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Abstract

We exploit the downward and common trend of profits' taxation across OECD countries rooted into tax competition to identify exogenous shocks to corporate taxation. By adopting an *internal instrument* SVAR strategy, our evidence reveals that a permanent decline in profits' taxation leads to significant technology improvements concentrated in traded industries and generates an expansionary effect on hours concentrated in the non-traded sector. While technology dramatically improves in English-speaking and Scandinavian countries, hours significantly and persistently increase in continental Europe. A two-sector open economy model with endogenous technology decisions can rationalize the evidence conditional on a set of elements related to preferences and technology. To account for large technology improvements in former countries, traded industries must be highly intensive in R&D, exposed to foreign technology and display low technology utilization adjustment costs while habit persistence in consumption 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

As capital controls were lifted, the top statutory corporate income tax (CIT henceforth) has continuously declined in industrialized countries over the last forty years. Amid the removal of barriers to capital mobility, the CIT has been divided by two, dropping from 48% in 1981 to 35% in 2000 and settling at 25% from 2018 onwards in high-income countries.[1] According to our own estimates and the evidence documented by Devereux et al. [2002], [2008], Overesch et al. [2011], Egger [2019], the downward trend in corporate taxation is mainly the result of a race to the bottom as countries compete with each other over statutory corporate tax rates to attract capital. In this work, we exploit this property to identify permanent changes in international corporate taxation which are exogenous to domestic economic activity and lead the home country to cut its own tax rate.

While as stressed by Gechert et al. [2022], the debate about the magnitude of the effect of a CIT cut on economic activity is unsettled, it is undisputable that lower profits' taxation boosts investment, see e.g., Djankow et al. [2010], Mertens and Ravn [2013], Ohrn [2018], Cloyne et al. [2025a]. The effects on labor and technology in OECD countries remain instead unclear and most importantly, the literature is surprisingly silent about how these effects vary across sectors and between countries.[2] The goal of our research work is to answer three questions. Is higher economic activity after a CIT cut enhanced through innovation or a rise in hours or both? Are technology improvements and labor growth uniformly distributed between sectors and across countries? What are the factors explaining these sectoral and international differences?

Our first key contribution is to show that the effects of a corporate tax cut vary dramatically both across sectors and across countries. Our SVAR evidence reveals that after an exogenous CIT cut, 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.

The second key contribution is to rationalize both sectoral and international differences we uncover empirically by developing a new two-sector open economy setup with endogenous technology decisions. Building on the estimation of key parameters of our model, our quantitative analysis shows that sectoral and international differences in the effects of a

[1] The figures are based on the cross-country average of top statutory CIT rates in 23 OECD countries. Source: Tax Foundation. Sample: 23 high-income countries, 1981-2023, see Online Appendix A.1 for further details

[2] Exceptions are Djankov et al. [2010], Cloyne et al. [2025a] who differentiate the effects between manufacturing and services and find that only manufacturing firms increase capital investment after a CIT cut. Besides the fact that we differentiate the effects between a traded and a non-traded sector, the former being intensive in R&D and the latter in labor, one crucial difference with these two papers is that we provide a structural interpretation of our estimates and confront our model's predictions with our SVAR evidence.

CIT cut rest on technology and preferences' factors: the capacity to transform R&D in technology advances, the ability to use more intensively the existing stock of knowledge, the exposition to foreign technology, the degree of wage stickiness and habit persistence in consumption.

One major challenge is to identify exogenous variations in corporate taxation, i.e., changes which are exogenous to the state of the economy. The solution we put forward to ensure that CIT changes are not aimed at offsetting a domestic recession is to use the international component of the CIT rate which is driven by tax competition (and thus by long-run growth or ideological) 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 to domestic economic activity.

To capture more accurately the degree of (international) tax pressure faced by each country, we construct a country-specific international (statutory) corporate income tax rate by considering the (averaged) trade intensity between the home country and its trade partner as a weight. 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 major trade partners. The existence of a cointegrating relationship between the country-level and the international CIT rate allows us to replace the former with the latter in the VAR model which ensures the exogeneity of the shock. One important aspect of our 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. In estimating a VAR model which comprises the IV (i.e., the international CIT index) ordered first and domestic macroeconomic variables, our approach collapses to the *internal instrument* SVAR strategy recommended by Plagborg-Møller and Wolf [2021]. In the same vein, the international macroeconomics literature has recently exploited the exogenous nature of international variables coupled with capital mobility to identify exogenous devaluations, see Fukui et al. [2023], or exogenous monetary policy shocks, see Jordà et al. [2019].

We follow Shapiro and Watson [1988] in using an instrumental variable for an identification with long-run restrictions, see Stock and Watson [2016]. We identify shocks to international corporate taxation by assuming that shocks to the other domestic macroeconomic variables included in the VAR model have no permanent effects on the international CIT rate. Our identification assumption is based on the existence of a common trend in CIT which is only guided by tax competition motives and thus excludes the possibility that a cut in the international component of profits' taxation is designed to compensate for a domestic recession. Indeed, our estimates show that identified shocks to international corporate taxation are exogenous to domestic economic activity.

One potential concern is that the variation in the international component of the CIT rate might be the result of an endogenous policy decision after a global recession. Our estimates show instead that world demand shocks do not predict our identified shocks to international corporate taxation which exclude the possibility that the shocks we identify are designed to offset a global recession. If this were the case, it would go against our main finding as it would bias our estimates towards finding contractionary effects of global CIT cuts. Since these cuts are found to be strongly expansionary, this eliminates the possibility of such a bias. As a second robustness check, following Jordà et al. [2019], we construct a second version of our instrument which is exogenous to the world business cycle and adjusted with capital openness because after all, tax pressure from abroad operates only if capital can freely move across borders. We do not detect any statistically significant differences in the VAR point estimate whether we use the baseline international CIT index or its alternative (business cycle adjusted) version.

According to the classification detailed by Cloyne [2013] who adopt a narrative approach, the shocks to international corporate taxation we identify leading the home country to cut its own tax rate to keep its economy competitive fall into the category of long-run growth or ideological motives. By using the augmented dataset of narratively-identified shocks constructed by Dabla-Norris and Lima [2023], we find that domestic CIT cuts driven by long-run growth or ideological motives produce the same effects qualitatively than a permanent shock to international corporate taxation we identify in this work. The advantage of our empirical strategy over the narrative approach is that it is straightforward, data-driven and not subject to the potential biases mentioned by Perotti [2012] (e.g., the motivation of decision-makers may not be completely reliable) and Mertens and Ravn [2013] (e.g., historical records lead inevitably to calls of judgement). The second advantage is that we focus on one unique transmission mechanism as shocks to international corporate taxation are driven by long-run growth motives. As we base our identification on one unique competitive motive, our empirical strategy allows us to compare consistently the dynamic effects of a CIT cut across countries. Moreover, by adapting the empirical strategy proposed by Beaudry and Portier [2006] to our case, we find empirically that our identified shocks to international corporate taxation are uncorrelated with tax news shocks and thus are unanticipated.

While all of our estimates are based on the estimation of a VAR model which includes the international component of corporate taxation, the effects are re-scaled so that they reflect the responses to a 1 percentage point decline in the country-level CIT rate (which itself responds to an international CIT cut). In estimating the effects of CIT cuts on innovation and labor at a sectoral level in OECD countries, we differentiate 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).

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. We find empirically that continental European countries display a much larger degree of wage stickiness and are also characterized by an elasticity of utilization-adjusted-aggregate-TFP w.r.t. the stock of knowledge which is essentially zero. Conversely, wages are more flexible in English-speaking and Scandinavian countries which also display a high elasticity of technology w.r.t. the stock of R&D.

Building on this dichotomy based on wage flexibility 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. Like Cloyne et al. [2025b], we find that a CIT cut stimulates innovation but in contrast to them who restrict their attention to the U.S. economy, we show that technology improvements are concentrated within traded industries and take place only in English-speaking and Scandinavian countries. Conversely, our evidence reveals that real GDP growth is driven by the significant and persistent increase in hours in continental Europe as technology does not improve.

To provide a structural interpretation of these new 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 Laitner et al. [2003], Corhay et al. [2025] 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. We augment Corhay et al.'s [2025] 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) spill over 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 is small. 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 more than two times larger than what we estimate empirically in the long-run. Conversely, when we assume Shimer [2009] preferences (which allow for a wealth effect on labor supply), the model understates the rise in 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. Like Chodorow-Reich et al. [2023], we introduce wage stickiness at a sectoral level. 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 our own estimates and 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 w.r.t. the identification and estimation strategy, and details the steps to solve the model.

2 Dynamic Effects of Corporate Taxation: Evidence

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

2.1 Identification of Shocks to Corporate Taxation

One major challenge when analyzing the dynamic effects of a CIT cut is to identify changes in corporate taxation which are not designed to offset a past or a current recession. Our approach to tackling this challenge is to use the fact that the long-run movement in country-level CIT rates are driven by tax competition (and thus long-run growth or ideological) motives. While we are using the top statutory CIT rate (which are more likely to be exogenous than effective tax rates) like Vegh and Vuletin [2015] and Akcigit et al. [2022], we cannot exclude that the country-level tax rate is correlated with economic activity. Indeed, as shown in Online Appendix D.5, country-specific demand shocks predict shocks to country-level corporate taxation. In this work, we avoid endogeneity by considering a broad (i.e., international) measure of CIT rates relevant to each country whose variations exert tax pressure on the domestic economy. As supported by our own evidence below, the removal of barriers to capital mobility across borders has led countries to compete with each other for capital. Because country-level CIT rates respond to the tax pressure of competitor countries, they share a common trend. Since the international component of corporate taxation is uncorrelated with country-specific demand shocks, we estimate a SVAR model which includes the international CIT index defined later and country-level macroeconomic variables.

Our approach. We follow the approach labelled as *internal instruments* by Plagborg-Møller and Wolf [2021], which has been adopted by Ramey [2011] and recently by Surico and Antolin-Diaz [2025] for short-run restrictions, and Shapiro and Watson [1988] for long-run restrictions. This approach includes the instrumental variable (in our case the international CIT series defined later) in the VAR model and identifies the shock of interest by ordering the instrument first and imposing the matrix of long-run cumulative effects to be lower triangular.[3] We also develop a second version of the internal instrument by constructing international CIT series in a way that ensures its exogeneity to the world business cycle.

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. This idea has also been adopted recently by Jordà et al. [2019]. The authors replace the domestic with the base country's interest rate in estimating the dynamic responses to a monetary policy shock. Intuitively, countries with credible fixed exchange which have removed capital controls must follow the interest rate of the base country they peg to. Fukui et al. [2023] also use a similar idea to identify exogenous depreciations in the exchange rate.

Advantages of using the common component approach over the narrative approach. Mertens and Ravn [2013], Cloyne et al. [2025b] use narratively-identified CIT changes to investigate the dynamic effects of corporate tax cut in the United States. Lastly, Dabla-Norris and Lima [2023] have constructed a narratively-identified tax shocks database covering 10 OECD countries from 1978 to 2014. As summarized by Cloyne [2013], changes in corporate taxation can be considered as exogenous actions when they are motivated by ideology, long-run economic growth, or fiscal consolidation motives. When we focus on tax measures classified as exogenous changes due to long-run or ideological motivation, it is striking to see that these CIT cuts episodes are driven by the willingness of governments to restore the competitiveness of the economy in the long-run. One prominent example is Australia where corporate tax cuts in 1988, 2000, 2001 were justified to compete internationally, see Australia Budget Paper 2000-01. A second example is Austria which has cut its corporate tax rate in 1989 under the motive of a long-term improvement of the international competitiveness of Austrian firms, see Genser [1995]. A third example is the corporate tax reform in the U.K. (2010-2020) aimed at creating "the most competitive corporate tax regime in the G20, while protecting manufacturing industries", see the Commons Library

[3] As shown by Plagborg-Møller and Wolf [2021], the *internal instrument* strategy of ordering the IV first in a VAR yields valid impulse response estimates even if the shock of interest is noninvertible, unlike the well-known *external instrument* proxy-SVAR approach (Mertens and Ravn [2013]).

Research Briefing [2021].

If narratively-identified tax changes aimed at increasing long-run growth collapse to CIT cuts with the objective of promoting competitiveness, such episodes should produce the same effects than a corporate tax cut driven by tax competition motives. Indeed, we have augmented the dataset of Dabla-Norris and Lima [2023] to cover all countries of our sample which includes forty exogenous domestic CIT cuts episodes over 1973-2017 period which are driven by long-run growth or ideological motives. Because the goal of these tax cuts is to keep the domestic economy competitive, the evidence based on narratively-identified CIT cuts episodes are qualitatively identical to those obtained after an exogenous decline in international corporate taxation, see Online Appendix D.8.

In this work, we propose a new identification of exogenous corporate tax changes which has several advantages over the narrative approach. First, our methodology is simple, straightforward and data-driven as it relies on a SVAR identification and it simply requires the construction of an international CIT index. Second, since we base our identification on tax competition motives, the effects we estimate are driven by one unique transmission channel while in fact, a narratively-identified tax cut episode may have several purposes. Third, our approach allows a consistent comparison of the effects between countries or groups of countries because the purpose of the tax cut is unique. Fourth, our identification is based on the behavior of international corporate taxation and thus takes into account the increase in the international stock of ideas while this channel is shut down if the country-level CIT rate is used. Fifth, our identification cannot be biased by judgments (see e.g., Mertens and Ravn [2013]) or false assertions by decision-makers. 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. Sixth, the literature adopting the narrative approach currently uses the average corporate income tax rate (e.g., Mertens and Ravn [2013], Cloyne et al. [2025b]) which displays more endogeneity to economic activity than the top statutory CIT rate.

Conditions to be met to identify exogenous and unanticipated corporate tax cuts. We estimate a VAR model which includes the instrument as captured by the import-share-weighted-average of trade partners' CIT rates and domestic macroeconomic variables. To be valid, the SVAR identification of shocks to international corporate taxation must fulfill three conditions. First, the internal instrument must be relevant which requires that the domestic and international CIT rate are cointegrated. Second, the shock must be exogenous to domestic and world economic activity. Third, the shock must be unanticipated.

Because we base our identification on tax competition motives which leads to a race to the bottom, countries' CIT rates should be integrated of order one and the corollary is that we identify permanent shocks to (international) profits' taxation. According to the tax competition hypothesis, the country-level corporate taxation should closely track the tax rate of its neighbors, and therefore domestic and international corporate taxation should have a common stochastic trend. Conditional on the two variables being cointegrated, the domestic is replaced with the international tax rate on corporate income in the SVAR model as only the latter should be exogenous to country-level business cycle.

According to the second condition, identified shocks to international corporate taxation should not be predicted by past domestic macroeconomic conditions. We have run Granger causality tests (discussed later) to ensure that condition 2 is fulfilled. A violation of the exclusion restriction could occur if changes in international profit taxation were driven by world demand shocks because the domestic country could potentially respond to the global recession by cutting its corporate tax rate. We provide strong evidence (later) which shows that identified shocks to international corporate taxation are predicted neither by domestic nor world economic activity.

Finally, according to the third condition, identified shocks to international CIT should be unanticipated. While domestic CIT cuts are often announced several quarters before their implementation, since we identify exogenous changes in the foreign component of profits' taxation, anticipation effects are implausible. Our estimates (discussed later) reveal that identified exogenous variations in international profits' taxation are uncorrelated with tax news shocks and thus the former are unanticipated.

2.2 Data

CIT data. We use the top statutory CIT rates taken from Vegh and Vuletin's [2015] Global tax rate dataset.[4] 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. This set of countries is dictated by the need to have a long enough time horizon for CIT rates and the fact that we need a balanced panel to construct the international CIT rate index.[5]

Classification of industries as tradables or non-tradables and sectoral data. 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

[4] The dataset is available at `https://www.guillermovuletin.com/datasets`.

[5] 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 several OECD countries from the sample due to the absence of data on CIT rates or missing observations before 1980.

and Fishing", "Mining and Quarrying", "Total Manufacturing","Transport, Storage and Communication", and "Financial Intermediation" in the traded sector. The 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.

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 in sector j averaged over the period 1973-2017.[6] Since we are using hours instead of employment, our TFP measure controls for observed labor effort. 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 $u^{K,j}_{it}$:

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

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.7, we find that our empirical findings are little sensitive to the use of alternative measures of technology which include i) Basu's [1996] approach which has the advantage of controlling for unobserved changes in both capital utilization and labor effort, ii) and the use of time series for utilization-adjusted-TFP from Huo et al. [2023] and Basu et al. [2006]. Our preferred measure is based on Imbs's [1999] method because it fits our model setup where we consider an endogenous capital utilization rate and the last two measures can only be constructed over a shorter period of time and for a limited number of OECD countries.

2.3 Tax Competition and Race to the Bottom's Assumption

In this subsection, we document a set of evidence which corroborates the assumption of a race to the bottom and paves the way for the SVAR identification of exogenous shocks to corporate taxation.

[6] 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; next we split the gross capital stock into traded and non-traded industries by using sectoral value added shares likewise Garofalo et Yamarik [2002].

International tax competition and the downward trend in corporate taxation common to OECD countries. 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 motives and not the result of the desire to offset a recession. 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, see Online Appendix A.1 where we plot country-level CIT rates. Because countries respond to tax cuts by competitors to attract businesses, in addition to generating a downward trend in corporate taxation, tax competition leads country-level tax rates to share a common component.

Construction of the instrument: the international CIT index. While financial openness and capital mobility have caused a race to the bottom, as corroborated by our evidence below, 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 CIT index as a linear combination of other countries' tax rates. Since the tax competition effect is decreasing in the distance (see Overesch et al. [2011]) just like trade, we consider the trade intensity between the home country and its trade partner $k = 1...10$ within ten countries 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 time average of trade (measured by imports) share of the home country i with its trade partner k, the latter having a statutory CIT rate τ_{ikt}. By considering a constant weight, $\alpha_{IM}^{i,k}$, we remove any potential endogeneity passing through trade between countries. The correlation between τ_{it}^{int} and τ_{it} averages 0.865, see Online Appendix D.1. One important feature of the international CIT rate defined in eq. (2) is that it does not contain the country's own CIT which should make the international tax rate exogenous to the country's economic conditions.

Financial openness and the race to the bottom: Evidence on tax competition. To further support our assumption that the movements in country-level profits' taxation are driven by tax competition motives, 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)). Denoting the error term by ν_{it}, the panel data estimations (with t-stat reported in parentheses) yield:

$$\tau_{it} = \underset{(37.015)}{0.482} - \underset{(-30.747)}{0.454}\ \kappa_{it} + \underset{(20.678)}{0.829}\ \kappa_{it} \times \tau_{it}^{int} + \nu_{it}, \tag{3}$$

In this analysis, we are using the Chinn-Ito index which measures the intensity of legal restrictions on external accounts and thus captures the country's degree of capital account openness denoted by κ_{it}.[7] For reasons of space, the complete set of evidence is relegated to Online Appendix D.4. 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 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, see Online Appendix D.4 which provides a lot of details.

Construction of a second version of the instrument: adjusted international CIT index. Because the movements in international corporate taxation might be potentially driven by the world business cycle, we construct an alternative measure of the international CIT index denoted by $\tau_{it}^{int,IV}$. The construction of our instrument is an adaptation of the methodology proposed by Jordà et al. [2019]. We run the regression of the change in τ_{it}^{int} (in panel data with country fixed effects) on the world unemployment gap which tracks the world business cycle.[8] We calculate the unpredictable component of international profits' taxation by subtracting from $d\tau_{it}^{int}$ the change in the predictable component of the international CIT index denoted by $d\bar{\tau}_{it}^{int}$, and we multiply the unpredictable movement by the capital openness index κ_{it} (which varies between 0 and 1) to further capture the tax competition motives:

$$d\tau_{it}^{int,IV} = \kappa_{it}\left[d\tau_{it}^{int} - d\bar{\tau}_{it}^{int}\right]. \tag{4}$$

We will use this second version of our instrument to check whether our identification is not contaminated by the world business cycles. The construction of $d\tau_{it}^{int,IV}$ involves an additional step which results in point estimates associated with larger confidence bounds, especially when we are left with a limited number of observations when conducting the country-split. Therefore, we consider below the first instrument (2) as the baseline.

[7] 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.

[8] Since the international CIT index is country-specific, we construct the world unemployment rate as an import-share-weighted-average of trade partners' unemployment rates, i.e., $u_{it}^{W} = \sum_{k\neq i}^{10} \alpha_{IM}^{i,k} u_{ikt}$ where i indexes countries, k trade partners and t time in years. To compute the world unemployment gap, we estimate the trend of world unemployment, denoted by $\bar{u}_{it}^{W}$, by applying a Hodrick-Prescott filter with a smoothing parameter of 100 (as we use annual data), and we calculate the difference between the actual world unemployment rate and its trend, i.e., $u_{it}^{gap,W} = u_{it}^{W} - \bar{u}_{it}^{W}$.

2.4 SVAR Identification of Shocks to Corporate Taxation

Cointegration between domestic and international CIT. While the evidence documented in the previous subsection supports our assumption that the downward trend in OECD countries' CIT rates is driven by tax competition motives, a more formal check is to test that there is a common stochastic trend between $\log \tau_{it}$ and $\log \tau_{it}^{int}$ for the eleven OECD countries of our sample. After checking in Online Appendix D.2 that the variables display a unit root process, 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.

SVAR model. 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 $n-1$ domestic variables of interest collected in vector V, 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:

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

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. We estimate the reduced form of the VAR model $C(L)\hat{X}_{it} = \eta_{it}$ with two lags and country fixed effects where η_{it} is a vector of reduced-form innovations with a variance-covariance matrix given by $\Sigma = A_0A_0'$. The matrices C_k and the variance-covariance matrix Σ are assumed to be invariant across time and countries. As shall be useful, let us denote $A(L) = B(L)A_0$ with $A(L) = \sum_{k=0}^{\infty} A_k L^k$.

SVAR identification. To identify the first element of the vector ε_{it} (see eq. (5)), 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 amounts to assuming that the shocks to domestic economic activity have no impact in the long-run on τ^{int}. Formally, the assumption on the long-run cumulative matrix implies that once the reduced form has been estimated using OLS, structural shocks can then be recovered from $\varepsilon_{it} = A(1)^{-1}B(1)\eta_{it}$ where the matrix $A(1)$ is computed as the Cholesky decomposition of $B(1)\Sigma B(1)'$.

Internal instrument and exogeneity to the world business cycle. To check the robustness of our identification, in particular to ensure that our identification is not contaminated by the world business cycle, we estimate a second version of our VAR model which includes the alternative instrument $d\tau_{it}^{int,IV}$ (see eq. (4)). As we shall see in the next subsection, the shock itself and the responses from the SVAR model are not statistically different whether the internal instrument τ_{it}^{int} is adjusted with the world business cycle or not.

Testing the predictability of our identified shocks to corporate taxation. One key identifying assumption is that the shocks to corporate taxation we identify are not predictable on the basis of past information and are exogenous to other shocks in the VAR model, see Ramey [2016]. First, Granger causality tests confirm that identified shocks to international corporate taxation, $\varepsilon_{it}^{\tau^{int}}$, are not predictable on the basis of domestic (real GDP, hours, utilization-adjusted-TFP) and foreign (world real GDP) macroeconomic activity (the p-value is 0.842). Second, identified shocks $\varepsilon_{it}^{\tau^{int}}$ are not predicted by lagged values of shocks to other domestic variables included in the VAR model.

One additional concern is that our identified shock to τ_{it}^{int} is driven by shocks not included in the VAR model. To further test the predictability of shocks $\varepsilon_{it}^{\tau^{int}}$, we identify both domestic and world demand shocks.[9] We do find that past country-specific demand shocks predict shocks to country-level CIT rates. Conversely, neither country-specific demand shocks nor world demand shocks predict our identified shocks to international corporate taxation. More details can be found in Online Appendix D.5.

Testing the capital flow channel. In the same spirit as Jordà et al. [2019], we base our identification on the shifts of foreign variables which are exogenous to domestic economic activity. A violation of the exclusion restriction could occur if the international CIT rate affects home outcomes through channels other than movements in domestic CIT rates. In Online Appendix D.6, we investigate empirically the effects of a permanent decline in τ_{it}^{int} on capital flows by using time series for inward and outward FDI taken from Lane and Milesi-Ferretti [2007]. In accordance with the assumption of tax competition motives, a CIT cut implemented by neighbor countries causes a capital outflow (outward FDI) which is offset by a capital inflow (inward FDI) of the same magnitude (and occurring at the same time) driven by the CIT cut by the home country. If the home country had decided to cut its own rate to offset a recession caused by the capital outflow, a permanent decline

[9] To identify domestic (world) demand shocks, we adopt the Blanchard and Quah [1989] SVAR identification approach and estimate a VAR model which includes the rate of growth of domestic (world) real GDP, and the domestic (world) unemployment rate. To identify shocks to the country-level CIT rate, we estimate a VAR model which includes the country-level CIT rate ordered first and we assume that shocks to other domestic macroeconomic variables have no long-run effect on the CIT rate.

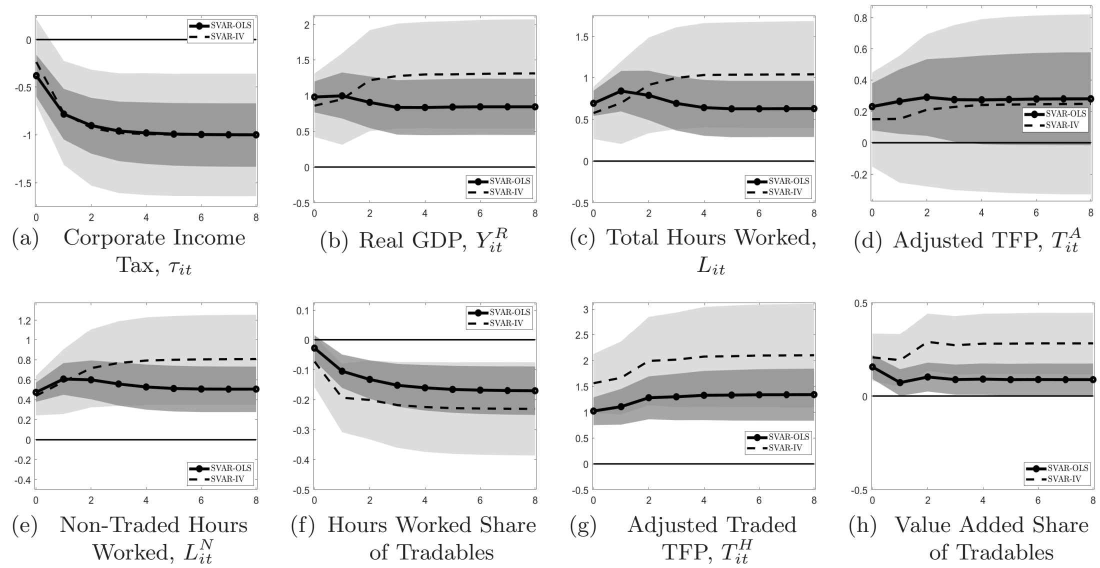
in international corporate taxation would lower domestic activity. We find instead that a decline in international corporate taxation has a strong expansionary effect on domestic economic activity which eliminates the possibility of a violation of the exclusion restriction.

Robustness checks w.r.t. to estimation 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). 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.7, we increase the lags from two to five and find that all of our conclusions stand.

Are our identified CIT shocks anticipated? To investigate whether exogenous changes in the international CIT index are surprise shocks or tax news shocks, we adapt the methodology pioneered by Beaudry and Portier [2006] in Online Appendix D.9 by estimating a VAR model which includes τ_{it}^{int} in variation and stock prices, SP_{it}, in rate of change and by identifying shocks to τ_{it}^{int} and SP_{it} under short- and long-run restrictions. A surprise (permanent) shock to corporate taxation (obtained from long-run restrictions) produces an immediate permanent increase in τ_{it}^{int} while a CIT news shock (obtained from short-run restrictions) is a shock to stock prices which is associated with a muted impact response of τ_{it}^{int}, the latter gradually decreasing over time (since stock prices increase). If the correlation between the two shocks were -1, then it would mean that the shocks to τ_{it}^{int} we identify are eventually tax news shocks (i.e., they are anticipated to take place in the future). On the contrary, we find that the correlation between the two disturbances is low at -0.31 when we use τ_{it}^{int} and -0.18 when we consider the second version of the instrument $\tau_{it}^{int,IV}$. Conversely, we find that shocks to τ_{it}^{int} obtained under short-run and long-run identification have a correlation of 0.95 for τ_{it}^{int} and 0.98 for $\tau_{it}^{int,IV}$. In summary, our identified shocks are unambiguously surprise (permanent) shocks to international CIT.

2.5 Dynamic Effects of Corporate Tax Shocks across Sectors

Solid black lines with circles in Fig. 1 show the effects of an exogenous permanent decline in the international CIT index. 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 domestic macroeconomic variables which are detailed in Online Appendix B. For robustness purposes, dashed black lines display the responses to a shock to the second version of our instrument $\tau_{it}^{int,IV}$. Dark (light) shaded areas are 68% confidence bounds associated with the VAR point estimate obtained with the baseline instrument τ_{it}^{int} (second instrument $\tau_{it}^{int,IV}$). While we detect some quantitative differences between the effects of a shock to τ_{it}^{int} and those caused by a shock to $\tau_{it}^{int,IV}$,



(a) Corporate Income Tax, τ_{it}

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

(c) Total Hours Worked, L_{it}

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

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

(f) Hours Worked Share of Tradables

(g) Adjusted Traded TFP, T_{it}^{H}

(h) Value Added Share of Tradables

Figure 1: Dynamic Effects of a Corporate Tax Shock in OECD Countries ($N = 11$). Notes: Adjusted TFP means Utilization-Adjusted-TFP. The dynamic adjustment generated from a SVAR model with long-run restrictions is displayed by the black lines. The solid black line with circles shows results for the baseline instrument, τ_{it}^{int}, defined as an import-share-weighted-average of trade partners' CIT rates, see eq. (2), while the dashed black line shows results for the second instrument, $\tau_{it}^{int,IV}$, which is world business cycle- and capital openness-adjusted, see eq. (4). In both cases, the solid and dashed lines display responses to an exogenous decline in trade partners' CIT leading the home country to cut its own CIT rate by 1 percentage point in the long-run. Dark (light) shaded areas indicate the 68 percent confidence bounds based on bootstrap sampling for the baseline (second) instrument. Horizontal axes indicate years. Vertical axes measure percentage deviation from trend. Sample: 11 OECD countries, 1973-2017, annual data.

the discrepancy is not statistically significant. Differences come from the fact that the construction of $\tau_{it}^{int,IV}$ requires to adjust τ_{it}^{int} with the business cycle and capital openness which in turn increases the variance of the estimator in the second step (thus resulting in larger confidence bounds) compared with τ_{it}^{int}. For clarity purposes, in the sequel, we base our discussion on the shock to τ_{it}^{int} (shown in solid lines with circles associated with dark shaded areas) which is considered throughout the paper as the baseline. To highlight the most significant findings, we restrict our attention to a limited set of macroeconomic variables below while the remaining responses are relegated to Online Appendix C.8.

Aggregate Effects. As shown in Fig. 1(a), when neighbors lower their CIT rate (i.e., $d\tau_{it}^{int} < 0$), the home country also reduces its own tax rate τ_{it}, which corroborates our tax competition hypothesis.[10] According to our estimates, on average, an exogenous decline in the international CIT rate by -1 ppt leads the home country to lower its CIT rate by -0.53 ppt. The corporate tax cut has an expansionary effect on real GDP, total hours worked, and utilization-adjusted-aggregate-TFP (see Fig. 1(d)). Total hours rise by 0.71% on impact and by 0.58% in the long-run (see Fig. 1(c)). Importantly, the combined effect of higher labor and technology improvements generates a real GDP growth of 1.3% on impact while real GDP remains permanently 0.77% higher than its initial steady-state level (see Fig. 1(b)) after a CIT cut by -1 ppt in the long-run.

Effects on technology. As can be seen in Fig. 1(d), we detect a significant rise in

[10] We re-scale the shock to international CIT so that it lowers the home CIT by 1 ppt in the long-run. More specifically, in response to a decline in neighbors' profit taxation by -1.79 ppt, the home country cuts its CIT by -1 ppt in the long-run.

utilization-adjusted-aggregate TFP (by 0.35%) only in the short-run after a CIT cut. By contrast, Fig. 1(g) reveals that utilization-adjusted-TFP of tradables significantly increases in traded industries by more than 1% in the first two years and 1.3% in the long-run. The response of T_{it}^{N} (relegated to Online Appendix C.8) is quite distinct as it remains essentially unchanged. We show in the theoretical part that technology improvements in the traded sector come from three different forces, i.e., short-run productivity gains necessary to meet a higher demand, the exposition of domestic traded firms to foreign technology and the long-run increase in the stock of ideas.

While the first factor capturing an increase in the intensity in the use of stock of knowledge cannot be tested empirically (but is essential to reconcile the theory with the evidence), international R&D spillovers and domestic innovation find strong support in our estimates relegated to Online Appendix C.10. To measure the level of foreign technology that the domestic country can access through international openness, we construct a world technology index as an import-share-weighted-average of trade partners' utilization-adjusted TFP which is sector-specific. Our evidence reveals that a permanent decline in international CIT is associated with a significant and permanent world technology improvement only in traded industries.

We also investigate the impact on investment in R&D (for nine countries due to limited data availability) and on the stock of R&D (for ten countries) at a sectoral level. We find that a CIT cut has a strong expansionary effect on domestic investment in R&D but only in the traded sector. While the stock of R&D in the traded sector rises by more than 2% in the long-run, the point estimate is not statistically significant which can be explained by large international differences in the effects of corporate taxation on technology.

Effects on sectoral hours. While technology improvements are concentrated within traded industries, labor growth originates from non-traded sectors. As displayed by Fig. 1(e), a CIT cut gives rise to a significant and persistent rise in hours worked in non-traded industries which accounts for 88% of the rise in total hours in the long-run. The large and significant increase in L_{it}^{N} is permitted by the reallocation of labor toward non-traded industries as reflected into a decline in the hours worked share of tradables (see Fig. 1(f)).

Effects on sectoral value added. Which sector contributes the most to real GDP growth? While the traded sector accounts for 35% of GDP only, on average 55% of real GDP growth is driven by the rise in traded value added. More specifically, while a CIT cut increases significantly both traded and non-traded value added, technology improvements concentrated in the traded sector are large enough to raise the value added share of tradables at constant prices by almost 0.2 ppt of real GDP in the long-run as shown in Fig. 1(h).

Does a CIT cut pay for itself? In Online Appendix C.11, evidence shows that a reduction in corporate taxation reduces the public debt. Such a decline is found to be driven by a rise in tax revenues brought about by higher (consumption and labor) tax base. A CIT cut pays for itself because it has a strong expansionary effect on economic activity while the loss in tax revenues is mitigated by the fact that its tax base is (relatively) small.

2.6 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 averages 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 has an elasticity which is significantly different from zero and characterized by the greatest technology improvement after a permanent CIT cut, see Online Appendix C.4 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. The second dimension is related to the degree of wage flexibility. In subsection C.5, we document evidence which reveals that English-speaking and Scandinavian countries are characterized by a higher wage flexibility than continental European countries where wages are more sticky.

International differences in the effects of corporate taxation on technology. In Fig. 2, we contrast the effects of a permanent corporate tax cut between continental European countries (displayed by solid blue lines) and English-speaking and Scandinavian countries (shown in solid red lines). Shaded areas are 68% confidence bounds. As can be seen in Fig. 2(a) and Fig. 2(c), both groups respond to a decline in profits' taxation abroad by cutting their own tax rate on corporate income which corroborates the tax competition's hypothesis. For both groups, we normalized the shock to the international CIT index such that the country-level CIT rate declines by 1 percentage point in the long-run.

While Fig. 2(b) and Fig. 2(d) reveal that a CIT cut has a strong and persistent expansionary effect on real GDP growth, the factors driving economic growth are quite

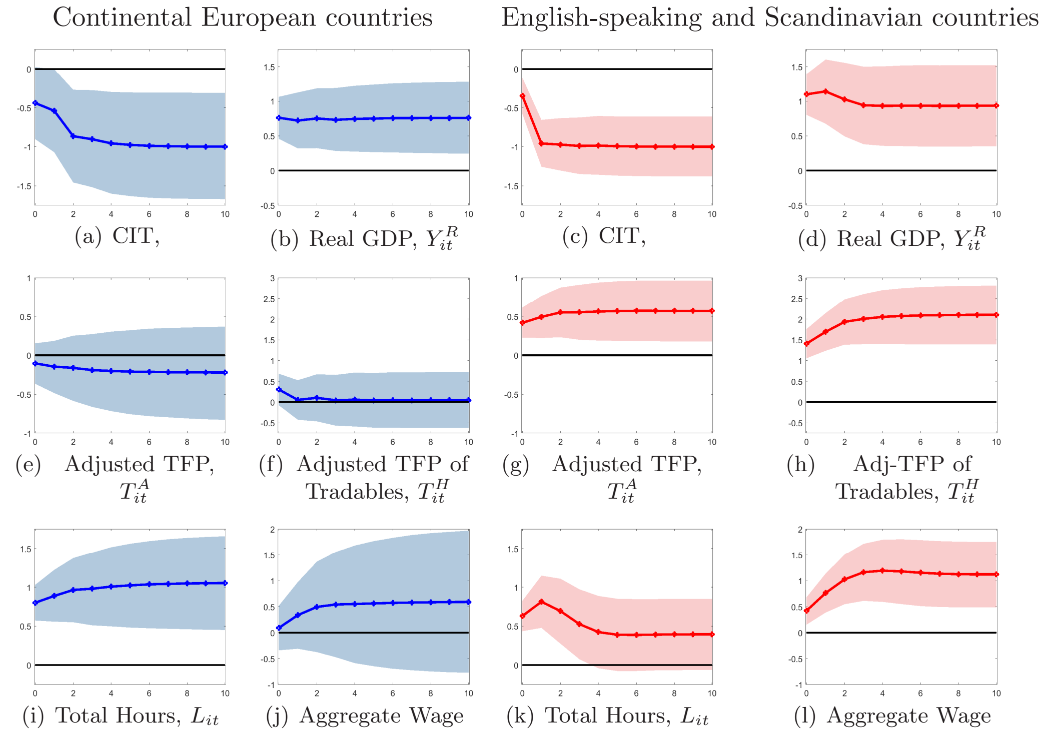


Figure 2: Dynamic Effects of a CIT Shock: Country-Split. Notes: We investigate the effects of an exogenous decline in CIT by 1 percentage point in the long-run for two groups of countries. The solid blue line shows the responses of continental European countries while the solid red line displays the responses of English-speaking and Scandinavian 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.

distinct between the two groups of countries. Fig. 2(e) reveals that in continental Europe technology is essentially unchanged after a permanent corporate tax cut while utilization-adjusted-aggregate-TFP (see Fig. 2(g)) permanently improves by almost 0.6% in the long-run in English-speaking and Scandinavian countries (see the red line). As shown in Fig. 2(h), technology improvements are concentrated in traded industries where utilization-adjusted-TFP rises by 1.41% on impact and 2.1% in the long-run after a CIT cut by 1 percentage point. In Online Appendix C.4, 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 traded sector and in English-speaking and Scandinavian countries. By contrast R&D activity remains unresponsive to the CIT shock in continental Europe.

International differences in the effects of corporate taxation on hours. While technology only improves in English-speaking and Scandinavian countries, as can be seen in Fig. 2(i), hours only significantly and persistently increase in continental European countries. As displayed by Fig. 2(k), the response of hours in English-speaking and Scandinavian countries is smaller (0.4% vs 1.05%) and not statistically significant in the long-run. Moreover, the impact response of hours displays a greater magnitude in continental European countries. Large and persistent responses of hours on impact and the long-run in continental Europe are both puzzling as technology remains essentially unchanged. One potential explanation of this discrepancy is the presence of wage stickiness (and habit persistence as explained later). Inspection of Fig. 2(j) and Fig. 2(l) reveals that the response of the aggregate wage rate is muted in continental European countries while it significantly rises at all horizons in English-speaking and Scandinavian countries.

International differences in real GDP growth. Because we estimate the response of real GDP after a domestic CIT cut (driven by a CIT cut by competitors) 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_{it}^R, 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 0.83 and 0.97 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. The traded sector contributes almost 65% of the long-run increase in real GDP and technology improvements concentrated in the traded sector remain the main driver of economic growth in English-speaking and Scandinavian countries. Conversely, the non-traded sector contributes 62% of the long-run increase in real GDP in continental Europe and the main driver is labor growth.

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.7. 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, except for a slight increase in the traded labor income share, see Online Appendix C.9. The fact that the labor income shares do not decline after a permanent CIT cut 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. Time is continuous and indexed by t. 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. For reasons of space, we present essential elements of the model and relegate the full description of the model to Online Appendix E. We abstract from trend growth below and thus do not characterize the convergence of the economy toward a balanced growth path which is supposed to exist as it is unessential to our analysis as we are only interested in the dynamics generated by a permanent CIT cut. Indeed, in the numerical part, we calibrate the shock so as to generate the permanent decline in corporate taxation we estimate empirically and we contrast the responses predicted by the model with the responses (conditional on the CIT shock) generated from the SVAR model. The solution method is detailed in Online Appendix F.

3.1 Households

Consumption in sectoral goods. Aggregate consumption $C(t)$ is made up of traded, $C^T(t)$, and non-traded goods, $C^N(t)$, which are aggregated by means of a CES function:

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

where $0 < \varphi < 1$ is the weight of the traded good in the overall consumption bundle and ϕ corresponds to the elasticity of substitution between traded goods and non-traded goods.

The traded consumption index $C^T(t)$ is defined as a CES aggregator of home-produced traded goods, $C^H(t)$, and foreign-produced traded goods, $C^F(t)$:

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

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

Labor supply across sectors. The representative household 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:

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

where $0 < \vartheta_L < 1$ parametrizes the weight attached to the supply of hours worked in the traded sector and ϵ_L is the elasticity of substitution between sectoral hours worked. 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 $K(t)$ ($Z(t)$). Denoting $V = K, Z$, we allow for imperfect mobility of (tangible or intangible) assets by assuming that traded $V^H(t)$ and non-traded $V^N(t)$ (tangible or intangible) assets are imperfect substitutes:

$$V(t) = \left[\vartheta_V^{-1/\epsilon_V} \left(V^H(t)\right)^{\frac{\epsilon_V+1}{\epsilon_V}} + (1-\vartheta_V)^{-1/\epsilon_V} \left(V^N(t)\right)^{\frac{\epsilon_V+1}{\epsilon}} \right]^{\frac{\epsilon_V}{\epsilon_V+1}}, \quad (9)$$

where $0 < \vartheta_V < 1$ is the weight of traded assets and ϵ_V captures the degree of mobility of capital (ϵ_K) or ideas (ϵ_Z) 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:

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

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:

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

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 $C S^{-\gamma_S} \equiv C^{1-\gamma_S} \left(C/S\right)^{\gamma_S}$.

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].[11] In eq. (12), the reference stock is 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:[12]

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

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:

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

[11] 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.

[12] 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 $\nu^{K,j}(t) = K^j(t)/K(t)$ ($\nu^{Z,j}(t) = Z^j(t)/Z(t)$), 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. Installation of new investment goods involves convex costs, assumed to be quadratic. Thus, total investment, $J^K(t)$, differs from effectively installed new capital:

$$J^K(t) = I^K(t) + \frac{\kappa}{2}\left(\frac{I^K(t)}{K(t)} - \delta_K\right)^2 K(t), \tag{16}$$

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:

$$\dot{K}(t) = I^K(t) - \delta_K K(t). \tag{17}$$

As in Fernández de Córdoba and Kehoe [2000], the investment good inclusive of installation expenditure, $J^K(t)$, is (costlessly) produced by using traded and non-traded inputs, i.e., $J^{K,T}(t)$ and $J^{K,N}(t)$, which are aggregated by means of a CES technology with an elasticity of substitution ϕ_K and a weight of $J^{K,T}(t)$ denoted by $0 < \iota < 1$. The traded investment good (inclusive of installation costs), $J^{K,T}(t)$, is a CES aggregator of home-produced traded inputs, $J^{K,H}(t)$, and foreign-produced traded inputs, $J^{K,F}(t)$, with an elasticity of substitution ρ_K and a weight of home-produced traded input denoted by $0 < \iota^H < 1$. See Online Appendix E.1 for further details.

Investment in intangible assets. Accumulation of intangible assets is governed by the following law of motion:

$$\dot{Z}(t) = I^Z(t) - \delta_Z Z(t), \tag{18}$$

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 $\zeta > 0$:

$$J^Z(t) = I^Z(t) + \frac{\zeta}{2}\left(\frac{I^Z(t)}{Z(t)} - \delta_Z\right)^2 Z(t), \tag{19}$$

where $J^Z(t)$ stands for total 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, $J^{Z,N}(t)$, which are aggregated by means of a CES technology with an elasticity of substitution denoted by ϕ_Z and a weight of the intangible traded input denoted by $0 < \iota_Z < 1$.

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:

$$Y^j = \left[\int_0^1 \left(X_i^j\right)^{\frac{\omega^j-1}{\omega^j}} \mathrm{d}i\right]^{\frac{\omega^j}{\omega^j-1}}, \tag{20}$$

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:

$$X_i^j(t) = T^j(t)\left(L_i^j(t)\right)^{\theta^j}\left(\tilde{K}_i^j(t)\right)^{1-\theta^j}, \tag{21}$$

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. (21) 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 $Z^{W,j}(t)$:

$$\mathsf{Z}^j(t) = \left(\tilde{Z}_i^j(t)\right)^{\theta_Z^j}\left(Z^{W,j}(t)\right)^{1-\theta_Z^j}, \tag{22}$$

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:[13]

$$T^j(t) = \left(\tilde{Z}_i^j(t)\right)^{\nu_Z^j\theta_Z^j}\left(Z^{W,j}(t)\right)^{\nu_Z^{W,j}(1-\theta_Z^j)}, \tag{23}$$

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.

