1-\phi_Z}, \tag{245}$$

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):

$$\alpha_J^K = \iota \left(\frac{P_J^T}{P_J^K}\right)^{1-\phi_K}, \tag{246}$$

where ϕ_K is the elasticity of substitution between traded and non-traded capital 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. 22(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. 22(c) shows that the tradable content of investment expenditure is stale over time. We detect a slight gradual decline in α_J in Fig. 22(d).

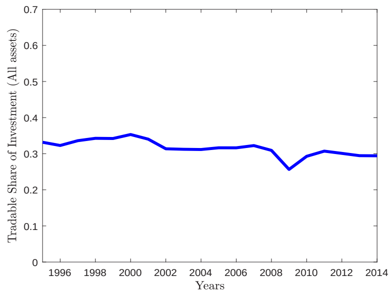
In Fig. 22(b), we plot the tradable share of investment in R&D. As it stands out, α_J^Z is stable over time. Since the tradable content of total investment expenditure (i.e., α_J) and the tradable content of investment in R&D (i.e., α_J^Z) are both stable over time, the tradable content of investment 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 Extending the Model to Wage Stickiness

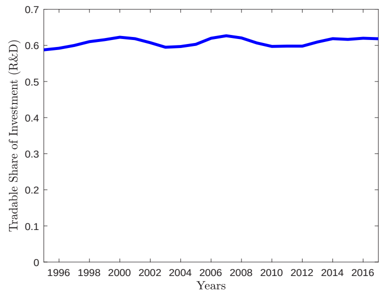
In this section, we detail the steps followed to extend the semi-small open economy model laid out in section E to sticky wages at a sectoral level. We emphasize the main changes. Households supply labor, L, and must decide on the allocation of total hours worked between the traded sector, L^H, and the non-traded sector, L^N. We assume that these labor services are sold 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 $R^{W,j}$ in exchange for labor services. Quadratic costs faced by employment agencies in adjusting the price of labor services create a gap between wages received by workers $R^{W,j}$ and the labor cost paid by intermediate good producers, W^j and are the source of sticky wages.

H.1 Households

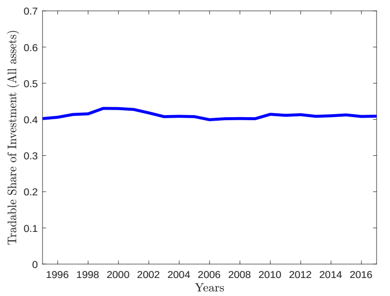
Households supply labor services to employment agencies and receive a wage rate $R^{W,j}(t)$. Thus labor income received by households reads $\sum_j R^{W,j}(t) L^j(t)$. The aggregate wage



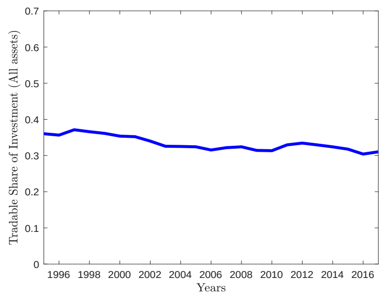
(a) Tradable Share of GFCF (Source: WIOD)



(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 22: The Investment Share in Tradables (995-2017) for 11 OECD Countries. Notes: In Fig. 22(a), 22(c), 22(d), the blue line shows the share of investment expenditure spent on tradables by using three different sources: WIOD, OECD, EU KLEMS, respectively. Fig. 22(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.

index, R^W, associated with the CES aggregator of sectoral hours defined by (64), is:

$$R^W = \left[\vartheta_L \left(R^{W,H}\right)^{\epsilon_L+1} + (1-\vartheta_L)\left(R^{W,N}\right)^{\epsilon_L+1}\right]^{\frac{1}{\epsilon_L+1}}, \tag{247}$$

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

Given the aggregate wage index, we can derive the allocation of aggregate labor supply to the traded and the non-traded sector:

$$L^H = \vartheta \left(\frac{R^{W,H}(t)}{R^W(t)}\right)^{\epsilon} L(t), \tag{248a}$$

$$L^N = (1-\vartheta) \left(\frac{R^{W,N}(t)}{R^W(t)}\right)^{\epsilon} L(t). \tag{248b}$$

As will be useful later, log-linearizing the aggregate wage index in the neighborhood of the initial steady-state leads to:

$$\hat{R}^W(t) = \alpha_L \hat{R}^{W,H}(t) + (1-\alpha_L)\hat{R}^{W,N}(t), \tag{249}$$

where α_L is the tradable content of aggregate labor compensation:

$$\alpha_L = \vartheta_L \left(\frac{R^{W,H}}{R^W}\right)^{1+\epsilon_L}, \tag{250a}$$

$$1-\alpha_L = (1-\vartheta_L) \left(\frac{R^{W,N}}{R^W}\right)^{1+\epsilon_L}. \tag{250b}$$

We assume that households are the owners of employment and human resource agencies. Imperfectly competitive employment agencies purchase labor inputs from the households, differentiate them and sell them to perfectly competitive human resource agencies in sector $j = H, N$. While the government provides a subsidy $\tau^{W,j}$ to employment agencies so as to reduce the wage markup to one, the subsidy is financed by means of a lump-sump tax $T^{W,j}$ which is transferred to the households lump sum. Employment agencies purchase labor inputs at a wage rate $R^{W,j}$ and sell it to a rate W_i^j to human resources agencies which aggregate differentiated labor services supplied by employment agencies and sell them to intermediate good producers.

Households supply labor services to firms in sector j at a wage rate $R^{W,j}(t)$. Thus labor income received by households reads $\sum_j W^j(t)L^j(t)$. The budget constraint reads:

$$
\begin{aligned}
&\dot{N}(t) + P_C(t)C(t) + \sum_{V=K,Z} P_J^V(t)J^V t) + \sum_{j=H,N} P^j(t)\left(C^{K,j}(t)\nu^{K,j}(t)K(t) + C^{Z,j}(t)\nu^{Z,j}(t)Z^A(t)\right) \\
&= r^\star N(t) + R^W(t)L(t) + R^Z(t)Z^A(t)\sum_{j=H,N}\alpha_Z^j(t)u^{Z,j} + R^K(t)K(t)\sum_{j=H,N}\alpha_K^j(t)u^{K,j} + \\
&+ \int_0^1 \Pi_i^{W,j}(t)di - \text{Tax}(t),
\end{aligned}
\tag{251}
$$

The optimal decision for consumption and labor supply read as follows:

$$
\Lambda_C\left(C(t), S(t), L(t)\right) = \bar{\lambda}P_C(t), \tag{252a}
$$

$$
-\Lambda_L\left(C(t), S(t), L(t)\right) = \bar{\lambda}R^W(t). \tag{252b}
$$

H.2 Employment Agencies, Human Resources and Wage Stickiness

Human Resource Agencies

Perfectly-competitive human resources purchases the differentiated labor services supplied by employment agencies and aggregate them using the CES technology:

$$
L^j = \left[\int_0^1 \left(L_i^j\right)^{\frac{\epsilon_W^j - 1}{\epsilon_W^j}} \mathrm{d}i\right]^{\frac{\epsilon_W^j}{\epsilon_W^j - 1}}, \tag{253}
$$

where ϵ_W^j measures the elasticity of substitution between the different types of labor. The final labor input $L^j$is then sold to intermediate goods producers. Nominal profits of the human resources agency are given by:

$$
\Pi_W^H = W^j L^j - \int_0^1 W_i^j L_i^j di, \tag{254}
$$

where W^j denotes the gross wage rate in sector j which differs from the wage rate received by the household $R^{W,j}$. Profit maximization leads to the demand for type-i of labor services:

$$
L_i^j = \left(\frac{W_i^j}{W^j}\right)^{-\epsilon_W^j} L^j. \tag{255}
$$

Employment Agencies

We assume that the monopolistic competition occurs at the employment agency level. They purchase labor inputs from the households, differentiate them and sell them to human resource agencies in sector $j = H, N$. Employment agencies experience quadratic costs in adjusting type-i labor variety and thus are the source of sticky wages: the wage wage W^j is therefore a state variable. Each employment agency i in sector j chooses the wage rate W_i^j to maximize profits subject to wage adjustment costs à la Rotemberg [1982], taking as given the demand curve for type-i of labor services and the aggregate wage rate in sector j W^j. The employment agency is subject to a nominal flow adjustment costs that are assumed to be quadratic in the rate of wage rate change and to be proportional to labor compensation in sector j:

$$
\Theta^j\left(\frac{\dot{W}_i^j}{W_i^j}\right) = \frac{\phi_W^j}{2}\left(\frac{\dot{W}_i^j}{W_i^j}\right)^2 W^j L^j, \tag{256}
$$

where $\phi_W^j > 0$ the individual wage inflation is $\pi_i^{W,j} = \frac{\dot{W}_i^j}{W_i^j}$; ϕ_W^j determines the degree of wage stickiness in sector j. We assume employment agencies receive a proportional constant subsidy on type-i labor variety, $\tau^{W,j}$, setting the steady-state markup to one. This subsidy is financed by a lump sum tax on the employment agency $T^{W,j}$.

Each employment agency maximizes the expected profit stream discounted at the real rate $r^W = r^\star - \pi^{W,j}$, i.e.,

$$
\begin{aligned}
&\max_{\dot{W}_i^j, W_i^j} \frac{\Pi_i^{W,j}(t)}{W^j(t)},\\
&\max_{\dot{W}_i^j, W_i^j} \int_0^\infty e^{-\int_0^t r^{W,j}(s)ds} \left[\frac{W_i^j\left(1+\tau^{W,j}\right) - R^{W,j}}{W^j} L_i^j - \frac{\phi_W^j}{2} \left(\frac{\dot{W}_i^j}{W_i^j}\right)^2 L^j \right], \qquad (257)
\end{aligned}
$$

subject to $\dot{W}_i^j(t) = \pi_i^{W,j}(t) W_i^j(t)$. Note that in line with the current practice, we divide the profit by the price index which collapses to the aggregate wage rate in sector j. The control variable is $\dot{W}_i^j(t)$ and the state variable is $W_i^j(t)$. To solve the optimization problem, we set up the current-value Hamiltonian:

$$
\begin{aligned}
\mathcal{H}_i^{W,j} &= \frac{W_i^j}{W^j}\left(1+\tau^{W,j}\right)\left(\frac{W_i^j}{W^j}\right)^{-\epsilon_W^j} L^j - \frac{R^{W,j}}{W^j}\left(\frac{W_i^j}{W^j}\right)^{-\epsilon_W^j} L^j - \frac{\phi_W^j}{2}\left(\frac{\dot{W}_i^j}{W_i^j}\right)^2 L^j + \Lambda_i^{W,j}\dot{W}_i^j,\\
&= \left(\frac{W_i^j}{W^j}\right)^{1-\epsilon_W^j}\left(1+\tau^{W,j}\right) L^j - \frac{R^{W,j}}{\left(W^j\right)^{1-\epsilon_W^j}}\left(W_i^j\right)^{-\epsilon_W^j} L^j - \frac{\phi_W^j}{2}\left(\frac{\dot{W}_i^j}{W_i^j}\right)^2 L^j + \Lambda_i^{W,j}\dot{W}_i^j \qquad (258)
\end{aligned}
$$

where we have inserted $L_i^j = \left(\frac{W_i^j}{W^j}\right)^{-\epsilon_W^j} L^j$ (see eq. (255)). First-order conditions read:

$$
\begin{aligned}
\frac{\partial \mathcal{H}_i^{W,j}}{\partial \dot{W}_i^j} &= 0, \qquad \phi_W^j \frac{\pi_i^{W,j}}{W_i^j} = \Lambda_i^{W,j}, \qquad (259a)\\
\frac{\partial \mathcal{H}_i^{W,j}}{\partial W_i^j} &= \left(r^\star - \pi^{W,j}\right)\Lambda_i^{W,j} - \dot{\Lambda}_i^{W,j},
\end{aligned}
$$

$$
\begin{aligned}
&\frac{\left(1-\epsilon_W^j\right)\left(W_i^j\right)^{-\epsilon_W^j}}{\left(W^j\right)^{1-\epsilon_W^j}}\left(1+\tau^{W,j}\right)L^j + \frac{R^{W,j}}{\left(W^j\right)^{1-\epsilon_W^j}}\epsilon_W^j\left(W_i^j\right)^{-\epsilon_W^j-1} L^j + \phi_W^j \frac{\left(\dot{W}_i^j\right)^2}{\left(W_i^j\right)^3} L^j\\
&\qquad = \left(r^\star - \pi^{W,j}\right)\Lambda_i^{W,j} - \dot{\Lambda}_i^{W,j},\\
&\frac{\left(1-\epsilon_W^j\right)\left(1+\tau^{W,j}\right)L^j}{W^j} + \frac{R^{W,j}\epsilon_W^j L^j}{\left(W^j\right)^2} + \phi_W^j \frac{\left(\pi^{W,j}\right)^2}{W^j} L^j\\
&\qquad = \left(r^\star - \pi^{W,j}\right)\phi_W^j \frac{\pi^{W,j}}{W^j} L^j - \phi_W^j \frac{\dot{\pi}^{W,j}}{W^j} L^j - \phi_W^j \frac{\pi^{W,j}}{W^j}\dot{L}^j + \phi_W^j \frac{\pi^{W,j}}{W^j}\frac{\dot{W}^j}{W^j} L^j,\\
&\frac{\left(1-\epsilon_W^j\right)\left(1+\tau^{W,j}\right)}{\phi_W^j} + \frac{R^{W,j}}{\phi_W^j}\frac{\epsilon_W^j}{W^j} + \left(\pi^{W,j}\right)^2 = \left(r^\star - \pi^{W,j}\right)\pi^{W,j} - \dot{\pi}^{W,j} - \pi^{W,j}\frac{\dot{L}^j}{L^j} + \left(\pi^{W,j}\right)^2,\\
&\dot{\pi}^{W,j} + \frac{\epsilon_W^j}{\phi_W^j}\left[\frac{R^{W,j}}{W^j} - \left(\frac{\epsilon_W^j - 1}{\epsilon_W^j}\right)\left(1+\tau^{W,j}\right)\right] = \pi^{W,j}\left[r^\star - \pi^{W,j} - \frac{\dot{L}^j}{L^j}\right],\\
&\dot{\pi}^{W,j} + \frac{\epsilon_W^j}{\phi_W^j}\left[\frac{R^{W,j}}{W^j} - 1\right] = \pi^{W,j}\left[r^\star - \pi^{W,j} - \frac{\dot{L}^j}{L^j}\right], \qquad (259b)
\end{aligned}
$$