[13] 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.

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:

$$\Pi_i^j(t) \equiv (1-\tau)\,\mathrm{NOS}_i^j(t) - \left(R^{K,j}(t)-\delta_K\right)\tilde{K}_i^j(t) - R^{Z,j}(t)\tilde{Z}_i^j(t) - P^j(t)F^j, \tag{24}$$

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.3):

$$P_i^j\theta^j\frac{X_i^j}{L_i^j} = \mu^j W^j, \tag{25a}$$

$$P_i^j\left(1-\theta^j\right)\frac{X_i^j}{\tilde{K}_i^j} = \mu^j\left[\left(\frac{R^{K,j}-\delta_K}{1-\tau}\right)+\delta_K\right], \tag{25b}$$

$$(1-\tau)\,P_i^j\nu_Z^j\theta_Z^j\frac{X_i^j}{\tilde{Z}_i^j} = \mu^j R^{Z,j}, \tag{25c}$$

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 (25a)-(25c) into profit (24), and setting to zero implies that $(1-\tau)\,P_i^jX_i^j\left[1-\frac{1+\nu_Z^j\theta_Z^j}{\mu^j}\right] - P_i^jF^j = 0$. We require the markup to be larger than the degree of increasing returns to scale, i.e.,

$$1+\nu_Z^j\theta_Z^j < \mu^j, \tag{26}$$

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 $Q^j = Y^j - F^j$ which reads as follows $Q^j = Y^j\left[1-(1-\tau)\left(1-\frac{1+\nu_Z^j\theta_Z^j}{\mu^j}\right)\right]$ 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., $G \equiv P^NG^N + G^T$ where G^T includes home and imported goods, i.e., $G^T = P^HG^H + G^F$, is financed by raising lump-sum taxes in addition to corporate taxes levied on firms' profits:

$$P^N(t)G^N + P^H(t)G^H + G^F = \text{Tax}(t) + \sum_{j=H,N} \tau(t)\text{NOS}^j(t). \tag{27}$$

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:

$$Q^N(t) = C^N(t) + G^N(t) + \sum_{V=K,Z} \left(J^{V,N}(t) + C^{V,N}(t)V^N(t)\right), \tag{28a}$$

$$Q^H(t) = C^H(t) + G^H(t) + X^H(t) + \sum_{V=K,Z} \left(J^{V,H}(t) + C^{V,H}(t)V^H(t)\right), \tag{28b}$$

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

$$X^H(t) = \varphi_X \left(P^H(t)\right)^{-\phi_X}, \tag{29}$$

where $\varphi_X > 0$ is a scaling parameter, and ϕ_X is the price-elasticity of exports. Using (25a)-(25c) and market clearing conditions (28), the current account equation (15) can be rewritten as a function of the trade balance:

$$\dot{N}(t) = r^\star N(t) + P^H(t)X^H(t) - M^F(t), \tag{30}$$

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 (new and permanently lower) long-run level, τ, expressed in deviation relative to the initial steady-state is governed by the following continuous time process:

$$d\tau(t) = d\tau + x_T e^{-\xi_T t}, \tag{31}$$

where x_T is a parameter which is calibrated to match the impact response of the tax rate and $\xi_T > 0$ captures the persistence of the tax shock. Letting time tend toward infinity into (31) leads to $d\tau(\infty) = d\tau$ where $d\tau$ is the steady-state (permanent) change in the CIT rate.

Model solution. The adjustment of the open economy toward the steady-state is described by a dynamic system which comprises the equations for 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, $Z(t)$, 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, $Z^{W,j}(t)$ for tradables and non-tradables. 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 (non-traded) firms freely benefit from the progression of the stock of ideas. As we shall see, this element is an important driver of technology improvements for tradables. As detailed in Online Appendix E.5 and F, we linearize the dynamic equations in the neighborhood of the steady-state and solve the system of first-order linear differential equations.

4 Quantitative Analysis

In this section, we take the model to the data. For this purpose we solve the model numerically.[14] 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.

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 $L^H/L = 35\%$, a weight of traded tangible and intangible assets of $K^H/K = 38\%$ and $Z^H/Z = 59\%$, 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 $\omega_G = 19.5\%$ $(= G/Y)$, a tradable and home-tradable share of government spending of $\omega_{G^T} = 17\%$ $(= 1 - (P^N G^N/G))$, and $\omega_{G^H} = 83\%$ $(= P^H G^H/G^T)$, 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

[14] 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].

discount rate, β, is set to 2.6%. 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 0.67, respectively, which leads to an aggregate labor income share 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 0.95 for ϵ_L (see column 16 of Table 1) which is close to the value of one 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 0.14 (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 0.53 (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. (23)) 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, excluding values which are not consistent (i.e., values which are negative and not statistically significant), FMOLS estimates average 0.332 (0.02) and 0.141 (0.01) for the elasticity of utilization-adjusted-TFP of tradables (non-tradables) w.r.t. the domestic and international stock of R&D, respectively.

As shown in eq. (23), 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

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

Tradable share					Home share				Labor share		Input ratios		
Q^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
(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	0.83	0.65	0.67	0.35	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)
0.53	0.95	0.14	0.57	0.03	0.34	0.04	0.58	0.63	0.21	0.027	0.19	1.42	0.026

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 home content of government spending in tradables; 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.

countries, we infer values for the domestic component of technology for the traded and the non-traded sectors, i.e., $\theta_Z^H = 0.58$ 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 $\nu_Z^H = 0.572$ ($= 0.332/0.58$), and $\nu_Z^{W,H} = 0.335$ ($= 0.141/0.42$), see columns 18 and 20 of Table 1. For non-tradables, we set $\nu_Z^N = 0.03$ and $\nu_Z^{W,N} = 0.037$, see columns 19 and 21 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 1.42, 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 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. Because we want to assess the ability of the model to account for the responses of hours and technology we estimate empirically, we generate the same endogenous response of the home CIT rate, $\tau(t)$, to our identified shock to international corporate taxation, τ^{int}. For this purpose, we normalize the steady-state decline in the domestic CIT rate to -1 percentage point (i.e., $d\tau = -0.01$) and set $x_T = 0.5$ together with $\xi_T = 0.95$ in eq. (31). To identify the tax shock, we use top statutory CIT rates because they are more likely to be exogenous than effective CIT rates. However, to calibrate the model to the data, top statutory CIT rates are too high as they do not reflect the true profits' taxation; we thus take effective CIT rates from Bachas et al. [2022] and set the tax rate on corporate income to its cross-country average $\tau = 22.5\%$.

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. Because lower corporate taxation leads countries to innovate, the international stock of ideas increases when τ^{int} is lowered. This prediction is corroborated by our VAR evidence relegated to Online Appendix C.10 which shows that a cut in the international CIT index raises the world utilization-adjusted-TFP of tradables by 0.71% on impact and 0.82% in the long-run. By contrast, world technology of non-tradables, $T^{W,N}(t)$, slightly declines in the short-run as R&D is reallocated toward the traded sector. Because domestic traded firms are exposed to foreign technology, they can take advantage of a higher international stock of ideas. We assume that the sector-specific international stock of ideas, $Z^{W,j}(t)$, expressed in deviation relative to the initial steady-state is governed by the following continuous time process:

$$dZ^{W,j}(t) = dZ^{W,j} + x_Z^j e^{-\xi_Z^j t}, \tag{32}$$

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, $\xi_Z^j > 0$ parameterize the change on impact in $Z^{W,j}(t)$ and the speed of adjustment, respectively. We infer the adjustment of the sector-specific-international stock of ideas, $Z^{W,j}(t)$, toward its long-run level by using the relationship $T^{W,j}(t) = (Z^{W,j}(t))^{\nu_Z^{W,j}}$ and estimates of $\nu_Z^{W,j}$, and choose values for $\hat{Z}^{W,j}$, x_Z^j, ξ_Z^j so as to reproduce the dynamics of $Z^{W,j}(t)$.[15]

Capital and technology utilization adjustment costs. We set the adjustment cost in the capital utilization rate, ξ_2^j, to 0.25 for tradables and 0.2 for non-tradables 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

[15] In line with our empirical estimates, we choose $\hat{Z}^{W,H} = 1.6\%$ and $\hat{Z}^{W,N} = -0.30\%$, $\xi_Z^H = \xi_Z^N = 0.4$, and $x_Z^H = 0.9\%$ and $x_Z^N = -0.01\%$.

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 elements is related to technology's factors which include three dimensions. First, households invest in R&D giving rise to a stock of ideas $Z(t)$ which is allocated to sectors in accordance with its contribution to the marginal revenue product of sector $j = H, N$. Because $Z^j(t)$ builds up only gradually over time, it will contribute to technology improvements 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 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, $Q^R(t)$, and in the real value added share of tradables, $d\nu^{Q,H}(t)$. 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 the behavior of the aggregate wage rate.

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 -0.50 ppt on impact, close to our estimates.

First ingredient: Investment in R&D. In columns 7 and 14 of Table 2, we report results from a restricted version of the baseline model where we consider a two-sector small open economy model which collapses to the KR model with GHH preferences. In this model's version, we 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 so that 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 0.15% on impact which is more than four times smaller than what we estimate empirically (i.e., 0.71%, 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

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, $dL(t)$	0.71	0.65	0.21	0.10	0.61	0.34	0.15	0.58	0.66	0.52	0.44	1.48	0.78	0.56
H-hours, $dL^H(t)$	0.24	0.15	-0.02	-0.11	0.02	-0.02	0.02	0.07	0.14	0.07	0.07	0.41	0.13	0.15
N-hours, $dL^N(t)$	0.47	0.50	0.23	0.21	0.59	0.36	0.13	0.51	0.52	0.45	0.38	1.08	0.65	0.41
Hours share of H, $d\nu^{L,H}(t)$	-0.02	-0.04	-0.08	-0.14	-0.17	-0.13	-0.03	-0.14	-0.06	-0.09	-0.07	-0.07	-0.12	-0.04
B. Technology														
Adjusted TFP, $dT^A(t)$	0.35	0.22	0.00	0.12	0.14	0.00	0.00	0.39	0.35	0.07	0.32	0.44	0.09	0.00
Adjusted H-TFP, $dT^H(t)$	1.02	0.75	0.00	0.41	0.45	0.00	0.00	1.34	1.10	0.19	1.00	1.30	0.23	0.00
C. Real GDP														
Real GDP, $dQ^R(t)$	0.87	0.68	0.05	0.11	0.47	0.13	-0.02	0.99	0.99	0.47	0.76	1.76	0.68	0.35
VA share of H, $d\nu^{Q,H}(t)$	0.22	0.15	-0.07	-0.01	-0.06	-0.12	-0.03	0.19	0.26	0.00	0.24	0.26	-0.03	-0.04
D. Relative Prices														
N-prices, $\hat{P}^N(t)$	0.90	0.75	0.56	1.41	1.12	0.65	0.22	1.39	1.13	0.59	1.21	0.85	0.55	0.18
H-prices, $\hat{P}^H(t)$	-0.03	-0.18	0.20	0.22	-0.11	0.09	0.05	-0.29	-0.28	-0.01	-0.19	-0.61	-0.15	-0.02
E. Consumption and Wage														
Consumption $dC(t)$	0.43	0.23	-0.06	0.13	0.46	0.13	-0.14	0.56	0.36	0.14	0.23	0.92	0.37	0.06
Aggregate Wage, $dW(t)$	0.79	0.60	0.45	1.20	0.80	0.48	0.19	1.30	1.26	0.64	1.32	0.90	0.54	0.29

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 (expressed in percentage point of GDP) and aggregate wage rate. 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: $Y^j = \left(L_i^j(t)\right)^{\theta^j} \left(\tilde{K}_i^j(t)\right)^{1-\theta^j}$.

sectoral goods is intensive in intangible assets (i.e., we set $\nu_Z^H = 0.57$), but we shut down the intensity in the use of the stock of ideas, 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 spill over on domestic firms' technology. Because the aggregate stock of ideas is a state variable which adjusts only gradually and ideas are subject to high mobility costs between sectors, neither $T^A(t)$ nor $T^H(t)$ are modified on impact. Because technology remains unchanged in the short-run, the model cannot account for the adjustment in hours on impact (0.34% vs. 0.71% in the data, see panel A in columns 6 and 1, respectively). It is only once the stock of ideas has built up that productivity gains amount to 0.23% in the traded sector, thus leading to an increase in utilization-adjusted-aggregate-TFP by 0.09% (see panel B of column 13). This figure is however far below what we estimate empirically in the long-run (0.39%). The model also understates real GDP growth in the long-run due to the considerable lack of investment in physical capital.

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 0.45% driven by the rise in the international stock of R&D and the increased intensity in the use of the stock of intangible assets, $u^{Z,H}(t)$. Indeed, traded firms find it optimal to raise $u^{Z,H}(t)$ 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, $Q^H(t)$, and depreciates the terms of trade by -0.11% in line with the VAR evidence.

By pushing up the aggregate wage (see panel E), technology improvements provide a strong incentive to increase labor supply. As shown in panel A, the model generates a rise in total hours by 0.61% on impact (see column 5) which is close of the empirically estimated impact response (0.71%, see column 1). However, contrasting the long-run response of hours of 1.48% (see column 12) with the rise in hours estimated empirically over a ten-year horizon which stands at 0.58%, 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 more than two times smaller (at 0.66%) and thus squares well with what we estimate empirically (0.58%, see column 8).

More specifically, the model abstracting from consumption habits (see column 12) generates a rise in household's consumption by 0.92 ppt of GDP (see panel E) while in the data, we find a rise of 0.56 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 considerably understate the rise in total hours in the short-run (0.10% vs. 0.71% in the data at time $t = 0$). Conversely, the model overstates the reallocation of labor toward the non-traded sector which produces a decline in $L^H(t)$ in contradiction with the evidence (-0.11% vs. 0.24% in the data).[16]

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 0.75% (1.02% in the data), leading to a rise in utilization-adjusted-aggregate-TFP of 0.22% (0.35% in the data). By stimulating wages, technology improvements have a positive impact on labor supply which raises hours by 0.65% (see column 2), a magnitude which almost collapses to what we estimate empirically (0.71%, see column 1). While the specification of GHH preferences removes the negative impact of the wealth effect on hours, allowing for consumption habits curbs the increase in consumption in the short- and especially in the long-run 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 0.58% 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) while increasing 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

[16] 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.

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 0.75% on impact (0.90% in the data) and by 1.13% in the long-run (1.39% 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 -0.04 ppt) and in the long-run (by -0.06 ppt).

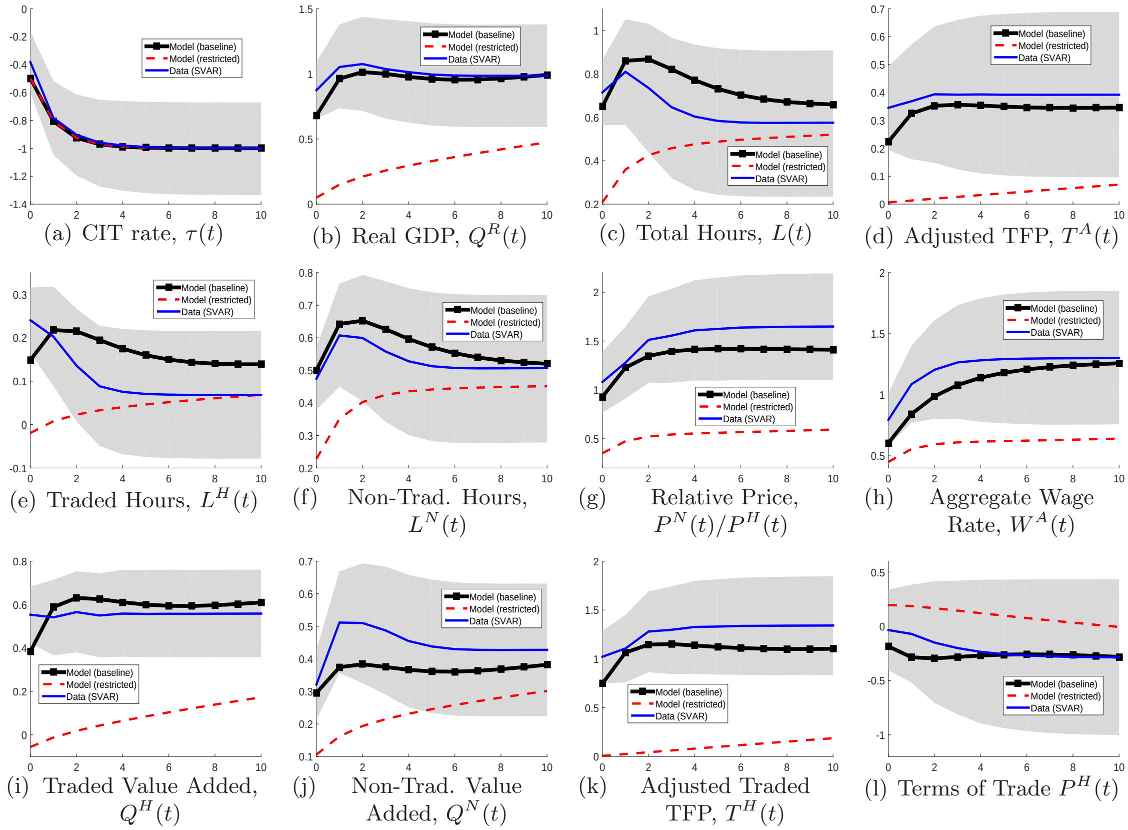
As technology improvements are concentrated within traded industries, the value added share of tradables increases by 0.26 ppt in the long-run (close to 0.19 ppt in the data), see panel C. It gives rises to an excess supply on the home-produced traded goods market which depreciates the terms of trade by -0.18% on impact and -0.28% in the long-run (-0.29% in the data), see the last line of panel D.

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. 3, we contrast theoretical (displayed by solid black lines with squares) with empirical (displayed by solid blue lines) dynamic responses with the shaded area indicating the 68% confidence bounds. We also contrast theoretical responses from the baseline model with the predictions of a restricted model shown in dashed red lines which imposes prohibitive technology utilization adjustment costs in both sectors (i.e., $\chi_2^j \to \infty$) so that $u^{Z,j} = 1$ and assumes that the international stock of ideas does not spill over 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. 3(a). We focus below on key macroeconomic variables while Online Appendix I.1 shows more numerical results.

Dynamics. As shown in the first row of Fig. 3, the baseline model (black lines with squares) reproduces well the expansionary effect of a permanent CIT cut on real GDP, total hours and technology we estimate empirically (solid blue lines) while the same model abstracting from both an endogenous technology utilization rate in the traded sector and international R&D spillovers (shown in dashed red lines) fails to account for the evidence. The reason for this is that as shown in Fig. 3(d) and Fig. 3(k), 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 the dashed red line in Fig. 3(h), the CIT cut has a mitigated impact on wages which in turn results in small (and insufficient) increases in $L^H(t)$ and $L^N(t)$, as displayed by Fig. 3(e)-3(f).

In contrast, the baseline model can generate a rise in total hours by 0.65% 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



(a) CIT rate, $\tau(t)$ (b) Real GDP, $Q^R(t)$ (c) Total Hours, $L(t)$ (d) Adjusted TFP, $T^A(t)$ (e) Traded Hours, $L^H(t)$ (f) Non-Trad. Hours, $L^N(t)$ (g) Relative Price, $P^N(t)/P^H(t)$ (h) Aggregate Wage Rate, $W^A(t)$ (i) Traded Value Added, $Q^H(t)$ (j) Non-Trad. Value Added, $Q^N(t)$ (k) Adjusted Traded TFP, $T^H(t)$ (l) Terms of Trade $P^H(t)$

Figure 3: Theoretical vs. Empirical Responses Following a 1 ppt Permanent CIT Cut. Notes: Adjusted TFP means utilization-adjusted-TFP. The solid blue line displays point estimate from the VAR model with shaded areas indicating 68% confidence bounds. The thick solid black line with squares displays model predictions in the baseline scenario; the dashed red 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 (i.e., we set $x_Z = \hat{Z}^{W,j} = \xi_Z^j = 0$ into the law of motion (32)).

line of Fig. 3(k). 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. 3(i)) and in real GDP (see Fig. 3(b)) 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. 3(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.

Because technology is essentially unchanged in the non-traded sector while C^N increases, the model gives rise to an appreciation in the relative price of non-tradables which squares well with the evidence, see Fig. 3(g). As shown in the black line in Fig. 3(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 red lines in Fig. 3(l). By lowering exports, the rise in $P^H(t)$ in the restricted model amplifies the shift of labor away from traded industries, explaining the slight decline in $L^H(t)$ (see Fig. 3(e)) in contradiction with our evidence.

4.4 English-Speaking/Scandinavian vs. Continental European Countries

Calibration. In this subsection, we calibrate our baseline model to two different sub-samples. We keep the same calibration as in section 4.1 except for three sets of parameters: the elasticity of domestic and international component of technology w.r.t. the domestic and international stock of knowledge (i.e., ν_Z^j and $\nu_Z^{W,j}$, respectively), wage flexibility, and habit persistence in consumption (i.e., γ_S). 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.

English-speaking and Scandinavian countries is a sub-sample 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 0.78 and 0.53, respectively, for tradables, and we set η_Z^N and $\eta_Z^{W,N}$ to 0.098 and 0.145, respectively, for non-tradables, see Online Appendix I.3 for more details. In accordance with our empirical findings documented in Online Appendix C.6, this group of countries is also characterized by a high degree of habit persistence in consumption. We set γ_S to 0.9. To account for the responses of capital utilization rates to a CIT cut, we keep ξ_2^N unchanged at 0.2 and raise ξ_2^H to 0.4 as $u^{K,H}$ only slightly increases on impact.

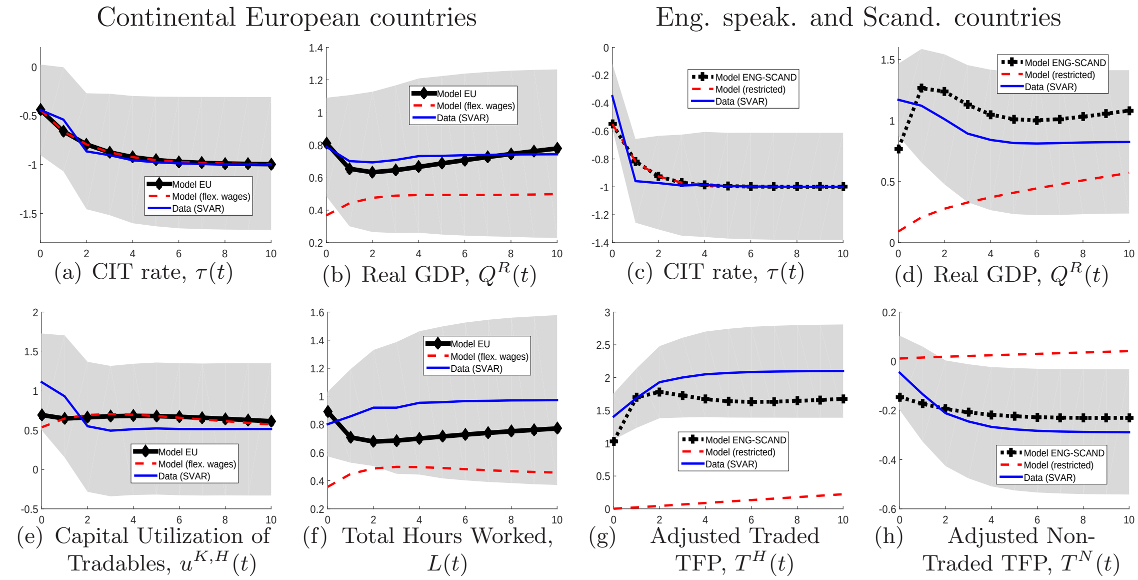
Continental Europe is a sub-sample made up of four OECD countries which are characterized by sticky wages, low international R&D spillovers for tradables (i.e., $\eta_Z^{W,H} = 0.14$) and no spillovers for non-tradables (i.e., $\eta_Z^{W,N} = 0$), an elasticity of (the domestic component of) technology w.r.t. to the domestic stock of knowledge, ν_Z^j, which collapses to zero for both tradables and non-tradables. In accordance with our own estimates (see Online Appendix C.6) and 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 0.02. This value allows the model to avoid under-estimating the rise in consumption and is key to giving rise to a persistent increase in hours in the long-run.

Fig. 4 contrasts the baseline model's predictions (shown in black lines) with empirical responses. The solid blue line displays point estimate from the VAR model with shaded areas indicating 68% confidence bounds. The solid black lines in the first two columns show the model's predictions for continental Europe while the dotted black lines in the last two columns display model's predictions for English-speaking and Scandinavian countries.

The dashed red lines show the predictions of a restricted variant of the baseline model which is specific to each sub-sample. For English-speaking and Scandinavian countries, the dashed red lines show responses when 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, the dashed red lines show the predictions of a restricted model model with flexible wages in both sectors and a weight of habits in preferences of $\gamma_S = 0.7$. In the reference model, we abstract from habit persistence in consumption and assume wage stickiness. 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 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, i.e., $\Theta^j\left(\pi_i^{W,j}(t)\right) \equiv \frac{\phi_W^j}{2}\left(\pi_i^{W,j}(t)\right)^2 W^j(t)L^j(t)$ 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.

English-speaking and Scandinavian countries. We consider a permanent decline in international corporate taxation which lowers the domestic CIT rate by -1 ppt in the long-run. Fig. 4(c) shows that English-speaking and Scandinavian countries respond quickly to the decline in neighbors' taxation of profits by cutting their own CIT rate after one year. As shown in Fig. 4(g), the model can reproduce the technology improvement concentrated in the traded sector. The performance of the model 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 $Z^H(t)$ (i.e., low values of χ_2^H) and the exposition to foreign innovation. An endogenous $u^{Z,H}(t)$ contributes 47% to the technology improvement of tradables on impact and 45% in the long-run while international R&D spillovers account for 53% at $t = 0$ and 29% over a ten-year horizon. The contribution of the increase in the stock of knowledge to the rise in utilization-adjusted-traded-TFP is relatively modest at 13% in the long-run. As it stands out, the restricted variant of the baseline model in Fig. 4(g) where we shut down international R&D spillovers and the technology utilization rate fails to account for the magnitude of technology improvement in traded industries and as a matter of fact cannot generate the real GDP stimulus we estimate empirically, especially in the short-run (see Fig. 4(d)).



(a) CIT rate, $\tau(t)$ (b) Real GDP, $Q^R(t)$ (c) CIT rate, $\tau(t)$ (d) Real GDP, $Q^R(t)$

(e) Capital Utilization of Tradables, $u^{K,H}(t)$ (f) Total Hours Worked, $L(t)$ (g) Adjusted Traded TFP, $T^H(t)$ (h) Adjusted Non-Traded TFP, $T^N(t)$

Figure 4: Theoretical vs. Empirical Responses Following a 1 ppt Permanent CIT Cut: English-speaking and Scandinavian countries vs. continental European countries. Notes: In Fig. 4, we contrast the model's predictions shown in black lines with the point estimate from the SVAR model shown in solid blue lines with shaded areas indicating 68% confidence bounds. While the first two columns show results for continental European countries, the last two columns show results for English-speaking and Scandinavian countries. For continental Europe, we keep the same calibration as the baseline except for $\nu_Z^H = \nu_Z^N = \nu_Z^{W,N} = 0$ and $\nu_Z^{W,H} = 0.14$, see Online Appendix G.5; we abstract from consumption habits by setting γ_S to 0.02; we assume wage stickiness in accordance with the evidence we document in Online Appendix C.5 and C.6; and we assume low adjustment costs for capital utilization rate, i.e., we set $\xi_2^H = \xi_2^N = 0.08$. In the dashed red lines, we show the predictions of a restricted version of the model where we allow for wage flexibility and set $\gamma_S = 0.7$. For English-speaking and Scandinavian countries, elasticities of (domestic and international component of) technology w.r.t. the (domestic and international) stock of knowledge are set in accordance with our empirical estimates, i.e., we choose $\nu_Z^H = 0.78$ and $\nu_Z^{W,H} = 0.53$ for tradables, $\nu_Z^N = 0.098$ and $\nu_Z^{W,N} = 0.145$ for non-tradables. We also allow for high habit persistence in consumption by setting $\gamma_S = 0.9$. In the dashed red lines, we show the predictions of a variant of the model where we abstract from the technology utilization rate (i.e., we let $\chi_2^H \to \infty$) and shut down international R&D spillovers (i.e., we set $x_Z = \hat{Z}^{W,j} = \xi_Z^j = 0$ into the law of motion (32)).

As can be seen in Fig. 4(h), the baseline model can account for the decline in non-traded utilization-adjusted-TFP which is brought about by the fall in world utilization-adjusted-TFP which is specific to non-tradables (i.e., $T^{W,N}(t)$). This decline is driven by the reallocation of ideas away from non-traded industries and toward the traded sector which displays a much higher return on R&D.

Continental European countries. The first two columns of Fig. 4 show the effects for continental Europe. As can be seen in Fig. 4(b), the baseline model with sticky wages and abstracting from habit persistence in consumption reproduces well the real GDP stimulus caused by a CIT cut by -1 ppt in the long-run. In contrast to English-speaking and Scandinavian countries, technology merely improves and real GDP growth is mostly driven by the significant and persistent rise in total hours. The ability of the model to increase in hours rests on three key factors: the increase in the capital utilization rate, sticky wages, and low habit persistence in consumption. According to our estimates, both traded and non-traded firms use more intensively tangible assets after a CIT cut (see Fig. 4(e)) which raises the marginal revenue product of labor. As shown in the dashed red lines (flexible wages and high habit persistence) in Fig. 4(f), the rise in $u^{K,H}(t)$ is not sufficient on its own to generate the labor stimulus. 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. Moreover, shutting down habit persistence in consumption leads households to supply more labor. Intuitively, as γ_S takes lower values, households have more incentives to increase consumption in goods and to a lesser extent consumption in leisure.

Because technology is essentially unchanged, the three aforementioned elements are key to producing the labor growth (see Fig. 4(f)) we estimate empirically. To be more specific, a model assuming flexible wages and high habit persistence in consumption (i.e., $\gamma_S = 0.7$) would generate an increase in hours by 0.36% (0.80% at time $t = 0$ in the data) on impact and 0.46% in the long-run (0.97% at time $t = 10$ in the data). When we allow for sticky wages and keep $\gamma_S = 0.7$, the model understates the rise in hours as it produces an increase in $L(t)$ by 0.65% on impact and 0.37% in the long-run. Sticky wages are essential to generate the increase in hours in the short-run while abstracting from habit persistence is necessary to generate a persistent increase in labor in the long-run (see the black lines with squares in Fig. 4(f)).

5 Conclusion

In this paper, we adopt the *internal instrument* SVAR strategy recommended by Plagborg-Møller and Wolf [2021] and propose a new SVAR identification of exogenous and permanent shocks to profits' taxation. Our identification is 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. We estimate the SVAR model in panel format on annual data which comprises the instrument (i.e., the international CIT index) ordered first and domestic macroeconomic variables. Like Shapiro and Watson [1988], we impose long-run restrictions and identify exogenous shocks to international corporate taxation by assuming that the domestic economic activity has no impact in the long-run on trade partners' CIT rates.

In accordance with our identification hypothesis, the tax pressure from abroad leads the home country to lower its own tax rate on corporate income. 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 an open economy model where traded and non-traded industries take endogenous technology decisions. Our quantitative analysis reveals that our model can account for the rise in utilization-adjusted-TFP in tradables we estimate empirically once we allow for i) a high ability to transform the domestic and international stock of knowledge into technology improvement, ii) an exposition to the international stock of ideas, and iii) low adjustment costs in the intensity in the use of the existing domestic stock of knowledge.

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 Europe, hours sizeably and persistently increase, especially in non-traded industries). Building on our model's predictions, the distinct technology effects across the two groups of countries rest on the R&D intensity of production among traded firms. While 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. Wage stickiness and low habit persistence in consumption are essential to generate a significant increase in hours in continental Europe as technology improvements are absent.

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A Data Description for Empirical Analysis

A.1 Time Series for Corporate Income Taxation

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 take the top statutory CIT rates from the dataset constructed and updated by Vegh and Vuletin [2015]. 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).

As shown in the green dotted line in Fig. 5, the rate of corporate income taxation has dropped

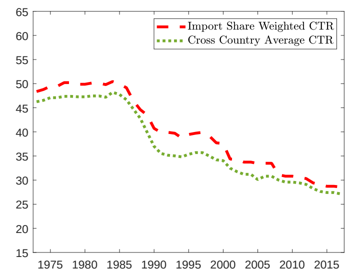
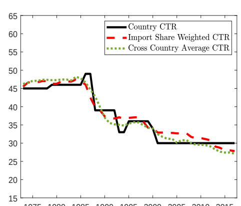
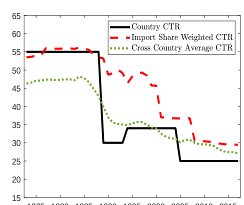


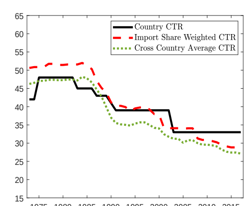
Figure 5: Evolution of CIT rates in OECD Countries over 1973-2017 Notes: In the dotted green line, we plot the country-average-CIT-rates against time. In the dashed green line, we plot the country-average-CIT-rates against time while the dashed red line plots the import-share-weighted-average of trade partners' CIT rates, τ^{int}. Sample: 11 OECD countries, 1973-2017, annual data. Source: Vegh and Vuletin [2015]



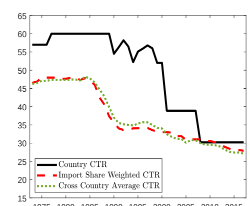
(a) Australia



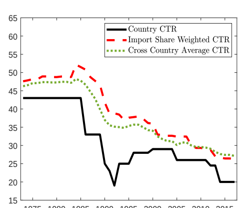
(b) Austria



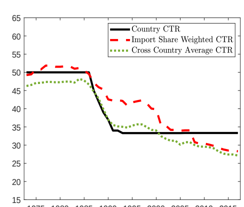
(c) Belgium



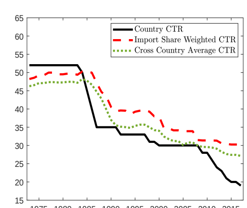
(d) Germany



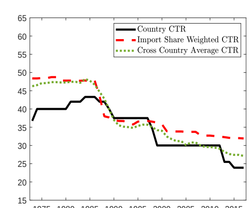
(e) Finland



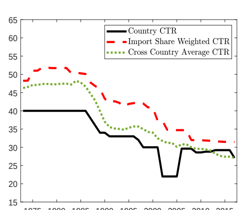
(f) France



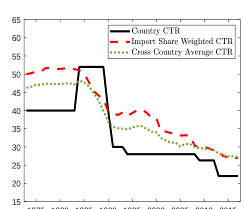
(g) United-Kingdom



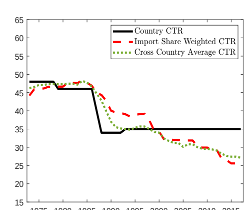
(h) Japan



(i) Luxembourg



(j) Sweden



(k) United States

Figure 6: Evolution of the CIT in Eleven OECD Countries 1973-2017 Notes: In Fig. 6, 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}. Sample: 11 OECD countries, 1973-2017, annual data.

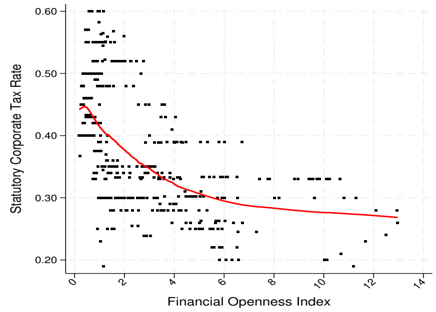


Figure 7: Corporate Tax Rates vs. Financial Openness across Time and Space. Notes We plot the corporate tax rates (vertical axis) against the measure of financial openness. The latter is calculated as the sum of total assets and total liabilities divided by GDP which are taken from Lane and Milesi-Ferretti [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.

dramatically from 47% in 1981 to 27% in 2017 in OECD countries. As it stands out, the evolution of average profits taxation (green dotted line) tracks well the movements in the international component of profits' taxation defined as a (trade-intensity-) weighted average of trade partners' CIT rates (dashed red lines). The comovement between domestic and international profits' taxation suggests that changes in corporate taxation are driven by tax competition motives.

Plot of corporate income tax rates. Fig. 6 plots the country-level CIT rate against time in the solid black lines for the eleven OECD countries of the sample. As it stands out, corporate taxation starts declining from the beginning or mid-eighties which coincides with the removal of capital controls. Because international tax competition is driven by the removal of frictions to capital mobility 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. 7 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 downward-sloping red curve (obtained from non-parametric regression technique) suggests that countries-years with more open capital markets tend to have lower CIT rates. While the financial openness indicator in Fig. 7 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, we are using the Chinn-Ito index which measures the intensity of legal restrictions on external accounts.

One important feature of the international CIT rate defined in eq. (2) is that it does not contain the country's own CIT contrary to the cross-country average shown in the dotted green line. While this makes international tax rate exogenous to the country's economic conditions, it is striking to see in Fig. 6 that country-level CIT rates (black lines) track well the long-run movement in τ_{it}^{int} (dashed red lines).

A.2 Sectoral Data

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 mapping Table 3. 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 3: 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_{it}^R) 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 at current (constant, VA_QI) prices are constructed by adding value added at current (constant) prices for all sub-industries k in sector $j = H, N$, i.e., $P_{it}^j Y_{it}^j = \sum_k P_{k,it}^j Y_{k,it}^j$ ($\bar{P}_{it}^j Y_{it}^j = \sum_k \bar{P}_{k,it}^j Y_{k,it}^j$ 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_{it}^j.
- 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_{it}^R 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. 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.

Table 4: 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 - 2017	45
Japan	(JPN)	1973 - 2017	45
Luxembourg	(LUX)	1973 - 2017	45
Sweden	(SWE)	1973 - 2017	45
United States	(USA)	1973 - 2017	45
Total number of obs.			495
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.

- 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:

$$K_{t+1} = I_t + (1 - \delta_K) K_t. \tag{33}$$

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:

$$\frac{1}{45} \sum_{t=1973}^{2017} \frac{\delta_K P_{J,t} K_t}{Y_t} = \frac{CFC}{Y}, \tag{34}$$

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:

$$K_{1973} = \frac{I_{1973}}{g_I + \delta_K}, \tag{35}$$

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 (33), (34) and (35) 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 (33), where $t = 1974, ..., 2017$, (34), and (35). 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. 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]):

$$u_t^{K,j} = \left[\frac{\left(1 - s_{L,t}^j\right)}{\delta_K \phi_K} \frac{P_t Y_{R,t}}{P_{J,t} K_t} \right]^{\frac{1}{\phi_K}}, \tag{36}$$

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:

$$\begin{aligned} \hat{Z}_t^j &= \hat{\text{TFP}}_t^j - \left(1 - s_L^j\right) \hat{u}_t^{K,j}, \\ \ln Z_t^j - \ln \bar{Z}_t^j &= \left(\ln \text{TFP}_t^j - \ln \bar{\text{TFP}}_t^j\right) - \left(1 - s_L^j\right) \left(\ln u_t^{K,j} - \ln \bar{u}_t^{K,j}\right). \end{aligned} \tag{37}$$

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 $\ln Z_t^j$:

$$\ln Z_t^j = \left(\ln Z_t^j - \ln \bar{Z}_t^j\right) + \ln \bar{Z}_t^j. \tag{38}$$

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 $\hat{X}_{it} = \left[\Delta\tau_{it}^{int}, \hat{V}_{it}\right]$, where $d\tau_{it}^{int}$ captures the variation in the international component of the corporate income tax rate (as defined in eq. (2)) and $\hat{V}_{it}$ denotes the $n-1$ domestic macroeconomic variables of interest (in growth rate) detailed later. Let us consider the following reduced form of the VAR(p) model:

$$C(L)\hat{X}_{it} = \eta_{it}, \tag{39}$$

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

$$\eta_{it} = A_0 \varepsilon_{it}, \tag{40}$$

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:

$$\hat{X}_{it} = B(L) A_0 \varepsilon_{it}, \tag{41}$$

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_{it}^{τ}, 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_{it}^{int} and a vector of domestic macroeconomic variables such as real GDP, Y_{it}^{R}, total hours worked, L_{it}, utilization-adjusted-aggregate-TFP, T_{it}^{A}. We also consider additional VAR specifications to estimate the sectoral effects:

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

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

Because we consider alternative VAR models, the fact that identified shocks to corporate taxation display substantial differences across VAR specifications might potentially 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 5 is the most interesting as it shows the correlation between structural tax shocks whose identification is based on the first baseline VAR model with aggregate macroeconomic variables and those identified on the basis of alternative VAR models which includes sectoral variables. The correlation varies from a low of 0.856 for the VAR model which includes non-traded goods prices to a high of 0.987 for the VAR model which includes consumption and investment. 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

Table 5: Correlation Matrix between Structural Tax Shocks across VAR models

VAR models	Correlations										
	VAR agg. (1)	VAR agg. $C-I$ (2)	VAR agg. Wage (3)	VAR sec-H (4)	VAR sec-N (5)	VAR tech (6)	VAR sec-comp (7)	VAR-P (8)	VAR-P^H (9)	VAR-P^N (10)	VAR-W^j (11)
Aggregate - Baeline	1.000	0.956	0.987	0.969	0,967	0,879	0,902	0,894	0,915	0,856	0,852
Aggregate - GDP components		1.000	0.948	0.929	0,921	0,854	0,862	0,855	0,873	0,816	0,837
Aggregate - Wage			1.000	0.953	0,950	0,849	0,874	0,867	0,889	0,855	0,848
Sectoral Level - Traded variables				1.000	0,908	0,900	0,953	0,950	0,969	0,916	0,872
Sectoral Level - Non-Traded variables					1.0000	0,865	0,886	0,861	0,882	0,835	0,863
Technology						1.000	0,938	0,962	0,921	0,898	0,925
Sectoral Composition							1.000	0,978	0,991	0,952	0,921
Relative Price of Non-Tradables								1.000	0,977	0,958	0,898
Terms of Trade									1.000	0,956	0,915
Non-Traded Goods' Prices										1.000	0,893
Sectoral Wages											1.000

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.

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 wage rigidity. Subsection C.4 provides evidence which supports our country-split. More specifically we estimate the effects of a permanent decline in international corporate taxation on technology, aggregate wage rate and non-traded hours and find that technology dramatically improves and the wage rate increases in English-speaking and Scandinavian countries while the other way around is true in Continental European countries. Non-traded hours significantly and persistently increase in the later group of economies while the response is not significant in countries of the former group. In subsection C.5, we provide evidence which reveals that English-speaking and Scandinavian countries are characterized by a higher wage flexibility than continental European countries where the wage rate displays much greater persistence. In subsection C.6, we estimate the magnitude of consumption's persistence over time and find that English-speaking and Scandinavian countries are characterized by a greater and significant consumption persistence while in the second group of countries consumption persistence is low and not statistically significant.

In subsection C.7, we investigate the effects of a CIT cut on dividends. Our objective is to check whether the dividend policy does not drive the technology and labor effects of a decline in profits' taxation.

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 subsection C.8, we show additional empirical results for the international CIT index, consumption and investment, the terms of trade, the relative price of non-tradables, the responses of aggregate and sectoral wages, and the responses of capital-labor ratios and capital utilization rates. In Online Appendix C.9, we investigate the dynamic responses of LISs to a shock to international corporal taxation. In Online Appendix C.10, we explore the effects of corporate taxation on investment in R&D, the stock of R&D and world technology for tradables and non-tradables. In Online Appendix C.11, we explore the effects of a permanent CIT cut on the domestic public debt. In Online Appendix C.12, we investigate whether labor growth in the non-traded sector operates at the intensive or extensive margin or both.

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 6 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 6: 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 7. The last line provides the matching between the color line (when displaying IRFs below) and the classification between tradables and non tradables.

Table 7: 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 8		red	black	blue	green	cyan

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

Fig. 8 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 main variables. The green line and the blue line show results when 'Hotels and Restaurants' and 'Real Estate, Renting and Business Services' are treated as tradables, respectively. The black 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.