where we assume a symmetric situation to get the second line of the second first-order condition, i.e., $W_i^j = W^j$, and we have inserted (259a) which has also been differentiated w.r.t. time:

$$
\dot{\Lambda}_i^{W,j} = \phi_W^j \frac{\dot{\pi}^{W,j}}{W^j} L^j + \phi_W^j \frac{\pi^{W,j}}{W^j}\dot{L}^j - \phi_W^j \frac{\pi^{W,j}}{W^j}\frac{\dot{W}^j}{W^j} L^j.
$$

To get the last line, we assume that the government sets the revenue subsidy $\tau^{W,j}$ so that

$\left(\frac{\epsilon^j_W - 1}{\epsilon^j_W}\right)\left(1+\tau^{W,j}\right) = 1$, i.e.,

$$\tau^{W,j} = \frac{1}{\epsilon^{W,j} - 1} > 0. \tag{260}$$

This subsidy $\tau^{W,j}$ is financed by a lump sum tax on the employment agency $T^{W,j}$ which is transferred to the households lump sum. We drop the subindex i because we consider a symmetric situation. The total profit of employment agencies, net of the lump sum tax is:

$$\Pi^{W,j}_i = \Pi^{W,j} = \left(W^j - R^{W,j}\right) L^j_i - \frac{\phi^j_W}{2}\left(\frac{\dot{W}^j_i}{W^j_i}\right)^2 W^j L^j. \tag{261}$$

H.3 Solving the Model

We follow the same solution method as in section E.3; $R^{W,j}$ is a flexible wage while W^j is a state variable.

Consumption in goods $g = H, N, F$. Eqs. (252a)-(252b) can be solved for consumption and hours:

$$C = C\left(\bar{\lambda}, S, P^H, P^N, R^W\right), \qquad L = L\left(\bar{\lambda}, S, P^H, P^N, R^W\right). \tag{262}$$

Consumption in goods $g = H, N, F$. Inserting first the solution for consumption (262) into (60b), (61a)-(61b), allows us to solve for C^g (with $g = H, N, F$)

$$C^g = C^g\left(\bar{\lambda}, P^N, P^H, R^{W,H}, R^{W,N}\right), \tag{263}$$

Labor supply to sector $j = H, N$. Inserting first the solution for labor (262) into (248) allows us to solve for L^j (with $j = H, N$):

$$L^j = L^j\left(\bar{\lambda}, P^N, P^H, W^H, W^N\right), \tag{264}$$

Sectoral Wages and Sectoral Rental Rates for Tangible and Intangible Assets. Inserting intermediate solutions for L^j, K^j, Z^j described by (264), (142), (144), respectively, into (147a)-(147c), and invoking the theorem of implicit functions leads to:

$$R^{W,j}, R^{K,j}, R^{Z,j}\left(P^j, K, Z^A, W^j, u^{K,j}, u^{Z,j}, \tau, Z^{W,j}\right). \tag{265}$$

Plugging back (265) into (140), (142), (144) leads to solutions for L^j, K^j, Z^j; inserting these solutions into the production function (112)-(113) allows us to solve for Y^j; thus intermediate solutions read:

$$L^j, K^j, Z^j, Y^j\left(P^j, K, Z^A, W^j, u^{K,j}, u^{Z,j}, \tau, Z^{W,j}\right). \tag{266}$$

Solutions to capital and technology utilization rates in sector $j = H, N$. Inserting (266)-(266) into (152) and (153) and invoking the implicit function theorem leads to:

$$u^{K,j}, u^{Z,j}\left(P^j, K, Z^A, W^j, Z^{W,j}, \tau\right). \tag{267}$$

Plugging back (267) into (265) and (266) leads to

$$R^j, R^{K,j}, R^{Z,j}, L^j, K^j, Y^j\left(P^j, K, Z^A, W^j, Z^{W,j}, \tau\right). \tag{268}$$

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

$$P^H, P^N\left(K, Q^K, Z^A, Q^Z, W^j, Z^{W,j}, \tau\right). \tag{269}$$

Plugging back these solutions (269) into (267), (268) leads to:

$$u^{K,j}, R^{W,j}, R^{K,j}, R^{Z,j}, L^j, K^j, Y^j\left(K, Q^K, Z^A, Q^Z, W^j, Z^{W,j}, \tau\right). \tag{270}$$

Inserting solutions for sectoral prices (269) into intermediate solutions for investment in tangible (162) and intangible assets (166) and consumption (263) in goods $g = H, N, F$, leads to:

$$C^g, J^{K,g}, J^{Z,g}\left(K, Q^K, Z^A, Q^Z, W^j, Z^{W,j}, \tau\right), \qquad g = H, N, F. \tag{271}$$

Dynamic system. In addition to (171a)-(171g), the dynamic system comprises four additional dynamic equations when we allow for sticky wages at a sectoral level:

$$\dot{\pi}^{W,H}(t) = \pi^{W,H}(t)\left[r^\star - \pi^{W,H}(t) - \frac{\dot{L}^H(t)}{L^H(t)}\right] - \frac{\epsilon_W^H}{\phi_W^H}\left[\frac{R^{W,H}(t)}{W^H(t)} - 1\right], \tag{272a}$$

$$\dot{W}^H(t) = W^H(t)\pi^{W,H}(t), \tag{272b}$$

$$\dot{\pi}^{W,N}(t) = \pi^{W,N}(t)\left[r^\star - \pi^{W,N}(t) - \frac{\dot{L}^N(t)}{L^N(t)}\right] - \frac{\epsilon_W^N}{\phi_W^N}\left[\frac{R^{W,N}(t)}{W^N(t)} - 1\right], \tag{272c}$$

$$\dot{W}^N(t) = W^N(t)\pi^{W,N}(t). \tag{272d}$$

The dynamic system can be written in a compact form:

$$\dot{K}(t) = \Upsilon\left(K(t), Q^K(t), Z^A(t), Q^Z(t), S(t), W^H(t), W^N(t), \tau(t), Z^{W,j}(t)\right), \tag{273a}$$

$$\dot{Q}^K(t) = \Sigma\left(K(t), Q^K(t), Z^A(t), Q^Z(t), S(t), W^H(t), W^N(t), \tau(t), Z^{W,j}(t)\right), \tag{273b}$$

$$\dot{Z}^A(t) = \Pi\left(K(t), Q^K(t), Z^A(t), Q^Z(t), S(t), W^H(t), W^N(t), \tau(t), Z^{W,j}(t)\right), \tag{273c}$$

$$\dot{Q}^Z(t) = \Gamma\left(K(t), Q^K(t), Z^A(t), Q^Z(t), S(t), W^H(t), W^N(t), \tau(t), Z^{W,j}(t)\right), \tag{273d}$$

$$\dot{S}(t) = \Theta\left(K(t), Q^K(t), Z^A(t), Q^Z(t), S(t), W^H(t), W^N(t), \tau(t), Z^{W,j}(t)\right), \tag{273e}$$

$$\dot{\pi}^{W,H}(t) = \Pi^{W,H}\left(K(t), Q^K(t), Z^A(t), Q^Z(t), S(t), W^H(t), W^N(t), \tau(t), Z^{W,j}(t)\right), \tag{273f}$$

$$\dot{W}^H(t) = W^H(t)\pi^{W,H}(t), \tag{273g}$$

$$\dot{\pi}^{W,N}(t) = \Pi^{W,N}\left(K(t), Q^K(t), Z^A(t), Q^Z(t), S(t), W^H(t), W^N(t), \tau(t), Z^{W,j}(t)\right), \tag{273h}$$

$$\dot{W}^N(t) = W^N(t)\pi^{W,N}(t), \tag{273i}$$

$$\dot{\tau}(t) = -\xi_T\left(\tau(t) - \tau\right), \tag{273j}$$

$$\dot{Z}^{W,j}(t) = -\xi_Z^j\left(Z^{W,j}(t) - Z^{W,j}\right), \tag{273k}$$

where $j = H, N$.

H.4 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 eleven equations. Linearizing (273)-(273k), the linearized system can be written in a matrix form:

$$\begin{pmatrix} \dot{K}(t) \\ \dot{Q}^K(t) \\ \dot{Z}^A(t) \\ \dot{Q}^Z(t) \\ \dot{S}(t) \\ \dot{W}^H(t) \\ \dot{\pi}^{W,H}(t) \\ \dot{W}^N(t) \\ \dot{\pi}^{W,N}(t) \\ \dot{\tau}(t) \\ \dot{Z}^{W,j}(t) \end{pmatrix} = \begin{pmatrix} \Upsilon_K & \Upsilon_{Q^K} & \Upsilon_{Z^A} & \Upsilon_{Q^Z} & \Upsilon_S & \Upsilon_{W^H} & 0 & \Upsilon_{W^N} & 0 & \Upsilon_\tau & \Upsilon_{Z^{W,j}} \\ \Sigma_K & \Sigma_{Q^K} & \Sigma_{Z^A} & \Sigma_{Q^Z} & \Sigma_{Z^A} & \Sigma_{W^H} & 0 & \Sigma_{W^H} & 0 & \Sigma_\tau & \Sigma_{Z^{W,j}} \\ \Pi_K & \Pi_{Q^K} & \Pi_{Z^A} & \Pi_{Q^Z} & \Pi_S & \Pi_{W^H} & 0 & \Pi_\tau & \Pi_{Z^{W,j}} & & \\ \Gamma_K & \Gamma_{Q^K} & \Gamma_{Z^A} & \Gamma_{Q^Z} & \Gamma_S & \Gamma_{W^H} & 0 & \Gamma_\tau & \Gamma_{Z^{W,j}} & & \\ \Theta_K & \Theta_{Q^K} & \Theta_{Z^A} & \Theta_{Q^Z} & \Theta_S & \Theta_{W^H} & 0 & \Theta_\tau & \Theta_{Z^{W,j}} & & \\ 0 & 0 & 0 & 0 & 0 & 0 & W^H & 0 & 0 & 0 & 0 \\ \Pi_K^{W,H} & \Pi_{Q^K}^{W,H} & \Pi_{Z^A}^{W,H} & \Pi_{Q^Z}^{W,H} & \Pi_S^{W,H} & \Pi_{W^H}^{W,H} & r^\star & \Pi_{W^N}^{W,H} & 0 & \Pi_\tau^{W,H} & \Pi_{Z^{W,j}}^{W,H} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & W^N & 0 & 0 \\ \Pi_K^{W,N} & \Pi_{Q^K}^{W,N} & \Pi_{Z^A}^{W,N} & \Pi_{Q^Z}^{W,N} & \Pi_S^{W,N} & \Pi_{W^H}^{W,N} & 0 & \Pi_{W^N}^{W,N} & r^\star & \Pi_\tau^{W,N} & \Pi_{Z^{W,j}}^{W,N} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -\xi_T & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -\xi_Z^j \end{pmatrix}$$

$$\times \begin{pmatrix} dK(t) \\ dQ^K(t) \\ dZ^A(t) \\ dQ^Z(t) \\ dS(t) \\ dW^H(t) \\ d\pi^{W,H}(t) \\ dW^N(t) \\ d\pi^{W,N}(t) \\ d\tau(t) \\ dZ^{W,j}(t) \end{pmatrix}. \tag{274}$$

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: $V(t) - V = \sum_{i=1}^{11} \omega^i D_i e^{\nu_i t}$ where V is the vector of state and control variables. Denoting the positive eigenvalue by $\nu_6, \nu_7, \nu_8, \nu_9 > 0$, we set $D_6 = D_7 = D_8 = D_9 = 0$ to eliminate explosive paths and determine the seven arbitrary constants D_i (with $i = 1, ..., 7$, $i \neq 6, 7, 8, 9$) by using the seven initial conditions, i.e., $K(0) = K_0$, $Z^A(0) = Z_0^A$, $S(0) = S_0$, $W^H(0) = W_0^H$, $W^N(0) = W_0^N$, $\tau(0) = \tau_0$, $Z^{W,j}(0) = Z_0^{W,j}$. Convergent solutions toward the stable manifold read:

$$dK(t) = D_1 e^{\nu_1 t} + D_2 e^{\nu_2 t} + D_3 e^{\nu_3 t} + D_4 e^{\nu_4 t} + D_5 e^{\nu_5 t} + \omega_1^{10} D_{10} e^{\nu_{10} t} + \omega_1^{11} D_{11} e^{\nu_{11} t}, \tag{275a}$$

$$dQ^K(t) = \omega_2^1 D_1 e^{\nu_1 t} + \omega_2^2 D_2 e^{\nu_2 t} + \omega_2^3 D_3 e^{\nu_3 t} + \omega_2^4 D_4 e^{\nu_4 t} + \omega_2^5 D_5 e^{\nu_5 t} + \omega_2^{10} D_{10} e^{\nu_{10} t} + \omega_2^{11} D_{11} e^{\nu_{11} t}, \tag{275b}$$

$$dZ^A(t) = \omega_3^1 D_1 e^{\nu_1 t} + \omega_3^2 D_2 e^{\nu_2 t} + \omega_3^3 D_3 e^{\nu_3 t} + \omega_3^4 D_4 e^{\nu_4 t} + \omega_3^5 D_5 e^{\nu_5 t} + \omega_3^{10} D_{10} e^{\nu_{10} t} + \omega_3^{11} D_{11} e^{\nu_{11} t}, \tag{275c}$$