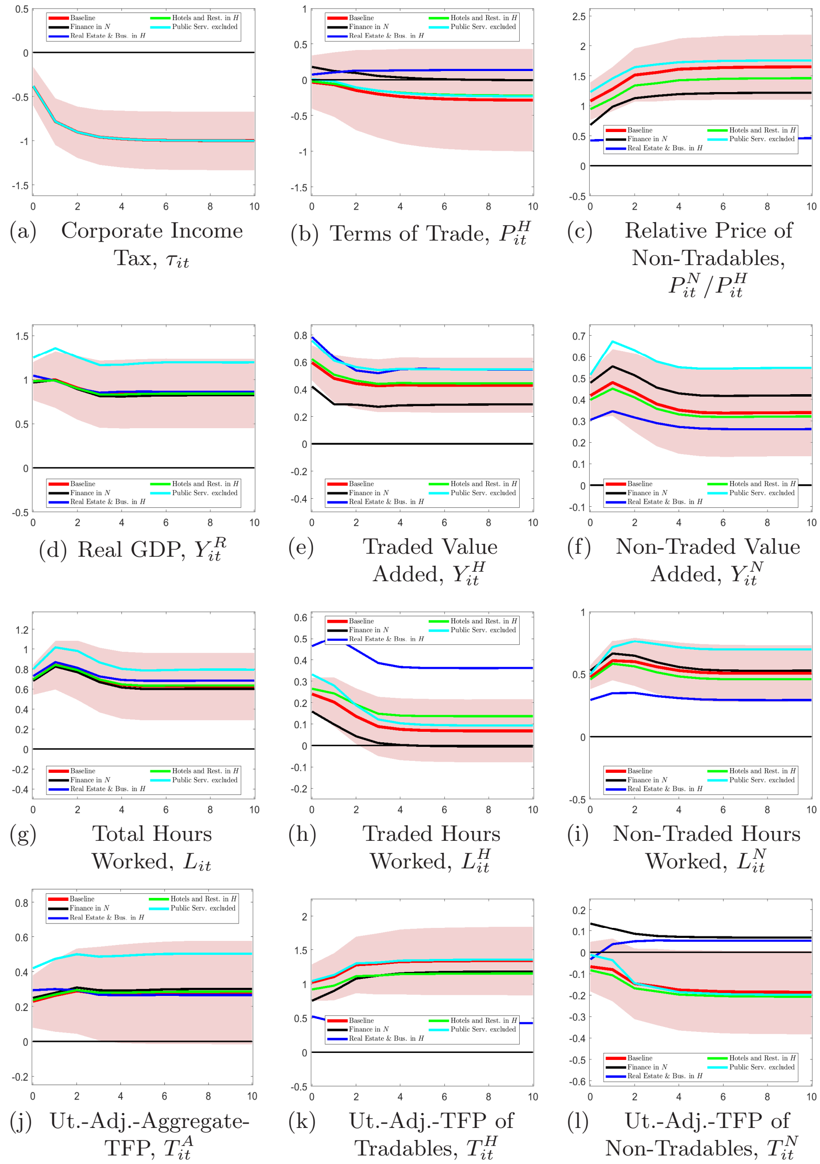
In each panel, the shaded area corresponds to the 68% confidence bounds for the baseline. The first row of Fig. 8 contrasts the responses of the CIT and relative prices which comprise the terms of trade and the relative price of non-tradables. The second row displays the responses for real GDP and both traded and non-traded value added. The third row shows the responses of total hours and both traded and non-traded hours worked. The last row of Fig. 8 displays results for aggregate, traded and non-traded utilization-adjusted-TFP.

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 last row reveals that the classification of industries as tradables or non-tradables has an impact on the utilization-adjusted-TFP of tradables only when 'Real Estate, Renting and Business Services' is treated as tradables (classification #2 and shown in the green line). Utilization-adjusted-aggregate-TFP is not sensitive to the classification except when we remove the public sector since technology improves more as utilization-adjusted TFP growth is almost twice as high.

Overall, alternative responses are fairly close to those estimated for the baseline classification as they lie within the confidence interval (for the baseline classification) of the baseline 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



(a) Corporate Income Tax, τ_{it}

(b) Terms of Trade, P_{it}^H

(c) Relative Price of Non-Tradables, P_{it}^N/P_{it}^H

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

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

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

(g) Total Hours Worked, L_{it}

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

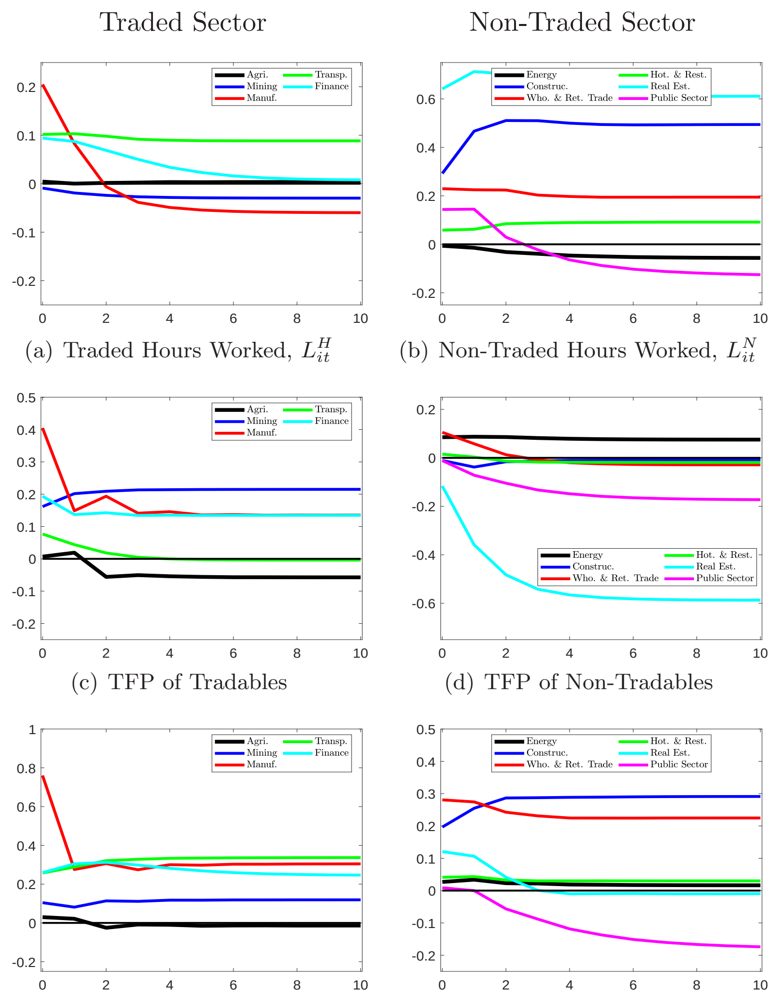
(i) Non-Traded Hours Worked, L_{it}^N

(j) Ut.-Adj.-Aggregate-TFP, T_{it}^A

(k) Ut.-Adj.-TFP of Tradables, T_{it}^H

(l) Ut.-Adj.-TFP of Non-Tradables, T_{it}^N

Figure 8: Dynamic Effects of a Corporate Tax Shock: Robustness Check w.r.t. the Classification of Industries as Tradables or Non-Tradables. Notes: Solid red lines show the response of aggregate and sectoral variables to an exogenous decrease in international corporate tax rate which leads to a domestic CIT cut by -1 ppt in the long-run. Shaded areas indicate the 68 percent confidence bounds. Horizontal axes indicate years. Vertical axes measure percentage deviation from trend. The green line and the blue line show results when 'Hotels and restaurants' and 'Real Estate, renting and business services' are treated as tradables, respectively. The black 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.



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

(c) TFP of Tradables (d) TFP of Non-Tradables

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

Figure 9: 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 68 percent confidence bounds. 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 in sub-sector k by its labor compensation share (in the traded sector or the non-traded sector), 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 cyan 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.

subsection, we conduct our empirical analysis at a more disaggregate level. The objective is twofold. First, we investigate whether all industries classified as tradables or non-tradables behave homogeneously or heterogeneously. Second, we explore empirically which industry drives the responses of broad sectors following a 1 percentage point cut in corporate tax.

Empirical analysis at a disaggregate sectoral level. To conduct a decomposition of the sectoral effects at a sub-sector level, we estimate the responses of sub-sectors to the same identified 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., $\omega^{Y,k,j} = \frac{P^{k,j}Y^{k,j}}{P^jY^j}$. We multiply the responses of hours worked within the broad sector j by its labor compensation share, i.e., $\alpha^{L,k,j} = \frac{W^{k,j}L^{k,j}}{W^jL^j}$. 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 $\frac{W^{k,j}L^{k,j}}{W^jL^j}\hat{L}_t^{k,j}$ where $\frac{W^{k,j}L^{k,j}}{W^jL^j}$ is the share of labor compensation of sub-sector k in labor compensation of the broad sector j:

$$\begin{aligned}
\hat{L}_t^j &= \sum_{k\in j} \frac{W^{k,j}L^{k,j}}{W^jL^j}\hat{L}_t^{k,j}, \\
\frac{W^jL^j}{WL}\hat{L}_t^j &= \sum_{k\in j} \frac{W^{k,j}L^{k,j}}{WL}\hat{L}_t^j, \\
\alpha^{L,j}\hat{L}_t^j &= \sum_{k\in j} \alpha^{L,k,j}\hat{L}_t^{k,j}, \qquad (42)
\end{aligned}$$

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 $\alpha^{L,k,j} = \frac{W^{k,j}L^{k,j}}{W^jL^j}$ 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:

$$\begin{aligned}
\text{TFP}_t^{k,j} &= \sum_{k\in j} \frac{P^{k,j}Y^{k,j}}{P^jY^j}\hat{\text{TFP}}_t^{k,j}, \\
\text{TFP}_t^j &= \sum_{k\in j} \frac{P^{k,j}Y^{k,j}}{P^jY^j}\hat{\text{TFP}}_t^{k,j}, \\
\text{TFP}_t^j &= \sum_{k\in j} \omega^{Y,k,j}\hat{\text{TFP}}_t^{k,j}, \qquad (43)
\end{aligned}$$

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

The first column of Fig. 9 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. 9 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', 'Financial Intermediation' and 'Mining'. Traded hours is mostly driven by the rise in hours in 'Transport and

Communication', especially in the long-run since hours in other sectors are unresponsive. 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 of sub-sector 'Community Social and Personal Services' (i.e., the public sector which also includes health and education services) do not increase. Technology does not improve in any non-traded industries, except for 'Electricity, Gas and Water Supply' (Energy in the legend) where TFP slightly increases. The rise in traded value added is mostly driven by 'Manufacturing', 'Financial Intermediation' and 'Transport and Communication' while the rise in non-traded value added originates from 'Construction' and 'Wholesale and Retail Trade'.

C.3 Alternative Measures of Technology

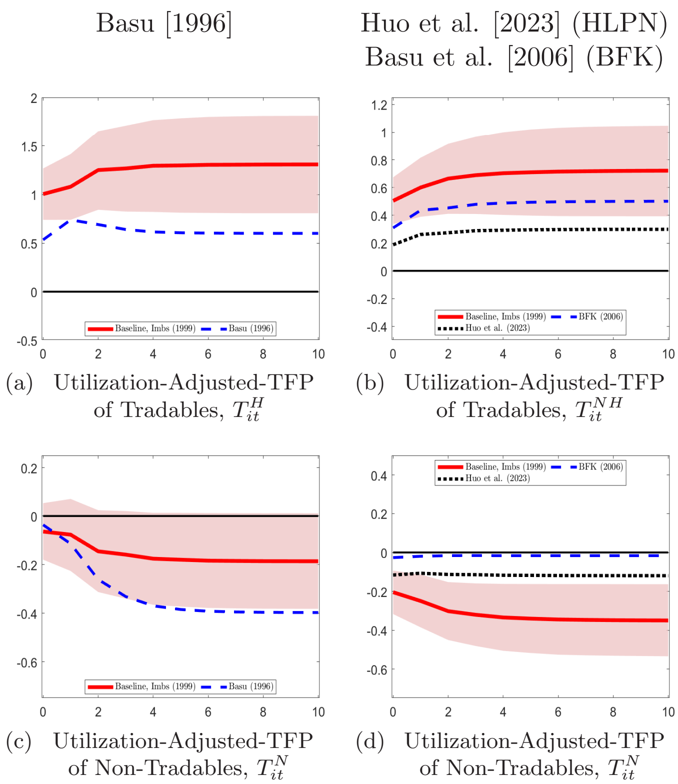
In this subsection, we conduct a robustness check with respect to the measure of utilization-adjusted TFP. We replace the measure of utilization-adjusted-TFP based on the Solow residual adjusted with the capital utilization rate obtained by applying the Imbs method with three alternative measures: i)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

Source and construction. 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. To construct time series utilization-adjusted TFP based on Basu's [1996] methodology, see Online Appendix Q.3 of Cardi and Restout [2023] who detail the steps of derivation of the utilization rate. The sample includes our 11 OECD countries over 1973-2017 except Australia (1973-2007).

The measure by BFK [2006] is thinner than ours because the authors construct a measure of aggregate technology change, controlling for varying utilization of capital and labor, non-constant returns to scale, and imperfect competition. Huo et al. [2023] construct time series for utilization-adjusted TFP for a sample of 29 OECD countries, 30 sectors and up to 37 years (1970-2007). The authors control for the capital utilization rate, the labor utilization rate (or worker's efforts), hours per worker, by adapting the approach initiated by BFK [2006]. We exclude Luxembourg (no data) and Sweden (limited data availability, 1994-2007) from the sample and consider the period 1973-2007 for nine out of eleven OECD countries of our sample.

Results. The first column of Fig. 10 compares the response of technology of tradables (first row) and of non-tradables (second row) when we control for capital utilization (see the solid red line) and when we control for both capital utilization and work effort along with some additional factors like returns to scale. Note that the baseline results are different in column 1 and 2 because the sample varies. In column 1, the sample comprises 11 countries over 1973-2017 (except Australia 1973-2007) while in column 2, the period ends in 2007 and it includes only nine countries instead of eleven.

Overall, Fig. 10 corroborates the robustness of our measure. We can notice some quantitative differences between our own measure (shown in the solid red line) of technological change and that based on Basu's [1996] (shown in the dashed blue line) since in the latter case, technology of tradables improves by about 0.5% while in the baseline it improves by 1%. 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. However, when we consider the measure of technology proposed by BFK [2006], which also controls for work effort, shown in the dashed blue line in the second column, we find a smaller difference between our own measure and the latter's. Technology improves less when we consider the measure of technology proposed by Huo et al. [2023] (shown in the dotted black line). 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. Note that in contrast to existing methods which 'purify' TFP measure from variations in the utilization rate, our method has the advantage that we are able to construct time series at a sectoral level in line with our classification T/N for our sample of eleven OECD countries over 1973-2017. We do not



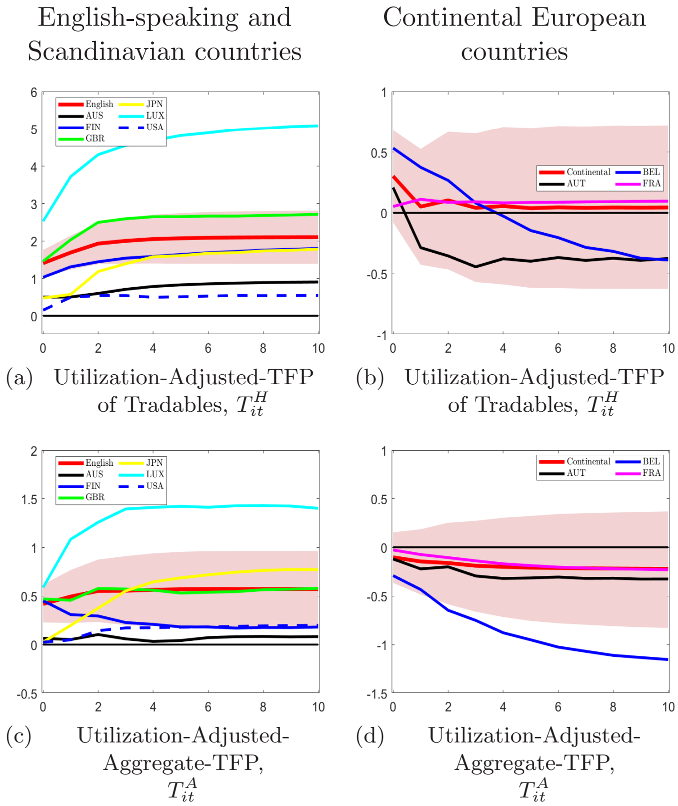
(a) Utilization-Adjusted-TFP of Tradables, T_{it}^{H}

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

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

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

Figure 10: 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. The solid red 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 green line displays results when using utilization-adjusted-TFP time series from Basu et al. [2006] and the black line when using utilization-adjusted-TFP time series from Huo et al. [2023]. Sample: 11 OECD countries, 1973-2017 (except for Australia, 1973-2007). We have dropped Luxembourg and Sweden since data are not available or over a limited period of time for two technology measures, i.e., Huo et al. [2023] and Basu et al. [2006].



(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}^A

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

Figure 11: Dynamic Effects of a Corporate Tax Shock on Technology: International Differences. Notes: The red line in Fig. 11(a) and Fig. 11(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, blue: Finland, green: Great-Britain, yellow: Japan, Luxembourg: cyan, dashed blue: United States) show impulse responses for each country which is part of this sub-sample. The red line in Fig. 11(b) and Fig. 11(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, blue: Belgium, magenta: France) show impulse responses for each country which is part of this sub-sample. We have removed the responses of Sweden and Germany as for these countries, the number of observations was too short to obtain consistent estimates. The first row of Fig. 11 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: 9 (i.e., 11 less Germany and Sweden) OECD countries, 1970-2017, annual data.

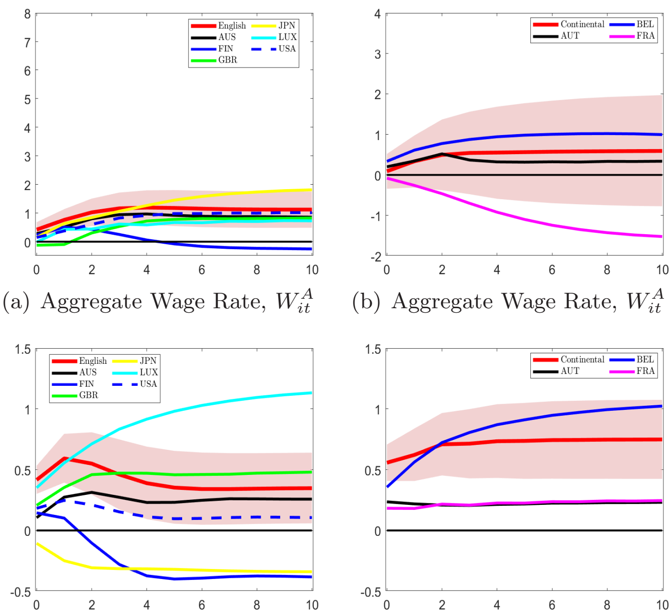
detect significant differences either when using the measure of technology by Basu et al. [2006]. In all cases, technology significantly improves in traded industries while technology is essentially unchanged in non-traded industries.

C.4 Empirical Results Supporting our Country-Split

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. To give a sense of the homogeneity of responses within each sub-group of countries, we have estimated a VAR model with long-run restrictions for one country at a time where the corporate income tax rate is ordered first in the VAR model and we present country-level results corresponding to one sub-group on one specific figure.

Dynamic effects of a corporate tax cut on technology improvement at country level. Fig. 11 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 red line in Fig. 11(a) and Fig. 11(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. 11(b) and Fig. 11(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

English-speaking and Scandinavian countries | Continental European countries



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

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

Figure 12: Dynamic Effects of a Corporate Tax Shock on Aggregate Wages: International Differences. Notes: The first row of Fig. 12 shows responses for the aggregate wage rate and the second row shows dynamic responses for non-traded hours. The red line in Fig. 12(a) and in Fig. 12(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, blue: Finland, green: Great-Britain, yellow: Japan, Luxembourg: cyan, dashed blue: United States) show impulse responses for each country which is part of this sub-sample. The red line in Fig. 12(b) and Fig. 12(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, blue: Belgium, magenta: France) show impulse responses for each country which is part of this sub-sample. We have removed the responses of Sweden and Germany as for these countries, the number of observations was too short to obtain consistent estimates. Horizontal axes indicate years. Vertical axes measure percentage deviation from trend. Vertical axes measure percentage deviation from trend. Sample: 9 (i.e., 11 less Germany and Sweden) OECD countries, 1970-2017, annual data.

as in the main text. We have removed the responses of Sweden and Germany as for these countries, the number of observations was too short to obtain consistent estimates. As can be seen in the first column of Fig. 11, 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 in all English-speaking and Scandinavian countries, see Fig. 11(c). In contrast, as can be seen in the second column of Fig. 11, overall, technology remains unresponsive to a CIT cut in continental European countries. We may notice however that technology slightly increases on impact in Belgium but it does not improve persistently in contrast to English-speaking and Scandinavian's group of countries.

Dynamic effects of corporate tax cut on aggregate wages et non-traded hours at country level. The first row of Fig. 12 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. 12(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. 12(b) reveals that the response of the aggregate wage rate is muted on impact for the four continental European countries. We may notice that the aggregate wage rate slightly increases in Belgium in the long-run but both responses remain not statistically significant. Conversely, the aggregate wage rate declines in the long-run in France.

The second row of Fig. 12 shows the dynamic responses of non-traded hours for each sub-sample. Fig. 12(d) reveals that all continental European countries experience a significant and persistent increase in non-traded hours. Fig. 12(d) reveals that except for Luxembourg displayed by the cyan line which experiences a sizeable and permanent increase in non-traded hours, L_{it}^N does not increase persistently in English-speaking and Scandinavian countries. Non-traded hours decline in Finland and Japan.

C.5 Wage Flexibility vs. Wage Rigidity

In the main text, we differentiate the effects of a CIT cut between two groups of countries. To split the sample into two groups, we use two dimensions. The first dimension is related to the ability to improve technology say to transform R&D into innovation. Estimates are shown in section G.6. According to our estimates, the elasticity of aggregate technology w.r.t. the domestic stock of knowledge is low and insignificant in Continental European countries while the estimated values of the elasticity are high and significant in the second group which includes English-speaking and Scandinavian countries along with Japan. Although Luxembourg displays a low elasticity of technology w.r.t. the stock of knowledge, we move this country in the latter group because it experiences the largest increase in utilization-adjusted-TFP of tradables and importantly, the estimated value for its elasticity is statistically significant.

We also base our classification on a second dimension which is the degree of wage stickiness. We index country by the subscript i and time by the subscript t. To estimate the degree of wage stickiness for each group of OECD countries, we run the regression of the rate of change in the real aggregate wage index, $d\log W_{it}^A = \log W_{it}^A - \log W_{it-1}^A$, on its past value $d\log W_{it-1}^A$:

$$d\log W_{it}^A = f_i + f_t + \phi_W d\log W_{it-1}^A + \varepsilon_{it}, \tag{44}$$

where country fixed effects are captured by country dummies, f_i, common macroeconomic shocks by year dummies, f_t, and ε_{it} is an i.i.d. error term. As estimated values of ϕ_W approach one, the wage rate displays more persistence over time and thus is more rigid. For the whole sample, the real aggregate wage displays relatively low persistence as we estimate a value of 0.271. When we differentiate between the two groups of countries, we find a clear country split. While the estimated past value is low and not statistically significant for English-speaking and Scandinavian countries (see column 2), thus suggesting wage

Table 8: Estimates of the Degree of Real Wage Rigidity ($\hat{\phi}_W$)

	Whole Sample (1)	Continental (2)	English-Scandinacian (3)
$\hat{\phi}_W$	0.271^a (2.77)	0.530^a (5.32)	0.183 (1.61)
Countries	11	4	7
Observations	473	172	301
Data coverage	1973-2017	1973-2017	1973-2017
Country fixed effects	yes	yes	yes
Time dummies	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.

Table 9: Estimates of the Degree of Persistence in Consumption ($\hat{\rho}_C$)

	Whole Sample	Continental	English
$\hat{\rho}_C$	0.301^a (4.70)	-0.056 (-0.59)	0.361^a (5.58)
Countries	11	4	7
Observations	495	180	315
Data coverage	1973-2017	1973-2017	1973-2017
Country fixed effects	yes	yes	yes
Time dummies	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.

flexibility, the estimated value for continental European countries is high and statistically significant (see column 3).

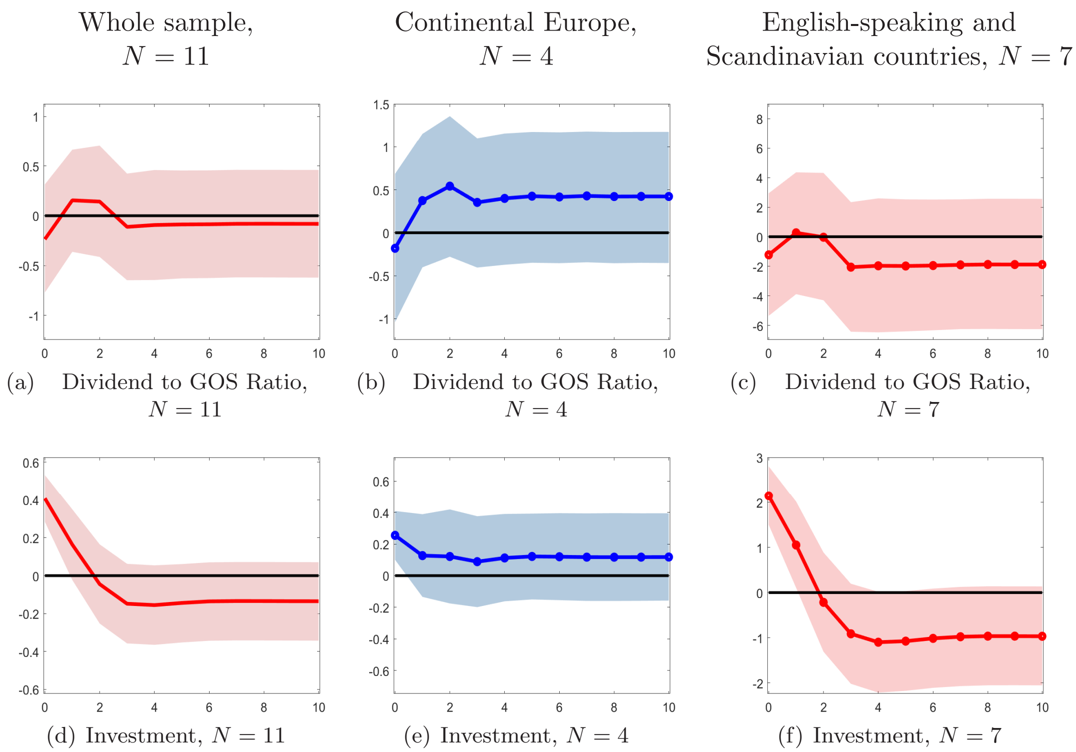
C.6 International Differences in Consumption Persistence

As we mentioned above, we perform a country-split which is based on two dimensions which include the ability to transform R&D in innovation as captured by ν_Z^j, and the degree of wage stickiness. Besides these two key factors which differentiate the two groups of countries, we also consider a third dimension when we calibrate the model to the data. More specifically, we keep the same calibration as for the whole sample except for technology parameters, the degree of wage stickiness and habit persistence in consumption. While the meta-analysis by Havranek et al. [2017] shows that European countries display a much lower habit persistence in consumption than the United States, we have estimated the degree of persistence in consumption for each sub-sample. Denoting $d\ln C_{it} = \ln C_{it} - \ln C_{it-1}$, we run the regression of the rate of change in consumption at constant prices on its past value $d\ln C_{i,t-1}$:

$$d\ln C_{i,t} = f_i + f_t + \rho_C d\ln C_{i,t-1} + \varepsilon_{i,t}, \tag{45}$$

where i and t index country and time, country fixed effects are captured by country dummies, f_i, common macroeconomic shocks are captured by time dummies, f_t, and ε_{it} is an i.i.d. error term.

For the whole sample, the consumption displays medium persistence as we estimate a statistically significant value of 0.332. When we differentiate between the two groups of countries, we find a clear country split. While the estimated past value is low and not statistically significant for continental European countries (see column 2), thus suggesting the absence of consumption habits, the estimated value for English-speaking and Scandinavian countries is high and statistically significant (see column 3), suggesting high habit persistence in consumption.



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

(d) Investment, $N = 11$ (e) Investment, $N = 4$ (f) Investment, $N = 7$

Figure 13: Dynamic Effects of a Corporate Tax Shock on Dividends Notes: Effects of an exogenous shock on dividends (first row) and investment (second row) that gives rise to a 1 percentage point cut in the corporate tax rate. We consider non financial corporations. The solid line shows the response the dividend to gross operating surplus (GOS) to an exogenous decline in the international CIT index which lowers the domestic CIT by 1 ppt in the long-run. The first column shows results when we consider the whole sample of $N = 11$ OECD countries. Shaded areas indicate the 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 with circles displays the effects for European countries (i.e., $N = 4$) while the solid red line with circles displays results where we estimate the same VAR model for the flexible-wage-countries-group (i.e., $N = 7$). Sample: 11 OECD countries, 1973-2017, annual data..

C.7 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. [2025a] 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.

Table 10: 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

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 10 displays the period for the dividend to gross operating surplus ratio for the eleven OECD countries. We consider only non-financial corporations but adding financial corporations does not change the conclusion.

Our objective is to check whether a permanent decline in corporate taxation gives rise to a significant increase in dividends. Fig. 13 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 solid red line. The response is not significant and thus we can conclude that the change in the dividend policy, if any, plays no role in driving our results. To the contrary, as shown in the second row, the CIT cut gives rise to an increase in investment.

We have also conducted the same investigation for the two sub-groups of countries in column 2 and column 3 of Fig. 13. The solid blue line with circles displays the effects for continental European countries (i.e., $N = 4$) while the solid red line with circles displays results where we estimate the same VAR model for the flexible-wage-countries-group (i.e., $N = 7$). For English-speaking and Scandinavian countries, dividends remain unchanged and thus they cannot explain insignificant long-run labor effects and are consistent with the high and significant technology improvements we detect empirically. For continental European countries (see the solid blue line with circles), dividends slightly increase but the response is not statistically significant.

C.8 Additional VAR Evidence

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. In Fig. 14, we show results for the international CIT index, consumption and investment in the first row, the ratio of traded to non-traded value added, the terms of trade, and the relative price of non-tradables in the second row, and the responses of the aggregate wage rate along with the non-traded and traded wage rate in the third row.

Results. As mentioned in the main text, see section 2.5, we re-scale the effects of a shock to international CIT index on domestic macroeconomic variables so that they reflect the impact of domestic CIT cut by 1 ppt in the long-run. As can be seen in the solid black line with circles in Fig. 14(a), the international CIT index τ_{it}^{int} declines by -1.3 ppt on impact and by -1.8 ppt in the long-run. According to our estimates, on average, a decline in the international CIT rate by -1 ppt leads the home country to lower its CIT rate by -0.53 ppt. When we replace τ_{it}^{int} with the international CIT index $\tau_{it}^{int,IV}$ which is exogenous to the world business cycle and adjusted with capital openness to further capture tax competition motives, the decline in $\tau^{int,IV}$ giving rise to a domestic CIT cut by -1 ppt in the long-run is larger. More specifically, while τ_{it}^{int} must decrease by -1.79 ppt in the long-run, $\tau_{it}^{int,IV}$ must fall by -2.64 ppt. On average, a decline in the international CIT rate $\tau_{it}^{int,IV}$ by -1 ppt leads the home country to lower its CIT rate by -0.35 ppt.

As is clear from Fig. 14(a), the shock to $\tau_{it}^{int,IV}$ must be larger than a shock to τ_{it}^{int} to generate a decline in the domestic CIT rate by -1 ppt because $\tau_{it}^{int,IV}$ is adjusted with capital openness which takes values lower than 1 before the beginning of the nineties. As shown in the first row, a shock to international CIT leads to a rise in consumption and investment. By giving rise to a technology improvement in the traded sector, a fall in τ^{int} raises traded relative to non-traded value added, see Fig. 14(d). Because a CIT cut makes the economy richer, households consume more which puts upward pressure on non-traded goods prices, see Fig. 14(f). While the technology improvement raises the traded wage W_{it}^{H}, see Fig. 14(i), the appreciation is the relative price of non-tradables increases the non-traded wage W_{it}^{N}, see Fig. 14(h). As shown in the last row, the relative price of non-tradables defined as the ratio of non-traded good prices to home-produced-traded-good prices appreciates.

Traded hours significantly increase in the short-run while its response is not statistically significant after three years onwards. A CIT cut tends to produce a negative impact on technology in the non-traded sector although its response is not statistically significant. Overall, the effects of a shock to τ^{int} are not statistically different from those caused by a shock to $\tau^{int,IV}$ except for non-traded goods prices.

Fig. 15 shows results for sectoral capital labor ratios, k^j_{it}, and capital utilization rates, $u^{K,j}_{it}$. On impact, both traded and non-traded capital-labor ratios decline because households supply more labor while the aggregate capital stock is a state variable and the reallocation of capital across sectors is subject to mobility costs. Overall, the responses of capital utilization rates are muted.

C.9 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. 16 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 a CIT cut does not lower the LIS either in the traded or the non-traded sector. More specifically, the traded LIS slightly increases for the whole sample (column 1) and in English-speaking and Scandinavian countries (column 3). Conversely, the response of the traded LIS remains muted in continental European countries. The response of the non-traded LIS is not statistically significant neither for the whole sample nor sub-samples. Since labor growth is concentrated in non-traded industries, the rise in hours is not driven by the fact that the non-traded production turns out to be more labor intensive.

C.10 Additional VAR Evidence: Effects on R&D

In this subsection, we explore the effects of a permanent decline in international corporate taxation leading the home country to cut its corporate income tax rate on investment in R&D and the stock of R&D at a sectoral level. Since technology improvements are concentrated within traded industries, especially in English-speaking and Scandinavian countries, we expect an increase in investment in R&D and in the stock of R&D in traded industries for this group of countries.

As shall be useful below, we write down a number of definitions. The stock of knowledge in sector j is a weighted average of the domestic stock of knowledge and the world stock of knowledge in sector $j = H, N$. Formally, the stock of ideas Z^j_t has a domestic component $\tilde{Z}^j_t$ and an international component denoted by $Z^{W,j}(t)$:

$$\mathsf{Z}^j(t) = \left(\tilde{Z}^j_i(t)\right)^{\theta^j_Z} \left(Z^{W,j}(t)\right)^{1-\theta^j_Z}, \tag{46}$$

where θ^j_Z 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. They produce differentiated effects on utilization-adjusted-TFP in sector j:

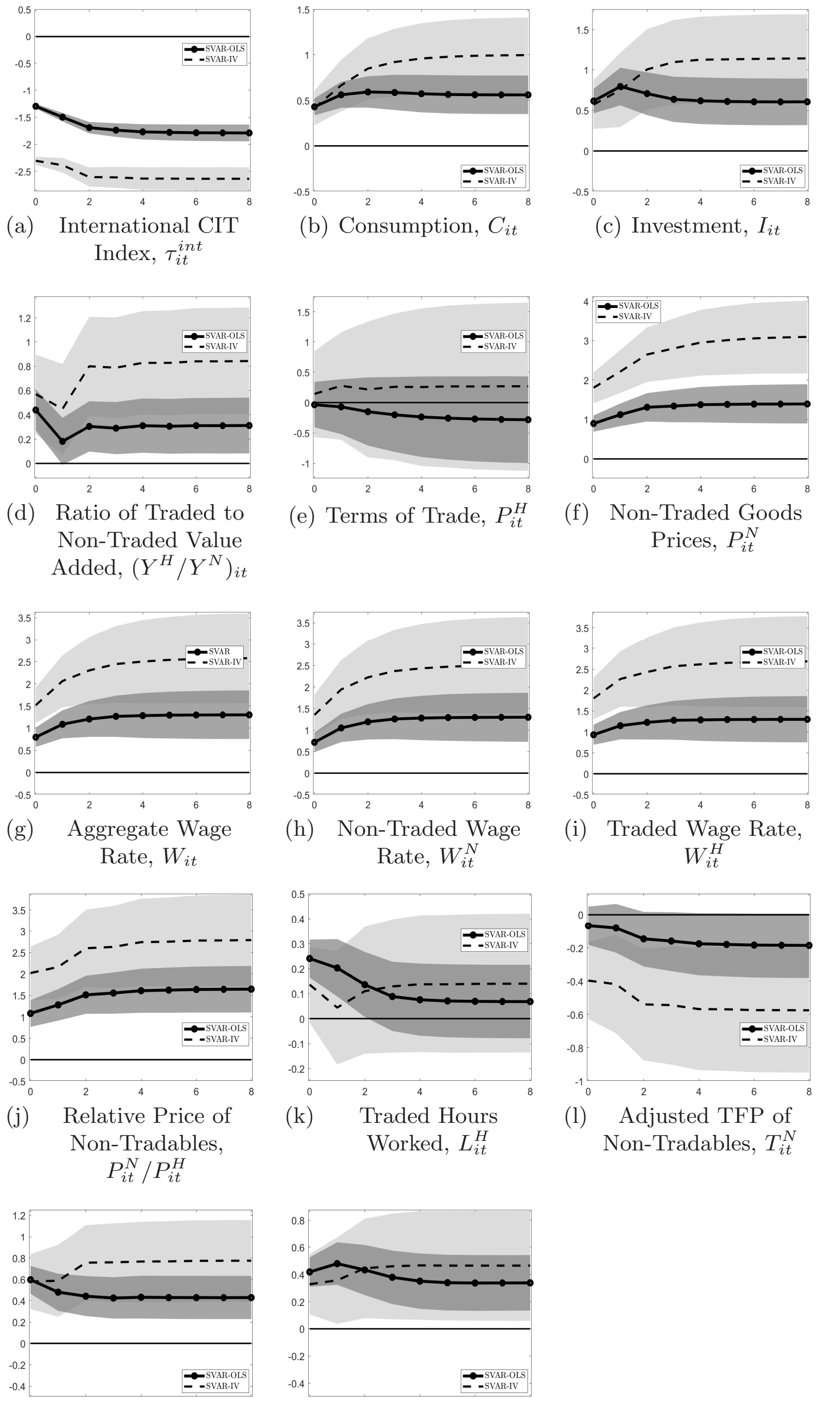
$$T^j(t) = \left(\tilde{Z}^j_i(t)\right)^{\nu^j_Z \theta^j_Z} \left(Z^{W,j}(t)\right)^{\nu^{W,j}_Z (1-\theta^j_Z)}, \tag{47}$$

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

The level of technology j can be defined as weighted average of the domestic and international level of technology:

$$T^j(t) = \left(T^{c,j}(t)\right)^{\theta^j_Z} \left(T^{W,j}(t)\right)^{\left(1-\theta^j_Z\right)}, \tag{48}$$

where $T^{c,j}(t) = \left(\tilde{Z}^j_i(t)\right)^{\nu^j_Z}$ and $T^{W,j}(t) = \left(Z^{W,j}(t)\right)^{\nu^{W,j}_Z}$.



(a) International CIT Index, τ_{it}^{int}

(b) Consumption, C_{it}

(c) Investment, I_{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

(g) Aggregate Wage Rate, W_{it}

(h) Non-Traded Wage Rate, W_{it}^N

(i) Traded Wage Rate, W_{it}^H

(j) Relative Price of Non-Tradables, P_{it}^N/P_{it}^H

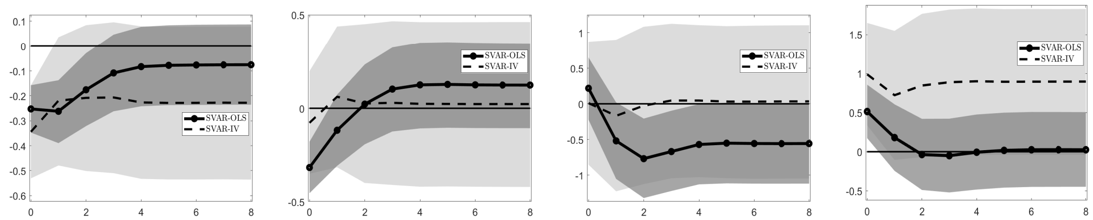
(k) Traded Hours Worked, L_{it}^H

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

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

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

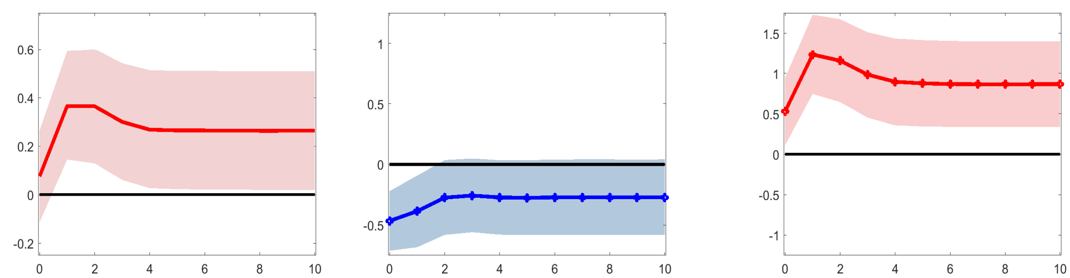
Figure 14: Dynamic Effects of a Corporate Tax Shock in OECD Countries ($N = 11$): More VAR evidence. Notes: The solid (dashed) black line with circles shows the dynamic adjustment generated from a SVAR with long-run restrictions where the international CIT index $\tau_{it}^{\int}$ (the instrumented CIT index $\tau_{it}^{int,IV}$) is ordered first. In both cases, the solid and dashed lines display responses to an exogenous decline in trade partners' CIT of the domestic country leading to a corporate income taxation by 1 percentage point in the long-run. Light and dark shaded areas 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.



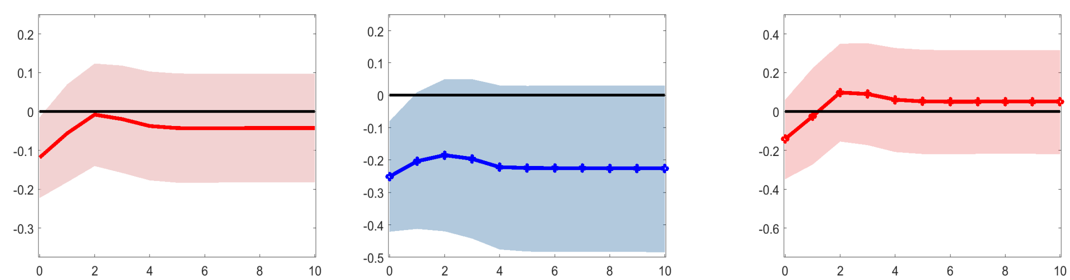
(a) Traded Capital-Labor Ratio, k_{it}^{H} (b) Non-Traded Capital-Labor Ratio, k_{it}^{N} (c) Capital Utilization Rate of Tradables, $u_{it}^{K,H}$ (d) Capital Utilization Rate of Non-Tradables, $u_{it}^{K,N}$

Figure 15: Dynamic Effects of a Corporate Tax Shock in OECD Countries ($N = 11$) on Capital-Labor Ratios and Capital Utilization Rates Notes: The solid (dashed) black line with circles shows the dynamic adjustment generated from a SVAR with long-run restrictions where the international CIT index τ_{it}^{f} (the instrumented CIT index $\tau_{it}^{int,IV}$) is ordered first. In both cases, the solid and dashed lines display responses to an exogenous decline in trade partners' CIT of the domestic country leading to a corporate income taxation by 1 percentage point in the long-run. Light and dark shaded areas 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.

Whole Sample | Cont. European Countries | Eng.-speak. and Scand. Countries



(a) Traded Labor Income Share, $s_{L,it}^{H}$ (b) Traded Labor Income Share, $s_{L,it}^{H}$ (c) Traded Labor Income Share, $s_{L,it}^{H}$



(d) Non-Traded Labor Income Share, $s_{L,it}^{N}$ (e) Non-Traded Labor Income Share, $s_{L,it}^{N}$ (f) Non-Traded Labor Income Share, $s_{L,it}^{N}$

Figure 16: Dynamic Effects of a Corporate Tax Shock in OECD Countries ($N = 11$) on Sectoral Labor Income Shares. Notes: The solid line shows the response of the LIS in the traded sector (first row) and the non-traded sector (second row) to a permanent decline in international CIT leading to a domestic CIT cut by 1 percentage point in the long-run. Shaded areas indicate the 68 percent confidence bounds based on bootstrap sampling. Horizontal axes indicate years. Vertical axes measure percentage deviation from trend. Column 1 shows results for the whole sample whole columns 2 and 3 display results for continental European countries and English-speaking and Scandinavian countries, respectively. Sample: 11 OECD countries, 1973-2017, annual data.

Aggregate technology is a value added share weighted average of technology of tradables and non-tradables:

$$
\begin{aligned}
T^A(t) &= \left(T^H(t)\right)^{\nu^{Y,H}} \left(T^N(t)\right)^{1-\nu^{Y,H}}, \\
&= \left(T^{c,H}(t)\right)^{\nu^{Y,H}\theta_Z^H} \left(T^{W,H}(t)\right)^{\nu^{Y,H}\left(1-\theta_Z^H\right)} \left(T^{c,N}(t)\right)^{\nu^{Y,N}\theta_Z^N} \left(T^{W,N}(t)\right)^{\nu^{Y,N}\left(1-\theta_Z^N\right)}, \\
&= \left(T^{c,A}(t)\right)^{\theta_Z^A} \left(T^{W,A}(t)\right)^{1-\theta_Z^A}, \qquad (49)
\end{aligned}
$$

where the world aggregate technology $T^{W,A}(t)$ is defined as follows:

$$
\left(T^{W,A}(t)\right)^{1-\theta_Z^A} = \left(T^{W,H}(t)\right)^{\nu^{Y,H}\left(1-\theta_Z^H\right)} \left(T^{W,N}(t)\right)^{\nu^{Y,N}\left(1-\theta_Z^N\right)}, \qquad (50)
$$

and the country specific component reads:

$$
\left(T^{c,A}(t)\right)^{\theta_Z^A} = \left(T^{c,H}(t)\right)^{\nu^{Y,H}\theta_Z^H} \left(T^{c,N}(t)\right)^{\nu^{Y,N}\theta_Z^N}. \qquad (51)
$$

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 11 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 data are not available for Australia, the difference between the two samples is that Belgium has data for the capital stock in R&D only.