$$dQ^Z(t) = \omega_4^1 D_1 e^{\nu_1 t} + \omega_4^2 D_2 e^{\nu_2 t} + \omega_4^3 D_3 e^{\nu_3 t} + \omega_4^4 D_4 e^{\nu_4 t} + \omega_4^5 D_5 e^{\nu_5 t} + \omega_4^{10} D_{10} e^{\nu_{10} t} + \omega_4^{11} D_{11} e^{\nu_{11} t}, \tag{275d}$$

$$dS(t) = \omega_5^1 D_1 e^{\nu_1 t} + \omega_5^2 D_2 e^{\nu_2 t} + \omega_5^3 D_3 e^{\nu_3 t} + \omega_5^4 D_4 e^{\nu_4 t} + \omega_5^5 D_5 e^{\nu_5 t} + \omega_5^{10} D_{10} e^{\nu_{10} t} + \omega_5^{11} D_{11} e^{\nu_{11} t}, \tag{275e}$$

$$dW^H(t) = \omega_6^1 D_1 e^{\nu_1 t} + \omega_6^2 D_2 e^{\nu_2 t} + \omega_6^3 D_3 e^{\nu_3 t} + \omega_6^4 D_4 e^{\nu_4 t} + \omega_6^5 D_5 e^{\nu_5 t} + \omega_6^{10} D_{10} e^{\nu_{10} t} + \omega_6^{11} D_{11} e^{\nu_{11} t}, \tag{275f}$$

$$d\pi^{W,H}(t) = \omega_7^1 D_1 e^{\nu_1 t} + \omega_7^2 D_2 e^{\nu_2 t} + \omega_7^3 D_3 e^{\nu_3 t} + \omega_7^4 D_4 e^{\nu_4 t} + \omega_7^5 D_5 e^{\nu_5 t} + \omega_7^{10} D_{10} e^{\nu_{10} t} + \omega_7^{11} D_{11} e^{\nu_{11} t}, \tag{275g}$$

$$dW^N(t) = \omega_8^1 D_1 e^{\nu_1 t} + \omega_8^2 D_2 e^{\nu_2 t} + \omega_8^3 D_3 e^{\nu_3 t} + \omega_8^4 D_4 e^{\nu_4 t} + \omega_8^5 D_5 e^{\nu_5 t} + \omega_8^{10} D_{10} e^{\nu_{10} t} + \omega_8^{11} D_{11} e^{\nu_{11} t}, \tag{275h}$$

$$d\pi^{W,N}(t) = \omega_9^1 D_1 e^{\nu_1 t} + \omega_9^2 D_2 e^{\nu_2 t} + \omega_9^3 D_3 e^{\nu_3 t} + \omega_9^4 D_4 e^{\nu_4 t} + \omega_9^5 D_5 e^{\nu_5 t} + \omega_9^{10} D_{10} e^{\nu_{10} t} + \omega_9^{11} D_{11} e^{\nu_{11} t}, \tag{275i}$$

$$d\tau(t) = D_{10} e^{\nu_{10} t}, \tag{275j}$$

$$dZ^{W,j}(t) = D_{11} e^{\nu_{11} t}, \tag{275k}$$

where $dX(t) = X(t) - X$ with X corresponding to the steady-state value in the next steady-state, and $\nu_6 = -\xi_T < 0$, $\nu_{11} = -\xi_Z^j < 0$. We normalized ω_1^1, ω_1^2, ω_1^3, ω_1^4, ω_1^5, ω_{10}^{10}, and ω_{11}^{11} to 1.

Setting $t = 0$ into the solutions for the stock of capital, the stock of knowledge, and the stock of habits, i.e., $K_0 - K - \omega_1^{10} D_{10} - \omega_1^{11} D_{11} = D_1 + D_2 + D_3 + D_4 + D_5$, $Z_0^A - Z^A - \omega_3^{10} D_{10} - \omega_3^{11} D_{11} = \omega_3^1 D_1 + \omega_3^2 D_2 + \omega_3^3 D_3 + \omega_3^4 D_4 + \omega_3^5 D_5$, $S_0 - S - \omega_5^{10} D_{10} - \omega_5^{11} D_{11} = \omega_5^1 D_1 + \omega_5^2 D_2 + \omega_5^3 D_3 + \omega_5^4 D_4 + \omega_5^5 D_5$, $W_0^H - W^H - \omega_6^{10} D_{10} - \omega_6^{11} D_{11} = \omega_6^1 D_1 + \omega_6^2 D_2 + \omega_6^3 D_3 + \omega_6^4 D_4 + \omega_6^5 D_5$, $W_0^N - W^N - \omega_8^{10} D_{10} - \omega_8^{11} D_{11} = \omega_8^1 D_1 + \omega_8^2 D_2 + \omega_8^3 D_3 + \omega_8^4 D_4 + \omega_8^5 D_5$, which can be rewritten in a matrix form:

$$\begin{pmatrix} 1 & 1 & 1 & 1 & 1 \\ \omega_3^1 & \omega_3^2 & \omega_3^3 & \omega_3^4 & \omega_3^5 \\ \omega_5^1 & \omega_5^2 & \omega_5^3 & \omega_5^4 & \omega_5^5 \\ \omega_6^1 & \omega_6^2 & \omega_6^3 & \omega_6^4 & \omega_6^5 \\ \omega_8^1 & \omega_8^2 & \omega_8^3 & \omega_8^4 & \omega_8^5 \end{pmatrix} \begin{pmatrix} D_1 \\ D_2 \\ D_3 \\ D_4 \\ D_5 \end{pmatrix} = \begin{pmatrix} K_0 - K - \omega_1^{10} D_{10} - \omega_1^{11} D_{11} \\ Z_0^A - Z^A - \omega_3^{10} D_{10} - \omega_3^{11} D_{11} \\ S_0 - S - \omega_5^{10} D_{10} - \omega_5^{11} D_{11} \\ W_0^H - W^H - \omega_6^{10} D_{10} - \omega_6^{11} D_{11} \\ W_0^N - W^N - \omega_8^{10} D_{10} - \omega_8^{11} D_{11} \end{pmatrix}. \tag{276}$$

where solutions for arbitrary constants depend on initial conditions and eigenvectors. The five equations can be jointly solved for the three arbitrary constants D_1, D_2, D_3, D_4, D_5 associated with the three negative eigenvalues $\nu_1 < 0$, $\nu_2 < 0$, $\nu_3 < 0$, $\nu_4 < 0$, $\nu_5 < 0$.

It is straightforward to solve for the arbitrary constants D_{10} and D_{11}: by setting $t = 0$ into (275j)-(275k):

$$\tau(0) - \tau = \tau_0 - \tau = D_{10} = x_T, \tag{277a}$$

$$Z^{W,j}(0) - Z^{W,j} = Z_0^{W,j} - Z^{W,j} = D_{11} = x_Z^j. \tag{277b}$$

To find eigenvectors ω_k^{10}, we solve

$$\begin{pmatrix}
\Upsilon_K - \nu_{10} & \Upsilon_{Q^K} & \Upsilon_{Z^A} & \Upsilon_{Q^Z} & \Upsilon_S & \Upsilon_{W^H} & \Upsilon_{\pi^{W,H}} & \Upsilon_{W^N} & \Upsilon_{\pi^{W,N}} \\
\Sigma_K & \Sigma_{Q^K} - \nu_{10} & \Sigma_{Z^A} & \Sigma_{Q^Z} & \Sigma_S & \Sigma_{W^H} & \Sigma_{\pi^{W,H}} & \Sigma_{W^N} & \Sigma_{\pi^{W,N}} \\
\Pi_K & \Pi_{Q^K} & \Pi_{Z^A} - \nu_{10} & \Pi_{Q^Z} & \Pi_S & \Pi_{W^H} & \Pi_{\pi^{W,H}} & \Pi_{W^N} & \Pi_{\pi^{W,N}} \\
\Gamma_K & \Gamma_{Q^K} & \Gamma_{Z^A} & \Gamma_{Q^Z} - \nu_{10} & \Gamma_S & \Gamma_{W^H} & \Gamma_{\pi^{W,H}} & \Gamma_{W^N} & \Gamma_{\pi^{W,N}} \\
\Theta_K & \Theta_{Q^K} & \Theta_{Z^A} & \Theta_{Q^Z} & \Theta_S - \nu_{10} & \Theta_{W^H} & \Theta_{\pi^{W,H}} & \Theta_{W^N} & \Theta_{\pi^{W,N}} \\
0 & 0 & 0 & 0 & 0 & -\nu_{10} & W^H & 0 & 0 \\
\Pi_K^{W,H} & \Pi_{Q^K}^{W,H} & \Pi_{Z^A}^{W,H} & \Pi_{Q^Z}^{W,H} & \Pi_S^{W,H} & \Pi_{W^H}^{W,H} & \Pi_{\pi^{W,H}}^{W,H} - \nu_{10} & \Pi_{W^N}^{W,H} & Pi_{\pi^{W,N}}^{W,H} \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & -\nu_{10} & W^N \\
\Pi_K^{W,N} & \Pi_{Q^K}^{W,N} & \Pi_{Z^A}^{W,N} & \Pi_{Q^Z}^{W,N} & \Pi_S^{W,N} & \Pi_{W^H}^{W,N} & \Pi_{\pi^{W,N}}^{W,N} - \nu_{10} & \Pi_{W^N}^{W,N} & \Pi_{\pi^{W,N}}^{W,N} - \nu_{10}
\end{pmatrix}$$

$$\times \begin{pmatrix} \omega_1^{10} \\ \omega_2^{10} \\ \omega_3^{10} \\ \omega_4^{10} \\ \omega_5^{10} \\ \omega_6^{10} \\ \omega_7^{10} \\ \omega_8^{10} \\ \omega_9^{10} \end{pmatrix} = \begin{pmatrix} -\Upsilon_\tau \\ -\Sigma_\tau \\ -\Pi_\tau \\ -\Gamma_\tau \\ -\Theta_\tau \\ 0 \\ -\Pi_\tau^{W,H} \\ 0 \\ -\Pi_\tau^{W,N} \end{pmatrix}, \tag{278}$$

and to find eigenvectors ω_k^{11}, we solve:

$$\begin{pmatrix}
\Upsilon_K - \nu_{11} & \Upsilon_{Q^K} & \Upsilon_{Z^A} & \Upsilon_{Q^Z} & \Upsilon_S & \Upsilon_{W^H} & \Upsilon_{\pi^{W,H}} & \Upsilon_{W^N} & \Upsilon_{\pi^{W,N}} \\
\Sigma_K & \Sigma_{Q^K} - \nu_{11} & \Sigma_{Z^A} & \Sigma_{Q^Z} & \Sigma_S & \Sigma_{W^H} & \Sigma_{\pi^{W,H}} & \Sigma_{W^N} & \Sigma_{\pi^{W,N}} \\
\Pi_K & \Pi_{Q^K} & \Pi_{Z^A} - \nu_{11} & \Pi_{Q^Z} & \Pi_S & \Pi_{W^H} & \Pi_{\pi^{W,H}} & \Pi_{W^N} & \Pi_{\pi^{W,N}} \\
\Gamma_K & \Gamma_{Q^K} & \Gamma_{Z^A} & \Gamma_{Q^Z} - \nu_{11} & \Gamma_S & \Gamma_{W^H} & \Gamma_{\pi^{W,H}} & \Gamma_{W^N} & \Gamma_{\pi^{W,N}} \\
\Theta_K & \Theta_{Q^K} & \Theta_{Z^A} & \Theta_{Q^Z} & \Theta_S - \nu_{11} & \Theta_{W^H} & \Theta_{\pi^{W,H}} & \Theta_{W^N} & \Theta_{\pi^{W,N}} \\
0 & 0 & 0 & 0 & 0 & -\nu_{11} & W^H & 0 & 0 \\
\Pi_K^{W,H} & \Pi_{Q^K}^{W,H} & \Pi_{Z^A}^{W,H} & \Pi_{Q^Z}^{W,H} & \Pi_S^{W,H} & \Pi_{W^H}^{W,H} & \Pi_{\pi^{W,H}}^{W,H} - \nu_{11} & \Pi_{W^N}^{W,H} & Pi_{\pi^{W,N}}^{W,H} \\
0 & 0 & 0 & 0 & 0 & & 0 & -\nu_{11} & W^N \\
\Pi_K^{W,N} & \Pi_{Q^K}^{W,N} & \Pi_{Z^A}^{W,N} & \Pi_{Q^Z}^{W,N} & \Pi_S^{W,N} & \Pi_{W^H}^{W,N} & \Pi_{\pi^{W,N}}^{W,N} - \nu_{11} & \Pi_{W^N}^{W,N} & \Pi_{\pi^{W,N}}^{W,N} - \nu_{11}
\end{pmatrix}$$

$$\times \begin{pmatrix} \omega_1^{11} \\ \omega_2^{11} \\ \omega_3^{11} \\ \omega_4^{11} \\ \omega_5^{11} \\ \omega_6^{11} \\ \omega_7^{11} \\ \omega_8^{11} \\ \omega_9^{11} \end{pmatrix} = \begin{pmatrix} -\Upsilon_{Z^{W,j}} \\ -\Sigma_{Z^{W,j}} \\ -\Pi_{Z^{W,j}} \\ -\Gamma_{Z^{W,j}} \\ -\Theta_{Z^{W,j}} \\ 0 \\ -\Pi_{Z^{W,j}}^{W,H} \\ 0 \\ -\Pi_{Z^{W,j}}^{W,N} \end{pmatrix}. \tag{279}$$

I 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 Shimer [2009] preferences and when we calibrate the model to the data related to each sub-samples; we also show more numerical results.