Table 11: Investment in R&D and Stocks of R&D: Data Availability

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

Effects on R&D for $N = 9, 10$ Countries. In the first column of Fig. 17, we investigate the impact of a permanent decline in international corporate taxation leading to a domestic CIT 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. In column 2, we show results for continental European countries and in column 3, we show results for English-speaking and Scandinavian countries (including Japan and Luxembourg). As shown in column 1, a CIT cut leads to a significant increase in investment in R&D in the traded sector while the response of investment in R&D in the non-traded sector is muted. The stock of R&D which measures the stock of knowledge gradually builds but the response is not significant. When we split the sample into two groups, we find that the responses of investment in R&D are muted in both the traded and the non-traded sector in continental European countries (see column 2) while investment in R&D significantly increases in the traded sector in English-speaking and Scandinavian countries. Importantly, the stock of R&D also significantly builds up over time in English-speaking and Scandinavian countries while its response remains muted in continental European countries.

Effects on World Technology. In Fig. 18, we show the response of the world utilization-adjusted-aggregate-TFP (column 1) and the responses of utilization-adjusted-TFP of tradables (column 2) and non-tradables (column 3). We construct our measure

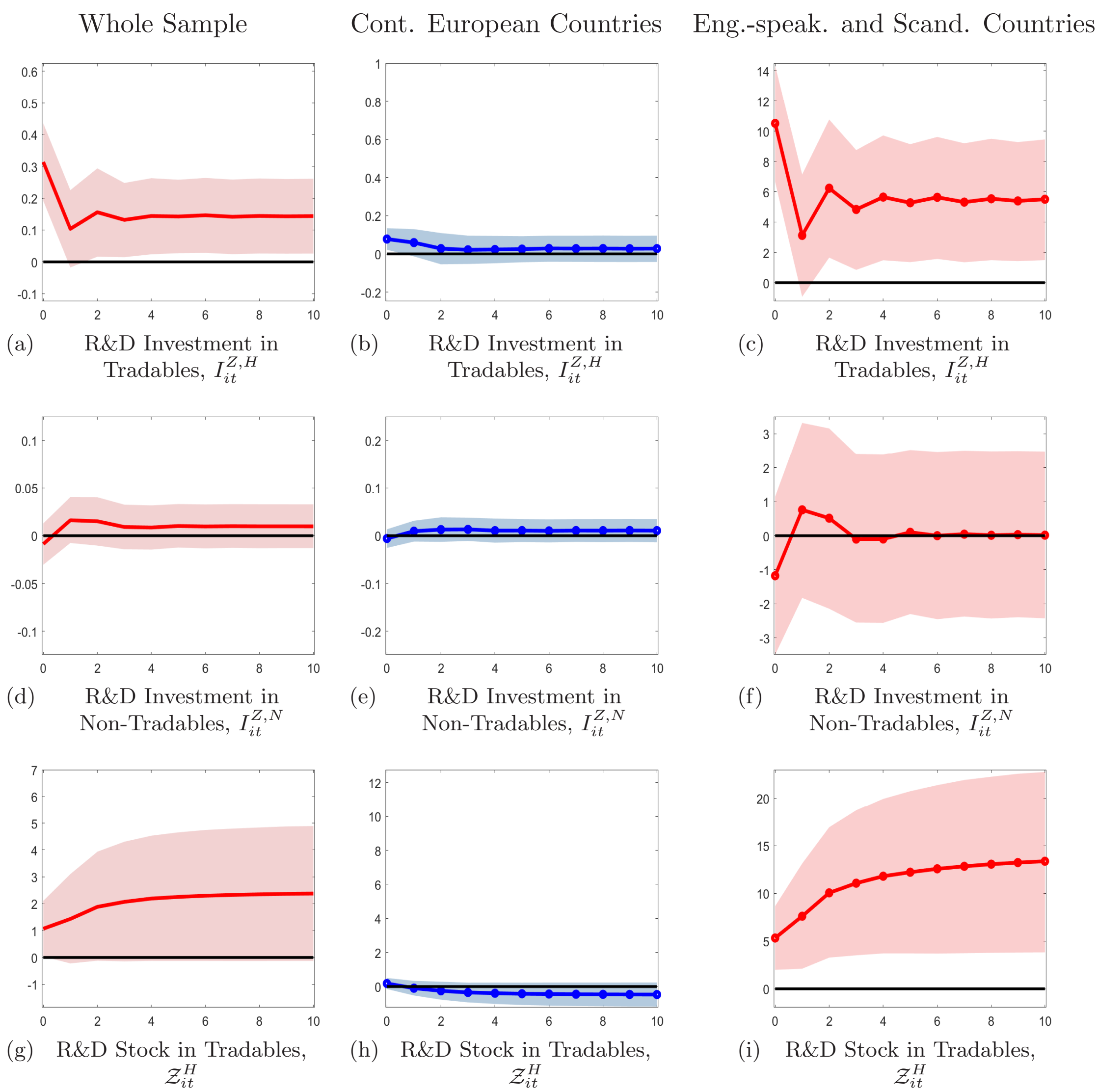
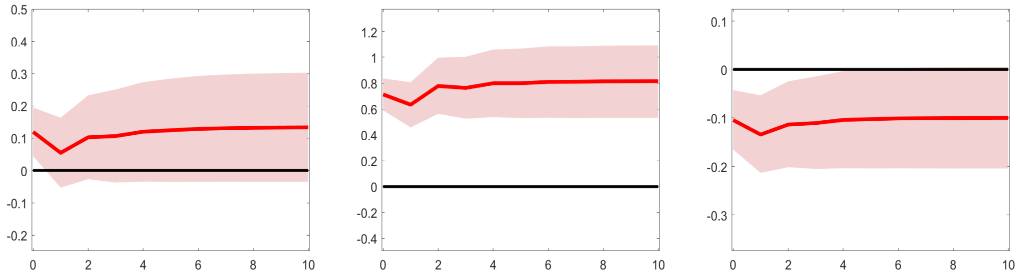


Figure 17: Dynamic Effects of a Corporate Tax Shock in OECD Countries on R&D. Notes: The solid line shows the response of R&D variables to an exogenous decline in corporate income taxation by 1 percentage point in the long-run. Shaded areas indicate the 68 percent confidence bounds based on bootstrap 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, 10 (9) OECD countries, 1995-2017, annual data. The solid red line in the first column shows responses for the whole sample. The red line with circles in the third column refers to the point estimate for the English-speaking and Scandinavian countries while the blue line with circles in the second column refers to the point estimate for the 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.



(a) World Utilization-Adjusted-Aggregate-TFP $Z_{it}^{A,W}$ (b) Utilization-Adjusted-TFP of Tradables, $Z_{it}^{H,W}$ (c) Utilization-Adjusted-TFP of Non-Tradables, $Z_{it}^{N,W}$

Figure 18: Effects of Corporate Tax Shocks on World Technology:Notes: Fig. 18 shows the responses of world technology measures to a shock to international corporate tax taxation. We construct a measure of world technology by calculating an import-share-weighted-average of trade partners' utilization-adjusted-aggregate-TFP, $Z_{it}^{W,A}$, utilization-adjusted-TFP of tradables, $Z^{W,H}(t)$, and utilization-adjusted-TFP of non-tradables, $Z^{W,N}(t)$. Sample: 11 OECD countries, 1973-2017.

of foreign innovation by calculating the import-share-weighted-average of trade partners' utilization-adjusted-TFP. It gives a sense of the extent of international R&D spillovers. For the whole sample or sub-samples, world technology significantly improves for tradables while it declines for non-tradables (see Fig 18(b) and 18(c)). The world utilization-adjusted-aggregate-TFP increases but not significantly (see Fig. 18(a)).

C.11 Effects on Public Debt: Does a CIT Cut Pay for Itself?

On major question is whether a tax cut pays for itself. In other words, does a corporate income tax cut produce a rise in the tax base which is large enough to more than offset the decline in tax revenues caused by the CIT cut. To explore this question, it is useful to write down the dynamic equation for the public debt. Denoting the public by D_t, government spending by G_t and tax revenues by T_t, the public debt evolves according to the following law of motion:

$$\dot{D}_t = r^\star D_t + G_t - T_t, \tag{52}$$

where tax revenues are made up of taxes on labor, taxes on consumption and taxes on corporate income in the traded and the non-traded sector. Denoting the labor tax rate by τ^L, the consumption tax rate by τ^C, the corporate income tax rate by τ, and the net operating surplus by NOS, tax revenues read

$$\text{Tax}_t = \tau_t^L W_t L_t + \tau_t^C P_t^C C_t + \sum_{j=H,N} \tau_t \text{NOS}_t^j. \tag{53}$$

Linearizing around the steady-state and dividing by GDP leads to the change in tax revenues following a variation in the CIT rate:

$$\begin{aligned} d\text{Tax}_t &= \tau^L W L \left[\hat{W}_t + \hat{L}_t\right] + \tau^C P^C C \left[\hat{P}_t^C + \hat{C}_t\right] + \sum_{j=H,N} \tau d\text{NOS}_t^j + \sum_{j=H,N} NOS^j d\tau_t, \\ \frac{d\text{Tax}_t}{Y} &\simeq \tau^L s_L \left[\hat{W}_t + \hat{L}_t\right] + \tau^C P^C C \left[\hat{P}_t^C + \hat{C}_t\right] + \sum_{j=H,N} \text{NOS}^j d\tau_t, \end{aligned} \tag{54}$$

where we assume that the change in the net operating surplus is negligible (compared with the change in the consumption and labor tax base), i.e., $\sum_{j=H,N} \tau d\text{NOS}_t^j \simeq 0$, $s_L \equiv \frac{WL}{Y}$ is the aggregate labor income share, and ω_C is the consumption-to-GDP ratio. According to the RHS of eq. (54), a CIT cut will have opposite effects on tax revenues. As shown in the last term, a CIT cut lowers tax revenues. As captured by the first and the second term on the RHS, by increasing wages, hours, the CPI and consumption, a CIT cut raises both the labor and the consumption tax base. Because the loss of tax revenues following a CIT cut is relatively low and the effects of a CIT on economic activity are significant, a CIT cut should pay for itself.

Table 12: Data to Calibrate the Two Open Economy Sector Model and Infer the Public Debt Dynamics

Tax rates			Parameters							
τ^L	τ^C	τ	$r^\star$	δ_K	ω_C	α_C	α^H	s_L	θ^H	θ^N
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
0.33	0.20	0.22	0.03	0.13	0.57	0.42	0.63	0.66	0.65	0.67
Ratios										
$\alpha_L = \frac{W^H L^H}{WL}$	$\frac{P^H Y^H}{Y}$	$\frac{W^H L^H}{Y}$	$\frac{W^N L^N}{Y}$	$R^{K,H}$	$R^{K,N}$	$\frac{K^H}{Y}$	$\frac{K^N}{Y}$	$\frac{\text{NOS}^H}{Y}$	$\frac{\text{NOS}^N}{Y}$	$\frac{D_0}{Y}$
(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
0.37	0.38	0.24	0.39	0.30	0.37	0.39	0.43	0.09	0.17	0.64

Notes: The Table shows the values we have used to infer the change in tax revenues following a CIT cut. τ^L is the labor income tax rate (tax rate on labor income and social contributions), τ^C is the consumption tax rae, τ is the CIT rate, s_L is the aggregate LIS. The rest of the variables are defined in the main text. The last ratio is average public debt in percentage of GDP.

Linearizing eq. (52) around the steady-state, keeping government spending G_t fixed, integrating over $(0, t)$, and solving, and subtracting from both sides the initial public debt in percentage of GDP, $\frac{D_0}{Y}$, leads to:

$$\begin{aligned} \frac{D_t}{Y} &= e^{r^\star t}\frac{D_0}{Y} - \int_0^t \frac{d\text{Tax}_\tau}{Y} e^{-r^\star \tau} d\tau, \\ \frac{D_t - D_0}{Y} &= \frac{D_0}{Y}\left(e^{r^\star t} - 1\right) - e^{r^\star t}\int_0^t \frac{d\text{Tax}_\tau}{Y} e^{-r^\star \tau} d\tau . e^{r^\star t} \end{aligned} \quad (55)$$

The first term on the RHS of eq. (55) captures the capitalized value of the public debt at time t relative to its initial value. The initial debt contributes to increase the public debt over time due to interest rate payments. Conversely, the second term on the RHS of eq. (55) reflects the fact that if the CIT can pay for itself and produce and increase in tax revenues as a result of the rise in economic activity, it will lower the public debt.

To explore empirically whether a CIT produces such an expansionary effect on economic activity and thus a rise in the tax base so that the tax cut pays for itself, we explore the effects of a permanent decline in international CIT index leading to a decline in the country-level CIT rate by 1 ppt in the long-run. We use time series for public debt expressed in percentage of GDP (both in current prices) taken from OECD Economic Outlook. Data are available over 1973-2017 for all countries except for Austria (1976-2017) et Luxembourg (1990-2017).

As shown in Fig. 19, a CIT cut lowers the public debt which implies that a CIT cut pays for itself and the growth effect is large enough to lower the public debt. The capacity of a CIT to lower the public debt lies on the fact that the tax base of corporate taxation is relatively small, i.e., collapses to profits in the traded and the non-traded sector, while at the same time it has a strong expansionary effect on consumption and total hours which raises the tax revenues originating from both consumption and labor taxation.

In Fig. 19, we plot the dynamic response of public debt (in percentage of GDP) to a shock to international corporate taxation. We have estimated the baseline VAR model which includes the international CIT index, real GDP, total hours and the public debt in percentage of GDP. As it stands put, the public debt declines. Table 12 summarizes the values of the parameters. We find numerically that $\frac{D_t - D_0}{Y}$ is -0.38 ppt of GDP on impact, -2.36 ppt of GDP after 5 years and -4 ppt of GDP after ten years. Overall, these predictions are in line with what we estimate empirically, especially in the medium-run while our model understates the decline in the public debt on impact and overstates its decline in the long-run.

C.12 Effects of a CIT Shock on Hours: Intensive vs. Extensive Margin

Decomposition of hours into intensive and extensive margin. Because total hours are the product of employment and hours per worker, we can decompose empirically the adjustment of total hours into the adjustment at the intensive margin and the adjustment at the extensive margin. Since the rise in hours originates from the non-traded sector,

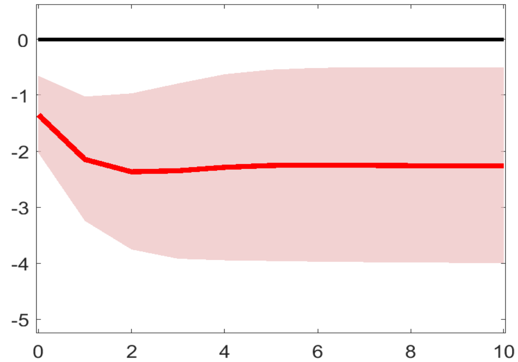
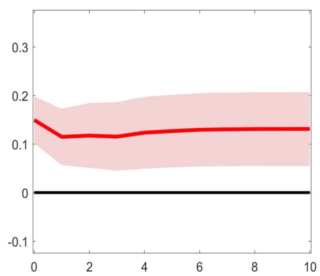
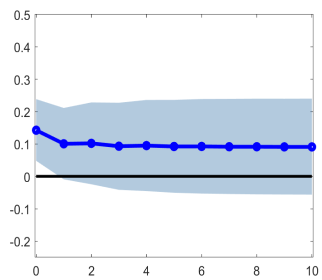


Figure 19: Dynamic Response of Public Debt to a Permanent CIT cut Notes: In Fig. 19, we plot the dynamic response of public debt (in percentage of GDP) to a shock to international corporate taxation. We have estimated the baseline VAR model which includes the international CIT index, real GDP, total hours and the public debt in percentage of GDP. Sample: 11 OECD countries, 1973-2017, annual data.

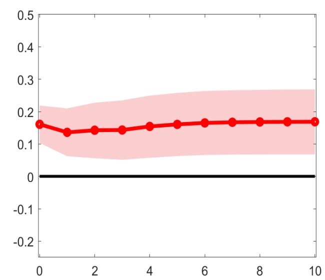
Whole Sample	Continental European (EU) Countries	English-speaking and Scandinavian (ES) Countries



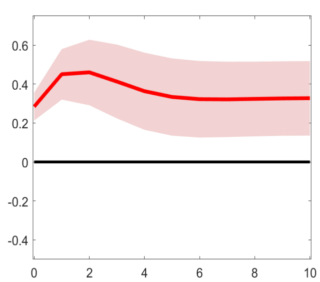
(a) Non-Traded Hours per Worker, $\left(\frac{L^N}{E^N}\right)_{it}$



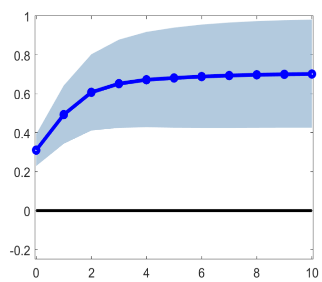
(b) Non-Traded Hours per Worker in EU Countries, $\left(\frac{L^N}{E^N}\right)_{it}$



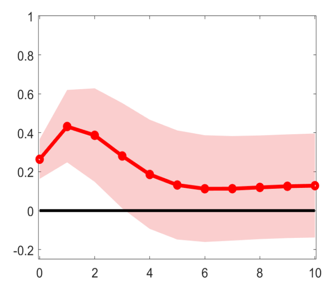
(c) Non-Traded Hours per Worker in ES Countries, $\left(\frac{L^N}{E^N}\right)_{it}$



(d) Non-Traded Employment, E^N_{it}



(e) Non-Traded Employment in EU Countries, E^N_{it}



(f) Non-Traded Employment in ES Countries, E^N_{it}

Figure 20: Decomposition of the Effects of a Corporate Tax Shock in OECD Countries ($N = 11$) on Non-Traded Hours: Extensive vs. Intensive Margin. Notes: The solid line shows the response of hours per worker in the non-traded sector (first row) and the response of employment in the non-traded sector (second row) to a permanent decline in international CIT leading to a decline in corporate income taxation by 1 percentage point in the long-run in the home country. Shaded areas indicate the 68 percent confidence bounds based on bootstrap sampling. Horizontal axes indicate years. Vertical axes measure percentage deviation from trend. Column 1 shows results for the whole sample. Columns 2 and 3 display results for continental European (EU) countries and English-speaking and Scandinavian (ES) countries, respectively. Sample: 11 OECD countries, 1973-2017, annual data.

we exclusively focus on this sector in Fig. 20 where we estimate the dynamic effects of a CIT cut by 1 ppt in the long-run on non-traded hours per worker (first row) and non-traded employment (second row). Before discussing empirical results, since $\hat{L}_{it} = \alpha^L_{it}\hat{L}^H_{it} + \left(1-\alpha^L_{it}\right)\hat{L}^N_{it}$, it is useful to remind that we re-scale the response of non-traded hours by the corresponding labor compensation share measured by the ratio $1-\alpha_L = \frac{W^N L^N}{WL}$ for non-tradables. Denoting employment in sector j by E^j_{it}, hours in sector N is the product of hours per worker and employment, i.e., $L^N_t = \frac{L^N_{it}}{E^N_{it}} E^N_{it}$. To be consistent with the normalization of the response of L^N, we normalize the responses of hours per worker and employment by multiplying by $1-\alpha^L_i$.

Responses of non-traded hours per worker and non-traded employment to a CIT shock. Fig. 20 shows the response of non-traded hours per worker in the first row and the response of non-traded employment in the second row. While column 1 displays the responses for the whole sample, columns 2 and 3 show the effects for continental European countries and English-speaking and Scandinavian countries, respectively. As shown in column 1, following a permanent CIT cut by 1% in the long-run, hours per worker increases by 0.15 ppt of total hours on impact while employment rises by 0.28 ppt. On average the intensive margin drives 28% of labor growth in the non-traded sector. For English-speaking and Scandinavian countries, almost 50% of labor growth operates at the intensive margin in the non-traded sector. For continental European countries, the rise in hours tends to operate more at the extensive margin (between 69% and 89% depending on the horizon). Overall, on average, depending on the group of countries, the rise in non-traded hours per worker contributes between 15% and 50% to labor growth in the non-traded sector.

We have made an extension of the baseline model to intensive and extensive margin. While it does not change the effects of a CIT on hours, it enables us to decompose the response of total hours into employment and hours per worker. In the short-run, the change in hours operates at the intensive margin since employment is a state variable while in the long-run, more than one-third of the rise in total hours originates from the employment stimulus.

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. We also show the number of CIT cuts per year.

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 a potential endogeneity with the current domestic economic activity with a measure of the intensity of tax pressure on the home country from abroad constructed as an import-share-weighted-average of trade partners' corporate tax rates. The country-level tax rate can be replaced with the international CIT index as long as they share a common stochastic trend between the two variables. 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.4, 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. However, the potential bias is very limited in our case since we use an international measure of corporate taxation which should be disconnected from the domestic economic activity. In subsection D.5, we use Granger causality tests to show that variables included in the VAR model do not predict our identified tax shocks and 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, we show that the effects of a permanent decline in corporate taxation on the domestic country do not operate through capital flows between countries. In subsection D.7, 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.8, we compare the dynamic effects estimated from the SVAR where we impose long-run restrictions with those estimated from narratively-identified shocks by using the dataset by Dabla-Norris and Lima [2023] we have augmented by adding five countries. In total, we have forty CIT cuts episodes which spread over 1973-2017. We find that narratively-identified CIT cut episodes produce qualitatively the same effects as shocks to the international CIT index.

In subsection D.9, we conduct a robustness check with respect to the tax foresight. For this purpose, we adapt the methodology pioneered by Beaudry and Portier [2006] to our case by estimating a SVAR model which includes the international CIT rate and stock prices and by identifying shocks to the former and the latter variables by using shot-run or long-run restrictions. When we compare the shocks, we find that the tax news shocks which are anticipated future permanent tax shocks display a low correlation with our identified surprise tax shocks. The evidence we document unambiguously reveals that changes in international CIT are unanticipated.

In subsection D.10, we further address the potential complications arising from possibly anticipated tax changes by adding stock prices in the VAR model as they are forward-looking variables and thus they are likely a good variable for capturing any changes in agents' expectations about future economic conditions. We find that adding stock prices in the VAR model leave the estimated effects unchanged. We find that an unexpected permanent decline in international corporate taxation causes an immediate (and weakly

Table 13:

Parameters	Correlation between τ and τ^{int} corr($\tau_{it}, \bar{\tau}_{it}^{int}$)
AUS	0.956
AUT	0.844
BEL	0.954
DEU	0.795
FIN	0.862
FRA	0.865
GBR	0.937
JPN	0.832
LUX	0.887
SWE	0.811
USA	0.776
OECD (11)	0.865

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}. The last row of the table 'OECD (11)' shows the country average.

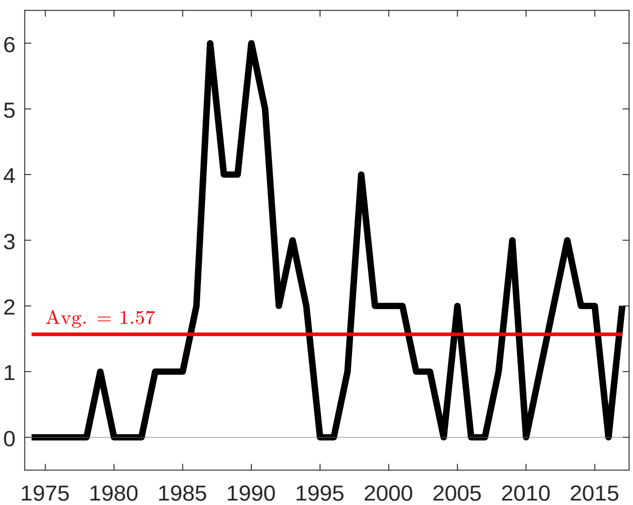


Figure 21: Number of CIT cuts per year in OECD countries over 1973-2017 Notes In Fig. 21, we plot the number of CIT cuts per year for our sample of eleven OECD countries. Sample: 11 OECD countries, 1973-2017, annual data, top statutory CIT rates.

persistent) increase in domestic stock prices.

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

Correlation between the country-level and international corporate taxation. Table 13 shows the correlation between the country-level corporate income tax rate, τ_{it}, and the import-share-weighted-average tax rates of trade partners of the home country, τ_{it}^{int}. The correlation is high for Australia, Belgium, and Great-Britain and relatively lower for large countries such as Germany and the United States. The correlation between the country-level CIT rate and the international CIT index averages 0.866.

Frequency of CIT cuts In Fig. 21, we plot the number of CIT cuts per year for our sample of eleven OECD countries. The number of CIT tax cuts averages 1.6 per year. Because it is smaller than two, it means that on average, only one or two countries lower their CIT rate per year. While this empirical finding suggests that there is no international coordination on average during the period 1973-2017, Fig. 21 reveals that during the period 1988-1991 where European countries have opened their financial account to foreign investors, the number of CIT cuts have significantly increased and culminated to 6 in 1990. It is worth mentioning that 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 by Table 14. 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.[17]

As noted above, IPS test allows for heterogeneity of the autoregressive root, accordingly, we will focus our attention on these tests when running panel unit root tests. 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.

[17]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 14: Panel Unit Root Tests

	LLC		Breitung		IPS		Hadri	
	Stat.	p-value	Stat.	p-value	Stat.	p-value	Stat.	p-value
τ	-0.364	0.358	3.359	1.000	2.498	0.994	82.048	0.000
τ^{int}	-0.368	0.356	2.050	0.980	1.336	0.909	72.891	0.000
τ_{IV}^{int}	-0.568	0.285	-3.659	0.000	-0.898	0.184	51.708	0.000
T^A	-5.942	0.000	2.140	0.984	-2.260	0.012	82.540	0.000
T^H	-4.442	0.000	1.807	0.965	-0.691	0.245	84.297	0.000
T^N	-2.206	0.014	1.476	0.930	-1.294	0.098	65.279	0.000
TFP^A	-6.392	0.000	1.658	0.951	-3.015	0.001	81.889	0.000
TFP^H	-5.347	0.000	1.804	0.964	-1.476	0.070	84.836	0.000
TFP^N	-4.837	0.000	1.290	0.901	-3.292	0.000	68.649	0.000
$T^{W,A}$	-9.021	0.000	1.895	0.971	-4.892	0.000	86.141	0.000
$T^{W,H}$	-6.331	0.000	0.764	0.778	-1.816	0.035	86.909	0.000
$T^{W,N}$	-6.686	0.000	2.881	0.998	-4.516	0.000	77.101	0.000
Y^R	-2.564	0.005	3.979	1.000	1.283	0.900	86.066	0.000
L	-1.279	0.100	-1.264	0.103	-2.255	0.012	43.597	0.000
C	-2.339	0.010	3.912	1.000	1.543	0.939	86.163	0.000
W^A	-4.115	0.000	1.395	0.919	-0.403	0.344	78.401	0.000
W^H	-4.024	0.000	1.346	0.911	-0.405	0.343	78.841	0.000
W^N	-3.562	0.000	1.717	0.957	0.040	0.516	79.000	0.000
Y^H	-1.286	0.099	4.129	1.000	2.215	0.987	84.080	0.000
L^H	-4.370	0.000	1.724	0.958	-0.505	0.307	81.989	0.000
Y^N	-2.857	0.002	3.820	1.000	0.884	0.812	86.367	0.000
L^N	1.862	0.969	2.867	0.998	3.908	1.000	74.496	0.000
Y^H/Y^R	-0.804	0.211	1.169	0.879	0.213	0.584	59.662	0.000
L^H/L	-0.863	0.194	1.934	0.973	3.705	1.000	86.816	0.000
Y^N/Y	-0.775	0.219	1.058	0.855	0.239	0.594	59.552	0.000
L^N/L	-5.799	0.000	1.767	0.961	-1.138	0.128	86.331	0.000
P^N/P^H	-1.889	0.029	2.052	0.980	1.178	0.881	82.602	0.000
$P^H/P^{H,\star}$	-1.857	0.032	-0.474	0.318	-1.907	0.028	51.139	0.000
$P^N/P^{H,\star}$	-2.069	0.019	1.609	0.946	1.273	0.898	77.556	0.000
s_L^H	1.209	0.887	1.278	0.899	0.442	0.671	61.403	0.000
k^H	-2.284	0.011	2.375	0.991	2.060	0.980	86.188	0.000
s_L^N	-2.067	0.019	0.288	0.613	-2.052	0.020	59.234	0.000
k^N	-1.717	0.043	3.543	1.000	1.818	0.965	84.762	0.000
u_K^H	-0.848	0.198	1.153	0.875	-0.617	0.269	65.785	0.000
u_K^N	-2.781	0.003	-0.122	0.451	-2.482	0.007	56.329	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 have for lags in the Augmented Dickey-Fuller regressions. With the exceptions of τ, τ^{int} and τ_{IV}^{int}, all variables enter in log in the different tests.

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 14 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 and is not predictable on the basis of domestic macroeconomic variables so that variations in the international tax rate are exogenous, 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 three sets of panel cointegration tests: those proposed by Kao [1999], Pedroni

[1999], [2004], and Westerlund [2007], respectively.

Among the five stats of Kao [1999] shown in panel A, all of them, reject the no cointegration null hypothesis (Dickey-Fuller, Modified-, Augmented-, Unadjusted-modified-, Unadjusted-DF) at the 10% significance level. We report the results of parametric and non parametric cointegration tests developed by Pedroni [1999], [2004] in panel B. Cointegration tests are based on the estimated residuals of the regression of logged τ_{it} on logged τ_{it}^{int}. Five panel tests reject the null hypothesis of no cointegration between $\log \tau_{it}$ and τ_{it}^{int} at 1% significance level while three panel tests reject the null hypothesis of no cointegration between at the 10% significance level. Among the four stats of Westerlund [2007] displayed by panel C, the 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 15: Panel cointegration tests between country CIT rate (τ_{it}) and import-share-weighted-average of trade partners's CIT rates (τ_{it}^{int})

A. Kao [1999]	Value	p-value
Modified Dickey-Fuller t	-2.408	0.008
Dickey-Fuller t	-1.410	0.079
Augmented Dickey-Fuller t	-1.775	0.038
Unadjusted modified Dickey-Fuller t	-2.302	0.011
Unadjusted Dickey-Fuller t	-1.363	0.086
B. Pedroni [1999], [2004]	Value	p-value
Panel tests		
Non-parametric ν	1.412	0.079
Non-parametric ρ	-1.667	0.048
Non-parametric t	-1.654	0.049
Parametric t	-1.571	0.058
Group-mean tests		
Non-parametric ρ	-0.595	0.276
Non-parametric t	-1.215	0.112
Parametric t	-1.645	0.050
C. Westerlund [2007]	Value	p-value
G_τ	-2.271	0.028
G_α	-8.812	0.034
P_τ	-6.357	0.107
P_α	-6.403	0.073

Notes: The null hypothesis of no cointegration is rejected if the p-value is below 0.05 (0.10 resp.) at 5% (10% resp.) significance level. For Westerlund test, the width of the Bartlett kernel window used in the semi-parametric estimation of long-run variances is defined according to the number $4(T/100)^{2/9} \approx 3$. The number of bootstrap replications is 1000. One lag and one lead have been considered. The estimated specifications include an intercept. Sample: 11 OECD countries, 1973-2017, annual data.

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

Testing the tax competition hypothesis. 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) [18] To test our assumptions, we run the regression of corporate tax rates on capital openness and a measure of the intensity of tax competition:

$$\tau_{it} = \beta_i + \beta_1 \kappa_{it} + \beta_2 \kappa_{it} \times \tau_{it}^{int} + \beta_3 X_{it} + \nu_{it}, \tag{56}$$

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:

$$\frac{\partial \tau_{it}}{\partial \kappa_{it}} = \beta_1 + \beta_2 \times \tau_{it}^{int}, \tag{57a}$$

$$\frac{\partial \tau_{it}}{\partial \tau_{it}^{int}} = \beta_2 \times \kappa_{it}, \tag{57b}$$

eq. (56) 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, see eq. (57b); 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 16 displays the results of the regression specified in eq. 56. As shown in the first row which displays the impact of capital openness, the variable has a significant and strong negative impact on the corporate tax rate. The interaction term shown in the second row reveals that the impact of capital openness on the home country's tax rate is smaller where corporate tax rates of neighbors (i.e., trade partners) are higher. Even if capital is perfectly mobile between countries, some economies might use the corporate tax rate for other purposes than attracting capital, such as reducing the public debt which in turn reduces the intensity of tax competition. All these conclusions hold even once we add some controls, as shown in column 3. 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. Neither the public debt nor the unemployment rate has a significant effect.

Construction of instrumental variable. Because international corporate taxation can potentially be affected by the world business cycle, we construct an instrumental variable by adapting the methodology developed by Jordà et al. [2019]. We run the regression of the change in τ_{it}^{int} (in panel data with country fixed effects) on a variable which tracks the world business cycle, say the world unemployment gap. Since the international CIT

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

Table 16: Effects of Capital Openness and International Corporate Taxation on Country-Level CIT: Eq. (56))

	Country-level CIT: eq. (56)		
	(1)	(2)	(3)
	τ_{it}	τ_{it}	τ_{it}
Capital Openness, κ_{it}	-0.299***	-0.454***	-0.414***
	(-17.129)	(-30.747)	(-14.484)
Cap. Open. × international CIT, $\kappa_{it} \times \tau_{it}^{int}$		0.829***	0.717***
		(20.678)	(10.318)
log Population			0.027
			(0.515)
log Unemployment			-0.000
			(-0.084)
log Public debt % GDP			-0.005
			(-0.667)
Constant	0.591***	0.482***	0.042
	(36.127)	(37.015)	(0.049)
Observations	495	495	415
R-squared	0.509	0.740	0.702

t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

index is country-specific, we construct the world unemployment rate as an import-share-weighted-average of trade partners' unemployment rates, i.e., $u_{it}^{W} = \sum_{k\neq i}^{10} \alpha_{IM}^{i,k} u_{ikt}$ where i indexes countries, k trade partners and t time in years. To compute the world unemployment gap, we estimate the trend of world unemployment, denoted by $\bar{u}_{it}^{W}$, by applying a Hodrick-Prescott filter with a smoothing parameter of 100 (as we use annual data), and we calculate the difference between the actual world unemployment rate and its trend, i.e., $u_{it}^{gap,W} = u_{it}^{W} - \bar{u}_{it}^{W}$. Denoting the predictable component of the change in the international CIT index by $d\bar{\tau}^{int}$, we calculate the unpredictable component international profits' taxation by subtracting the component potentially driven by the world business cycle from actual series of $d\tau_{it}^{int}$ and we multiply the unpredictable component $d\tau_{it}^{int} - d\bar{\tau}^{int}$ by capital openness κ_{it} to further capture the tax competition motives:

$$d\tau_{it}^{int,IV} = \kappa_{it}\left[d\tau_{it}^{int} - d\bar{\tau}^{int}\right]. \quad (58)$$

Aside from being exogenous to the world business cycle, because $\tau_{it}^{int,IV}$ is adjusted with capital openness, the variable defined by eq. (58) closely tracks the tax pressure from abroad on country-level CIT.

Regression with instrumented international CIT. To ensure the robustness of our empirical results, we have adopted an instrumental variable approach. We run the regression of the country-level CIT rate, i.e., τ_{it}, on the instrumented international CIT index which is exogenous to the world business cycle:

$$\tau_{i,t} = \delta_i + \delta_1\tau_{i,t-1} + \delta_2\tau_{i,t-1}^{int,IV} + \eta_{it}. \quad (59)$$

Column 1 of Table 17 reports results from the regression of country-level CIT τ_{it} on the lagged instrumented international CIT index $\tau_{i,t-1}^{int,IV}$. We find a strong and positive effect of profits' taxation by competitor countries on domestic corporate taxation. The impact is significant at a 1% threshold. It clearly shows that (58) is not a weak instrument. Because the country-level CIT rate could adjust with some delay to the tax pressure from competitor countries, in column 2 of Table 17, following Overesch et al. [2011], we include lagged values for the domestic tax rate and the (instrumented) tax rate of neighbors in eq. (59) to capture the delay to adjust its own tax rate. When the lagged own tax rate is added in column 2, we find that corporate tax rates strongly depend on past levels and also responds positively

Table 17: Effects of Capital Openness and International Corporate Taxation on Country-Level CIT

	Country-level CIT: eq. (59)	
	(1)	(2)
	$\tau_{i,t}$	$\tau_{i,t}$
$\tau_{i,t}^{int,IV}$	1.966***	
	(15.99)	
$\tau_{i,t-1}^{int,IV}$		0.093*
		(1.898)
$\tau_{i,t-1}$		0.954***
		(65.487)
Constant	-0.491***	-0.027
	(-8.638)	(-1.411)
Observations	484	484
R-squared	0.478	0.948

t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

and significantly to the tax rate of neighbors, keeping in mind that we have adjusted the international CIT rate with capital openness. Despite the difference in the econometric specification, our estimates confirm the main finding of Devereux et al. [2002], [2008].

D.5 Testing the Predictability of SVAR Identified Shocks to Corporate Taxation

Identification assumption. 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. To circumvent the potential endogeneity issue, we propose a SVAR identification of exogenous variations in CIT rates which lies on the existence of a downward trend in CIT rates which is common to a large set of OECD countries. Such a downward trend is driven by tax competition motives as OECD countries were removing the barriers to capital mobility across borders. Since the tax competition hypothesis implies that the tax rate of the home country and the tax rate of neighbors are cointegrated and thus share a common downward trend, we estimate a SVAR model where we replace the country-level CIT rate with the tax rate of neighbors; more specifically, the VAR model includes the instrument, i.e., the international CIT rate index, ordered first and country-level macroeconomic variables. We identify shocks to international corporate taxation by imposing long-run restrictions, i.e., by assuming that shocks to domestic economic activity has no impact in the long-run on international corporate taxation. We thus assume that the tax rate of neighbors is unsensitive to the country-specific macroeconomic situation in the long-run which is a reasonable assumption. The exogeneity of the constructed tax series is the key identifying assumption. To confirm that changes in τ_{it}^{int} are unpredictable, we run Granger causality tests.

Identification assumption. As emphasized by Ramey [2016], identified shocks should be exogenous with respect to the other current and lagged endogenous variables in the VAR model and should be exogenous to the other shocks in the model (otherwise, we cannot identify the unique causal effects of one exogenous shock relative to another). We cannot test the contemporaneous exogeneity of our tax shock series, see Cloyne [2013], but we can confirm that tax changes are unpredictable on the basis of past information. Like Cloyne [2013], to test the exogeneity of our identified shocks to international corporate taxation, we perform Granger causality tests.

We test how predictable series are on the basis of movements in domestic real GDP, total hours, and utilization-adjusted-TFP which are the domestic macroeconomic indicators included in the baseline VAR model. We estimate the following specification where we regress identified shocks $\varepsilon_{it}^{\tau^{int}}$

$$\varepsilon_{it}^{\tau^{int}} = \alpha_i + \gamma(L)x_{it-1} + \mu(L)\varepsilon_{it-1}^{\tau^{int}} + \nu_{i,t}, \tag{60}$$

where x_{it-1} are predictive variables and α_i are country effects. We allow for two lags. To test whether our identified shocks are also exogenous to the international business cycle, we add the world real GDP, $Y_{it}^{R,W}$, to predictive values. We also perform identical Granger causality tests by replacing shocks to international corporate taxation with shocks to domestic corporate taxation, ε_{it}^{τ}, and thus we add time dummies α_t

$$\varepsilon_{it}^{\tau} = \alpha_i + \alpha_t + \gamma(L)x_{it-1} + \mu(L)\varepsilon_{it-1}^{\tau}, +\eta_{i,t}. \tag{61}$$

The results are presented in panel A of Table 18. As is stands out, it is not possible to reject the hypothesis that all the coefficients are zero. The p-value is 0.990 when we consider only domestic variables as predictive variables and 0.842 when we add the world real GDP. For comparison, we check if idenfied shocks to domestic corporate taxation are also exogenous. The p-value is lower at 0.716 when predictive values are domestic and 0.810 when predictive values are both domestic and foreign.

In panel B of Table 18, we test whether identified shocks to international corporate taxation are exogenous to other shocks in the VAR model. For this purpose, we run Granger causality tests with lagged values of identified shocks to variables included VAR model. More specifically, we denote by $\epsilon_{it}^{Y^R}$, ϵ_{it}^{L}, $\epsilon_{it}^{T^A}$, the shocks to real GDP, hours and utilization-adjusted-TFP, respectively. We run the following regression:

$$\varepsilon_{it}^{\tau^{int}} = \alpha_i + \gamma(L)\epsilon_{it-1}^{k} + \mu(L)\varepsilon_{it-1}^{\tau^{int}} + \nu_{i,t}, \tag{62}$$

where $k = Y^R, L, T^A$. The p-value is 0.986 lagged values on identified shocks to variables included in the VAR model.

Do past domestic demand shocks predict changes in the domestic CIT rate? We identify shocks to domestic CIT denoted by ε_{it}^{τ} by estimating a SVAR model which includes the domestic CIT rate in variation, and domestic macroeconomic variables (real GDP, total hours, utilization-adjusted-TFP) in rate of growth. We run Granger causality tests 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:

$$\varepsilon_{i,t}^{\tau} = \alpha_i + \alpha_t + \mu\left(L\right)\epsilon_{i,t-1}^{D} + \gamma\left(L\right)\varepsilon_{i,t-1}^{\tau} + \eta_{i,t}. \tag{63}$$

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, $\hat{Y}_{it}^{R}$, 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 of Table 19. 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 at a 10% significance level.

Are past demand shocks predictive of variations in the international CIT rate? One additional concern is that shocks which are external to the SVAR model might influence the CIT rate and domestic macroeconomic variables at the same time thus creating an endogeneity problem. We run a robustness check by performing Granger causality tests in panel format by estimating the following specification:

$$\varepsilon_{it}^{\tau^{int}} = \alpha_i + \mu\left(L\right)\epsilon_{i,t-1}^{D} + \gamma\left(L\right)\varepsilon_{i,t-1}^{\tau^{int}} + \eta_{i,t}, \tag{64}$$

where $\varepsilon_{it}^{\tau^{int}}$ are shocks to international corporate taxation. While past domestic demand shocks predict shocks to domestic corporate taxation (p-value equals to 0.069), the second row of Table 19 reveal that past domestic demand shocks do not predict international tax changes with a p-value of 0.268.

Table 18: Granger Causality Panel Tests

	Time Dummies	Test Statistic	p-value
A. Exogeneity test w.r.t. to lagged endogenous variables			
2 lags on Y_{it}^{R}, L_{it} and $T_{it}^{A} \nrightarrow \varepsilon_{it}^{\tau^{int}}$	No	0.142	0.990
2 lags on Y_{it}^{R}, L_{it}, T_{it}^{A} and $Y_{it}^{R,W} \nrightarrow \varepsilon_{it}^{\tau^{int}}$	No	0.520	0.842
2 lags on Y_{it}^{R}, L_{it} and $T_{it}^{A} \nrightarrow \varepsilon_{it}^{\tau}$	Yes	0.618	0.716
2 lags on Y_{it}^{R}, L_{it}, T_{it}^{A} and $Y_{it}^{R,W} \nrightarrow \varepsilon_{it}^{\tau}$	No	0.560	0.810
B. Exogeneity test w.r.t. to other shocks			
$\varepsilon_{it}^{Y^R}$, ε_{it}^{L} and $\varepsilon_{it}^{T^A}$ and 2 lags on $\varepsilon_{it}^{Y^R}$, ε_{it}^{L} and $\varepsilon_{it}^{T^A} \nrightarrow \varepsilon_{it}^{\tau^{int}}$	No	0.254	0.986

Notes: The null hypothesis that X_{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.

Table 19: Granger Causality Panel Tests

	Test Statistic	p-value
$\varepsilon_{it}^{D} \nrightarrow \varepsilon_{it}^{\tau}$	2.684	0.069
$\varepsilon_{it}^{D} \nrightarrow \varepsilon_{it}^{\tau^{int}}$	1.323	0.268
$\varepsilon_{it}^{D,W} \nrightarrow \varepsilon_{it}^{\tau}$	0.452	0.637
$\varepsilon_{it}^{D,W} \nrightarrow \varepsilon_{it}^{\tau^{int}}$	1.043	0.354

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.

Are past world demand shocks predictive of variations in the international CIT rate? Because we might be concerned by the fact that past global recessions could predict shocks to international corporate taxation, we perform Granger causality tests in panel format by estimating the following specification:

$$\varepsilon_{it}^{\tau^{int}} = \alpha_i + \alpha_t + \mu(L)\,\epsilon_{i,t-1}^{D,W} + \gamma(L)\,\varepsilon_{i,t-1}^{\tau^{int}} + \eta_{i,t}, \tag{65}$$

where $\epsilon_{i,t-1}^{D,W}$ are world demand shocks. To identify world demand shocks, we estimate a VAR model which includes foreign real GDP (constructed as an import share weighted average of trade partners' real GDP), $Y_{it}^{R,W}$, 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 19 reveal that shocks to both country-level and international corporate taxation, i.e., ε_{it}^{τ} and $\varepsilon_{it}^{\tau^{int}}$, respectively, are exogenous to past global demand shocks, $\epsilon_{it}^{D,W}$.

D.6 Checking for Capital Flows across Countries: Robustness of the Exclusion Restriction

In estimating the VAR model, we assume that the domestic CIT does not respond to the current or past economic situation in the home-country. Since we use the international corporate income tax rate instead of domestic profits' taxation, our measure of corporate taxation should be exogenous to the domestic economic activity. When neighbor countries decide to lower their tax rate, tax competition pressure leads the home country to lower its own tax rate. Our assumption is that the effects of the international CIT rate on domestic variables pass through the domestic CIT cut. Economically speaking, a violation of the exclusion restriction could occur if a change in the international CIT rate affects home outcomes through channels other than movements in the domestic CIT rate. Additional influences via such channels could occur through capital flows between countries. For example, when neighbor countries decide to lower their tax rate to attract businesses, it might produce capital outflows, i.e., outward FDI, which generate a decline in economic activity in industries hit by offshoring. If it were the case, a decline in international corporate taxation should be associated with a decline in domestic economic activity while we find the opposite.

Although this simple observation should make us confident about the fact that there is not violation of the exclusion restriction, we have estimated the effects of a tax cut in profits' taxation by neighbor countries in Fig. 22 on outward FDI (see the solid red line) and on inward FDI (see the solid blue line) in the domestic country. As expected, when neighbor countries lower their CIT rate, this generates FDI outflows (see the solid red line) since capital moves away from the domestic country. However, the domestic country immediately reacts by reducing its own tax rate which causes inward FDI (see the solid blue line). As is clear from Fig. 22, both FDI outflows and inflows are synchronized and display the same magnitude which means the domestic country responds quickly to the reduction in the international CIT rate. Since capital inflows exactly compensate for capital outflows, capital flows across borders have no impact on the domestic country and thus a decline in international profits' taxation has an impact on domestic economic activity other than through the fall in the domestic CIT rate.

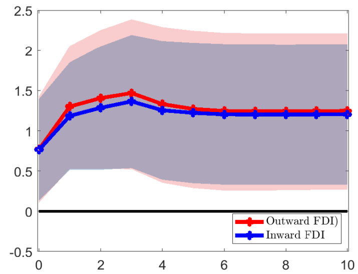


Figure 22: Dynamic Effects of a Shock to International CIT on Capital Flows across Countries. Notes: The solid line with crosses shows the dynamic effects of a permanent decline in the international CIT index which leads to a domestic CIT cut by -1 ppt in the long-run. Shaded areas are 68% confidence bands. The solid red line with crosses shows the effects of a CIT cut on outward FDI while the solid blue line with crosses shows the effects on inward FDI. We have estimated a VAR model which includes the international CIT index and FDI as a percentage of GDP. Time series for FDI are taken from Lane and Milesi-Ferretti [2007]. We exclude Luxembourg from the sample as FDI as a percentage of GDP takes extreme values for this country only. Sample: 10 OECD countries, 1973-2017, annual data.

D.7 The Number of Lags

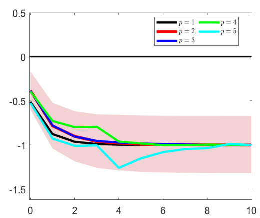
Chari et al. [2008] recommend to increase the number of lags to avoid the identification of a permanent shock by means of the estimation of a VAR model with long-run restrictions being contaminated by persistent demand shocks. De Graeve and Westermark [2013] find that raising the number of lags may be 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. 23 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 solid red line. Whilst in the black line we allow for one lag, in the blue line we allow for three lags, in the green line we allow for four lags and in the cyan line, we allow for five lags. Overall, all responses lie within the 68% confidence bounds of the original VAR model and all of our conclusions hold. More specifically, a permanent decline in international corporate taxation leading to a cut in the domestic CIT rate caused by tax competition motives 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.

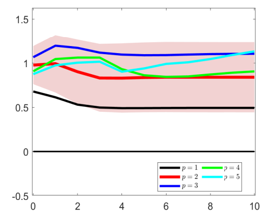
D.8 SVAR Identification vs. Narratively-Identified Corporate Income Tax Shocks

Narrative approach. 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. While Mertens and Ravn [2013] and Cloyne et al. [2025b] estimate the dynamic effects of a corporate income tax cut on U.S. data, Dabla-Norris and Lima [2023] have constructed a narratively-identified tax shocks database covering 10 OECD countries from 1978 to 2014. Like Cloyne [2013], tax changes are classified as exogenous when they are not designed to offset other macroeconomic shocks.

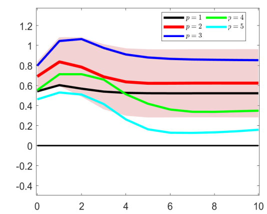
The dataset constructed by Dabla-Norris and Lima [2023] comprises narratively-identified shocks to corporate taxation for both long-run growth and fiscal consolidations motives for ten OECD countries. We have six OECD countries in common: Australia, Austria, France, Germany, Great Britain and the United States. To make our estimates based on shocks to international CIT directly comparable with those based on narratively-identified shocks, we have augmented the dataset kindly shared by Dabla-Norris and Lima [2023]. We include five countries: Belgium, Finland, Japan, Luxembourg, Sweden. Like the authors, we use



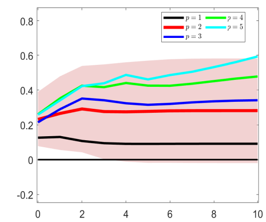
(a) Corporate Income Tax, τ_{it}



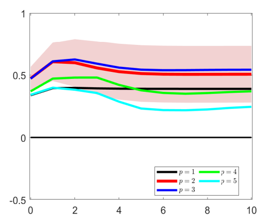
(b) Real GDP, Y_{it}^R



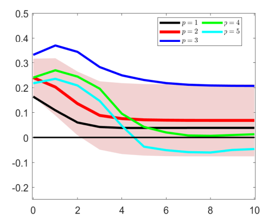
(c) Total Hours Worked, L_{it}



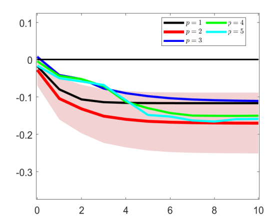
(d) Ut.-Adj.-Aggregate-TFP, T_{it}^A



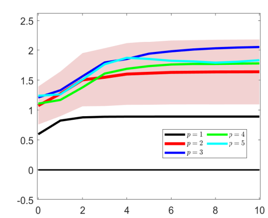
(e) Non-Traded Hours Worked, L_{it}^N



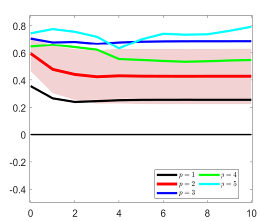
(f) Traded Hours Worked, L_{it}^H



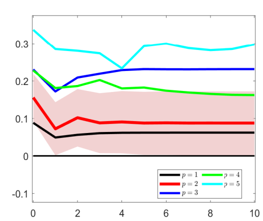
(g) Hours Worked Share of Tradables, $\nu_{it}^{L,H}$



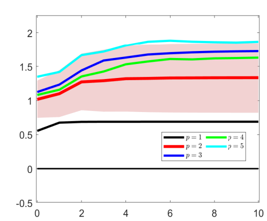
(h) Relative Price of Non-Tradables, P_{it}^N/P_{it}^H



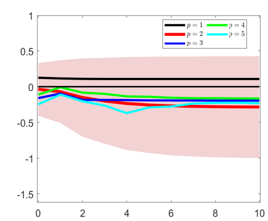
(i) Traded Value Added, Y_{it}^H



(j) Value Added Share of Tradables, $\nu_{it}^{Y,H}$



(k) Ut.-Adj.-TFP of Tradables, T_{it}^H



(l) Terms of Trade, P_{it}^H

Figure 23: Dynamic Effects of an International Corporate Tax Shock: Robustness Check w.r.t. Lags Notes: The solid 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 68 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 red line. Whilst in the black line we allow for one lag, in the blue line we allow for three lags, in the green line we allow for four lags and in the cyan line, we allow for five lags. Sample: 11 OECD countries, 1973-2017, annual data.

reports from the Ministry of Finance, technical reports, that we complement with IMF staff reports, OECD Economic Surveys. In contrast to Dabla-Norris and Lima [2023] who exclusively focus on exogenous tax changes driven by fiscal consolidation purposes, we have selected CIT changes for long-run growth purposes or ideological motives as these episodes collapse to changes in CIT driven for tax competition motives. With regards to the five additional OECD countries we have added, we have identified the following episodes.

- Belgium has reduced its CIT in 2003 from 39% to 33% to increase competitiveness. OECD [2003] report about the tax reform in Belgium: "The government has also announced a revenue-neutral reform of corporate income taxation that is principally motivated by international competitiveness concerns."

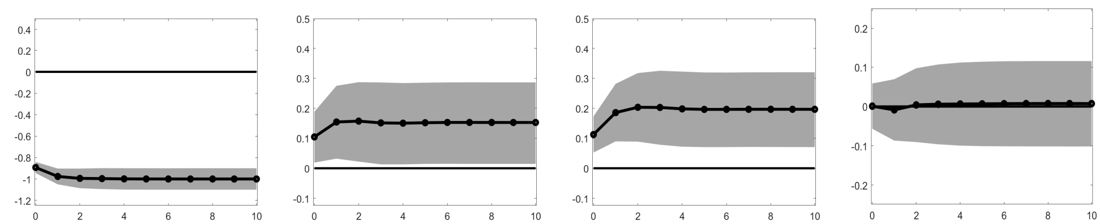
- Finland has reduced its CIT in 1986 from 43% to 33% to increase competitiveness. OECD [2002] report about the tax reform in Finland: "The desire to attract foreign investors and to keep domestic companies in Finland was one of the reasons for an ambitious reform of the taxation of capital and corporate income. Statutory tax rates, which have an important signalling function for investors (Hines, 2001), were more than halved between the mid-1980s and 1993".

- Japan has reduced its CIT three times in 1987 (Nakasone tax reform), 1989 (Takeshita Tax Reform), 1990 from 43% to 42%, from 42% to 40% and from 40% to 37.5%, respectively, to remain competitive. According to the NBER [1992] Chapter about the Tax reform in Japan: "It has been emphasized in Japan that active corporations might move their place of business to countries where tax burdens are lower, and such a reaction could damage Japanese competitiveness at the international level. (...) The main objective of corporate income tax reform has been to reduce the tax burden by lowering tax rates and broadening the tax base."

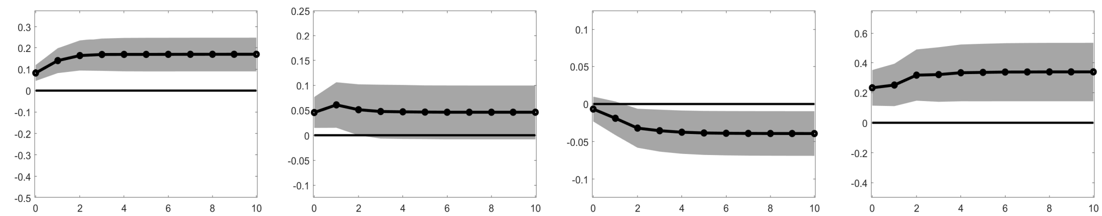
- Luxembourg has reduced it CIT twice in 1998 from 32% to 30% and next in 2002 from 30% to 22%. The first cut was to increase competitiveness while the second was aimed at promoting long-run growth according to IMF [2000] Luxembourg Staff report which noted that "Fiscal policy also aimed at bolstering Luxembourg's attraction as a business location. The 1998 budget included significant cuts in corporate and personal income taxes" and revealed that "The authorities plan for significant income tax reforms in 2002 (...) The broad reform aims were to lower the statutory corporate tax rate to less than 35 percent" and "Further income tax reforms would be desirable - a lower tax burden would boost competitiveness and a more neutral tax system would improve the overall functioning of the economy".

- Sweden has also cut its CIT twice in 1990 from 52% to 40% and next in 1991 from 40% to 30%. According to the NBER [1997] Chapter about the tax policy in Sweden: "Corporate taxation was also designed in order to increase neutrality. The statutory tax rate was decreased to 30 percent. (...) If reductions of tax rates in other countries were not matched, Sweden would have been left vulnerable in several respects. First, Sweden would have had difficulty competing with low-rate countries for investment from countries that exempt foreign-source income."

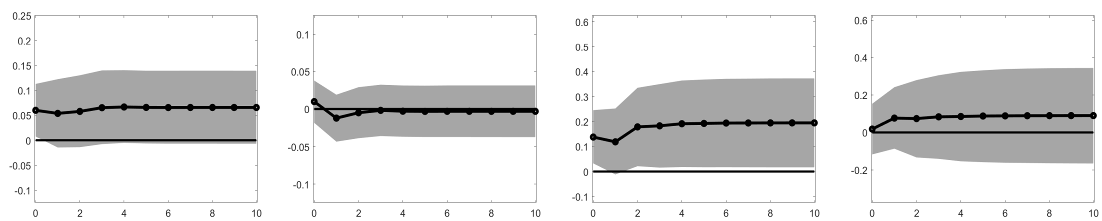
Results and discussion. In Fig. 24, we show results for 16 macroeconomic variables. As displayed by Fig. 24(a), we consider a domestic CIT cut by 1 ppt in the long-run. As shown in the fist row, the CIT cut significantly increases both real GDP and total hours. Labor growth is concentrated in the non-traded sector as hours shift toward this sector. Technology improvement is taking place only in traded industries. Overall, the evidence we document in the main text which are based on a shock to international CIT are qualitatively identical to the responses to narratively-identified shocks. This outcome is not surprising because most of the CIT episodes aimed at stimulating long-run growth or driven by ideological motives collapse to episodes where OECD countries have lowered their corporate tax rates to remain competitive internationally amid the lift of restrictions to capital mobility.



(a) Corporate Income Tax, τ_{it} (b) Real GDP, Y_{it}^{R} (c) Total Hours Worked, L_{it} (d) Adjusted TFP, T_{it}^{A}



(e) Non-Traded Hours Worked, L_{it}^{N} (f) Traded Hours Worked, L_{it}^{H} (g) Hours Worked Share of Tradables, $\nu_{it}^{L,H}$ (h) Relative Price of Non-Tradables, P_{it}^{N}/P_{it}^{H}



(i) Traded Value Added, Y_{it}^{H} (j) Value Added Share of Tradables, $\nu_{it}^{Y,H}$ (k) Adjusted TFP of Tradables, T_{it}^{H} (l) Terms of Trade, P_{it}^{H}

Figure 24: Dynamic Responses to Narratively-Identified Shocks to Corporate Taxation in OECD Countries (N = 11). Notes: Adjusted TFP means Utilization-adjusted-TFP. The solid black line shows the dynamic adjustment generated from a VAR model which includes the narratively-identified tax shocks ordered fist, and macroeconomic variables in rate of growth. We normalize the shock so that it leads to a corporate income taxation by 1 percentage point in the long-run. Dark shaded areas 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, 1976-2017, annual data.

D.9 Robustness Check w.r.t. Anticipations of Tax Changes

So far, we have shown that domestic CIT and the tax rate of neighbors are cointegrated, shocks to international CIT we identify are exogenous to both domestic and world economic activity, and the dynamic effects of shocks to international corporate taxation are qualitatively identical to those caused by narratively-identified CIT cut episodes. As emphasized by Ramey [2016], in addition to being not predictable by other variables included in the VAR model and being orthogonal to other shocks in the model, the shocks should represent either unanticipated movements in exogenous variables or news about future movements in exogenous variables. In our case, we consider surprise changes in international corporate taxation. In this subsection, we document evidence which corroborate the fact that the shocks to international corporate taxation we identify are eventually unanticipated.

To show this point, we adapt the methodology pioneered by Beaudry and Portier [2006]. We estimate a VAR model which comprises the variation in the international CIT index, $d\tau_{it}^{int}$, and the rate of growth of stock market prices, $\hat{\text{SP}}_{it}$. The VMA representation of the structural VAR model is:

$$\hat{X}_{it} = B(L)A_0\varepsilon_{it}, \tag{66}$$

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 $A(L) = \sum_{k=0}^{\infty} A_k L^k$.

- We can identify structural shocks ε_{it}^{τ} and ε_{it}^{SP} by imposing short-run restrictions which amounts to setting the 1, 2 element of A_0, i.e., a_{12} to zero. In doing this, we assume that stock market prices have no impact on the international corporate tax rate initially. An increase in stock market prices which is associated with an unchanged CIT rate on impact is a corporate tax news shock denoted by ε_{it}^{SP}.

- Alternatively, we can identify structural shocks $\tilde{\varepsilon}_{it}^{\tau}$ and $\tilde{\varepsilon}_{it}^{SP}$ by imposing long-run restrictions which amounts to setting the 1, 2 element of $A(1) = B(1)A_0$ to zero. In setting this restriction, we assume that shocks to international corporate taxation are shocks which modify permanently τ_{it}^{int} and thus stock market prices have no impact in the long-run on international corporate taxation. We denote the permanent tax shock by $\tilde{\varepsilon}_{it}^{\tau}$.

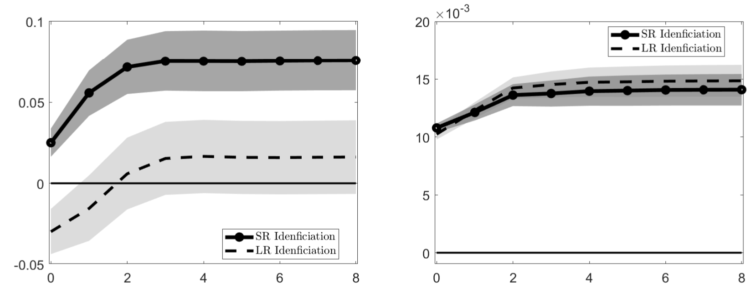
Beaudry and Portier [2006] focus on utilization-adjusted TFP instead of corporate taxation and find that shocks to stock market prices leaving unchanged technology on impact is strongly positively correlated with shocks to technology which increase permanently utilization-adjusted TFP. In our case, shocks to stock market prices associated with a muted tax rate of neighbors impact are corporate tax news shocks. In the main text, we identify shocks to international CIT which lead to a permanent change in corporate taxation. According to our assumption, the correlation between ε_{it}^{SP} and $\tilde{\varepsilon}_{it}^{\tau}$ should be close to zero and the correlation between ε_{it}^{τ} and $\tilde{\varepsilon}_{it}^{\tau}$ should be close to one. In line with our hypothesis, we find that:

- The correlation between ε_{it}^{SP} and $\tilde{\varepsilon}_{it}^{\tau}$ is low at -0.31; note that the correlation is negative because the corporate tax news shocks ε_{it}^{SP} is associated with a decline in international corporate taxation while $\tilde{\varepsilon}_{it}^{\tau}$ is a shock which increases international corporate taxation.

- Conversely, the correlation between ε_{it}^{τ} and $\tilde{\varepsilon}_{it}^{\tau}$ is high and close to one at 0.95.

In conclusion, the shocks to international corporate taxation we identify in the main text are eventually unanticipated corporate tax shocks.

In Fig. 25, we plot the responses of stock market prices, SP_{it}, and the international corporate taxation index, τ_{it}^{int}. The solid black lines display responses to a shock to τ^{int} identified in a SVAR with short-run restrictions. The dashed black lines show responses to



(a) Responses of Stock Market Prices to ε_{it}^{τ} and $\tilde{\varepsilon}_{it}^{\tau}$

(b) Responses of International Corporate Taxation Index to ε_{it}^{τ} and $\tilde{\varepsilon}_{it}^{\tau}$

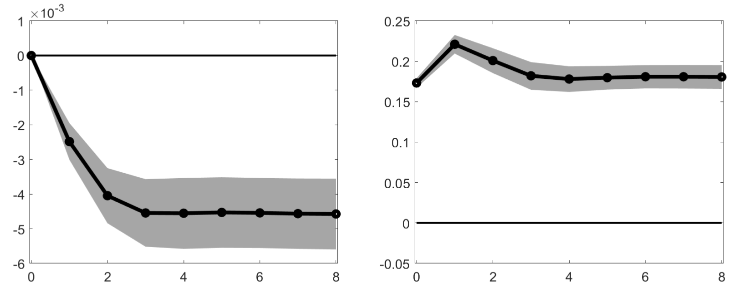
Figure 25: Dynamic Responses of Stock Market Prices and International Corporate Taxation Index to Corporate Tax Shocks Notes: In Fig. 25, we plot the dynamic responses of domestic stock prices (first column) and the tax rate of domestic country's neighbors (second column) to a shock to international corporate taxation. The solid black line with circles shows the responses to a tax shock $\tilde{\varepsilon}_{it}^{\tau}$ identified by imposing long-run restrictions. The dashed black line displays the responses to a tax shock ε_{it}^{τ} identified by imposing short-run restrictions. Sample: 11 OECD countries, 1973-2017, annual data.

a shock to τ_t^{int} identified in a SVAR with long-run restrictions. As can be seen in Fig. 25(a), the endogenous response of international corporate taxation to a shock to τ_{it}^{int} is almost identical whether it is identified under short- or long-run restrictions. There is a slight difference in the adjustment of stock market prices. The reason is that the country-level CIT rate seems to react by a different magnitude to a permanent increase in international corporate taxation. We expect that a shock to τ_{it}^{int} leads the country to increase its tax rate τ_{it} which in turn should produce a decline in stock prices. This is what we observe under long-run restrictions but not under short-run restrictions because the domestic CIT rate is less responsive (i.e., increases less) so that stock prices increase instead of declining.

In Fig. 26, we generate the dynamic responses of the international corporate tax index, τ_{it}^{int} and domestic stock prices SP_{it} to a shock to stock market prices. In the first row, we identify the shock to stock prices by imposing short-run restrictions, i.e., we assume that a change in stock prices is not associated with a change in the international CIT index on impact. Fig. 26(b) and Fig. 26(a) show that an exogenous shock to domestic stock prices such that international corporate taxation remains unchanged on impact increases stock prices permanently and also lower permanently the international CIT index. The shock ε_{it}^{SP} is a tax news shock. A permanent rise in stock market value indicates that the market anticipates a rise in future profits. Such a rise is brought by the expectation of a tax cut on domestic corporate income which is itself driven by the announcement of a tax cut in neighbor countries of the home country. In contrast, in the second row, we identify the shock to stock prices by imposing long-run restrictions, i.e., we assume that a change in domestic stock prices is not associated with a permanent change in the international CIT index. Fig. 26(d) and Fig. 26(c) show that an exogenous shock to domestic stock prices such that international corporate taxation remains unchanged in the long-run increases stock prices permanently while the response of international CIT index is positive in the short-run but muted in the long-run. The shock $\tilde{\varepsilon}_{it}^{SP}$ is not a tax shock. It captures all shocks which increase permanently stock prices while leaving unchanged the corporate income tax rate in the long-run. This could capture a technology news shock.

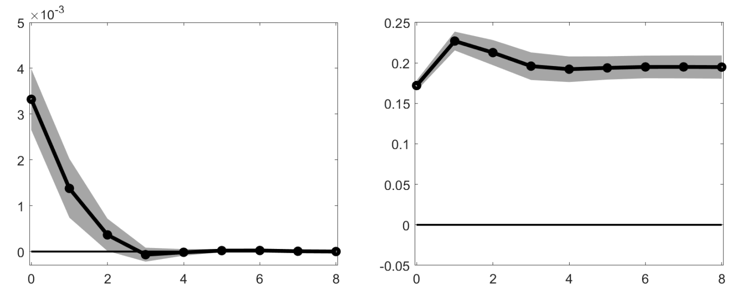
D.10 Controlling for Anticipations of Tax Changes

Anticipation effects and non-fundamentalness. As emphasized by Yang [2008], Leeper, et al. [2008], Mertens and Ravn [2012], implementation of tax changes might be preceded by lengthy debate, and thereby agents often anticipate a planned change several quarters before its realization. That is, private agents receive signals about future changes in taxes before these changes actually take place. If tax changes are anticipated in advance, then the IRFs won't capture correctly the short-run effects. From the perspective of a structural model, anticipation is a source of "non-fundamentalness". Non-fundamentalness may impair the ability of the econometrician to uncover the structural shocks from the innovations



(a) Response of International Corporate Taxation Index to ε_{it}^{SP}

(b) Response of Stock Market Prices to ε_{it}^{SP}



(c) Response of International Corporate Taxation Index to $\tilde{\varepsilon}_{it}^{SP}$

(d) Response of Stock Market Prices to $\tilde{\varepsilon}_{it}^{SP}$

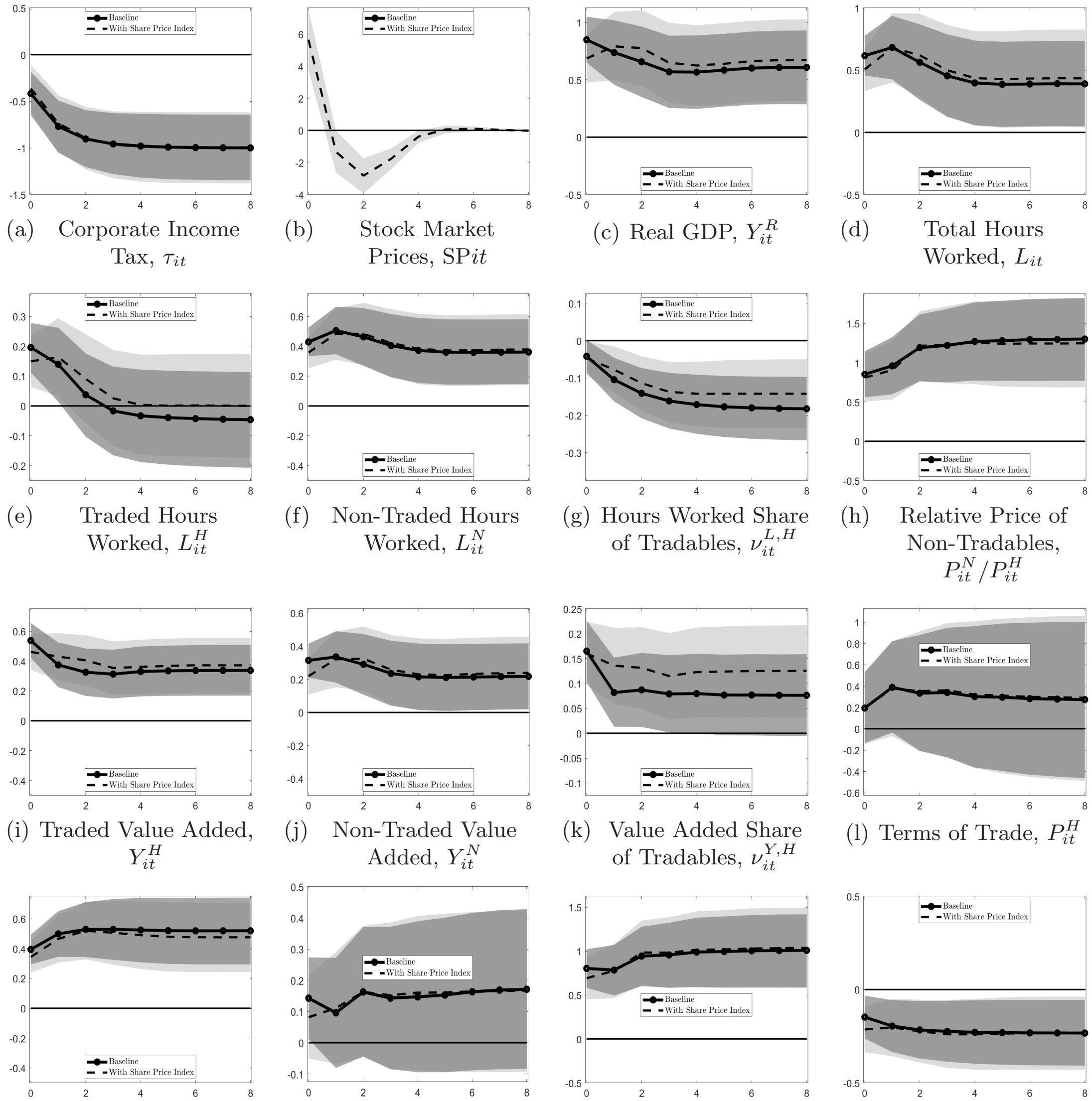
Figure 26: Dynamic Responses of Stock Prices and International Corporate Taxation Index to Shocks to Stock Prices Notes: In Fig. 26, we plot the dynamic responses of the tax rate of domestic country's neighbors (first column) and domestic stock market prices (second column) to a shock to domestic stock prices. The solid black line with circles shows the responses to a tax shock $\tilde{\varepsilon}_{it}^{SP}$ identified by imposing long-run restrictions. The dashed black line displays the responses to a tax shock identified by imposing short-run restrictions. Sample: 11 OECD countries, 1973-2017, annual data.

of an estimated VAR model. When the econometrician has less information than the agents in the economy, he/she might not recover the structural shocks from the present and past observations of the economy regardless the identification strategy, see Beaudry et al. [2019]. By adapting the methodology pioneered by Beaudry and Portier [2006] in section D.9, we have shown that the shocks to CIT we identify in the main text are surprise shocks which are uncorrelated with shocks to CIT which are anticipated.

Empirical strategy to tackle potential anticipation effects. As a second robustness check, in order to address the potential complications arising from possibly anticipated tax changes, we add a variable which accounts for the anticipated effects of corporate tax changes in the VAR model. We augment all VAR models with stock market prices stock market prices as they are forward-looking variables and thus they are likely a good variable for capturing any changes in agents' expectations about future economic conditions. This is especially true for shocks to CIT as they directly affect profits and thus stock market prices. Following a surprise CIT shock, the permanent decline in profits' taxation increases the after-tax net operating surplus which should be reflected in an immediate increase in stock market prices.

Sample and VAR model. Time series for stock market prices are taken from OECD, Main Economic Indicators Publication. We consider share prices, All shares/broad, index, 2015=100. Because the data for stock market prices are too short for Luxembourg (they start from 1999), we exclude this country from the dataset for this robustness check. We estimate different VAR models (see section B.2).

Empirical results. Fig. 27 contrasts the dynamic effects of a shock to international corporate taxation in the standard VAR model (see section B.2) with those obtained when we control for anticipation effects by augmenting the VAR models with stock market prices ordered last. As shown in Fig. 27, the anticipation effects are moderate if any since the differences between the estimates when we abstract or add stock market prices are negligible. As can be seen in Fig. 27(b), following a permanent decline in CIT displayed by Fig. 27(a),



(a) Corporate Income Tax, τ_{it} (b) Stock Market Prices, SPit (c) Real GDP, Y_{it}^R (d) Total Hours Worked, L_{it}

(e) Traded Hours Worked, L_{it}^H (f) Non-Traded Hours Worked, L_{it}^N (g) Hours Worked Share of Tradables, $\nu_{it}^{L,H}$ (h) Relative Price of Non-Tradables, P_{it}^N/P_{it}^H

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

(m) Consumption, C_{it} (n) Ut.-Adj.-Aggregate-TFP, T_{it}^A (o) Ut.-Adj.-TFP of Tradables, T_{it}^H (p) Ut.-Adj.-TFP of Non-Tradables, T_{it}^N

Figure 27: Dynamic Responses to Shocks to Corporate Taxation in OECD Countries ($N = 11$): Robustness Check w.r.t. Anticipation Effects. Notes: The solid black line shows the dynamic adjustment generated from the baseline VAR model which includes the international CIT index, real GDP, total hours, and utilization-adjusted-aggregate-TFP. We contrast the baseline results with those obtained when we control for anticipation effects by adding stock market prices ordered last in the VAR model. The responses from the VAR model augmented with stock market prices are shown in the dashed black line. We normalize the shock so that it leads to a corporate income taxation by 1 percentage point in the long-run. Dark shaded areas indicate the 68 percent confidence bounds based on bootstrap sampling. Horizontal axes indicate years. Vertical axes measure percentage deviation from trend. We have excluded Luxembourg from the sample as stock market prices are available from 1999 only. Therefore, we have re-estimated the baseline VAR models for 10 countries to have a consistent reference point. Sample: 10 OECD countries, 1973-2017, annual data.

stock market prices immediately increase as agents learn about lower profits' taxation. The conclusion which can be drawn from these empirical findings is that anticipation effects, if any, have no impact on our estimated effects.

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, $J^{K,T}$, and non-traded, $J^{K,N}$, sectors. As for consumption, input of the traded good to produce tangible investment goods is a composite of home-produced traded inputs, $J^{K,H}$, and foreign imported inputs, 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 inputs, $J^{Z,H}$, and non-traded inputs, $J^{Z,N}$. 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. Aggregate consumption $C(t)$ is made up of traded and non-traded goods denoted by $C^T(t)$ and $C^N(t)$, respectively, which are aggregated by means of a CES function:

$$C(t) = \left[\varphi^{\frac{1}{\phi}} \left(C^T(t)\right)^{\frac{\phi-1}{\phi}} + (1-\varphi)^{\frac{1}{\phi}} \left(C^N(t)\right)^{\frac{\phi-1}{\phi}}\right]^{\frac{\phi}{\phi-1}}, \tag{67}$$

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, $C^F(t)$:

$$C^T(t) = \left[\left(\varphi^H\right)^{\frac{1}{\rho}} \left(C^H(t)\right)^{\frac{\rho-1}{\rho}} + \left(1-\varphi^H\right)^{\frac{1}{\rho}} \left(C^F(t)\right)^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}}, \tag{68}$$

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:

$$P_C = \left[\varphi \left(P^T\right)^{1-\phi} + (1-\varphi) \left(P^N\right)^{1-\phi}\right]^{\frac{1}{1-\phi}}, \tag{69}$$

where the price index for traded goods is:

$$P^T = \left[\varphi_H \left(P^H\right)^{1-\rho} + (1-\varphi_H)\right]^{\frac{1}{1-\rho}}. \tag{70}$$

Given the consumption-based price index (69), the representative household has the following demand of traded and non-traded goods:

$$C^T = \varphi \left(\frac{P^T}{P_C}\right)^{-\phi} C, \tag{71a}$$

$$C^N = (1-\varphi) \left(\frac{P^N}{P_C}\right)^{-\phi} C. \tag{71b}$$

Given the price indices (69) and (70), the representative household has the following demand of home-produced traded goods and foreign-produced traded goods:

$$C^H = \varphi \left(\frac{P^T}{P_C}\right)^{-\phi} \varphi_H \left(\frac{P^H}{P^T}\right)^{-\rho} C, \tag{72a}$$

$$C^F = \varphi \left(\frac{P^T}{P_C}\right)^{-\phi} (1-\varphi_H) \left(\frac{1}{P_T}\right)^{-\rho} C. \tag{72b}$$

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:

$$\hat{P}_C = \alpha_C \hat{P}^T + (1-\alpha_C)\, \hat{P}^N, \tag{73a}$$

$$\hat{P}^T = \alpha_H \hat{P}^H, \tag{73b}$$

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:

$$\alpha_C = \varphi \left(\frac{P^T}{P_C}\right)^{1-\phi}, \tag{74a}$$

$$1-\alpha_C = (1-\varphi) \left(\frac{P^N}{P_C}\right)^{1-\phi}, \tag{74b}$$

$$\alpha^H = \varphi_H \left(\frac{P^H}{P^T}\right)^{1-\rho}, \tag{74c}$$

$$1-\alpha^H = (1-\varphi_H) \left(\frac{1}{P^T}\right)^{1-\rho}. \tag{74d}$$

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]:

$$L(t) = \left[\vartheta_L^{-1/\epsilon_L} \left(L^H(t)\right)^{\frac{\epsilon_L+1}{\epsilon_L}} + (1-\vartheta_L)^{-1/\epsilon_L} \left(L^N(t)\right)^{\frac{\epsilon_L+1}{\epsilon_L}}\right]^{\frac{\epsilon_L}{\epsilon_L+1}}, \tag{75}$$

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 (75), is:

$$W = \left[\vartheta_L \left(W^H\right)^{\epsilon_L+1} + (1-\vartheta_L) \left(W^N\right)^{\epsilon_L+1}\right]^{\frac{1}{\epsilon_L+1}}, \tag{76}$$

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:

$$L^H = \vartheta_L \left(\frac{W^H}{W}\right)^{\epsilon_L} L, \quad L^N = (1-\vartheta_L) \left(\frac{W^N}{W}\right)^{\epsilon_L} L. \tag{77}$$

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

$$\hat{W} = \alpha_L \hat{W}^H + (1-\alpha_L)\,\hat{W}^N, \tag{78}$$

where α_L is the tradable content of labor compensation:

$$\alpha_L = \vartheta_L \left(\frac{W^H}{W}\right)^{1+\epsilon_L}, \quad 1-\alpha_L = (1-\vartheta_L)\left(\frac{W^N}{W}\right)^{1+\epsilon_L}, \tag{79}$$

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:

$$K(t) = \left[\vartheta_K^{-1/\epsilon_K}\left(K^H(t)\right)^{\frac{\epsilon_K+1}{\epsilon_K}} + (1-\vartheta_K)^{-1/\epsilon_K}\left(K^N(t)\right)^{\frac{\epsilon_K+1}{\epsilon}}\right]^{\frac{\epsilon_K}{\epsilon_K+1}}, \tag{80}$$

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 (80) is:

$$R^K = \left[\vartheta_K\left(R^{K,H}\right)^{\epsilon_K+1} + (1-\vartheta_K)\left(R^{K,N}\right)^{\epsilon_K+1}\right]^{\frac{1}{\epsilon_K+1}}, \tag{81}$$

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:

$$K^H = \vartheta_K\left(\frac{R^{K,H}}{R^K}\right)^{\epsilon_K} K, \quad K^N = (1-\vartheta_K)\left(\frac{R^{K,N}}{R^K}\right)^{\epsilon_K} K, \tag{82}$$

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:

$$\hat{R}^K = \alpha_K \hat{R}^{K,H} + (1-\alpha_K)\,\hat{R}^{K,N}, \tag{83}$$

where α_K is the tradable content of capital return:

$$\alpha_K = \vartheta_K\left(\frac{R^{K,H}}{R^K}\right)^{1+\epsilon_K}, \quad 1-\alpha_K = (1-\vartheta_K)\left(\frac{R^{K,N}}{R^K}\right)^{1+\epsilon_K}. \tag{84}$$

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 the traded $Z^H(t)$ and non-traded $Z^N(t)$ stock of ideas are imperfect substitutes:

$$Z(t) = \left[\vartheta_Z^{-1/\epsilon_Z}\left(Z^H(t)\right)^{\frac{\epsilon_Z+1}{\epsilon_Z}} + (1-\vartheta_Z)^{-1/\epsilon_Z}\left(Z^N(t)\right)^{\frac{\epsilon_Z+1}{\epsilon}}\right]^{\frac{\epsilon_Z}{\epsilon_Z+1}}, \tag{85}$$

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:

$$Z^H = \vartheta_Z\left(\frac{R^{Z,H}}{R^Z}\right)^{\epsilon_Z} Z, \quad Z^N = (1-\vartheta_Z)\left(\frac{R^{Z,N}}{R^Z}\right)^{\epsilon_Z} Z. \tag{86}$$

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:

$$\hat{R}^Z = \alpha_Z \hat{R}^{Z,H} + (1-\alpha_Z)\,\hat{R}^{Z,N}, \tag{87}$$

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

$$\alpha_Z = \vartheta_Z \left(\frac{R^{Z,H}}{R^Z}\right)^{1+\epsilon_Z}, \quad 1 - \alpha_Z = (1 - \vartheta_Z) \left(\frac{R^{Z,N}}{R^Z}\right)^{1+\epsilon_Z}. \tag{88}$$

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:

$$\mathcal{U} = \int_0^\infty \Lambda\left(C(t), S(t), L(t)\right) e^{-\beta t} \mathrm{d}t, \tag{89}$$

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

$$\Lambda\left(C, S, L\right) \equiv \frac{X^{1-\sigma} - 1}{1-\sigma}, \quad X\left(C, S, L\right) \equiv C S^{-\gamma_S} - \frac{\sigma_L}{1+\sigma_L} \gamma_L L^{\frac{1+\sigma_L}{\sigma_L}}, \tag{90}$$

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:

$$S(t) = \delta_S \int_{-\infty}^t C\left(\tau\right) e^{-\delta_S (t-\tau)} \mathrm{d}\tau, \qquad \delta_S > 0. \tag{91}$$

where the parameter δ_S indexes the relative weight of recent consumption in determining the reference stock $S(t)$. Differentiating equation (91) with respect to time gives the law of motion of the stock of habits:

$$\dot{S}(t) = \delta_S \left[C(t) - S(t)\right]. \tag{92}$$

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:

$$U\left(C(t), S(t)\right) = C(t)^{\gamma_S} \left(\frac{C(t)}{S(t)}\right)^{1-\gamma_S}. \tag{93}$$

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. (90)):

$$X_C = S^{-\gamma_S}, \tag{94a}$$

$$X_{CC} = 0, \tag{94b}$$

$$X_S = -C\gamma_S S^{-(\gamma_S+1)} < 0, \tag{94c}$$

$$X_{SS} = \gamma_S\left(\gamma_S+1\right) C S^{-(\gamma_S+2)} > 0, \tag{94d}$$

$$X_{SC} = -\gamma_S S^{-(\gamma_S+1)} < 0, \tag{94e}$$

$$X_L = -\gamma_L L^{\frac{1}{\sigma_L}} < 0, \tag{94f}$$

$$X_{LL} = -\frac{\gamma_L}{\sigma_L} L^{\frac{1}{\sigma_L}-1} < 0, \tag{94g}$$

and the partial derivatives of $\Lambda = \Lambda((C, S, L)$ (see eq. (90)):

$$\Lambda_C = X^{-\sigma} X_C > 0, \tag{95a}$$

$$\Lambda_{CC} = -\sigma X^{-(\sigma+1)} \left(X_C\right)^2 < 0, \tag{95b}$$

$$\Lambda_S = X^{-\sigma} X_S < 0, \tag{95c}$$

$$\Lambda_{SS} = -\sigma X^{-(\sigma+1)} \left(X_S\right)^2 + X^{-\sigma} X_{SS}, \tag{95d}$$

$$\Lambda_{SC} = -\sigma X^{-(\sigma+1)} X_S X_C + X^{-\sigma} X_{SC}, \tag{95e}$$

$$\Lambda_L = X^{-\sigma} X_L, \tag{95f}$$

$$\Lambda_{LL} = -\sigma X^{-(\sigma+1)} \left(X_L\right)^2 + X^{-\sigma} X_{LL} < 0, \tag{95g}$$

$$\Lambda_{CL} = -\sigma X^{-(\sigma+1)} X_C X_L > 0, \tag{95h}$$

$$\Lambda_{SL} = -\sigma X^{-(\sigma+1)} X_S X_L < 0, \tag{95i}$$

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:

$$C^{K,j}(t) = \xi_1^j \left(u^{K,j}(t) - 1\right) + \frac{\xi_2^j}{2} \left(u^{K,j}(t) - 1\right)^2, \tag{96a}$$

$$C^{Z,j}(t) = \chi_1^j \left(u^{Z,j}(t) - 1\right) + \frac{\chi_2^j}{2} \left(u^{Z,j}(t) - 1\right)^2, \tag{96b}$$

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:

$$\dot{N}(t) + P_C(t)C(t) + \sum_{V=K,Z} P_J^V(t) J^V t) + \sum_{j=H,N} P^j(t) \left(C^{K,j}(t) \nu^{K,j}(t) K(t) + C^{Z,j}(t) \nu^{Z,j}(t) Z(t)\right)$$
$$= r^\star N(t) + W(t)L(t) + R^K(t)K(t) \sum_{j=H,N} \alpha_K^j(t) u^{K,j} + R^Z(t)Z(t) \sum_{j=H,N} \alpha_Z^j(t) u^{Z,j} - \text{Tax}(t), \tag{97}$$

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:

$$J^K(t) = \left[\iota^{\frac{1}{\phi_K}} \left(J^{K,T}(t)\right)^{\frac{\phi_K - 1}{\phi_K}} + (1-\iota)^{\frac{1}{\phi_K}} \left(J^{K,N}(t)\right)^{\frac{\phi_K - 1}{\phi_K}}\right]^{\frac{\phi_K}{\phi_K - 1}}, \tag{98}$$

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, $J^{K,F}(t)$:

$$J^{K,T}(t) = \left[\left(\iota^H\right)^{\frac{1}{\rho_K}} \left(J^{K,H}(t)\right)^{\frac{\rho_K-1}{\rho_K}} + \left(1-\iota^H\right)^{\frac{1}{\rho_K}} \left(J^{K,F}(t)\right)^{\frac{\rho_K-1}{\rho_K}}\right]^{\frac{\rho_K}{\rho_K-1}}, \tag{99}$$

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:

$$J^K(t) = I^K(t) + \frac{\kappa}{2}\left(\frac{I^K(t)}{K(t)} - \delta_K\right)^2 K(t), \tag{100}$$

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

$$\frac{\partial J^K(t)}{\partial I^K(t)} = 1 + \kappa\left(\frac{I^K(t)}{K(t)} - \delta_K\right), \tag{101a}$$

$$\frac{\partial J^K(t)}{\partial K(t)} = -\frac{\kappa}{2}\left(\frac{I^K(t)}{K(t)} - \delta_K\right)\left(\frac{I^K(t)}{K(t)} + \delta_K\right). \tag{101b}$$

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:

$$\dot{K}(t) = I^K(t) - \delta_K K(t). \tag{102}$$

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:

$$P_J^K = \left[\iota\left(P_J^T\right)^{1-\phi_K} + (1-\iota)\left(P^N\right)^{1-\phi_K}\right]^{\frac{1}{1-\phi_K}}, \tag{103}$$

where the price index for traded goods is:

$$P_J^T = \left[\iota^H\left(P^H\right)^{1-\rho_K} + \left(1-\iota^H\right)\right]^{\frac{1}{1-\rho_K}}. \tag{104}$$

Given the investment-based price index (103), we can derive the demand for inputs of the traded good and the non-traded good:

$$J^{K,T} = \iota^H\left(\frac{P_J^T}{P_J^K}\right)^{-\phi_K} J^K, \tag{105a}$$

$$J^{K,N} = \left(1-\iota^H\right)\left(\frac{P^N}{P_J^K}\right)^{-\phi_K} J^K. \tag{105b}$$