I.1 Calibration of the Model to the Data: Shimer [2009] 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:

$$\mathcal{U} = \int_0^\infty \Lambda\left(C(t), S(t), L(t)\right) e^{-\beta t} \mathrm{d}t, \tag{280}$$

where we consider the utility specification proposed by Shimer [2009]:

$$\Lambda\left(C, S, L\right) \equiv \frac{\left(CS^{-\gamma_S}\right)^{1-\sigma} V(L)^\sigma - 1}{1-\sigma}, \quad \text{if} \quad \sigma \neq 1, \quad V(L) \equiv \left(1 + (\sigma - 1)\,\gamma \frac{\sigma_L}{1+\sigma_L} L^{\frac{1+\sigma_L}{\sigma_L}}\right). \tag{281}$$

These preferences are characterized by two crucial parameters: σ_L is the Frisch elasticity of labor supply, and $\sigma > 0$ determines the substitutability between consumption and leisure;

if $\sigma > 1$, the marginal utility of consumption is increasing in hours worked. The inverse of σ collapses to the intertemporal elasticity of substitution for consumption. When we let σ equal to one, the felicity function is additively separable in consumption and labor. When we calibrate the model to the data, all parameters are identical to those chosen in the baseline.

I.2 Calibration of the Model to the Data for the Country-Split Analysis

At the steady-state, the capital and the technology utilization rates, $u^{K,j}$ and $u^{Z,j}$, collapse to one so that $\tilde{K}^j = K^j$ and $\tilde{Z}^j = Z^j$. 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 30. 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 30 shows the values of main parameters for our calibration for English-speaking and Scandinavian countries.

English-speaking and Scandinavian countries: Short description of the calibration. The parameters are set to target the averaged ratios of the first sub-sample made up of English-speaking and Scandinavian countries (plus Japan and Luxembourg). 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_Z^H, $\eta_Z^{W,H}$ and γ_S; building on our estimates, we set η_Z^H and $\eta_Z^{W,H}$ 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 $\eta_Z^N = \eta_Z^{W,N} = 0$ because our evidence shows that there is no technology improvement in the non-traded sector. To quantify the role of the endogenous technology utilization rate and international R&D spillovers, we compare the predictions of the baseline model shown in black dotted lines in Fig. 6(a)-6(b) with the prediction of a restricted version where $\chi_2^H \to \infty$ and $\nu_Z^{W,H} = 0$ displayed by the dashed red lines.

Continental European countries: Short description of the calibration. 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_Z^H and $\eta_Z^{W,H}$; building on our estimates, we set $\eta_Z^H = \eta_Z^N = \eta_Z^{W,N} = 0$ while $\eta_Z^{W,H} = 0.135$ which implies that traded firms benefit from international R&D spillovers, although the impact is more than three times smaller than the first group of countries. In accordance with the estimates documented by Havranek [2017] which reveal that the relative weight of habits is much smaller in Europe, we choose a value for γ_S of 0.05 which collapses to micro-estimates. This value allows the model to avoid under-estimating the rise in consumption and give rise to a persistent increase in hours in the long-run.

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 30, 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 30, 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 physical 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 30, 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 ν^j_Z, i.e., $\gamma^j = \theta^j_Z \nu^j_Z$. 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 $\nu^H_Z = 0.62$ so that $\mu^H = 1.35 > 1.349 = 1 + \theta^H_Z \nu^H_Z$. 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 $\nu^{W,H}_Z$, i.e., $\gamma^{W,H} = \left(1 - \theta^H_Z\right) \nu^{W,H}_Z$. 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 $\nu^{W,H}_Z$. When we turn to the non-traded sector, as shown in Table 26, the estimates of the elasticity γ^N and $\gamma^{W,N}$ are small at 0.024 and 0.044 which would lead values for ν^N_Z 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. (35) 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 0.00678 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. Like for a representative OECD economy, we choose a value of $\xi^H_2 = \xi^N_2 = 0.2$ for the adjustment cost in the capital utilization rate, i.e., ξ^j_2.

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

Table 30: 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.

and investment expenditure in tangible and intangible assets of $\alpha_C = 45\%$, $\alpha_J^K = 31\%$, $\alpha_J^Z = 62\%$, respectively, a home content of consumption and investment (in physical capital) expenditure in tradables of $\alpha^H = 60\%$ and $\alpha_J^H = 38\%$, 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 $\omega_J^K = 20.7\%$ and $\omega_J^K = 2.5\%$, 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_1^H, ξ_1^N, and technology, χ_1^H, χ_1^N, 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 30, the world interest rate, $r^\star$, which is equal to the subjective time discount rate, β, is set to 2.8%. In line with mean values shown in columns 10 and 11 of Table 30, 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 30, 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 $\nu_Z^{W,H} = 0.13$. We set $\nu_Z^H = 0.001$ because the estimated value for the elasticity of utilization-adjusted-TFP of tradables w.r.t. the domestic stock of knowledge is slightly negative and thus inconsistent, see Table 26. For the non-traded sector, we set $\nu_Z^N = \nu_Z^{W,N} = 0$ in line with our estimates.

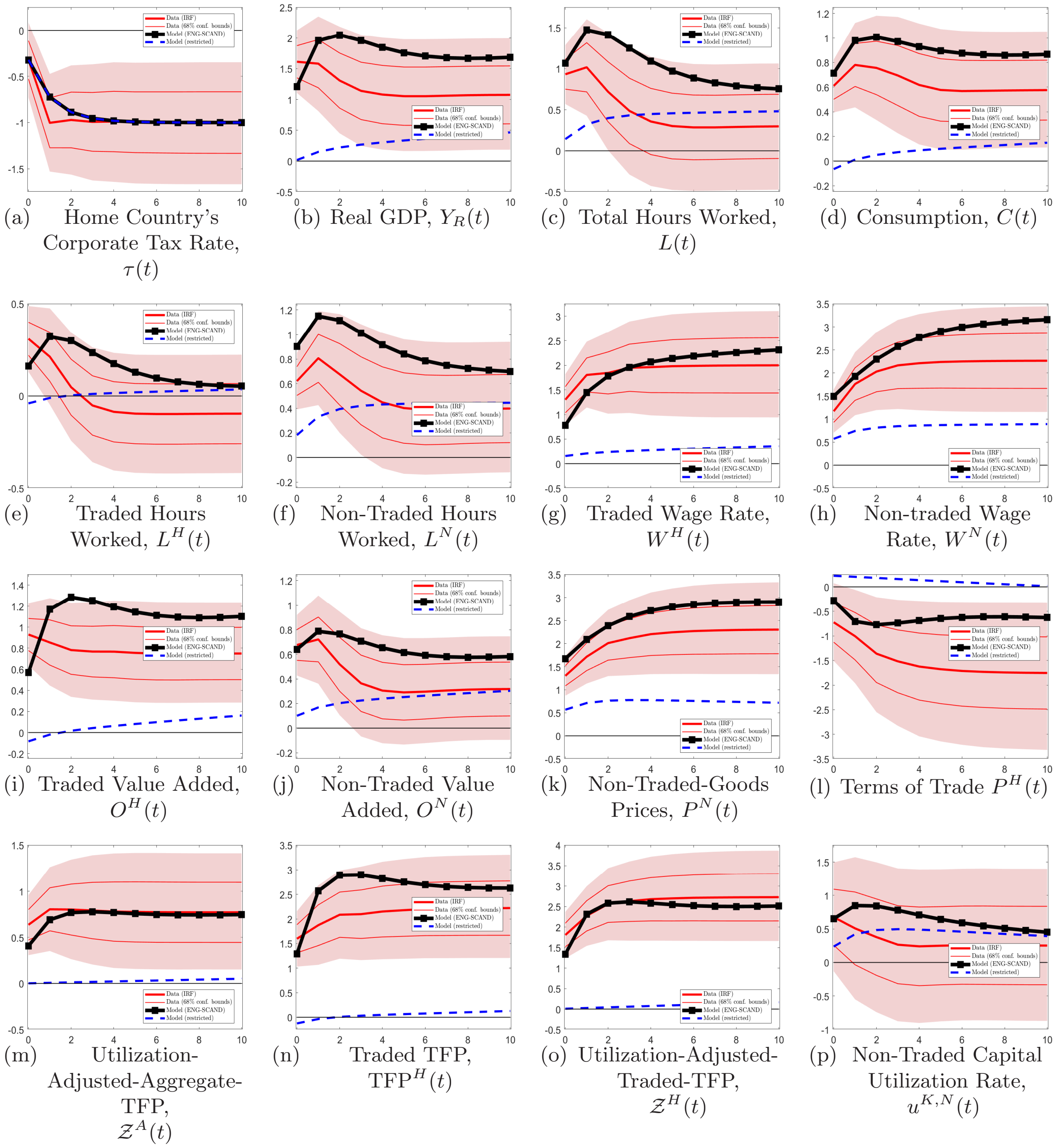
Eleven parameters are taken from external research works. These values are identical to those chosen for a representative OECD economy.