Given the price indices (103) and (104), we can derive the demand for inputs of home-produced traded goods and foreign-produced traded goods:

$$J^{K,H} = \iota\left(\frac{P_J^T}{P_J^K}\right)^{-\phi_K} \iota^H\left(\frac{P^H}{P_J^T}\right)^{-\rho_K} J^K, \tag{106a}$$

$$J^{K,F} = \iota\left(\frac{P_J^T}{P_J^K}\right)^{-\phi_K} \left(1-\iota^H\right)\left(\frac{1}{P_J^T}\right)^{-\rho_K} J^K. \tag{106b}$$

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:

$$\hat{P}_J^K = \alpha_J^K \hat{P}_J^T + \left(1 - \alpha_J^K\right) \hat{P}^N, \tag{107a}$$

$$\hat{P}_J^T = \alpha_J^H \hat{P}^H, \tag{107b}$$

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:

$$\alpha_J^K = \iota \left(\frac{P_J^T}{P_J}\right)^{1-\phi_K}, \tag{108a}$$

$$1 - \alpha_J^K = (1-\iota) \left(\frac{P^N}{P_J}\right)^{1-\phi_K}, \tag{108b}$$

$$\alpha_J^H = \iota^H \left(\frac{P^H}{P_J^T}\right)^{1-\rho_K}, \tag{108c}$$

$$1 - \alpha_J^H = \left(1-\iota^H\right) \left(\frac{1}{P_J^T}\right)^{1-\rho_K}. \tag{108d}$$

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:

$$J^Z(t) = \left[\iota_Z^{\frac{1}{\phi_Z}} \left(J^{Z,H}(t)\right)^{\frac{\phi_Z-1}{\phi_Z}} + (1-\iota_Z)^{\frac{1}{\phi_Z}} \left(J^{Z,N}(t)\right)^{\frac{\phi_Z-1}{\phi_Z}}\right]^{\frac{\phi_Z}{\phi_Z-1}}, \tag{109}$$

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 (109) is:

$$P_J^Z = \left[\iota_Z \left(P^H\right)^{1-\phi_Z} + (1-\iota_Z) \left(P^N\right)^{1-\phi_Z}\right]^{\frac{1}{1-\phi_Z}}. \tag{110}$$

Given the knowledge investment-based price index (110), we can derive the demand for inputs of the traded good and the non-traded good:

$$J^{Z,H} = \iota_Z \left(\frac{P^H}{P_J^Z}\right)^{-\phi_Z} J^Z, \tag{111a}$$

$$J^{Z,N} = (1-\iota_Z) \left(\frac{P^N}{P_J^Z}\right)^{-\phi_Z} J^Z. \tag{111b}$$

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:

$$\hat{P}_J^Z = \alpha_J^Z \hat{P}^H + \left(1 - \alpha_J^Z\right) \hat{P}^N, \tag{112}$$

where

$$\alpha_J^Z = \frac{P^H J^{Z,H}}{P_J^Z J^Z} = \iota_Z \left(\frac{P^H}{P_J^Z}\right)^{1-\phi_Z}. \tag{113}$$

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

$$\dot{Z}(t) = I^Z(t) - \delta_Z Z(t), \tag{114}$$

where I^Z is investment in intangible assets and $0 \leq \delta_Z < 1$ is a fixed depreciation rate of ideas.e assume that accumulation of intangible assets is also subject to adjustment costs whose magnitude is governed by $\zeta > 0$:

$$J^Z(t) = I^Z(t) + \frac{\zeta}{2}\left(\frac{I^Z(t)}{Z(t)} - \delta_Z\right)^2 Z(t), \tag{115}$$

with partial derivatives

$$\frac{\partial J^Z(t)}{\partial I^Z(t)} = 1 + \zeta \left(\frac{I^Z(t)}{Z(t)} - \delta_Z \right), \tag{116a}$$

$$\frac{\partial J^Z(t)}{\partial Z(t)} = -\frac{\zeta}{2} \left(\frac{I^Z(t)}{Z(t)} - \delta_Z \right) \left(\frac{I^Z(t)}{Z(t)} + \delta_Z \right). \tag{116b}$$

First-order conditions. Households choose consumption, worked hours, capital and technology utilization rates, investment in tangible and intangible assets by maximizing lifetime utility (89) subject to (97), (102) and (114). Denoting the co-state variables associated with the flow budget constraint (97), the physical capital accumulation equation (102) (i.e., $\dot{K}(t) = I(t) - \delta_K K(t)$), and the accumulation equation of ideas (114) by λ, $Q^{K,\prime}$, and $Q^{Z,\prime}$ respectively, the first-order conditions characterizing the representative household's optimal plans are described by

$$\Lambda_C \left(C(t), S(t), L(t) \right) = \bar{\lambda} P_C(t), \tag{117a}$$

$$-\Lambda_L \left(C(t), S(t), L(t) \right) = \bar{\lambda} W(t), \tag{117b}$$

$$Q^K(t) = P_J^K(t) \left[1 + \kappa \left(\frac{I^K(t)}{K(t)} - \delta_K \right) \right], \tag{117c}$$

$$Q^Z(t) = P_J^Z(t) \left[1 + \zeta \left(\frac{I^Z(t)}{Z(t)} - \delta_Z \right) \right], \tag{117d}$$

$$\frac{R^{K,j}(t)}{P^j(t)} = \xi_1^j + \xi_2^j \left(u^{K,j}(t) - 1 \right), \quad j = H, N, \tag{117e}$$

$$\frac{R^{Z,j}(t)}{P^j(t)} = \chi_1^j + \chi_2^j \left(u^{Z,j}(t) - 1 \right), \quad j = H, N, \tag{117f}$$

$$\dot{\lambda}(t) = \lambda \left(\beta - r^\star \right), \tag{117g}$$

$$\dot{Q}^K(t) = \left(r^\star + \delta_K \right) Q^K(t) - \Big\{ \sum_{j=H,N} \alpha_K^j(t) u^{K,j}(t) R^K(t) - \sum_{j=H,N} P^j(t) C^{K,j}(t) \nu^{K,j}(t) - P_J^K(t) \frac{\partial J^K(t)}{\partial K(t)} \Big\}, \tag{117h}$$

$$\dot{Q}^Z(t) = \left(r^\star + \delta_Z \right) Q^Z(t) - \Big\{ \sum_{j=H,N} \alpha_Z^j(t) u^{Z,j}(t) R^Z(t) - \sum_{j=H,N} P^j(t) C^{Z,j}(t) \nu^{Z,j}(t) - P_J^Z(t) \frac{\partial J^Z(t)}{\partial Z(t)} \Big\}, \tag{117i}$$

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 $\lim_{t\to\infty} Q^Z(t) Z(t) e^{-\beta t} = 0$; to derive (117h) and (117i), 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 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:

$$1 - \alpha_C(t) = \frac{P^N(t) C^N(t)}{P_C(t) C(t)} = (1 - \varphi) \left(\frac{P^N(t)}{P_C(t)} \right)^{1-\phi}, \tag{118}$$

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 (118), 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

E.3 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:

$$Y^j = \left[\int_0^1 \left(X_i^j\right)^{\frac{\omega^j-1}{\omega^j}} \mathrm{d}i\right]^{\frac{\omega^j}{\omega^j-1}}, \tag{119}$$

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 of the final good producer reads (the subscript F refers to final good in this context):

$$\Pi_F^j = P^j \left[\int_0^1 \left(X_i^j\right)^{\frac{\omega^j-1}{\omega^j}} \mathrm{d}i\right]^{\frac{\omega^j}{\omega^j-1}} - \int_0^1 P_i^j X_i^j \mathrm{d}i. \tag{120}$$

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

$$X_i^j = \left(\frac{P_i^j}{P^j}\right)^{-\omega^j} Y^j, \tag{121}$$

and the price of final output is given by:

$$P^j = \left(\int_0^1 \left(P_i^j\right)^{1-\omega^j} \mathrm{d}i\right)^{\frac{1}{1-\omega^j}}, \tag{122}$$

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

$$-\frac{\partial X_i^j}{\partial P_i^j}\frac{P_i^j}{X_i^j} = \omega^j. \tag{123}$$

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:

$$X^j(t) = T^j(t) \left(L_i^j(t)\right)^{\theta^j} \left(\tilde{K}_i^j(t)\right)^{1-\theta^j}, \tag{124}$$

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 $Z^{W,j}(t)$:

$$\mathsf{Z}^j(t) = \left(\tilde{Z}_i^j(t)\right)^{\theta_Z^j} \left(Z^{W,j}(t)\right)^{1-\theta_Z^j}, \tag{125}$$

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:

$$T^j(t) = \left(\tilde{Z}_i^j(t)\right)^{\nu_Z^j \theta_Z^j} \left(Z^{W,j}(t)\right)^{\nu_Z^{W,j}\left(1-\theta_Z^j\right)}, \tag{126}$$

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:

$$\max_{L_i^j(t), \tilde{K}_i^j(t), \tilde{Z}_i^j(t)} \Pi_i^j(t) \tag{127}$$

where

$$\Pi_i^j(t) \equiv (1-\tau)\left[P_i^j(t)X_i^j(t) - W^j(t)L_i^j(t) - \delta_K \tilde{K}_i^j(t)\right] - \left(R^{K,j}(t) - \delta_K\right)\tilde{K}_i^j(t) - R^{Z,j}(t)\tilde{Z}_i^j(t) - P^j F^j, \tag{128}$$

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:

$$\mathcal{L}_i^j = \Pi_i^j(t) + \eta_i^j \left[X_i^j(t) - \left(P_i^j\right)^{-\omega^j} \left(P^j\right)^{\omega^j} Y^j\right]. \tag{129}$$

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:

$$\left[(1-\tau) P_i^j + \eta_i^j\right] \frac{\partial F^j(.)}{\partial L_i^j} = (1-\tau) W^j, \tag{130a}$$

$$\left[(1-\tau) P_i^j + \eta_i^j\right) \frac{\partial F^j(.)}{\partial \tilde{K}_i^j} = \left(R^{K,j} - \delta_K\right) + \delta_K (1-\tau), \tag{130b}$$

$$\left[(1-\tau) P_i^j + \eta_i^j\right] \frac{\partial F^j(.)}{\partial \tilde{Z}_i^j} = R^{Z,j}, \tag{130c}$$

$$(1-\tau) X_i^j = -\eta_i^j \omega^j \left(P_i^j\right)^{-\omega^j - 1} \left(P^j\right)^{\omega^j} Y^j, \tag{130d}$$

Using $X_i^j = \left(\frac{P_i^j}{P^j}\right)^{-\omega^j} Y^j$, eq. (130d) can be rewritten as follows:

$$\eta_i^j = -\frac{(1-\tau) P_i^j}{\omega^j}. \tag{131}$$

Denoting the markup charged by intermediate good producers by $\mu^j = \frac{\omega^j}{\omega^j - 1} > 1$, and inserting (131) into (130a)-(130c), first-order conditions can be rewritten as follows:

$$P_i^j \theta^j \frac{X_i^j}{L_i^j} = \mu^j W^j, \tag{132a}$$

$$P_i^j \left(1-\theta^j\right) \frac{X_i^j}{\tilde{K}_i^j} = \mu^j \left[\left(\frac{R^{K,j} - \delta_K}{1-\tau}\right) + \delta_K\right], \tag{132b}$$

$$(1-\tau) P_i^j \nu_Z^j \theta_Z^j \frac{X_i^j}{\tilde{Z}_i^j} = \mu^j R^{Z,j}, \tag{132c}$$

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 (132a)-(132c)

$$\frac{P_i^j}{\mu^j}\theta^j X_i^j = W^j L_i^j, \tag{133a}$$

$$\frac{P_i^j}{\mu^j}\left(1-\theta^j\right) X_i^j = \left[\left(\frac{R^{K,j}-\delta_K}{1-\tau}\right) + \delta_K\right]\tilde{K}_i^j, \tag{133b}$$

$$(1-\tau)\frac{P_i^j}{\mu^j}\nu_Z^j\theta_Z^j X_i^j = R^{Z,j}\tilde{Z}_i^j. \tag{133c}$$

Inserting (133a)-(133c) into profit leads to:

$$\begin{aligned}
& P_i^j X_i^j - (1-\tau) W^j L_i^j (1-\tau)\left[\frac{R^K-\delta_K}{1-\tau} + \delta_K\right]\tilde{K}_i^j - R^Z\tilde{Z}_i^j - P^j F^j = 0, \\
= \quad & P_i^j X_i^j - (1-\tau)\frac{P_i^j}{\mu^j}\theta^j X_i^j - (1-\tau)\frac{P_i^j}{\mu^j}\left(1-\theta^j\right)X_i^j - (1-\tau)\frac{P_i^j}{\mu^j}\nu_Z^j\theta_Z^j X_i^j - P^j F^j = 0, \\
& (1-\tau) P_i^j X_i^j\left[1 - \frac{\theta^j + \left(1-\theta^j\right) + \nu_Z^j\theta_Z^j}{\mu^j}\right] - P_i^j F^j = 0, \\
& (1-\tau) P_i^j X_i^j\left[1 - \frac{1+\nu_Z^j\theta_Z^j}{\mu^j}\right] - P_i^j F^j = 0.
\end{aligned} \tag{134}$$

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:

$$\mu^j > 1 + \nu^j\theta_Z^j, \tag{135}$$

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. (134) 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:

$$(1-\tau) P^j Y^j = (1-\tau) W^j L^j + \left(R^{K,j} - \tau\delta_K\right)\tilde{K}^j + R^{Z,j}\tilde{Z}^j + P^j F^j. \tag{136}$$

Output Net of Fixed Costs

We denote output net of fixed costs by $Q^j = Y^j - F^j$. By using the free entry condition (134), 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:

$$\begin{aligned}
Q^j &= Y^j - F^j, \\
&= Y^j\left[1 - (1-\tau)\left(1 - \frac{1+\nu_Z^j\theta_Z^j}{\mu^j}\right)\right].
\end{aligned} \tag{137}$$

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

$$\begin{aligned}
(1-\tau) P^j Y^j - P^j F^j &= (1-\tau)\left[W^j L^j + \delta_K \tilde{K}_i^j\right] + \left[R^{K,j} - \delta_K\right]\tilde{K}^j + R^{Z,j}\tilde{Z}^j, \\
P^j Y^j - P^j \frac{F^j}{1-\tau} &= W^j L^j + \left[\frac{R^{K,j}-\delta_K}{1-\tau} + \delta_K\right]\tilde{K}^j + \frac{R^{Z,j}\tilde{Z}^j}{1-\tau}.
\end{aligned} \tag{138}$$

Unit Cost for Producing

As shall be useful, we derive the unit cost for producing in sector j. Dividing the demand for labor (132a) by the demand for capital (132b), and next dividing the demand for demand for tangible assets (132b) by the demand for intangible assets (132c), and finally the demand for labor (132a) by the demand for intangible assets (132c), we get:

$$\frac{1-\theta^j}{\theta^j}\frac{L^j}{\tilde{K}^j} = \frac{R^{K,j}-\tau\delta_K}{W^j\left(1-\tau\right)}, \tag{139a}$$

$$\frac{1-\theta^j}{\nu_Z^j\theta_Z^j}\frac{\tilde{Z}^j}{\tilde{K}^j} = \frac{R^{K,j}-\tau\delta_K}{R^{Z,j}}, \tag{139b}$$

$$\frac{\nu_Z^j\theta_Z^j}{\theta^j}\frac{L^j}{\tilde{Z}^j} = \frac{R^{Z,j}}{W^j\left(1-\tau\right)}. \tag{139c}$$

Making use of eq. (139a) and (139b) to eliminate L^j and $\tilde{Z}^j$ from the Cobb-Douglas production function (124)-(125) and solving for $\tilde{K}^j$, and next making use of eq. (139a) and (139c) to eliminate $\tilde{K}^j$ and $\tilde{Z}^j$ from the Cobb-Douglas production function (124)-(125) and solving for L^j, and finally making use of eq. (139b) and (139c) to eliminate $\tilde{K}^j$ and L^j from the Cobb-Douglas production function (124)-(125) and solving for $\tilde{Z}^j$ leads to the conditional demand for capital stock, for labor, and for intangible assets:

$$\left(\tilde{K}^j\right)^{1+\nu_Z^j\theta_Z^j} = \frac{Y^j}{\left(Z^{W,j}\right)^{(1-\theta_Z^j)\nu_Z^{W,j}}}\left(\frac{1-\theta^j}{\theta^j}\right)^{\theta^j}\left(\frac{1-\theta^j}{\nu_Z^j\theta_Z^j}\right)^{\nu_Z^j\theta_Z^j}\frac{\left(R^{Z,j}\right)^{\nu_Z^j\theta_Z^j}\left(W^j\left(1-\tau\right)\right)^{\theta^j}}{\left(R^{K,j}-\tau\delta_K\right)^{\theta^j+\nu_Z^j\theta_Z^j}}, \tag{140a}$$

$$\left(L^j\right)^{1+\nu_Z^j\theta_Z^j} = \frac{Y^j}{\left(Z^{W,j}\right)^{(1-\theta_Z^j)\nu_Z^{W,j}}}\left(\frac{\theta^j}{1-\theta^j}\right)^{1-\theta^j}\left(\frac{\theta^j}{\nu_Z^j\theta_Z^j}\right)^{\nu_Z^j\theta_Z^j}\frac{\left(R^{Z,j}\right)^{\nu_Z^j\theta_Z^j}\left(R^{K,j}-\tau\delta_K\right)^{1-\theta^j}}{\left(W^j\left(1-\tau\right)\right)^{(1-\theta^j)+\nu_Z^j\theta_Z^j}}, \tag{140b}$$

$$\left(\tilde{Z}^j\right)^{1+\nu_Z^j\theta_Z^j} = \frac{Y^j}{\left(Z^{W,j}\right)^{(1-\theta_Z^j)\nu_Z^{W,j}}}\frac{\nu_Z^j\theta_Z^j}{\left(1-\theta^j\right)^{1-\theta^j}\left(\theta^j\right)^{\theta^j}}\frac{\left(W^j\left(1-\tau\right)\right)^{\theta^j}\left(R^{K,j}-\tau\delta_K\right)^{1-\theta^j}}{R^{Z,j}}. \tag{140c}$$

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

$$C^j = \left(1-\tau\right)W^jL^j + \left[R^{K,j}-\tau\delta_K\right]\tilde{K}^j + R^{Z,j}\tilde{Z}^j. \tag{141}$$

Inserting conditional demand for inputs (140a)-(140c) into total cost (141), we find that C^j is homogenous of a degree smaller than one with respect to value added due to the fact that the production function displays increasing returns to scale:

$$C^j = \left[\frac{Y^j}{\left(Z^{W,j}\right)^{(1-\theta_Z^j)\nu_Z^{W,j}}}\right]^{\frac{1}{1+\nu_Z^j\theta_Z^j}}\left(M^j\right)^{\frac{1}{1+\nu_Z^j\theta_Z^j}}\left(1+\nu_Z^j\theta_Z^j\right) \tag{142}$$

where we set

$$M^j = \left(\Psi^j\right)^{-1}\left(W^j\left(1-\tau\right)\right)^{\theta^j}\left(R^{K,j}-\tau\delta_K\right)^{1-\theta^j}\left(R^{Z,j}\right)^{\nu_Z^j\theta_Z^j}, \tag{143}$$

where

$$\Psi^j = \left(\theta^j\right)^{\theta^j}\left(1-\theta^j\right)^{1-\theta^j}\left(\nu_Z^j\theta_Z^j\right)^{\nu_Z^j\theta_Z^j}. \tag{144}$$

By using (138) and the definition of total costs (141)) which implies that $\left(1-\tau\right)P^jY^j - P^jF^j = C^j$ and by using the fact that $P^jY^j - P^j\frac{F^j}{1-\tau} = P^jY^j\left(\frac{1+\nu_Z^j\theta_Z^j}{\mu^j}\right)$ (see eq. (137)), 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

$$\begin{aligned} c^j &= \frac{C^j}{(1-\tau)\,Y^j\left(1+\nu_Z^j\theta_Z^j\right)}, \\ &= \left(Y^j\right)^{-\frac{\nu_Z^j\theta_Z^j}{1+\nu_Z^j\theta_Z^j}}\left[\frac{M^{j,\prime}}{\left(Z^{W,j}\right)^{(1-\theta_Z^j)\nu_Z^{W,j}}}\right]^{\frac{1}{1+\nu_Z^j\theta_Z^j}}, \end{aligned} \tag{145}$$

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

$$M^{j,\prime} = \left(\Psi^j\right)^{-1}\left(W^j\right)^{\theta^j}\left(\frac{R^{K,j}-\delta_K}{1-\tau}+\delta_K\right)^{1-\theta^j}\left(\frac{R^{Z,j}}{1-\tau}\right)^{\nu_Z^j\theta_Z^j}. \tag{146}$$

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

$$\frac{P^j}{\mu^j} = c^j. \tag{147}$$

E.4 Solving the Model

Consumption and Labor. Totally differentiating first-order conditions for consumption (117a) and labor (117b) leads to:

$$\frac{\Lambda_{CC}}{\Lambda_C}dC + \frac{\Lambda_{CL}}{\Lambda_C}dL = \frac{d\bar{\lambda}}{\bar{\lambda}} - \frac{\Lambda_{CS}}{\Lambda_C}dS + \frac{\alpha_C\alpha^H}{P^H}dP^H + \frac{1-\alpha_C}{P^N}dP^N, \tag{148a}$$

$$\frac{\Lambda_{LC}}{\Lambda_L}dC + \frac{\Lambda_{LL}}{\Lambda_L}dL = \frac{d\bar{\lambda}}{\bar{\lambda}} + \frac{dW}{W} - \frac{\Lambda_{LS}}{\Lambda_L}dS. \tag{148b}$$

Eqs. (148a)-(148b) can be solved for consumption and hours:

$$C = C\left(\bar{\lambda}, S, P^H, P^N, W\right), \qquad L = L\left(\bar{\lambda}, S, P^H, P^N, W\right) \tag{149}$$

Note that plugging $\frac{X^{-\sigma}}{P_C} = \bar{\lambda}$ into eq. (117b) 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 (149) into (71b), (72a)-(72b), allows us to solve for C^g (with $g = H, N, F$)

$$C^g = C^g\left(\bar{\lambda}, P^N, P^H, W^H, W^N, S\right), \tag{150}$$

where we used the fact that

$$\hat{C}^N = -\phi\alpha_C\hat{P}^N + \phi\alpha_C\alpha^H\hat{P}^H + \hat{C}, \tag{151a}$$

$$\hat{C}^H = -\left[\rho\left(1-\alpha^H\right) + \phi\left(1-\alpha_C\right)\alpha^H\right]\hat{P}^H + \left(1-\alpha_C\right)\phi\hat{P}^N + \hat{C}, \tag{151b}$$

$$\hat{C}^F = \alpha^H\left[\rho - \phi\left(1-\alpha_C\right)\right]\hat{P}^H + \left(1-\alpha_C\right)\phi\hat{P}^N + \hat{C}. \tag{151c}$$

Labor supply to sector $j = H, N$. Inserting first the solution for labor (149) into (77) allows us to solve for L^j (with $j = H, N$):

$$L^j = L^j\left(\bar{\lambda}, P^N, P^H, W^H, W^N, S\right), \tag{152}$$

with partial derivatives given by:

$$\hat{L}^H = \epsilon_L\left(1-\alpha_L\right)\hat{W}^H - \left(1-\alpha_L\right)\epsilon_L\hat{W}^N + \hat{L}, \tag{153a}$$

$$\hat{L}^N = \epsilon_L\alpha_L\hat{W}^N - \alpha_L\epsilon_L\hat{W}^H + \hat{L}. \tag{153b}$$

Capital supply to sector $j = H, N$. The decision to allocate capital between to the traded and the non-traded sectors (82) allows us to solve for K^H and K^N:

$$K^j = K^j\left(K, R^{K,H}, R^{K,N}\right), \tag{154}$$

with partial derivatives given by:

$$\begin{aligned}\hat{K}^H &= \epsilon_K\left(1-\alpha_K\right)\hat{R}^{K,H} - \left(1-\alpha_K\right)\epsilon_K\hat{R}^{K,N} + \hat{K}, &(155a)\\ \hat{K}^N &= \epsilon_K\alpha_K\hat{R}^{K,N} - \alpha_K\epsilon_K\hat{R}^{K,H} + \hat{K}. &(155b)\end{aligned}$$

Supply of ideas to sector $j = H, N$. The decision to allocate intangible assets between the traded and the non-traded sectors (86) allows us to solve for Z^H and Z^N:

$$Z^j = Z^j\left(Z, R^{Z,H}, R^{Z,N}\right), \tag{156}$$

with partial derivatives given by:

$$\begin{aligned}\hat{Z}^H &= \epsilon_Z\left(1-\alpha_Z\right)\hat{R}^{Z,H} - \left(1-\alpha_Z\right)\epsilon_Z\hat{R}^{Z,N} + \hat{Z}, &(157a)\\ \hat{Z}^N &= \epsilon_Z\alpha_Z\hat{R}^{Z,N} - \alpha_Z\epsilon_Z\hat{R}^{Z,H} + \hat{Z}. &(157b)\end{aligned}$$

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

$$\frac{P^j}{\mu^j}\theta^j\left(u^{Z,j}Z^j\right)^{\nu_Z^j\theta_Z^j}\left(Z^{W,j}\right)^{\nu_Z^{W,j}\left(1-\theta_Z^j\right)}\left(L^j\right)^{\theta^j-1}\left(u^{K,j}K^j\right)^{1-\theta^j} = W^j, \tag{158a}$$

$$\frac{P^j}{\mu^j}\left(1-\theta^j\right)\left(u^{Z,j}Z^j\right)^{\nu_Z^j\theta_Z^j}\left(Z^{W,j}\right)^{\nu_Z^{W,j}\left(1-\theta_Z^j\right)}\left(L^j\right)^{\theta^j}\left(u^{K,j}K^j\right)^{-\theta^j} = \left[\left(\frac{R^{K,j}-\delta_K}{1-\tau}\right)+\delta_K\right], \tag{158b}$$

$$\left(1-\tau\right)\frac{P^j}{\mu^j}\nu_Z^j\theta_Z^j\left(u^{Z,j}Z^j\right)^{\left(\nu_Z^j\theta_Z^j-1\right)}\left(Z^{W,j}\right)^{\nu_Z^{W,j}\left(1-\theta_Z^j\right)}\left(L^j\right)^{\theta^j}\left(u^{K,j}K^j\right)^{1-\theta^j} = R^{Z,j}. \tag{158c}$$

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

$$\begin{aligned}&-\left[\left(1-\theta^j\right)\hat{L}^j + \hat{W}^j\right] + \left(1-\theta^j\right)\left(\hat{u}^{K,j}+\hat{K}^j\right) + \nu_Z^j\theta_Z^j\left(\hat{u}^{Z,j}+\hat{Z}^j\right)\\ &\qquad = -\hat{P}^j - \nu_Z^{W,j}\left(1-\theta_Z^j\right)\hat{Z}^{W,j}, &(159a)\\ &\theta^j\hat{L}^j - \left[\theta^j\left(\hat{u}^{K,j}+\hat{K}^j\right)+\hat{R}^{K,j}\right] + \nu_Z^j\theta_Z^j\left(\hat{u}^{Z,j}+\hat{Z}^j\right) = \frac{R^{K,j}-\delta_K}{\left(1-\tau\right)\left(R^{K,j}-\tau\delta_K\right)}d\tau\\ &\qquad -\hat{P}^j - \nu_Z^{W,j}\left(1-\theta_Z^j\right)\hat{Z}^{W,j}, &(159b)\\ &\theta^j\hat{L}^j + \left(1-\theta^j\right)\left(\hat{u}^{K,j}+\hat{K}^j\right) - \left[\left(1-\nu_Z^j\theta_Z^j\right)\left(\hat{u}^{Z,j}+\hat{Z}^j\right)+\hat{R}^{Z,j}\right] = \frac{d\tau}{1-\tau} - \hat{P}^j\\ &\qquad -\nu_Z^{W,j}\left(1-\theta_Z^j\right)\hat{Z}^{W,j}, &(159c)\end{aligned}$$

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 (159b).

Inserting intermediate solutions for L^j, K^j, Z^j described by (152), (154), (156), respectively, and invoking the theorem of implicit functions leads to:

$$W^j, R^{K,j}, R^{Z,j}\left(P^j, K, Z, u^{K,j}, u^{Z,j}, \tau, Z^{W,j}\right). \tag{160}$$

Plugging back (160) into (152), (154), (156) leads to solutions for L^j, K^j, Z^j; inserting these solutions into the production function (124)-(125) allows us to solve for Y^j; thus intermediate solutions read:

$$L^j, K^j, Z^j, Y^j\left(P^j, K, Z, u^{K,j}, u^{Z,j}, \tau, Z^{W,j}\right). \tag{161}$$

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

Inserting first the marginal revenue product of capital (158b) into the optimal decision for the capital utilization rate

$$\begin{aligned}\frac{R^{K,j}(t)}{P^j(t)} &= \xi_1^j + \xi_2^j\left(u^{K,j}(t)-1\right),\\ &= \frac{\delta_K\tau}{P^j(t)} + \frac{(1-\tau)}{\mu^j}\left(1-\theta^j\right)\left(u^{Z,j}(t)Z^j(t)\right)^{\nu_Z^j\theta_Z^j}\left(Z^{W,j}(t)\right)^{\nu_Z^{W,j}\left(1-\theta_Z^j\right)}\left(L^j(t)\right)^{\theta^j}\\ &\times \left(u^{K,j}(t)K^j(t)\right)^{-\theta^j}. \end{aligned} \tag{162}$$

Inserting first the marginal revenue product of ideas (158c) into the optimal decision for the technology utilization rate

$$\begin{aligned}\frac{R^{Z,j}(t)}{P^j(t)} &= \chi_1^j + \chi_2^j\left(u^{Z,j}(t)-1\right),\\ &= \frac{(1-\tau)}{\mu^j}\nu_Z^j\theta_Z^j\left(u^{Z,j}(t)Z^j(t)\right)^{\left(\nu_Z^j\theta_Z^j-1\right)}\left(Z^{W,j}(t)\right)^{\nu_Z^{W,j}\left(1-\theta_Z^j\right)}\left(L^j(t)\right)^{\theta^j}\left(u^{K,j}(t)K^j(t)\right)^{1-\theta^j}. \end{aligned} \tag{163}$$

Totally differentiating (162) leads to:

$$\begin{aligned}&\left[\frac{\xi_2^j}{\xi_1^j-\frac{\delta_K\tau}{P^j}}+\theta^j\right]\hat{u}^{K,j}-\theta^j\hat{L}^j+\theta^j\hat{K}^j-\nu_Z^j\theta_Z^j\left(\hat{u}^{Z,j}+\hat{Z}^j\right)\\ &= \frac{R^{K,j}-\delta_K}{(1-\tau)\left(R^{K,j}-\tau\delta_K\right)}d\tau+\nu_Z^{W,j}\left(1-\theta_Z^j\right)\hat{Z}^W, \end{aligned} \tag{164}$$

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 (163) leads to:

$$\begin{aligned}&\left[\frac{\chi_2^j}{\chi_1^j}+\left(1-\nu_Z^j\theta_Z^j\right)\right]\hat{u}^{Z,j}-\theta^j\hat{L}^j-\left(1-\theta^j\right)\left(\hat{u}^{K,j}+\hat{K}^j\right)+\left(1-\nu_Z^j\theta_Z^j\right)\hat{Z}^j\\ &= -\frac{d\tau}{(1-\tau)}+\nu_Z^{W,j}\left(1-\theta_Z^j\right)\hat{Z}^W. \end{aligned} \tag{165}$$

Inserting (160)-(161) into (164) and (165) and invoking the implicit function theorem leads to:

$$u^{K,j}, u^{Z,j}\left(P^j, K, Z, Z^{W,j}, \tau\right). \tag{166}$$

Plugging (166) into (160) and (161) leads to

$$W^j, R^{K,j}, R^{Z,j}, L^j, K^j, Y^j\left(P^j, K, Z, Z^{W,j}, \tau\right). \tag{167}$$

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

Eq. (117c) can be solved for the investment rate:

$$\frac{I^K}{K} = v^K\left(\frac{Q^K}{P_J^K\left(P^H, P^N\right)}\right)+\delta_K, \tag{168}$$

where

$$v^K(.) = \frac{1}{\kappa}\left(\frac{Q^K}{P_J^K}-1\right), \tag{169}$$

with

$$v_{Q^K}^K = \frac{\partial v^K(.)}{\partial Q^K} = \frac{1}{\kappa}\frac{1}{P_J^K} > 0, \tag{170a}$$

$$v_{P^H}^K = \frac{\partial v^K(.)}{\partial P^H} = -\frac{1}{\kappa}\frac{Q^K}{P_J^K}\frac{\alpha_J\alpha_J^H}{P^H} < 0, \tag{170b}$$

$$v_{P^N} = \frac{\partial v^K(.)}{\partial P^N} = -\frac{1}{\kappa}\frac{Q^K}{P_J^K}\frac{(1-\alpha_J)}{P^N} < 0. \tag{170c}$$

Inserting (168) into (117c), investment including capital installation costs can be rewritten as follows:

$$\begin{aligned} J^K &= K\left[\frac{I^K}{K}+\frac{\kappa}{2}\left(\frac{I^K}{K}-\delta_K\right)^2\right], \\ &= K\left[v^K(.)+\delta_K+\frac{\kappa}{2}\left(v^K(.)\right)^2\right]. \end{aligned} \tag{171}$$

Eq. (171) can be solved for investment including capital installation costs:

$$J^K = J^K\left(K, Q^K, P^N, P^H\right), \tag{172}$$

where

$$J_K = \frac{\partial J^K}{\partial K} = \frac{J}{K}, \tag{173a}$$

$$J^K_X = \frac{\partial J^K}{\partial X} = \kappa v_X\left(1+\kappa v^K(.)\right) > 0, \tag{173b}$$

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

Substituting (172) into (105b), (106a), and (106b) allows us to solve for the demand of non-traded, home-produced traded, and foreign inputs:

$$J^{K,g} = J^{K,g}\left(K, Q^K, P^N, P^H\right), \quad g = F, H, N, \tag{174}$$

with partial derivatives given by

$$\hat{J}^{K,N} = -\alpha_J\phi_J\hat{P}^N + \phi_J\alpha_J\alpha_J^H\hat{P}^H + \hat{J}^K, \tag{175a}$$

$$\hat{J}^{K,H} = -\left[\rho_K\left(1-\alpha_J^H\right)+\alpha_J^H\phi_J\left(1-\alpha_J\right)\right]\hat{P}^H + \phi_J\left(1-\alpha_J\right)\hat{P}^N + \hat{J}^K, \tag{175b}$$

$$\hat{J}^{K,F} = \alpha_J^H\left[\rho_K-\phi_J\left(1-\alpha_J\right)\right]\hat{P}^H + \phi_J\left(1-\alpha_J\right)\hat{P}^N + \hat{J}^K, \tag{175c}$$

where

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

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

From eq. (117d), we have $\frac{I^Z(t)}{Z(t)}$ which is a positive function of $\frac{1}{\zeta}\left(\frac{Q^Z(t)}{P_J^Z(t)}-1\right)+\delta_Z$. Setting

$$v^Z(.) = \frac{1}{\zeta}\left(\frac{Q^Z}{P^Z_J}-1\right) \tag{176}$$

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

$$J^Z = J^Z\left(Z, Q^Z, P^N, P^H\right). \tag{177}$$

Inserting first (177) into (111a)-(111b), we can solve for investment in traded and non-traded R&D:

$$J^{Z,H}, J^{Z,N}\left(Z, Q^Z, P^N, P^H\right). \tag{178}$$

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

$$Q^H = C^H + G^H + J^{K,H} + J^{Z,H} + X^H + C^{K,H}K^H + C^{Z,H}Z^H, \tag{179a}$$

$$Q^N = C^N + G^N + J^{K,N} + J^{Z,N} + C^{K,N}K^N + C^{Z,N}Z^N. \tag{179b}$$

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

$$P^H, P^N\left(K, Q^K, Z, Q^Z, Z^{W,j}, \tau\right). \tag{180}$$

Plugging back these solutions (180) into (166), (167) leads to:

$$u^{K,j}, W^j, R^{K,j}, R^{Z,j}, L^j, K^j, Y^j\left(K, Q^K, Z, Q^Z, Z^{W,j}, \tau, S\right). \tag{181}$$

Inserting solutions for sectoral prices (180) into intermediate solutions for investment in tangible (174) and intangible assets (178) and consumption (150) in goods $g = H, N, F$, leads to:

$$C^g, J^{K,g}, J^{Z,g}\left(K, Q^K, Z, Q^Z, Z^{W,j}, \tau, S\right), \qquad g = H, N, F. \tag{182}$$

E.5 Dynamics

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

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

$$-\delta_K K(t) - \frac{\kappa}{2}\left(\frac{I(t)}{K(t)} - \delta_K\right)^2 K(t), \tag{183a}$$

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

$$-\sum_{j=H,N} P^j(t)C^{K,j}(t)\nu^{K,j}(t) - P_J(t)\frac{\partial J(t)}{\partial K(t)}\Bigg\}, \tag{183b}$$

$$\dot{Z}(t) = v^Z\left(K(t), Q^K(t), Z(t), Q^Z(t), \tau(t), Z^{W,j}(t)\right)Z(t), \tag{183c}$$

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

$$-\sum_{j=H,N} P^j(t)C^{K,j}(t)\nu^{K,j}(t) - P^Z_J(t)\frac{\partial J^Z(t)}{\partial Z(t)}\Bigg], \tag{183d}$$

$$\dot{S}(t) = \delta_S\left(C(t) - S(t)\right), \tag{183e}$$

$$d\tau(t) = x_T e^{-\xi_T t}, \tag{183f}$$

$$dZ^{W,j}(t) = x^j_Z e^{-\xi^j_Z t}, \quad j = H, N, \tag{183g}$$

where we have used the fact that $v^Z = \frac{I^Z}{Z} - \delta_Z$ with $v^Z\left(Q^Z(t), P^N(t), P^H(t)\right)$, x_T, x^j_Z, ξ_T, ξ^j_Z 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:

$$\dot{K}(t) = \Upsilon\left(K(t), Q^K(t), Z(t), Q^Z(t), S(t), \tau(t), Z^{W,j}(t)\right), \tag{184a}$$

$$\dot{Q}^K(t) = \Sigma\left(K(t), Q^K(t), Z(t), Q^Z(t), S(t), \tau(t), Z^{W,j}(t)\right), \tag{184b}$$

$$\dot{Z}(t) = \Pi\left(K(t), Q^K(t), Z(t), Q^Z(t), S(t), \tau(t), Z^{W,j}(t)\right), \tag{184c}$$

$$\dot{Q}^Z(t) = \Gamma\left(K(t), Q^K(t), Z(t), Q^Z(t), S(t), \tau(t), Z^{W,j}(t)\right), \tag{184d}$$

$$\dot{S}(t) = \Theta\left(K(t), Q^K(t), Z(t), Q^Z(t), S(t), \tau(t), Z^{W,j}(t)\right), \tag{184e}$$

$$\dot{\tau}(t) = -\xi_T\left(\tau(t) - \tau\right), \tag{184f}$$

$$\dot{Z}^{W,H}(t) = -\xi^H_Z\left(Z^{W,H}(t) - Z^{W,H}\right), \tag{184g}$$

$$\dot{Z}^{W,N}(t) = -\xi^N_Z\left(Z^{W,N}(t) - Z^{W,N}\right). \tag{184h}$$

We linearize (184a)-(184h) around the steady-state:

$$\begin{pmatrix} \dot{K}(t) \\ \dot{Q}^K(t) \\ \dot{Z}(t) \\ \dot{Q}^Z(t) \\ \dot{S}(t) \\ \dot{\tau}(t) \\ \dot{Z}^{W,j}(t) \end{pmatrix} = \begin{pmatrix} \Upsilon_K & \Upsilon_{Q^K} & \Upsilon_Z & \Upsilon_{Q^Z} & \Upsilon_S & \Upsilon_\tau & \Upsilon_{Z^{W,j}} \\ \Sigma_K & \Sigma_{Q^K} & \Sigma_Z & \Sigma_{Q^Z} & \Sigma_S & \Sigma_\tau & \Sigma_{Z^{W,j}} \\ \Pi_K & \Pi_{Q^K} & \Pi_Z & \Pi_{Q^Z} & \Pi_S & \Pi_\tau & \Pi_{Z^{W,j}} \\ \Gamma_K & \Gamma_{Q^K} & \Gamma_Z & \Gamma_{Q^Z} & \Gamma_S & \Gamma_\tau & \Gamma_{Z^{W,j}} \\ \Theta_K & \Theta_{Q^K} & \Theta_Z & \Theta_{Q^Z} & \Theta_S & \Theta_\tau & \Theta_{Z^{W,j}} \\ 0 & 0 & 0 & 0 & 0 & -\xi_T & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & -\xi_Z^j \end{pmatrix} \begin{pmatrix} dK(t) \\ dQ^K(t) \\ dZ(t) \\ dQ^Z(t) \\ dS(t) \\ d\tau(t) \\ dZ^{W,j}(t) \end{pmatrix}. \quad (185)$$

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

$$dK(t) = D_1 e^{\nu_1 t} + D_2 e^{\nu_2 t} + D_3 e^{\nu_3 t} + \omega_1^6 D_6 e^{\nu_6 t} + \omega_1^7 D_7 e^{\nu_7 t}, \quad (186a)$$

$$dQ^K(t) = \omega_2^1 D_1 e^{\nu_1 t} + \omega_2^2 D_2 e^{\nu_2 t} + \omega_2^3 D_3 e^{\nu_3 t} + \omega_2^6 D_6 e^{\nu_6 t} + \omega_2^7 D_7 e^{\nu_7 t}, \quad (186b)$$

$$dZ(t) = \omega_3^1 D_1 e^{\nu_1 t} + \omega_3^2 D_2 e^{\nu_2 t} + \omega_3^3 D_3 e^{\nu_3 t} + \omega_3^6 D_6 e^{\nu_6 t} + \omega_3^7 D_7 e^{\nu_7 t}, \quad (186c)$$

$$dQ^Z(t) = \omega_4^1 D_1 e^{\nu_1 t} + \omega_4^2 D_2 e^{\nu_2 t} + \omega_4^3 D_3 e^{\nu_3 t} + \omega_4^6 D_6 e^{\nu_6 t} + \omega_4^7 D_7 e^{\nu_7 t}, \quad (186d)$$

$$dS(t) = \omega_5^1 D_1 e^{\nu_1 t} + \omega_5^2 D_2 e^{\nu_2 t} + \omega_5^3 D_3 e^{\nu_3 t} + \omega_5^6 D_6 e^{\nu_6 t} + \omega_5^7 D_7 e^{\nu_7 t}, \quad (186e)$$

$$d\tau(t) = D_6 e^{\nu_6 t}, \quad (186f)$$

$$dZ^{W,j}(t) = D_7 e^{\nu_7 t}, \quad (186g)$$

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, (186a), the stock of knowledge, (186c), and the stock of consumption habits, (186e), i.e., $\Psi_1 = K_0 - K - \omega_1^6 D_6 - \omega_1^7 D_7 = D_1 + D_2 + D_3$, $\Psi_2 = Z_0 - Z - \omega_3^6 D_6 - \omega_3^7 D_7 = \omega_3^1 D_1 + \omega_3^2 D_2 + \omega_3^3 D_3$, $\Psi_3 = S_0 - S - \omega_5^6 D_6 - \omega_5^7 D_7 = \omega_5^1 D_1 + \omega_5^2 D_2 + \omega_5^3 D_3$, and solving for arbitrary constants:

$$\begin{pmatrix} 1 & 1 & 1 \\ \omega_3^1 & \omega_3^2 & \omega_3^3 \\ \omega_5^1 & \omega_5^2 & \omega_5^3 \end{pmatrix} \begin{pmatrix} D_1 \\ D_2 \\ D_3 \end{pmatrix} = \begin{pmatrix} \Psi_1 \\ \Psi_2 \\ \Psi_3 \end{pmatrix}, \quad (187)$$

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

To find eigenvectors ω_k^6, we solve

$$\begin{pmatrix} \Upsilon_K - \nu_6 & \Upsilon_{Q^K} & \Upsilon_Z & \Upsilon_{Q^Z} & \Upsilon_S \\ \Sigma_K & \Sigma_{Q^K} - \nu_6 & \Sigma_Z & \Sigma_{Q^Z} & \Sigma_S \\ \Pi_K & \Pi_{Q^K} & \Pi_Z - \nu_6 & \Pi_{Q^Z} & \Pi_S \\ \Gamma_K & \Gamma_{Q^K} & \Gamma_Z & \Gamma_{Q^Z} - \nu_6 & \Gamma_S \\ \Theta_K & \Theta_{Q^K} & \Theta_Z & \Theta_{Q^Z} & \Theta_S - \nu_6 \end{pmatrix} \begin{pmatrix} \omega_1^6 \\ \omega_2^6 \\ \omega_3^6 \\ \omega_4^6 \\ \omega_5^6 \end{pmatrix} = \begin{pmatrix} -\Upsilon_\tau \\ -\Sigma_\tau \\ -\Pi_\tau \\ -\Gamma_\tau \\ -\Theta_\tau \end{pmatrix} \quad (188)$$

and to find eigenvectors ω_k^7, we solve:

$$\begin{pmatrix} \Upsilon_K - \nu_7 & \Upsilon_{Q^K} & \Upsilon_Z & \Upsilon_{Q^Z} & \Upsilon_S \\ \Sigma_K & \Sigma_{Q^K} - \nu_7 & \Sigma_Z & \Sigma_{Q^Z} & \Sigma_S \\ \Pi_K & \Pi_{Q^K} & \Pi_Z - \nu_7 & \Pi_{Q^Z} & \Pi_S \\ \Gamma_K & \Gamma_{Q^K} & \Gamma_Z & \Gamma_{Q^Z} - \nu_7 & \Gamma_S \\ \Theta_K & \Theta_{Q^K} & \Theta_Z & \Theta_{Q^Z} & \Theta_S - \nu_7 \end{pmatrix} \begin{pmatrix} \omega_1^7 \\ \omega_2^7 \\ \omega_3^7 \\ \omega_4^7 \\ \omega_5^7 \end{pmatrix} = \begin{pmatrix} -\Upsilon_{Z^{W,j}} \\ -\Sigma_{Z^{W,j}} \\ -\Pi_{Z^{W,j}} \\ -\Gamma_{Z^{W,j}} \\ -\Theta_{Z^{W,j}} \end{pmatrix} \quad (189)$$