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. (35) 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 0.00396 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 utilization adjustment costs. Like for a representative OECD economy, we choose a value of $\xi_2^H = \xi_2^N = 0.2$ for the adjustment cost in the capital utilization rate, i.e., ξ_2^j.

I.3 Additional Numerical Results

For reasons of space, in the main text i.e., in Fig. 6, we focus on a restricted set of variables. In this Appendix, we provide more numerical results. Fig. 23 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. 24 shows numerical results for the group of continental European countries by differentiating the predictions of the flexible wage model (dashed red lines) from those of 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, $O^H(t)$

(j) Non-Traded Value Added, $O^N(t)$

(k) Non-Traded-Goods Prices, $P^N(t)$

(l) Terms of Trade $P^H(t)$

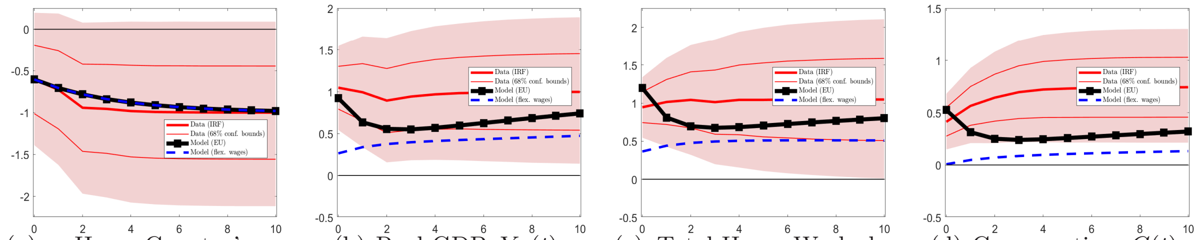
(m) Utilization-Adjusted-Aggregate-TFP, $\mathcal{Z}^A(t)$

(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 23: 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.

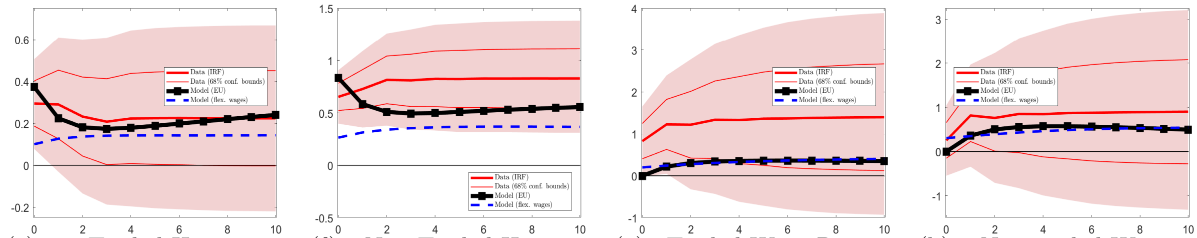


(a) Home Country's Corporate Tax Rate, $\tau(t)$

(b) Real GDP, $Y_R(t)$

(c) Total Hours Worked, $L(t)$

(d) Consumption, $C(t)$

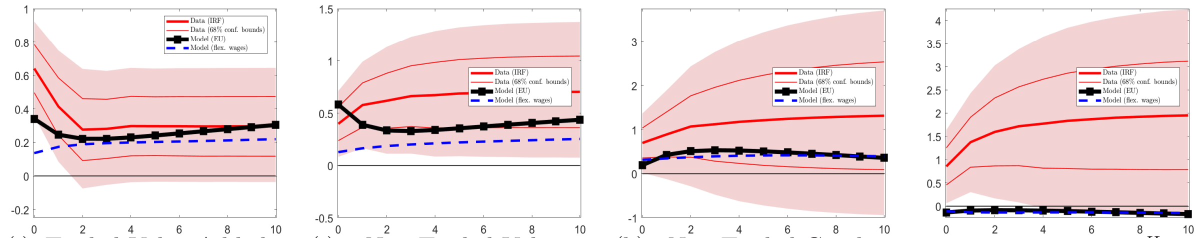


(e) Traded Hours Worked, $L^H(t)$

(f) Non-Traded Hours Worked, $L^N(t)$

(g) Traded Wage Rate, $W^H(t)$

(h) Non-traded Wage Rate, $W^N(t)$

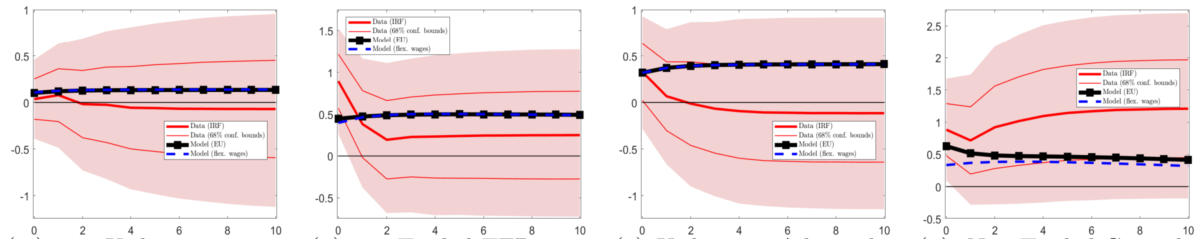


(i) Traded Value Added, $O^H(t)$

(j) Non-Traded Value Added, $O^N(t)$

(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 24: 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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