E.6 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:

$$R^{K,j,\prime} = \frac{R^{K,j} - \delta_K}{1-\tau} + \delta_K, \tag{190a}$$

$$R^{Z,j,\prime} = \frac{R^{Z,j}}{1-\tau}. \tag{190b}$$

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

$$P_C C = P^H C^H + C^F + P^N C^N, \tag{191a}$$

$$P_J^K J^K = P^H J^{K,H} + J^{K,F} + P^N J^{K,N}, \tag{191b}$$

$$P_J^Z J^Z = P^H J^{Z,H} + P^N J^{Z,N}, \tag{191c}$$

$$T = G = P^H G^H + G^F + P^N G^N, \tag{191d}$$

$$P^j Y^j \left(\frac{1+\nu_Z^j \theta_Z^j}{\mu^j}\right) = \left(W^j L^j + R^{K,j,\prime}\tilde{K}^j + R^{Z,j,\prime}\tilde{Z}^j\right). \tag{191e}$$

where (191e) follows from Euler theorem and free entry condition which implies

$$\frac{P^j F^j}{1-\tau} = P^j Y^j \left[1 - \frac{1+\nu_Z^j \theta_Z^j}{\mu^j}\right], \tag{192a}$$

$$Q^j \equiv Y^j - F^j = P^j Y^j \left(\frac{1+\nu_Z^j \theta_Z^j}{\mu^j}\right) = W^j L^j + R^{K,j,\prime}\tilde{K}^j + R^{Z,j,\prime}\tilde{Z}^j. \tag{192b}$$

Using (191e), inserting (191a)-(191c) into (97) and invoking market clearing conditions for non-traded goods (179b) and home-produced traded goods (179a) yields:

$$\begin{aligned} \dot{N} &= r^\star N + P^H \left(Y^H - C^H - G^H - J^{K,H} - J^{Z,H} - C^{K,H}K^H - C^{Z,H}Z^H\right) - \left(C^F + J^{K,F} + G^F\right), \\ &= r^\star N + P^H X^H - M^F, \end{aligned} \tag{193}$$

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:

$$M^F = C^F + G^F + J^{K,F}. \tag{194}$$

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 (193), inserting solutions (186a)-(186g), integrating over $(0,t)$, solving, invoking the transversality condition leads to the stable convergent path for the stock of net foreign assets:

$$dN(t) = \frac{E_1 D_1}{\nu_1 - r^\star} e^{\nu_1 t} + \frac{E_2 D_2}{\nu_2 - r^\star} e^{\nu_2 t} + \frac{E_3 D_3}{\nu_3 - r^\star} e^{\nu_3 t} + \frac{E_6 D_6}{\nu_6 - r^\star} e^{\nu_6 t} + \frac{E_7 D_7}{\nu_7 - r^\star} e^{\nu_7 t}, \tag{195}$$

and the intertemporal solvency condition

$$dN + \frac{E_1 D_1}{\nu_1 - r^\star} + \frac{E_2 D_2}{\nu_2 - r^\star} + \frac{E_3 D_3}{\nu_3 - r^\star} + \frac{E_6 D_6}{\nu_6 - r^\star} + \frac{E_7 D_7}{\nu_7 - r^\star}, \tag{196}$$

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

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:

$$d\tau(t) = d\tau + x_T e^{-\xi_T t}, \tag{197}$$

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

$$\dot{\tau}(t) = -\xi_T d\tau(t), \tag{198}$$

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:

$$dZ^{W,j}(t) = dZ^{W,j} + x_Z e^{-\xi_Z^j t} \tag{199}$$

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; ξ_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 (199) 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):

$$\hat{Z}^W(t) = \hat{Z}^{W,j} + x_Z^j e^{-\xi_Z^j t}, \tag{200}$$

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

$$\dot{Z}^{W,j}(t) = -\xi_Z^j dZ^{W,j}(t), \tag{201}$$

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 $K(t)$, $Q(t)$, $Z(t)$, $Q^Z(t)$, $S(t)$

The adjustment of the open economy towards the steady-state is described by a dynamic system which comprises seven equations. Linearizing (184a)-(184g), the linearized system can be written in a matrix form:

$$\begin{pmatrix} \dot{K}(t) \\ \dot{Q}^K(t) \\ \dot{Z}(t) \\ \dot{Q}^Z(t) \\ \dot{S}(t) \\ \dot{\tau}(t) \\ \dot{Z}^{W,j}(t) \end{pmatrix} = \begin{pmatrix} \Upsilon_K & \Upsilon_{Q^K} & \Upsilon_Z & \Upsilon_{Q^Z} & \Upsilon_S & \Upsilon_\tau & \Upsilon_{Z^{W,j}} \\ \Sigma_K & \Sigma_{Q^K} & \Sigma_Z & \Sigma_{Q^Z} & \Sigma_Z & \Sigma_\tau & \Sigma_{Z^{W,j}} \\ \Pi_K & \Pi_{Q^K} & \Pi_Z & \Pi_{Q^Z} & \Pi_S & \Pi_\tau & \Pi_{Z^{W,j}} \\ \Gamma_K & \Gamma_{Q^K} & \Gamma_Z & \Gamma_{Q^Z} & \Gamma_S & \Gamma_\tau & \Gamma_{Z^{W,j}} \\ \Theta_K & \Theta_{Q^K} & \Theta_Z & \Theta_{Q^Z} & \Theta_S & \Theta_\tau & \Theta_{Z^{W,j}} \\ 0 & 0 & 0 & 0 & 0 & -\xi_T & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & -\xi_Z^j \end{pmatrix} \begin{pmatrix} dK(t) \\ dQ^K(t) \\ dZ(t) \\ dQ^Z(t) \\ dS(t) \\ d\tau(t) \\ dZ^{W,j}(t) \end{pmatrix}. \tag{202}$$

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

$$dK(t) = D_1 e^{\nu_1 t} + D_2 e^{\nu_2 t} + D_3 e^{\nu_3 t} + \omega_1^6 D_6 e^{\nu_6 t} + \omega_1^7 D_7 e^{\nu_7 t}, \tag{203a}$$

$$dQ^K(t) = \omega_2^1 D_1 e^{\nu_1 t} + \omega_2^2 D_2 e^{\nu_2 t} + \omega_2^3 D_3 e^{\nu_3 t} + \omega_2^6 D_6 e^{\nu_6 t} + \omega_2^7 D_7 e^{\nu_7 t}, \tag{203b}$$

$$dZ(t) = \omega_3^1 D_1 e^{\nu_1 t} + \omega_3^2 D_2 e^{\nu_2 t} + \omega_3^3 D_3 e^{\nu_3 t} + \omega_3^6 D_6 e^{\nu_6 t} + \omega_3^7 D_7 e^{\nu_7 t}, \tag{203c}$$

$$dQ^Z(t) = \omega_4^1 D_1 e^{\nu_1 t} + \omega_4^2 D_2 e^{\nu_2 t} + \omega_4^3 D_3 e^{\nu_3 t} + \omega_4^6 D_6 e^{\nu_6 t} + \omega_4^7 D_7 e^{\nu_7 t}, \tag{203d}$$

$$dS(t) = \omega_5^1 D_1 e^{\nu_1 t} + \omega_5^2 D_2 e^{\nu_2 t} + \omega_5^3 D_3 e^{\nu_3 t} + \omega_5^6 D_6 e^{\nu_6 t} + \omega_5^7 D_7 e^{\nu_7 t}, \tag{203e}$$

$$d\tau(t) = D_6 e^{\nu_6 t}, \tag{203f}$$

$$dZ^{W,j}(t) = D_7 e^{\nu_7 t}, \tag{203g}$$

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., $K_0 - K - \omega_1^6 D_6 - \omega_1^7 D_7 = D_1 + D_2 + D_3$, $Z_0 - Z - \omega_3^6 D_6 - \omega_3^7 D_7 = \omega_3^1 D_1 + \omega_3^2 D_2 + \omega_3^3 D_3$, $S_0 - S - \omega_5^6 D_6 - \omega_5^7 D_7 = \omega_5^1 D_1 + \omega_5^2 D_2 + \omega_5^3 D_3$ which can be rewritten in a matrix form:

$$\begin{pmatrix} 1 & 1 & 1 \\ \omega_3^1 & \omega_3^2 & \omega_3^3 \\ \omega_5^1 & \omega_5^2 & \omega_5^3 \end{pmatrix} \begin{pmatrix} D_1 \\ D_2 \\ D_3 \end{pmatrix} = \begin{pmatrix} K_0 - K - \omega_1^6 D_6 - \omega_1^7 D_7 \\ Z_0 - Z - \omega_3^6 D_6 - \omega_3^7 D_7 \\ S_0 - S - \omega_5^6 D_6 - \omega_5^7 D_7 \end{pmatrix}. \tag{204}$$

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 (203f)-(203g):

$$\tau(0) - \tau = \tau_0 - \tau = D_6 = x_T, \tag{205a}$$

$$Z^{W,j}(0) - Z^{W,j} = Z_0^{W,j} - Z^{W,j} = D_7 = x_Z^j. \tag{205b}$$

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 $N(t) + Q^K(t)K(t) + Q^Z(t)Z(t)$; differentiating w.r.t. time, i.e., $\dot{A}(t) = \dot{N}(t) + \dot{Q}^K(t)K(t) + Q^K(t)\dot{K}(t) + \dot{Q}^Z(t)Z(t) + Q^Z(t)\dot{Z}(t)$, plugging the dynamic equation for the marginal value of physical capital (117h) and intangible capital (117i), inserting the accumulation equations for tangible assets (102), intangible assets (114), and for traded bonds (97), yields the accumulation equation for the stock of financial wealth or the dynamic equation for private savings:

$$\dot{A}(t) = r^\star A(t) + \sum_{j=H,N} W^j(t) L^j(t) - \mathrm{Tax}(t) - P_C(t) C(t), \tag{206}$$

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:

$$P_J J^K = P_J^K \frac{\partial J^K}{\partial I^K} I^K + P_J^K \frac{\partial J^K}{\partial K} K, \tag{207a}$$

$$P_J^Z J^Z = P_J \frac{\partial J^Z}{\partial I^Z} I^Z + P_J^Z \frac{\partial J^Z}{\partial Z} Z, \tag{207b}$$

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 (206) in the neighborhood of the steady-state

$$\dot{A}(t) = r^\star \left(A(t) - \tilde{A}\right) + \sum_X \Lambda_X \left(X(t) - \tilde{X}\right), \tag{208}$$

where $X = K, Q^K, Z, Q^Z, S, \tau, Z^{W,j}$, and substitute the solutions for $K(t)$, $Q^K(t)$, $Z(t)$, $Q^Z(t)$, $S(t)$, and the dynamic processers for τ and $Z^{W,j}$, which are described by (203a) and (203g), 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:

$$dA(t) = \frac{F_1 D_1}{\nu_1 - r^\star} e^{\nu_1 t} + \frac{F_2 D_2}{\nu_2 - r^\star} e^{\nu_2 t} + \frac{F_3 D_3}{\nu_3 - r^\star} e^{\nu_3 t} + \frac{F_6 D_6}{\nu_6 - r^\star} e^{\nu_6 t} + \frac{F_7 D_7}{\nu_7 - r^\star} e^{\nu_7 t}, \tag{209}$$

and the intertemporal solvency condition

$$dA + \frac{F_1 D_1}{\nu_1 - r^\star} + \frac{F_2 D_2}{\nu_2 - r^\star} + \frac{F_3 D_3}{\nu_3 - r^\star} + \frac{F_6 D_6}{\nu_6 - r^\star} + \frac{F_7 D_7}{\nu_7 - r^\star}, \tag{210}$$

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

F.4 Formal Solutions for $Q^K(t)K(t)$ and $Q^Z(t)Z(t)$

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:

$$Q^K(t)K(t) - P_J^K K = P_J \left(K(t) - K\right) + K\left(Q^K(t) - P_J^K\right), \tag{211}$$

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. (197) and eq. (199):

$$Q^K(t)K(t) - P_J^K K = \sum_{i=1,2,3,6,7} V_i^K D_i e^{\nu_i t}, \tag{212}$$

where $V_i^K = P_J^K\omega_1^i + K\omega_2^i$. Totally differentiating (212) w.r.t. time gives the trajectory for investment in tangible assets along the transitional path:

$$\frac{d(Q^K(t)K(t))}{dt} = \nu_i \sum_{i=1,2,3} V_i^K D_i e^{\nu_i t}. \tag{213}$$

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

$$Q^Z(t)Z(t) - P_J^Z Z = \sum_{i=1,2,3,6,7} V_i^Z D_i e^{\nu_i t}, \tag{214}$$

where $V_i^Z = P_J^Z \omega_1^i + Z\omega_2^i$. Totally differentiating (214) w.r.t. time gives the trajectory for investment in intangible assets along the transitional path:

$$\frac{d(Q^Z(t)Z(t))}{dt} = \nu_i \sum_{i=1,2,3} V_i^Z D_i e^{\nu_i t}. \tag{215}$$

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

$$\dot{N}(t) = \dot{A}(t) - \frac{d\left(Q^K(t)K(t)\right)}{dt} - \frac{dQ^Z(t)Z(t)}{dt}, \tag{216}$$

where expressions for the current account, national savings, investment in tangible assets and in intangible assets are given by (195), (209), (213), and (215), respectively.

G Data Description for Calibration

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

Table 20 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 4. 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 Table 20 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, and investment in R&D. 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:

$$\omega_C = 1 - \omega_J - \omega_G = 57\%. \tag{217}$$

As displayed by the last line of Table 20, 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 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:

$$\omega_J^K = \omega_J - \omega_J^Z = 23.7\% - 2.7\% = 21\%. \tag{218}$$

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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

Table 20: Ratios to Calibrate the Two-Sector Model

Countries	Tradable share					Input share						Home share				LIS		Aggregate ratios		
	GDP	C	K-Inv.	Z-inv.	G	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	0.34	0.35	0.39	0.45	n.a.	n.a.	0.09	0.76	0.49	0.96	0.57	0.67	0.27	0.18	n.a.
AUT	0.36	0.44	0.38	0.60	0.09	0.38	0.38	0.38	0.37	0.54	0.60	0.17	0.56	0.42	0.59	0.67	0.67	0.25	0.19	0.024
BEL	0.35	0.47	n.a.	n.a.	0.03	0.34	0.35	0.36	0.37	0.55	n.a.	0.21	0.44	0.20	1.00	0.65	0.68	0.23	0.22	n.a.
DEU	0.37	0.47	0.35	0.71	0.06	0.38	0.42	0.38	0.30	0.74	0.71	0.14	0.69	0.43	0.47	0.75	0.64	0.23	0.20	0.026
FIN	0.34	0.43	0.20	0.63	0.19	0.40	0.38	0.42	0.49	0.64	0.63	0.12	0.67	0.41	0.84	0.63	0.73	0.25	0.21	0.037
FRA	0.29	0.43	0.20	0.56	0.02	0.34	0.33	0.32	0.30	0.56	0.56	0.10	0.71	0.46	1.00	0.72	0.68	0.23	0.22	0.024
GBR	0.35	0.42	0.29	0.38	0.19	0.33	0.38	0.39	0.43	0.51	0.38	0.12	0.66	0.42	0.98	0.69	0.74	0.20	0.20	0.020
JPN	0.33	0.34	0.23	0.75	0.39	0.38	0.36	0.39	0.43	0.75	0.75	0.04	0.85	0.82	1.00	0.59	0.66	0.30	0.16	0.033
LUX	0.36	0.45	0.33	0.38	0.05	0.37	0.43	0.45	0.47	0.34	0.38	0.29	0.18	0.16	1.00	0.55	0.59	0.21	0.16	0.006
SWE	0.33	0.44	0.33	0.69	0.03	0.33	0.34	0.37	0.42	0.67	0.69	0.15	0.63	0.38	0.25	0.66	0.73	0.24	0.25	0.046
USA	0.33	0.31	0.36	0.56	0.37	0.29	0.33	0.33	0.33	0.57	0.56	0.06	0.83	0.68	1.00	0.61	0.62	0.22	0.16	0.030
OECD	0.35	0.42	0.29	0.58	0.17	0.35	0.37	0.38	0.40	0.59	0.58	0.14	0.63	0.44	0.83	0.65	0.67	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 tradables 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.

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 20 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:

$$\begin{aligned} \omega^{Y,N} &= = \frac{P^N Y^N}{Y}, \\ &= \omega_C (1-\alpha_C) + \omega_J (1-\alpha_J) + \omega_{G^N}\omega_G = 65\%, \end{aligned} \tag{219}$$

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 20 shows the GDP share of tradables calculated as one minus the value shown in eq. (219).

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, $\left(1-\alpha_J^K\right)$:

$$\left(1-\alpha_J^K\right) = \frac{\omega_J (1-\alpha_J) - \omega_J^Z \left(1-\alpha_J^Z\right)}{\omega_J^K} = 70.5\%, \tag{220}$$

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 20).

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. The tradable content of labor and labor compensation, shown in columns 6-7 of Table 20 average 35% and 37%, respectively.

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 20 average 38% 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 20 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 on traded goods averages 83%. Since the tradable content of government spending averages 17% (see column 5) and the home-produced traded goods content of government spending averages 16%, the import content of government spending is negligible at 1% 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 20 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:

$$\omega_X = \frac{P^H X^H}{Y} = \omega_C \alpha_C \left(1-\alpha^H\right) + \omega_J \alpha_J \left(1-\alpha_J^H\right) + \omega_G \omega_{G^F}, \tag{221}$$

$\omega_{G^F} = 1 - \omega_{G^{N,D}} - \omega_{G^{H,D}}$. The last line of column 12 of Table 20 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. As shown in columns 16 and 17 of Table 21, s_L^H and s_L^N averages 0.65 and 0.67, respectively.

Corporate income tax rate. In the empirical analysis, we use the top statutory corporate income tax rates taken from Vegh and Vuletin [2015] 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 model 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 21 shows that the effective corporate income tax rate, τ, averages 22.5%.

Estimated elasticities. Columns 2 and 3 of Table 21 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 0.95. 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 0.14. 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

Table 21: 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	0.029	1.16
AUT	0.15	1.34	0.19	0.028	1.27
BEL	0.26	0.56	0.12	0.031	1.18
DEU	0.13	1.02	0.04	0.030	1.33
FIN	0.18	0.39	0.11	0.023	1.29
FRA	0.30	1.41	0.11	0.030	1.29
GBR	0.22	0.54	0.04	0.022	2.64
JPN	0.33	0.93	0.57	0.015	1.38
LUX	0.21	0.01	0.04	0.020	1.24
SWE	0.17	0.52	0.00	0.029	1.63
USA	0.21	2.31	0.13	0.024	1.20
OECD	0.225	0.95	0.14	0.026	1.42

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.

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 21 shows the value of the real interest rate which averages 2.6% over the period 1973-2017.

Markup. Column 5 of Table 21 displays the economy-wide markup which averages 1.42. When we calculate the average for sub-samples, we find that the markup averages 1.50 in English-speaking and Scandinavian countries and averages to 1.27 in continental European countries.

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:

$$\hat{y}_t = \alpha + \beta^K \hat{x}_t^K + \beta^L \hat{x}_t^L + \varepsilon_t^j, \tag{222}$$

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:

$$\begin{aligned} \hat{y}_t &= \left(\hat{P}_t^Q + \hat{Q}_t\right) - \theta^L\left(\hat{W}_t + \hat{L}_t\right) \\ &- \theta^M\left(\hat{P}_t^M + \hat{M}_t\right) - \left(1 - \theta^L - \theta^M\right)\left(\hat{R}_t^K + \hat{K}_t\right). \end{aligned} \tag{223}$$

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:

$$L = \left[\int_0^M \left(\vartheta^j\right)^{-\frac{1}{\epsilon^L}} \left(L^j\right)^{\frac{\epsilon^L+1}{\epsilon^L}} dj \right]^{\frac{\epsilon^L}{\epsilon^L+1}}. \tag{224}$$

Optimal labor supply L^j to sector j is

$$L^j = \vartheta^j \left(\frac{W^j}{W}\right)^{\epsilon^L} L. \tag{225}$$

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:

$$s_L^j \frac{P^j Y^j}{L^j} = W^j, \tag{226a}$$

$$\left(1 - s_L^j\right) \frac{P^j Y^j}{K^j} = R^j. \tag{226b}$$

Inserting labor demand (226a) into labor supply to sector j (225) and solving leads the share of sector j in aggregate labor:

$$\frac{L^j}{L} = \left(\vartheta^j\right)^{\frac{1}{\epsilon^L+1}} \left(\frac{s_L^j P^j Y^j}{\int_0^M s_L^j P^j Y^j dj} \right)^{\frac{\epsilon^L}{\epsilon^L+1}}, \tag{227}$$

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

$$W = \frac{\int_0^M s_L^j P^j Y^j dj}{L}. \tag{228}$$

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

$$\beta^j = \frac{s_L^j P^j Y^j}{\sum_{j=1}^M s_L^j P^j Y^j}. \tag{229}$$

Using (229), the labor share in sector j (227) can be rewritten as follows:

$$\frac{L^j}{L} = \left(\vartheta^j\right)^{\frac{1}{\epsilon^L+1}} \left(\beta^j\right)^{\frac{\epsilon^L}{\epsilon^L+1}}. \tag{230}$$

Introducing a time subscript and taking logarithm, eq. (230) reads as:

$$\ln\left(\frac{L^j}{L}\right)_t = \frac{1}{\epsilon^L+1} \ln \vartheta^j + \frac{\epsilon^L}{\epsilon^L+1} \ln \beta_t^j. \tag{231}$$

Totally differentiating (231), 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:

$$\hat{L}_{it}^j - \hat{L}_{it} = f_i + f_t + \gamma_i \hat{\beta}_{it}^j + \nu_{it}^j, \tag{232}$$

where

$$\hat{L}_{it} = \sum_{j=1}^{M} \beta^j_{i,t-1} \hat{L}^j_{i,t}. \tag{233}$$

and

$$\beta^j_{it} = \frac{s^j_{L,i} P^j Y^j_{it}}{\sum_{j=1}^{M} s^j_{L,i} P^j_{it} Y^j_{it}}, \tag{234}$$

where $s^j_{L,i}$ 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 (232) where $\gamma_i = \frac{\epsilon^L_i}{\epsilon^L_i + 1}$ and β^j_{it} is given by (229). The LHS term of (232) is calculated as the difference between changes (in percentage) in hours worked in sector j, $\hat{L}^j_{i,t}$, and in total hours worked, $\hat{L}_{i,t}$. The RHS term β^j corresponds to the fraction of labor's share of value added accumulating to labor in sector j. Denoting by $P^j_t Y^j_t$ value added at current prices in sector $j = H, N$ at time t, β^j_t is computed as $\frac{s^j_L P^j_t Y^j_t}{\sum_{j=H}^{N} s^j_L P^j_t Y^j_t}$ where s^j_L is the LIS in sector $j = H, N$ defined as the ratio of the compensation of employees to value added in the jth sector, averaged over the period 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., $\hat{L}_t = \sum_{j=H}^{N} \beta^j_{t-1} \hat{L}^j_t$. The parameter we are interested in, say the degree of substitutability of hours worked across sectors, is given by $\epsilon^L_i = \gamma_i/(1-\gamma_i)$. In the regressions that follow, the parameter γ_i is assumed to be different across countries when estimating ϵ^L_i for each economy ($\gamma_i \neq \gamma_{i'}$ for $i \neq i'$).

To construct $\hat{L}^j$ and $\hat{\beta}^j$ we combine raw data on hours worked L^j, nominal value added $P^j Y^j$ and labor compensation $W^j L^j$. All required data are taken from the EU KLEMS and OECD STAN. The sample includes the 11 OECD countries mentioned above over the period 1974-2017).

Table 22 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 0.95 (not taking into account the estimated value for Luxembourg which is not statistically significant), as reported in the last line of column 2 of Table 21. Overall, we find that ϵ_L ranges from a low of 0.39 for Finland to a high of 2.31 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:

$$K = \left[\int_0^M \left(\vartheta^j_K\right)^{-\frac{1}{\epsilon^K}} \left(K^j\right)^{\frac{\epsilon^K+1}{\epsilon^K}} dj\right]^{\frac{\epsilon^K}{\epsilon^K+1}}. \tag{235}$$

Optimal capital supply K^j to sector j reads:

$$K^j = \vartheta^j_K \left(\frac{R^j}{R^K}\right)^{\epsilon^K} K. \tag{236}$$

The demand for labor and capital are described by:

$$s^j_L \frac{P^j Y^j}{L^j} = W^j, \tag{237a}$$

$$\left(1 - s^j_L\right) \frac{P^j Y^j}{K^j} = R^j. \tag{237b}$$

Table 22: Elasticity of Labor Supply across Sectors (ϵ_L), 1973-2017

Country	Elasticity of labor supply across Sectors (ϵ_L)
AUS	0.472^a (3.96)
AUT	1.339^a (2.98)
BEL	0.556^a (3.76)
DEU	1.018^a (3.52)
FIN	0.392^a (4.50)
FRA	1.412^a (3.07)
GBR	0.541^a (4.07)
JPN	0.926^a (3.84)
LUX	0.013 (0.35)
SWE	0.517^a (4.68)
USA	2.309^b (2.34)
Countries	11
Observations	944
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.

Inserting labor demand (237a) into capital supply to sector j (236) and solving leads the share of sector j in aggregate labor:

$$\frac{K^j}{K} = \left(\vartheta_K^j\right)^{\frac{1}{\epsilon^K+1}} \left(\frac{\left(1-s_L^j\right)P^jY^j}{\int_0^M \left(1-s_L^j\right)P^jY^j dj}\right)^{\frac{\epsilon^K}{\epsilon^K+1}}, \tag{238}$$

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

$$R^K = \frac{\int_0^M \left(1-s_L^j\right)P^jY^j dj}{K}. \tag{239}$$

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

$$\beta^{K,j} = \frac{\left(1-s_L^j\right)P^jY^j}{\sum_{j=1}^M \left(1-s_L^j\right)P^jY^j}. \tag{240}$$

Using (240), the share of capital in sector j (238) can be rewritten as follows:

$$\frac{K^j}{K} = \left(\vartheta_K^j\right)^{\frac{1}{1+\epsilon^K}} \left(\beta^{K,j}\right)^{\frac{\epsilon^K}{\epsilon^K+1}}. \tag{241}$$

Introducing a time subscript and taking logarithm, eq. (241) reads as:

$$\ln\left(\frac{K^j}{K}\right)_t = \frac{1}{\epsilon^K+1}\ln\vartheta_K^j + \frac{\epsilon^K}{\epsilon^K+1}\ln\beta_t^{K,j}. \tag{242}$$

We denote the rate of growth of the variable with a hat. We totally differentiate (242) and include country fixed effects captured by country dummies, g_i, and common macroeconomic shocks captured by year dummies, g_t:

$$\hat{K}_{it}^j - \hat{K}_{it} = g_i + g_t + \gamma_i^K \hat{\beta}_{it}^{K,j} + \nu_{it}^{K,j}. \tag{243}$$

Table 23: 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	0.186^c (1.74)
BEL	0.122 (1.14)
DEU	0.038 (0.56)
FIN	0.110^b (2.48)
FRA	0.114 (1.26)
GBR	0.042 (0.89)
JPN	0.574^a (4.45)
LUX	0.041 (1.00)
SWE	−0.030 (−0.49)
USA	0.129 (1.43)
Countries	11
Observations	768
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.

We use panel data to estimate (243). 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 $\beta^{K,j}_{it}$ for sector j, in country i at time t, we proceed as follows:

$$\hat{K}_{it} = \sum_{j=1}^{M} \beta^{K,j}_{i,t-1} \hat{K}^j_{i,t}. \tag{244}$$

and

$$\beta^{K,j}_{it} = \frac{\left(1 - s^j_{L,i}\right) P^j_{it} Y^j_{it}}{\sum_{j=1}^{M} \left(1 - s^j_{L,i}\right) P^j_{it} Y^j_{it}}, \tag{245}$$

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 25 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 $P^j Y^j$ and labor compensation $W^j L^j$ to calculate $1 - s^j_L$.

Degree of capital mobility across sectors. We use panel data to estimate eq. (243) where $\gamma^K_i = \frac{\epsilon_{K,i}}{\epsilon_{K,i}+1}$ and $\beta^{K,j}_{it}$ is given by (245). Table 23 reports empirical estimates that are consistent with $\epsilon_K > 0$. We average positive values for ϵ_K and exclude negative values (Sweden only) as they are inconsistent. We find an average value for ϵ_K of 0.14, as reported in last line of column 3 of Table 21. 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., $C_t^N = (1-\varphi)\left(\frac{P_t^N}{P_{C,t}}\right)^{-\phi} C_t$, since time series for consumption in non-traded goods are too short. More specifically, we derive an expression for the non-tradable content of consumption expenditure by using the market clearing condition for non-tradables and construct time series for $1-\alpha_{C,t}$ by using time series for non-traded value added and demand components of GDP while keeping the non-tradable content of investment and government expenditure fixed, in line with the evidence documented by Bems [2008] for the share of non-traded goods in investment and building on our own evidence for the non-tradable content of government spending. After verifying that the (logged) share of non-tradables and the (logged) ratio of non-traded prices to the consumption price index are both integrated of order one and cointegrated, we run the regression by adding country and time fixed effects together and including a country-specific time trend and estimate the coefficient by using a Fully Modified OLS estimator.

Multiplying both sides of $C_t^N = (1-\varphi)\left(\frac{P_t^N}{P_{C,t}}\right)^{-\phi} C_t$ by P^N/P_C leads to the non-tradable content of consumption expenditure:

$$1-\alpha_{C,t} = \frac{P_t^N C_t^N}{P_{C,t} C_t} = (1-\varphi)\left(\frac{P_t^N}{P_{C,t}}\right)^{1-\phi}. \tag{246}$$

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:

$$\frac{P_t^N C_t^N}{P_{C,t} C_t} = \frac{1}{\omega_{C,t}}\left[\frac{P_t^N Y_t^N}{Y_t} - (1-\alpha_J)\,\omega_{J,t} - \omega_{G^N}\omega_{G,t}\right]. \tag{247}$$

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 (246), we take the logarithm of both sides of (246) and run the regression of the logged share of non-tradables on the logged ratio of non-traded prices to the consumption price index:

$$\ln(1-\alpha_{C,it}) = f_i + f_t + \alpha_i\ .t + (1-\phi)\ln\left(P^N/P_C\right)_{it} + \mu_{it}, \tag{248}$$

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 (246) 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). 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 $(1-\alpha_J)$

Table 24: Elasticity of Substitution between Tradables and Non-Tradables (ϕ)

	eq. (248)
Whole Sample	0.528^{a} (5.06)
Countries	11
Observations	495
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.

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). 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 (248) 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 (248) is reported in Table 24. We find a value for the elasticity of substitution between traded and non-traded goods in consumption of 0.53 which remains close to the estimated value of 0.44 documented by Stockman and Tesar [1995] and commonly chosen by the open economy macroeconomics literature.

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 as well as the international stock of ideas. 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 $Z^{W,j}(t)$:

$$\mathsf{Z}^j(t) = \left(Z^j_i(t)\right)^{\theta^j_Z} \left(Z^{W,j}(t)\right)^{1-\theta^j_Z}, \tag{249}$$

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:

$$\mathcal{T}^j_t = \left(Z^j_i(t)\right)^{\nu^j_Z \theta^j_Z} \left(Z^{W,j}(t)\right)^{\nu^{W,j}_Z\left(1-\theta^j_Z\right)}, \tag{250}$$

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 (250), 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:

$$\ln \mathrm{T}^j_{it} = \alpha_i + \beta_i t + \gamma^j \ln Z^j_{it} + \gamma^{W,j} \ln Z^{W,j}_{it} + \eta_{it}, \tag{251}$$

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

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 25 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 $Z_{it}^{W,j}$ 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 $\alpha_i^{M,k}$ 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 26. The world component of traded technology amounts to 42% which implies that $\theta_Z^H = 58\%$ for tradables. The world component of non-traded technology is lower and stands at 37% which implies that $\theta_Z^N = 63\%$ for non-tradables.

Table 27 shows estimation results from the regression of eq. (251) 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 25: Stock of R&D (KLEMS) at Industry Level: Data Availability

	data availability on the stock of R&D
AUS	no data
AUT	1995-2017
BEL	1995-2017
DEU	1995-2017
FIN	1995-2017
FRA	1995-2017
GBR	1995-2017
JPN	1995-2015
LUX	1995-2017
SWE	1995-2016
USA	1995-2017

Table 26: 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	0.0025	0.0009	38.59	61.41
H-Technology	0.0084	0.0035	41.66	58.33
N-Technology	0.0022	0.0008	36.73	63.27

Notes: We run a principal component analysis to extract the common component to all country-level-adjusted-aggregate-TFP growth that we interpret as the world component. In columns 1 and 2, we show the variance of the rate of growth of country-level-adjusted-TFP and its common component, respectively. The figure in columns 3-4 denotes the fraction of the variance of country-level TFP growth attributable to the world component and country-specific component, respectively.

Table 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 ($\hat{\gamma}_i^{Wj}$) for the Whole Sample and the Country-Split

	Aggregate Economy		Sector H		Sector N	
	$\hat{\gamma}_i^j$	$\hat{\gamma}_i^{Wj}$	$\hat{\gamma}_i^j$	$\hat{\gamma}_i^{Wj}$	$\hat{\gamma}_i^j$	$\hat{\gamma}_i^{Wj}$
Whole Sample	-0.031^a	0.016	0.292^a	0.104^a	-0.007	0.012
	(3.33)	(0.55)	(8.10)	(5.39)	(-0.14)	(1.12)
Flex. wage N=6	0.110^a	0.043^a	0.506^a	0.134^a	0.024^b	0.044^a
	(7.94)	(2.62)	(11.89)	(4.62)	(2.50)	(4.83)
Rigid. wage N=4	-0.241^a	-0.023^b	-0.030^c	0.059^a	-0.053^a	-0.036^a
	(-4.46)	(2.34)	(-1.74)	(2.87)	(-3.29)	(-4.14)
Countries	10	10	10	10	10	10
Observations	226	226	226	226	226	226
Data coverage	1995-2017	1995-2017	1995-2017	1995-2017	1995-2017	1995-2017
Country fixed effects	yes	yes	yes	yes	yes	yes
Time dummies	no	no	no	no	no	no
Time trend	yes	yes	yes	yes	yes	yes

Notes: ^{a}, ^{b} and ^{c} denote significance at 1%, 5% and 10% levels. Heteroskedasticity and autocorrelation consistent t-statistics are reported in parentheses. Denoting utilization-adjusted-TFP in sector j by $\mathcal{Z}_{it}^j$ and domestic and international stocks of R&D by Z_{it}^j and $Z_{it}^{W,j}$ 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 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 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	0.161^a	0.135^a	0.043^c
	(10.04)	(4.02)	(3.27)	(1.89)
GBR	0.818^b	0.115	0.023	0.025
	(2.08)	(0.73)	(0.69)	(1.41)
JPN	0.066	0.555^a	0.260^a	0.276^a
	(0.49)	(7.01)	(5.42)	(6.07)
LUX	0.044^a	-0.076	0.024^a	-0.117^a
	(3.56)	(-0.71)	(3.13)	(-3.00)
SWE	0.337^a	0.061	-0.165	-0.001
	(4.28)	(0.60)	(-1.38)	(-0.03)
USA	1.533^a	-0.012	-0.133^a	0.039^a
	(8.67)	(-0.34)	(-5.00)	(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 29: 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 (−0.46)	0.051 (1.35)	−0.053 (−0.36)	-0.055^a (−4.44)
BEL	0.389^a (3.53)	0.076^c (1.67)	-0.139^a (−4.48)	0.049^a (2.69)
DEU	0.351^b (2.14)	0.030 (0.93)	-0.105^a (−3.24)	-0.070^a (−3.83)
FRA	-0.790^a (−8.70)	0.079^c (1.79)	0.085 (1.49)	-0.068^a (−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.

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 $\gamma^N = \gamma^{W,N} = 0$. Inspection of country-level estimated values in Table 28 and Table 29 reveal that some values are negative and not statistically significant. When we consider elasticities w.r.t. the domestic stock of R&D, leaving aside these negative values which are not statistically significant, i.e., $\gamma^H = -0.071$ and $\gamma^N = -0.053$ for Austria and $\gamma^N = -0.165$ for Sweden, we find a cross-country average $\bar{\gamma}^H = 0.332$ for the traded sector and $\bar{\gamma}^N = 0.019$ for the non-traded sector. When we focus on elasticities w.r.t. the international stock of knowledge, leaving aside these negative values which are not statistically significant, i.e., $\gamma^{W,H} = -0.076$ and $\gamma^{W,H} = -0.012$ for Luxembourg and the United States, and $\gamma^{W,N} = -0.001$ for Sweden, we find a cross-country average $\bar{\gamma}^{W,H} = 0.141$ for the traded sector and $\bar{\gamma}^N = 0.014$ for the non-traded sector.

By using the domestic component $\theta_Z^H = 0.58$ of the stock of knowledge accessible to domestic firms in the traded sector, we find an adjusted elasticity of technology T_{it}^H w.r.t. the stock of R&D Z_{it}^H equal to $\nu_Z^H = \frac{0.332}{0.58} = 0.572$. Using the international component of traded technology, i.e., $1-\theta_Z^H = 0.42$, we find an adjusted elasticity of technology T_{it}^H w.r.t. the international stock of R&D $Z_{it}^{W,H}$ equal to $\nu_Z^{W,H} = \frac{0.141}{0.42} = 0.335$.

The same logic applies to the non-traded sector. By using the domestic component $\theta_Z^N = 0.63$ of the stock of knowledge accessible to domestic firms in the non-traded sector, we find an adjusted elasticity of technology T_{it}^N w.r.t. the stock of R&D Z_{it}^N equal to $\nu_Z^N = \frac{0.019}{0.63} = 0.030$. Using the international component of non-traded technology, i.e., $1-\theta_Z^H = 0.37$, we find an adjusted elasticity of technology T_{it}^N w.r.t. the international stock of R&D $Z_{it}^{W,N}$ equal to $\nu_Z^{W,N} = \frac{0.014}{0.37} = 0.037$.

English-speaking and Scandinavian countries, $N = 6$. For English-speaking and Scandinavian countries, the second row of Table 27 shows that the elasticity of utilization-adjusted-TFP of tradables w.r.t. the domestic stock of R&D of tradables amounts to $\gamma^H =$

0.506 and the elasticity of utilization-adjusted-TFP of tradables w.r.t. the international stock of R&D of tradables amounts to $\gamma^{W,H} = 0.134$. While for the former elasticity, all elasticities are positive and significant (except for Japan), we keep this value because even if we ignored the value of Japan and replace it with zero, it won't affect much the mean. On the contrary, two estimates are negative and not statistically significant for $\gamma^{W,H}$. Ignoring these two values, i.e., leaving aside $\gamma^{W,H} = -0.076$ for Luxembourg and $\gamma^{W,H} = -0.012$ for the United States, we find a country average elasticity of $\bar{\gamma}^{W,H} = 0.223$.

By using the domestic component $\theta_Z^H = 0.58$ of the stock of knowledge accessible to domestic firms in the traded sector, we find an adjusted elasticity of technology T_{it}^H w.r.t. the stock of R&D Z_{it}^H equal to $\nu_Z^H = \frac{0.506}{0.58} = 0.873$. Using the international component of traded technology, i.e., $1-\theta_Z^H = 0.42$, we find an adjusted elasticity of technology T_{it}^H w.r.t. the international stock of R&D $Z_{it}^{W,H}$ equal to $\nu_Z^{W,H} = \frac{0.223}{0.42} = 0.531$.

Inspection of values of non-traded technology w.r.t. the domestic stock of knowledge, i.e., γ^N, estimated for one country at a time summarized in Table 28 reveals that Sweden ($\gamma^N = -0.165$) displays a negative value which is not statistically significant. Leaving aside this value, we find a country average of $\bar{\gamma}^N = 0.062$. When we focus on the elasticity of non-traded technology w.r.t. the international stock of knowledge, i.e., $\gamma^{W,N}$, and leaving aside the negative and not statistically significant value for Sweden (i.e., $\gamma^{W,N} = -0.001$), we find a country average elasticity equal to $\bar{\gamma}^{W,N} = 0.053$. By using the domestic component $\theta_Z^N = 0.63$ of the stock of knowledge accessible to domestic firms in the non-traded sector, we find an adjusted elasticity of technology T_{it}^N w.r.t. the stock of R&D Z_{it}^N equal to $\nu_Z^N = \frac{0.062}{0.63} = 0.098$. Using the international component of non-traded technology, i.e., $1-\theta_Z^H = 0.37$, we find an adjusted elasticity of technology T_{it}^N w.r.t. the international stock of R&D $Z_{it}^{W,N}$ equal to $\nu_Z^{W,N} = \frac{0.053}{0.37} = 0.145$.

Continental European countries, $N = 4$. For this group of countries, inspection of Table 29 reveals that γ^H and γ^N are negative and not statistically significant for Austria. Leaving aside $\gamma^H = -0.071$ and $\gamma^N = -0.053$ obtained for Austria, we find a cross-country average of $\bar{\gamma}^H = -0.016$ for tradables and $\bar{\gamma}^N = -0.053$ for non-tradables. Since these values are inconsistent, we set the adjusted elasticity of technology w.r.t. the domestic stock of knowledge to zero for both tradables and non-tradables, i.e., $\nu_Z^H = \nu_Z^N = 0$. As shown in Table 27, the elasticity of non-traded technology w.r.t. the international stock of knowledge is negative at $\gamma^{W,N} = -0.036$. According to Table 29, all values are statistically significant. When we calibrate the model to the data, we thus choose $\eta_Z^{W,N} = 0$. Only the elasticity of technology of tradables w.r.t. the international stock of knowledge has a consistent and statistically significant value. More specifically, we have $\gamma^{W,H} = 0.059$ which leads to an adjusted elasticity of $\nu_Z^{W,H} = \frac{\gamma^{W,H}}{1-\theta_Z^H} = \frac{0.059}{0.42} = 0.140$.

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.,

$$T^j(t) = \left(T^{c,j}(t)\right)^{\theta_Z^j} \left(T^{W,j}(t)\right)^{1-\theta_Z^j} \tag{252}$$

where the domestic component of technology, $T^{c,j}(t)$, is influenced by the domestic stock of knowledge $Z^j(t)$:

$$T^{c,j}(t) = \left(Z^j(t)\right)^{\nu_Z^j} \tag{253}$$

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 $j = H, N$:

$$T^{W,j}(t) = \left(Z^{W,j}(t)\right)^{\nu_Z^{W,j}}. \tag{254}$$

Table 30: 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	$\nu^{Y,N}$
	(1)	(2)	(3)	(4)
FRA	-0.25 (-8.70)	-0.79 (-8.70)	0.00 (1.49)	0.68
AUT	0.00	0.00 (-0.46)	0.00 (-0.36)	0.62
LUX	0.03 (4.72)	0.04 (3.56)	0.02 (3.13)	0.55
BEL	0.05 (1.14)	0.39 (3.53)	-0.14 (-4.48)	0.64
DEU	0.07 (1.05)	0.35 (2.14)	-0.10 (-3.24)	0.62
SWE	0.12 (4.28)	0.34 (4.28)	0.00 (-1.38)	0.63
JPN	0.16 (5.42)	0.00 (0.49)	0.26 (5.42)	0.61
FIN	0.18 (6.85)	0.24 (10.04)	0.13 (3.27)	0.58
GBR	0.32 (2.08)	0.82 (2.08)	0.00 (0.69)	0.61
USA	0.42 (6.84)	1.53 (8.67)	-0.13 (-5.00)	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 $Var\left(\gamma^A\right) = \left(\nu^{Y,H}\right)^2 Var\left(\gamma^H\right) + \left(\nu^{Y,N}\right)^2 Var\left(\gamma^N\right)$. Note that we assign the value zero when the coefficient is not statistically significant. 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.

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:

$$\gamma^j = \nu_Z^j \theta_Z^j. \tag{255}$$

In Table 30, 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. 11(c)-11(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. Moreover, Luxembourg is the unique country in continental Europe which displays a positive and statistically significant values for γ^A while the other countries display negative or statistically insignificant values. To be consistent with empirical responses and estimated values for γ^A, 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 since $\gamma^A = 0.03$ is positive and statistically significant and also because our evidence reveals the technology improvements after a CIT cut are the most pronounced among OECD countries of our sample.

As displayed by the first of the last three rows of Table 30 where we calculate the mean of our estimates for the ten OECD countries of our sample, the elasticity of technology w.r.t. the stock of knowledge is zero for the non-traded sector, 0.29 for the traded sector and 0.12 at an economy-wide 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 (because negative values are inconsistent) 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 27.

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 sample of OECD countries.

If we aggregate investment in tangible and in intangible assets, the optimal share of investment expenditure spent on traded inputs reads:

$$\alpha_J = \iota \left(\frac{P^T}{P_J} \right)^{1-\phi_J}, \tag{256}$$

where ϕ_J is the elasticity of substitution between traded and non-traded investment inputs. If we restrict our attention to the investment in R&D, the optimal share of investment in intangible assets spent on traded goods reads (see section E.1):

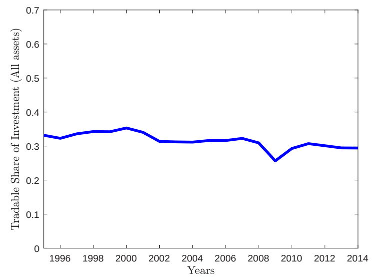
$$\alpha_J^Z = \frac{P^H J^{Z,H}}{P_J^Z J^Z} = \iota_Z \left(\frac{P^H}{P_J^Z} \right)^{1-\phi_Z}, \tag{257}$$

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):

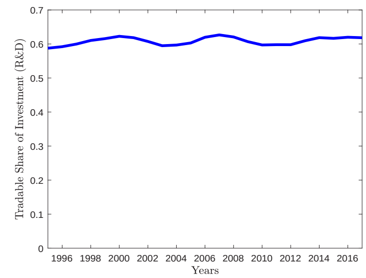
$$\alpha_J^K = \iota \left(\frac{P_J^T}{P_J^K} \right)^{1-\phi_K}, \tag{258}$$

where ϕ_K is the elasticity of substitution between traded and non-traded capital investment inputs.

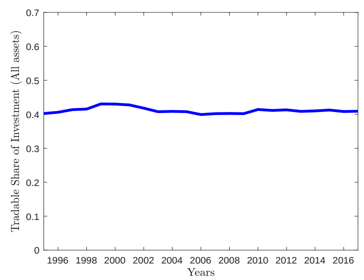
To calibrate our model, we have to choose values for parameters ϕ_K and ϕ_Z. We have time series for GFCF which includes both investment in tangible and in intangible assets. In Fig. 28(a), we plot the tradable content of investment expenditure when we use WIOD to construct the time series for GFCF at 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



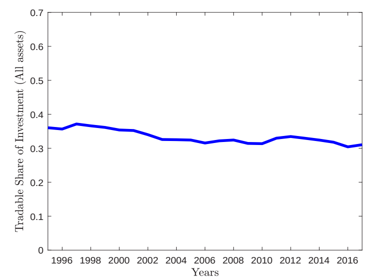
(a) Tradable Share of GFCF (Source: WIOD)



(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 28: The Investment Share in Tradables (995-2017) for 11 OECD Countries. Notes: In Fig. 28(a), 28(c), 28(d), the blue line shows the share of investment expenditure spent on tradables by using three different sources: WIOD, OECD, EU KLEMS, respectively. Fig. 28(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.

for OECD time series is higher, Fig. 28(c) shows that the tradable content of investment expenditure is stale over time. We detect a slight gradual decline in α_J in Fig. 28(d).

In Fig. 28(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 highlight only 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 index, R^W, associated with the CES aggregator of sectoral hours defined by (75), is:

$$R^W = \left[\vartheta_L \left(R^{W,H}\right)^{\epsilon_L+1} + (1-\vartheta_L)\left(R^{W,N}\right)^{\epsilon_L+1}\right]^{\frac{1}{\epsilon_L+1}}, \tag{259}$$

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:

$$L^H = \vartheta \left(\frac{R^{W,H}(t)}{R^W(t)}\right)^{\epsilon} L(t), \tag{260a}$$

$$L^N = (1-\vartheta) \left(\frac{R^{W,N}(t)}{R^W(t)}\right)^{\epsilon} L(t). \tag{260b}$$

As will be useful later, log-linearizing the aggregate wage index in the neighborhood of the initial steady-state leads to:

$$\hat{R}^W(t) = \alpha_L \hat{R}^{W,H}(t) + (1-\alpha_L)\hat{R}^{W,N}(t), \tag{261}$$

where α_L is the tradable content of aggregate labor compensation:

$$\alpha_L = \vartheta_L \left(\frac{R^{W,H}}{R^W}\right)^{1+\epsilon_L}, \tag{262a}$$

$$1-\alpha_L = (1-\vartheta_L)\left(\frac{R^{W,N}}{R^W}\right)^{1+\epsilon_L}. \tag{262b}$$

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:

$$\begin{aligned}
&\dot{N}(t) + P_C(t)C(t) + \sum_{V=K,Z} P_J^V(t)J^V t) + \sum_{j=H,N} P^j(t)\left(C^{K,j}(t)\nu^{K,j}(t)K(t) + C^{Z,j}(t)\nu^{Z,j}(t)Z(t)\right) \\
&= r^\star N(t) + R^W(t)L(t) + R^Z(t)Z(t)\sum_{j=H,N}\alpha_Z^j(t)u^{Z,j} + R^K(t)K(t)\sum_{j=H,N}\alpha_K^j(t)u^{K,j} + \\
&+ \int_0^1 \Pi_i^{W,j}(t)di - \text{Tax}(t),
\end{aligned} \tag{263}$$

The optimal decision for consumption and labor supply read as follows:

$$\Lambda_C\left(C(t), S(t), L(t)\right) = \bar{\lambda} P_C(t), \tag{264a}$$
$$-\Lambda_L\left(C(t), S(t), L(t)\right) = \bar{\lambda} R^W(t). \tag{264b}$$

H.2 Employment Agencies, Human Resources and Wage Stickiness

Human Resource Agencies

Perfectly-competitive human resources purchase the differentiated labor services supplied by employment agencies and aggregate them using the CES technology:

$$L^j = \left[\int_0^1 \left(L_i^j\right)^{\frac{\epsilon_W^j - 1}{\epsilon_W^j}} \mathrm{d}i\right]^{\frac{\epsilon_W^j}{\epsilon_W^j - 1}}, \tag{265}$$

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:

$$\Pi_W^H = W^j L^j - \int_0^1 W_i^j L_i^j di, \tag{266}$$

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:

$$L_i^j = \left(\frac{W_i^j}{W^j}\right)^{-\epsilon_W^j} L^j. \tag{267}$$

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 wage inflation rate and to be proportional to labor compensation in sector j:

$$\Theta^j\left(\frac{\dot{W}_i^j}{W_i^j}\right) = \frac{\phi_W^j}{2}\left(\frac{\dot{W}_i^j}{W_i^j}\right)^2 W^j L^j, \tag{268}$$

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.,

$$\max_{\dot{W}_i^j, W_i^j} \frac{\Pi_i^{W,j}(t)}{W^j(t)},$$

$$\max_{\dot{W}_i^j, W_i^j} \int_0^\infty e^{-\int_0^t r^{W,j}(s)ds}\left[\frac{W_i^j\left(1+\tau^{W,j}\right) - R^{W,j}}{W^j} L_i^j - \frac{\phi_W^j}{2}\left(\frac{\dot{W}_i^j}{W_i^j}\right)^2 L^j\right], \tag{269}$$

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:

$$\begin{aligned}\mathcal{H}_i^{W,j} &= \frac{W_i^j}{W^j}\left(1+\tau^{W,j}\right)\left(\frac{W_i^j}{W^j}\right)^{-\epsilon_W^j} L^j - \frac{R^{W,j}}{W^j}\left(\frac{W_i^j}{W^j}\right)^{-\epsilon_W^j} L^j - \frac{\phi_W^j}{2}\left(\frac{\dot{W}_i^j}{W_i^j}\right)^2 L^j + \Lambda_i^{W,j}\dot{W}_i^j,\\ &= \left(\frac{W_i^j}{W^j}\right)^{1-\epsilon_W^j}\left(1+\tau^{W,j}\right)L^j - \frac{R^{W,j}}{\left(W^j\right)^{1-\epsilon_W^j}}\left(W_i^j\right)^{-\epsilon_W^j} L^j - \frac{\phi_W^j}{2}\left(\frac{\dot{W}_i^j}{W_i^j}\right)^2 L^j + \Lambda_i^{W,j}\dot{W}_i^j \quad (270)\end{aligned}$$

where we have inserted $L_i^j = \left(\frac{W_i^j}{W^j}\right)^{-\epsilon_W^j} L^j$ (see eq. (267)). First-order conditions read:

$$\frac{\partial \mathcal{H}_i^{W,j}}{\partial \dot{W}_i^j} = 0, \qquad \phi_W^j \frac{\pi_i^{W,j}}{W_i^j} = \Lambda_i^{W,j}, \tag{271a}$$

$$\frac{\partial \mathcal{H}_i^{W,j}}{\partial W_i^j} = \left(r^\star - \pi^{W,j}\right)\Lambda_i^{W,j} - \dot{\Lambda}_i^{W,j},$$

$$\frac{\left(1-\epsilon_W^j\right)\left(W_i^j\right)^{-\epsilon_W^j}}{\left(W^j\right)^{1-\epsilon_W^j}}\left(1+\tau^{W,j}\right)L^j + \frac{R^{W,j}}{\left(W^j\right)^{1-\epsilon_W^j}}\epsilon_W^j\left(W_i^j\right)^{-\epsilon_W^j-1}L^j + \phi_W^j\frac{\left(\dot{W}_i^j\right)^2}{\left(W_i^j\right)^3}L^j$$

$$= \left(r^\star - \pi^{W,j}\right)\Lambda_i^{W,j} - \dot{\Lambda}_i^{W,j},$$

$$\frac{\left(1-\epsilon_W^j\right)\left(1+\tau^{W,j}\right)L^j}{W^j} + \frac{R^{W,j}\epsilon_W^j L^j}{\left(W^j\right)^2} + \phi_W^j\frac{\left(\pi^{W,j}\right)^2}{W^j}L^j$$

$$= \left(r^\star - \pi^{W,j}\right)\phi_W^j\frac{\pi^{W,j}}{W^j}L^j - \phi_W^j\frac{\dot{\pi}^{W,j}}{W^j}L^j - \phi_W^j\frac{\pi^{W,j}}{W^j}\dot{L}^j + \phi_W^j\frac{\pi^{W,j}}{W^j}\frac{\dot{W}^j}{W^j}L^j,$$

$$\frac{\left(1-\epsilon_W^j\right)\left(1+\tau^{W,j}\right)}{\phi_W^j} + \frac{R^{W,j}}{\phi_W^j}\frac{\epsilon_W^j}{W^j} + \left(\pi^{W,j}\right)^2 = \left(r^\star - \pi^{W,j}\right)\pi^{W,j} - \dot{\pi}^{W,j} - \pi^{W,j}\frac{\dot{L}^j}{L^j} + \left(\pi^{W,j}\right)^2,$$

$$\dot{\pi}^{W,j} + \frac{\epsilon_W^j}{\phi_W^j}\left[\frac{R^{W,j}}{W^j} - \left(\frac{\epsilon_W^j - 1}{\epsilon_W^j}\right)\left(1+\tau^{W,j}\right)\right] = \pi^{W,j}\left[r^\star - \pi^{W,j} - \frac{\dot{L}^j}{L^j}\right],$$

$$\dot{\pi}^{W,j} + \frac{\epsilon_W^j}{\phi_W^j}\left[\frac{R^{W,j}}{W^j} - 1\right] = \pi^{W,j}\left[r^\star - \pi^{W,j} - \frac{\dot{L}^j}{L^j}\right], \tag{271b}$$

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 (271a) 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 $\left(\frac{\epsilon_W^j - 1}{\epsilon_W^j}\right)\left(1+\tau^{W,j}\right) = 1$, i.e.,

$$\tau^{W,j} = \frac{1}{\epsilon^{W,j} - 1} > 0. \tag{272}$$

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:

$$\Pi_i^{W,j} = \Pi^{W,j} = \left(W^j - R^{W,j}\right)L_i^j - \frac{\phi_W^j}{2}\left(\frac{\dot{W}_i^j}{W_i^j}\right)^2 W^j L^j. \tag{273}$$

H.3 Solving the Model

We follow the same solution method as in section E.4; $R^{W,j}$ is a flexible wage while W^j is a state variable.

Consumption in goods $g = H, N, F$. Eqs. (264a)-(264b) can be solved for consumption and hours:

$$C = C\left(\bar{\lambda}, S, P^H, P^N, R^W\right), \qquad L = L\left(\bar{\lambda}, S, P^H, P^N, R^W\right). \tag{274}$$

Consumption in goods $g = H, N, F$. Inserting first the solution for consumption (274) into (71b), (72a)-(72b), allows us to solve for C^g (with $g = H, N, F$)

$$C^g = C^g\left(\bar{\lambda}, P^N, P^H, R^{W,H}, R^{W,N}\right), \tag{275}$$

Labor supply to sector $j = H, N$. Inserting first the solution for labor (274) into (260) allows us to solve for L^j (with $j = H, N$):

$$L^j = L^j\left(\bar{\lambda}, P^N, P^H, R^{W,H}, R^{W,N}\right), \tag{276}$$

Sectoral Wages and Sectoral Rental Rates for Tangible and Intangible Assets. Inserting intermediate solutions for L^j, K^j, Z^j described by (276), (154), (156), respectively, into (159a)-(159c), and invoking the theorem of implicit functions leads to:

$$R^{W,j}, R^{K,j}, R^{Z,j}\left(P^j, K, Z, W^j, u^{K,j}, u^{Z,j}, \tau, Z^{W,j}\right). \tag{277}$$

Plugging back (277) into (152), (154), (156) leads to solutions for L^j, K^j, Z^j; inserting these solutions into the production function (124)-(125) allows us to solve for Y^j; thus intermediate solutions read:

$$L^j, K^j, Z^j, Y^j\left(P^j, K, Z, W^j, u^{K,j}, u^{Z,j}, \tau, Z^{W,j}\right). \tag{278}$$

Solutions to capital and technology utilization rates in sector $j = H, N$. Inserting (277)-(278) into (164) and (165) and invoking the implicit function theorem leads to:

$$u^{K,j}, u^{Z,j}\left(P^j, K, Z, W^j, Z^{W,j}, \tau\right). \tag{279}$$

Plugging back (279) into (277) and (278) leads to

$$R^j, R^{K,j}, R^{Z,j}, L^j, K^j, Y^j\left(P^j, K, Z, W^j, Z^{W,j}, \tau\right). \tag{280}$$

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

$$P^H, P^N\left(K, Q^K, Z, Q^Z, W^j, Z^{W,j}, \tau\right). \tag{281}$$

Plugging back these solutions (281) into (279), (280) leads to:

$$u^{K,j}, R^{W,j}, R^{K,j}, R^{Z,j}, L^j, K^j, Y^j\left(K, Q^K, Z, Q^Z, W^j, Z^{W,j}, \tau\right). \tag{282}$$

Inserting solutions for sectoral prices (281) into intermediate solutions for investment in tangible (174) and intangible assets (178) and consumption (275) in goods $g = H, N, F$, leads to:

$$C^g, J^{K,g}, J^{Z,g}\left(K, Q^K, Z, Q^Z, W^j, Z^{W,j}, \tau\right), \qquad g = H, N, F. \tag{283}$$

Dynamic system. In addition to (183a)-(183g), the dynamic system comprises four additional dynamic equations when we allow for sticky wages at a sectoral level:

$$\dot{\pi}^{W,H}(t) = \pi^{W,H}(t)\left[r^\star - \pi^{W,H}(t) - \frac{\dot{L}^H(t)}{L^H(t)}\right] - \frac{\epsilon_W^H}{\phi_W^H}\left[\frac{R^{W,H}(t)}{W^H(t)} - 1\right], \tag{284a}$$

$$\dot{W}^H(t) = W^H(t)\pi^{W,H}(t), \tag{284b}$$

$$\dot{\pi}^{W,N}(t) = \pi^{W,N}(t)\left[r^\star - \pi^{W,N}(t) - \frac{\dot{L}^N(t)}{L^N(t)}\right] - \frac{\epsilon_W^N}{\phi_W^N}\left[\frac{R^{W,N}(t)}{W^N(t)} - 1\right], \tag{284c}$$

$$\dot{W}^N(t) = W^N(t)\pi^{W,N}(t). \tag{284d}$$

The dynamic system can be written in a compact form:

$$
\begin{aligned}
\dot{K}(t) &= \Upsilon\left(K(t), Q^K(t), Z(t), Q^Z(t), S(t), W^H(t), W^N(t), \tau(t), Z^{W,j}(t)\right), && \text{(285a)}\\
\dot{Q}^K(t) &= \Sigma\left(K(t), Q^K(t), Z(t), Q^Z(t), S(t), W^H(t), W^N(t), \tau(t), Z^{W,j}(t)\right), && \text{(285b)}\\
\dot{Z}^A(t) &= \Pi\left(K(t), Q^K(t), Z(t), Q^Z(t), S(t), W^H(t), W^N(t), \tau(t), Z^{W,j}(t)\right), && \text{(285c)}\\
\dot{Q}^Z(t) &= \Gamma\left(K(t), Q^K(t), Z(t), Q^Z(t), S(t), W^H(t), W^N(t), \tau(t), Z^{W,j}(t)\right), && \text{(285d)}\\
\dot{S}(t) &= \Theta\left(K(t), Q^K(t), Z(t), Q^Z(t), S(t), W^H(t), W^N(t), \tau(t), Z^{W,j}(t)\right), && \text{(285e)}\\
\dot{\pi}^{W,H}(t) &= \Pi^{W,H}\left(K(t), Q^K(t), Z(t), Q^Z(t), S(t), W^H(t), W^N(t), \tau(t), Z^{W,j}(t)\right), && \text{(285f)}\\
\dot{W}^H(t) &= W^H(t)\pi^{W,H}(t), && \text{(285g)}\\
\dot{\pi}^{W,N}(t) &= \Pi^{W,N}\left(K(t), Q^K(t), Z(t), Q^Z(t), S(t), W^H(t), W^N(t), \tau(t), Z^{W,j}(t)\right), && \text{(285h)}\\
\dot{W}^N(t) &= W^N(t)\pi^{W,N}(t), && \text{(285i)}\\
\dot{\tau}(t) &= -\xi_T\left(\tau(t) - \tau\right), && \text{(285j)}\\
\dot{Z}^{W,j}(t) &= -\xi_Z^j\left(Z^{W,j}(t) - Z^{W,j}\right), && \text{(285k)}
\end{aligned}
$$

where $j = H, N$.

H.4 Formal Solutions for $K(t)$, $Q(t)$, $Z(t)$, $Q^Z(t)$, $S(t)$

The adjustment of the open economy towards the steady-state is described by a dynamic system which comprises eleven equations. Linearizing (285a)-(285k), the linearized system can be written in a matrix form:

$$
\begin{pmatrix} \dot{K}(t) \\ \dot{Q}^K(t) \\ \dot{Z}^A(t) \\ \dot{Q}^Z(t) \\ \dot{S}(t) \\ \dot{W}^H(t) \\ \dot{\pi}^{W,H}(t) \\ \dot{W}^N(t) \\ \dot{\pi}^{W,N}(t) \\ \dot{\tau}(t) \\ \dot{Z}^{W,j}(t) \end{pmatrix}
=
\begin{pmatrix}
\Upsilon_K & \Upsilon_{Q^K} & \Upsilon_Z & \Upsilon_{Q^Z} & \Upsilon_S & \Upsilon_{W^H} & 0 & \Upsilon_{W^N} & 0 & \Upsilon_\tau & \Upsilon_{Z^{W,j}} \\
\Sigma_K & \Sigma_{Q^K} & \Sigma_Z & \Sigma_{Q^Z} & \Sigma_Z & \Sigma_{W^H} & 0 & \Sigma_{W^N} & 0 & \Sigma_\tau & \Sigma_{Z^{W,j}} \\
\Pi_K & \Pi_{Q^K} & \Pi_Z & \Pi_{Q^Z} & \Pi_S & \Pi_{W^H} & 0 & \Pi_{W^N} & 0 & \Pi_\tau & \Pi_{Z^{W,j}} \\
\Gamma_K & \Gamma_{Q^K} & \Gamma_Z & \Gamma_{Q^Z} & \Gamma_S & \Gamma_{W^H} & 0 & \Gamma_{W^N} & 0 & \Gamma_\tau & \Gamma_{Z^{W,j}} \\
\Theta_K & \Theta_{Q^K} & \Theta_Z & \Theta_{Q^Z} & \Theta_S & \Theta_{W^H} & 0 & \Theta_{W^N} & 0 & \Theta_\tau & \Theta_{Z^{W,j}} \\
0 & 0 & 0 & 0 & 0 & 0 & W^H & 0 & 0 & 0 & 0 \\
\Pi^{W,H}_K & \Pi^{W,H}_{Q^K} & \Pi^{W,H}_Z & \Pi^{W,H}_{Q^Z} & \Pi^{W,H}_S & \Pi^{W,H}_{W^H} & r^\star & \Pi^{W,H}_{W^N} & 0 & \Pi^{W,H}_\tau & \Pi^{W,H}_{Z^{W,j}} \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & W^N & 0 & 0 \\
\Pi^{W,N}_K & \Pi^{W,N}_{Q^K} & \Pi^{W,N}_Z & \Pi^{W,N}_{Q^Z} & \Pi^{W,N}_S & \Pi^{W,N}_{W^H} & 0 & \Pi^{W,N}_{W^N} & r^\star & \Pi^{W,N}_\tau & \Pi^{W,N}_{Z^{W,j}} \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -\xi_T & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -\xi_Z^j
\end{pmatrix}
\times
\begin{pmatrix} dK(t) \\ dQ^K(t) \\ dZ(t) \\ dQ^Z(t) \\ dS(t) \\ dW^H(t) \\ d\pi^{W,H}(t) \\ dW^N(t) \\ d\pi^{W,N}(t) \\ d\tau(t) \\ dZ^{W,j}(t) \end{pmatrix}. \quad \text{(286)}
$$

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., $K(0) = K_0$, $Z(0) = Z_0$, $S(0) = S_0$, $W^H(0) = W_0^H$, $W^N(0) = W_0^N$, $\tau(0) = \tau_0$, $Z^{W,j}(0) = Z_0^{W,j}$. Convergent solutions toward the stable manifold read:

$$dK(t) = D_1 e^{\nu_1 t} + D_2 e^{\nu_2 t} + D_3 e^{\nu_3 t} + D_4 e^{\nu_4 t} + D_5 e^{\nu_5 t} + \omega_1^{10} D_{10} e^{\nu_{10} t} + \omega_1^{11} D_{11} e^{\nu_{11} t}, \tag{287a}$$

$$dQ^K(t) = \omega_2^1 D_1 e^{\nu_1 t} + \omega_2^2 D_2 e^{\nu_2 t} + \omega_2^3 D_3 e^{\nu_3 t} + \omega_2^4 D_4 e^{\nu_4 t} + \omega_2^5 D_5 e^{\nu_5 t} + \omega_2^{10} D_{10} e^{\nu_{10} t} + \omega_2^{11} D_{11} e^{\nu_{11} t}, \tag{287b}$$

$$dZ(t) = \omega_3^1 D_1 e^{\nu_1 t} + \omega_3^2 D_2 e^{\nu_2 t} + \omega_3^3 D_3 e^{\nu_3 t} + \omega_3^4 D_4 e^{\nu_4 t} + \omega_3^5 D_5 e^{\nu_5 t} + \omega_3^{10} D_{10} e^{\nu_{10} t} + \omega_3^{11} D_{11} e^{\nu_{11} t}, \tag{287c}$$

$$dQ^Z(t) = \omega_4^1 D_1 e^{\nu_1 t} + \omega_4^2 D_2 e^{\nu_2 t} + \omega_4^3 D_3 e^{\nu_3 t} + \omega_4^4 D_4 e^{\nu_4 t} + \omega_4^5 D_5 e^{\nu_5 t} + \omega_4^{10} D_{10} e^{\nu_{10} t} + \omega_4^{11} D_{11} e^{\nu_{11} t}, \tag{287d}$$

$$dS(t) = \omega_5^1 D_1 e^{\nu_1 t} + \omega_5^2 D_2 e^{\nu_2 t} + \omega_5^3 D_3 e^{\nu_3 t} + \omega_5^4 D_4 e^{\nu_4 t} + \omega_5^5 D_5 e^{\nu_5 t} + \omega_5^{10} D_{10} e^{\nu_{10} t} + \omega_5^{11} D_{11} e^{\nu_{11} t}, \tag{287e}$$

$$dW^H(t) = \omega_6^1 D_1 e^{\nu_1 t} + \omega_6^2 D_2 e^{\nu_2 t} + \omega_6^3 D_3 e^{\nu_3 t} + \omega_6^4 D_4 e^{\nu_4 t} + \omega_6^5 D_5 e^{\nu_5 t} + \omega_6^{10} D_{10} e^{\nu_{10} t} + \omega_6^{11} D_{11} e^{\nu_{11} t}, \tag{287f}$$

$$d\pi^{W,H}(t) = \omega_7^1 D_1 e^{\nu_1 t} + \omega_7^2 D_2 e^{\nu_2 t} + \omega_7^3 D_3 e^{\nu_3 t} + \omega_7^4 D_4 e^{\nu_4 t} + \omega_7^5 D_5 e^{\nu_5 t} + \omega_7^{10} D_{10} e^{\nu_{10} t} + \omega_7^{11} D_{11} e^{\nu_{11} t}, \tag{287g}$$

$$dW^N(t) = \omega_8^1 D_1 e^{\nu_1 t} + \omega_8^2 D_2 e^{\nu_2 t} + \omega_8^3 D_3 e^{\nu_3 t} + \omega_8^4 D_4 e^{\nu_4 t} + \omega_8^5 D_5 e^{\nu_5 t} + \omega_8^{10} D_{10} e^{\nu_{10} t} + \omega_8^{11} D_{11} e^{\nu_{11} t}, \tag{287h}$$

$$d\pi^{W,N}(t) = \omega_9^1 D_1 e^{\nu_1 t} + \omega_9^2 D_2 e^{\nu_2 t} + \omega_9^3 D_3 e^{\nu_3 t} + \omega_9^4 D_4 e^{\nu_4 t} + \omega_9^5 D_5 e^{\nu_5 t} + \omega_9^{10} D_{10} e^{\nu_{10} t} + \omega_9^{11} D_{11} e^{\nu_{11} t}, \tag{287i}$$

$$d\tau(t) = D_{10} e^{\nu_{10} t}, \tag{287j}$$

$$dZ^{W,j}(t) = D_{11} e^{\nu_{11} t}, \tag{287k}$$

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., $K_0 - K - \omega_1^{10} D_{10} - \omega_1^{11} D_{11} = D_1 + D_2 + D_3 + D_4 + D_5$, $Z_0 - Z - \omega_3^{10} D_{10} - \omega_3^{11} D_{11} = \omega_3^1 D_1 + \omega_3^2 D_2 + \omega_3^3 D_3 + \omega_3^4 D_4 + \omega_3^5 D_5$, $S_0 - S - \omega_5^{10} D_{10} - \omega_5^{11} D_{11} = \omega_5^1 D_1 + \omega_5^2 D_2 + \omega_5^3 D_3 + \omega_5^4 D_4 + \omega_5^5 D_5$, $W_0^H - W^H - \omega_6^{10} D_{10} - \omega_6^{11} D_{11} = \omega_6^1 D_1 + \omega_6^2 D_2 + \omega_6^3 D_3 + \omega_6^4 D_4 + \omega_6^5 D_5$, $W_0^N - W^N - \omega_8^{10} D_{10} - \omega_8^{11} D_{11} = \omega_8^1 D_1 + \omega_8^2 D_2 + \omega_8^3 D_3 + \omega_8^4 D_4 + \omega_8^5 D_5$, which can be rewritten in a matrix form:

$$\begin{pmatrix} 1 & 1 & 1 & 1 & 1 \\ \omega_3^1 & \omega_3^2 & \omega_3^3 & \omega_3^4 & \omega_3^5 \\ \omega_5^1 & \omega_5^2 & \omega_5^3 & \omega_5^4 & \omega_5^5 \\ \omega_6^1 & \omega_6^2 & \omega_6^3 & \omega_6^4 & \omega_6^5 \\ \omega_8^1 & \omega_8^2 & \omega_8^3 & \omega_8^4 & \omega_8^5 \end{pmatrix} \begin{pmatrix} D_1 \\ D_2 \\ D_3 \\ D_4 \\ D_5 \end{pmatrix} = \begin{pmatrix} K_0 - K - \omega_1^{10} D_{10} - \omega_1^{11} D_{11} \\ Z_0 - Z - \omega_3^{10} D_{10} - \omega_3^{11} D_{11} \\ S_0 - S - \omega_5^{10} D_{10} - \omega_5^{11} D_{11} \\ W_0^H - W^H - \omega_6^{10} D_{10} - \omega_6^{11} D_{11} \\ W_0^N - W^N - \omega_8^{10} D_{10} - \omega_8^{11} D_{11} \end{pmatrix}. \tag{288}$$

where solutions for arbitrary constants depend on initial conditions and eigenvectors. The five equations can be jointly solved for the five 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 (287j)-(287k):

$$\tau(0) - \tau = \tau_0 - \tau = D_{10} = x_T, \tag{289a}$$

$$Z^{W,j}(0) - Z^{W,j} = Z_0^{W,j} - Z^{W,j} = D_{11} = x_Z^j. \tag{289b}$$

To find eigenvectors ω_k^{10}, we solve

$$\begin{pmatrix} \Upsilon_K - \nu_{10} & \Upsilon_{Q^K} & \Upsilon_Z & \Upsilon_{Q^Z} & \Upsilon_S & \Upsilon_{W^H} & \Upsilon_{\pi^{W,H}} & \Upsilon_{W^N} & \Upsilon_{\pi^{W,N}} \\ \Sigma_K & \Sigma_{Q^K} - \nu_{10} & \Sigma_Z & \Sigma_{Q^Z} & \Sigma_S & \Sigma_{W^H} & \Sigma_{\pi^{W,H}} & \Sigma_{W^N} & \Sigma_{\pi^{W,N}} \\ \Pi_K & \Pi_{Q^K} & \Pi_Z - \nu_{10} & \Pi_{Q^Z} & \Pi_S & \Pi_{W^H} & \Pi_{\pi^{W,H}} & \Pi_{W^N} & \Pi_{\pi^{W,N}} \\ \Gamma_K & \Gamma_{Q^K} & \Gamma_Z & \Gamma_{Q^Z} - \nu_{10} & \Gamma_S & \Gamma_{W^H} & \Gamma_{\pi^{W,H}} & \Gamma_{W^N} & \Gamma_{\pi^{W,N}} \\ \Theta_K & \Theta_{Q^K} & \Theta_Z & \Theta_{Q^Z} & \Theta_S - \nu_{10} & \Theta_{W^H} & \Theta_{\pi^{W,H}} & \Theta_{W^N} & \Theta_{\pi^{W,N}} \\ 0 & 0 & 0 & 0 & 0 & -\nu_{10} & W^H & 0 & 0 \\ \Pi_K^{W,H} & \Pi_{Q^K}^{W,H} & \Pi_Z^{W,H} & \Pi_{Q^Z}^{W,H} & \Pi_S^{W,H} & \Pi_{W^H}^{W,H} & \Pi_{\pi^{W,H}}^{W,H} - \nu_{10} & \Pi_{W^N}^{W,H} & Pi_{\pi^{W,N}}^{W,H} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & -\nu_{10} & W^N \\ \Pi_K^{W,N} & \Pi_{Q^K}^{W,N} & \Pi_Z^{W,N} & \Pi_{Q^Z}^{W,N} & \Pi_S^{W,N} & \Pi_{W^H}^{W,N} & \Pi_{\pi^{W,N}}^{W,N} - \nu_{10} & \Pi_{W^N}^{W,N} & \Pi_{\pi^{W,N}}^{W,N} - \nu_{10} \end{pmatrix}$$

$$\times \begin{pmatrix} \omega_1^{10} \\ \omega_2^{10} \\ \omega_3^{10} \\ \omega_4^{10} \\ \omega_5^{10} \\ \omega_6^{10} \\ \omega_7^{10} \\ \omega_8^{10} \\ \omega_9^{10} \end{pmatrix} = \begin{pmatrix} -\Upsilon_\tau \\ -\Sigma_\tau \\ -\Pi_\tau \\ -\Gamma_\tau \\ -\Theta_\tau \\ 0 \\ -\Pi_\tau^{W,H} \\ 0 \\ -\Pi_\tau^{W,N} \end{pmatrix}, \tag{290}$$

and to find eigenvectors ω_k^{11}, we solve:

$$\begin{pmatrix} \Upsilon_K - \nu_{11} & \Upsilon_{Q^K} & \Upsilon_Z & \Upsilon_{Q^Z} & \Upsilon_S & \Upsilon_{W^H} & \Upsilon_{\pi^{W,H}} & \Upsilon_{W^N} & \Upsilon_{\pi^{W,N}} \\ \Sigma_K & \Sigma_{Q^K} - \nu_{11} & \Sigma_Z & \Sigma_{Q^Z} & \Sigma_S & \Sigma_{W^H} & \Sigma_{\pi^{W,H}} & \Sigma_{W^N} & \Sigma_{\pi^{W,N}} \\ \Pi_K & \Pi_{Q^K} & \Pi_Z - \nu_{11} & \Pi_{Q^Z} & \Pi_S & \Pi_{W^H} & \Pi_{\pi^{W,H}} & \Pi_{W^N} & \Pi_{\pi^{W,N}} \\ \Gamma_K & \Gamma_{Q^K} & \Gamma_Z & \Gamma_{Q^Z} - \nu_{11} & \Gamma_S & \Gamma_{W^H} & \Gamma_{\pi^{W,H}} & \Gamma_{W^N} & \Gamma_{\pi^{W,N}} \\ \Theta_K & \Theta_{Q^K} & \Theta_Z & \Theta_{Q^Z} & \Theta_S - \nu_{11} & \Theta_{W^H} & \Theta_{\pi^{W,H}} & \Theta_{W^N} & \Theta_{\pi^{W,N}} \\ 0 & 0 & 0 & 0 & 0 & -\nu_{11} & W^H & 0 & 0 \\ \Pi_K^{W,H} & \Pi_{Q^K}^{W,H} & \Pi_Z^{W,H} & \Pi_{Q^Z}^{W,H} & \Pi_S^{W,H} & \Pi_{W^H}^{W,H} & \Pi_{\pi^{W,H}}^{W,H} - \nu_{11} & \Pi_{W^N}^{W,H} & Pi_{\pi^{W,N}}^{W,H} \\ 0 & 0 & 0 & 0 & 0 & & 0 & -\nu_{11} & W^N \\ \Pi_K^{W,N} & \Pi_{Q^K}^{W,N} & \Pi_Z^{W,N} & \Pi_{Q^Z}^{W,N} & \Pi_S^{W,N} & \Pi_{W^H}^{W,N} & \Pi_{\pi^{W,N}}^{W,N} - \nu_{11} & \Pi_{W^N}^{W,N} & \Pi_{\pi^{W,N}}^{W,N} - \nu_{11} \end{pmatrix}$$

$$\times \begin{pmatrix} \omega_1^{11} \\ \omega_2^{11} \\ \omega_3^{11} \\ \omega_4^{11} \\ \omega_5^{11} \\ \omega_6^{11} \\ \omega_7^{11} \\ \omega_8^{11} \\ \omega_9^{11} \end{pmatrix} = \begin{pmatrix} -\Upsilon_{Z^{W,j}} \\ -\Sigma_{Z^{W,j}} \\ -\Pi_{Z^{W,j}} \\ -\Gamma_{Z^{W,j}} \\ -\Theta_{Z^{W,j}} \\ 0 \\ -\Pi_{Z^{W,j}}^{W,H} \\ 0 \\ -\Pi_{Z^{W,j}}^{W,N} \end{pmatrix}. \tag{291}$$

I Numerical Analysis for the Country-Split Analysis

In section I.1, we show more numerical results when we calibrate the model to the data. In section I.2, we provide more information about the calibration of the model to the data when we consider Shimer [2009] preferences. In section I.3, we provide more details about how we calibrate the model to the data when we consider sub-samples;. In section I.4, we show more numerical results for sub-samples. We contrast the responses estimated empirically with those estimated numerically for a larger set of macroeconomic variables

I.1 More Numerical Results

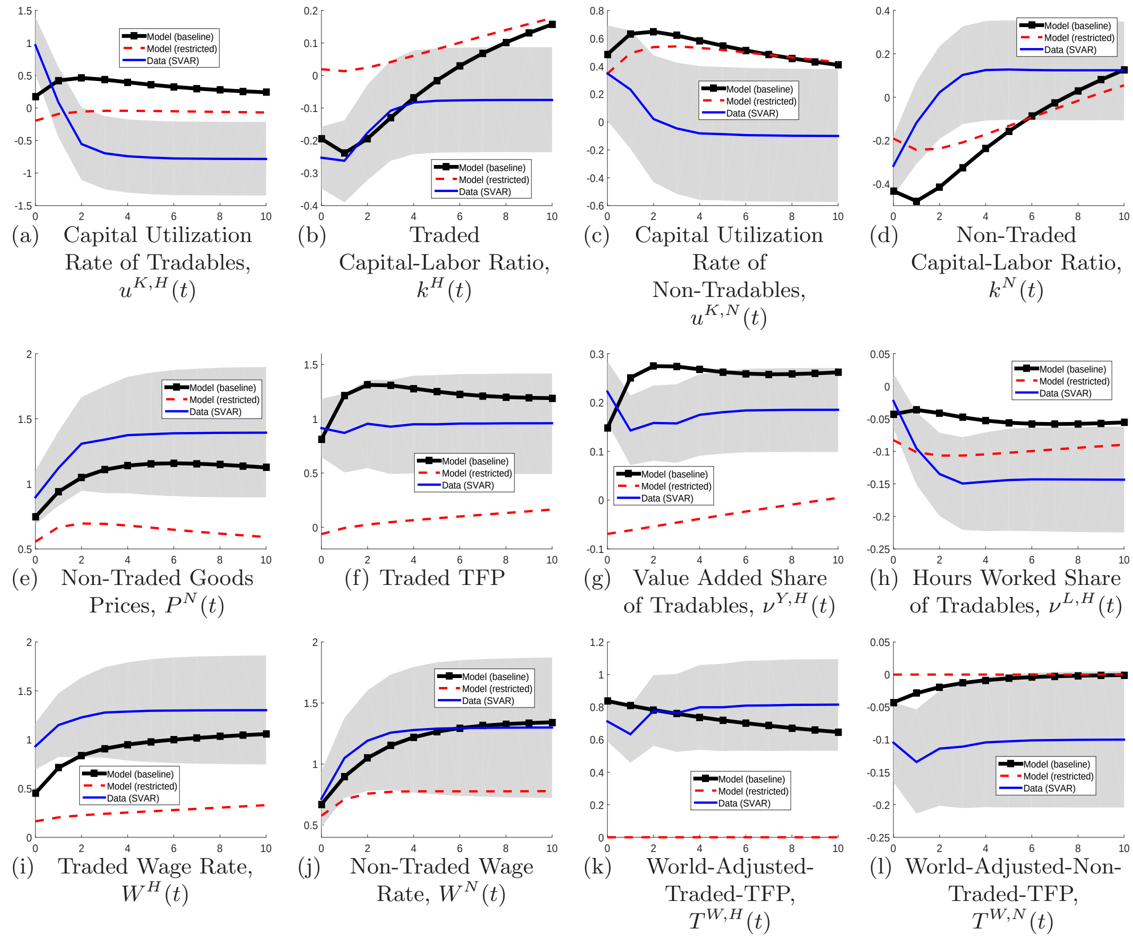
In section 4.2 of the main text, we discuss the impact and long-run effects of a permanent decline in the international CIT index leading the home country to cut its CIT rate by 1 ppt in the long-run. For reasons of space, we restrict tour attention to a limited set of macroeconomic variables. In this subsection, we show the dynamic responses of additional macroeconomic variables to a CIT cut. In addition, in Table 31, we decompose the contribution to technology improvement in the traded sector of international R&D spillovers, endogenous intensity in the use of the stock of knowledge of tradables, and the change in the stock of knowledge of tradables. The last column shows the contribution of the third factors to technology improvements in the traded sector (because they are concentrated within traded industries). On impact, international R&D spillovers account for 47% of technology improvements in tradables while a higher intensity in the use of the stock domestic stock of knowledge accounts for 51%. At time $t = 10$, these two factors contribute 26% and 39%, respectively, while the long-run adjustment of the stock of knowledge contributes 25% to the increase in utilization-adjusted-TFP of tradables over a ten-year horizon.

In section 4.3 of the main text, we contrast the dynamic effects we compute numerically with the dynamic responses we estimate numerically. In Fig. 29, we show more numerical results related to capital utilization rates, $u^{K,j}(t)$, capital-labor ratios, $k^j(t)$, traded and non-traded wage rate, $W^H(t)$ and $W^N(t)$, non-traded goods prices, $P^N(t)$, the value added share of tradables, $\nu^{Y,H}(t)$ and the hours worked share of tradables, $\nu^{L,H}(t)$.

I.2 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:

$$\mathcal{U} = \int_0^\infty \Lambda\left(C(t), S(t), L(t)\right) e^{-\beta t} \mathrm{d}t, \tag{292}$$



(a) Capital Utilization Rate of Tradables, $u^{K,H}(t)$
(b) Traded Capital-Labor Ratio, $k^{H}(t)$
(c) Capital Utilization Rate of Non-Tradables, $u^{K,N}(t)$
(d) Non-Traded Capital-Labor Ratio, $k^{N}(t)$
(e) Non-Traded Goods Prices, $P^{N}(t)$
(f) Traded TFP
(g) Value Added Share of Tradables, $\nu^{Y,H}(t)$
(h) Hours Worked Share of Tradables, $\nu^{L,H}(t)$
(i) Traded Wage Rate, $W^{H}(t)$
(j) Non-Traded Wage Rate, $W^{N}(t)$
(k) World-Adjusted-Traded-TFP, $T^{W,H}(t)$
(l) World-Adjusted-Non-Traded-TFP, $T^{W,N}(t)$

Figure 29: Theoretical vs. Empirical Responses Following a 1 ppt Permanent CIT Cut: More Numerical Results. Notes: The solid blue line displays point estimate from the VAR model with shaded areas indicating 68% confidence bounds; the thick solid black line with squares displays model predictions in the baseline scenario; the dashed red 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 $\nu_Z^{W,j} = 0$).

Table 31: Effects of a Permanent CIT Cut by 1 ppt on Technology: A Decomposition of Impact and Long-Run Effects

	Impact ($t=0$) and Long-run ($t=10$) Theoretical Responses		
	No $u^{Z,j}$ and $\nu_Z^{W,j}=0$	No $u^{Z,j}$	$\chi_2^j<\infty$ and $\nu_Z^{W,j}>0$
	(1)	(2)	(3)
A. Technology $t=0$			
Utilization-Adjusted-Traded-TFP, $dT^H(t)$	0.01	0.36	0.75
Decomposition (in %)			
Contribution $dZ^{W,H}(t)$			47%
Contribution $du^{Z,H}(t)$			51%
Utilization-Adjusted-Aggregate-TFP, $dT^A(t)$	0.01	0.10	0.22
B. Technology $t=10$			
Utilization-Adjusted-Traded-TFP, $dT^H(t)$	0.19	0.48	1.10
Decomposition (in %)			
Contribution $dZ^{W,H}(t)$			26%
Contribution $du^{Z,H}(t)$			39%
Utilization-Adjusted-Aggregate-TFP, $dT^A(t)$	0.07	0.16	0.35

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 and B show the deviation in percentage relative to steady-state for traded and economy-wide utilization-adjusted-TFP. Panel A shows the impact effects at time $t=0$ while panel B show long-run effect at time $t=10$. Column 1 displays the effects when we shut down the technology utilization rate (i.e., we let $\chi_2^j\to\infty$) and we abstract form international R&D spillovers (i.e., we set $\nu_Z^{W,j}=0$). In column 2, we allow for international R&D spillovers (i.e., $\nu_Z^{W,j}>0$) but keep shutting down $u^{Z,j}(t)$. Column 3 shows results for the baseline model when we allow for both international R&D spillovers and an endogenous technology utilization rate (i.e., $\chi_2^j<\infty$).

where we consider the utility specification proposed by Shimer [2009]:

$$\Lambda\left(C,S,L\right)\equiv\frac{\left(CS^{-\gamma_S}\right)^{1-\sigma}V(L)^{\sigma}-1}{1-\sigma},\quad \text{if}\quad \sigma\neq 1,\quad V(L)\equiv\left(1+(\sigma-1)\gamma\frac{\sigma_L}{1+\sigma_L}L^{\frac{1+\sigma_L}{\sigma_L}}\right). \tag{293}$$

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.3 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 32. 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) 17 parameters takes directly from our data or that we estimate empirically, and iii) 9 parameters which are taken from external research works. The first and the third row of the Table 32 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 0.86, 0.16, 0.16, 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 the elasticity of traded technology w.r.t. the domestic (η_Z^H) and international ($\eta_Z^{W,H}$) stock of knowledge to 0.78 and 0.53, respectively; for non-tradables, in accordance with our estimates, we choose $\eta_Z^N = 0.098$ and and $\eta_Z^{W,N} = 0.145$. Note that we compute the country average of our estimates by excluding negative values which are not statistically significant. See section G.5 and G.7 for a detailed description of the empirical strategy to estimates technology's elasticities at a sectoral level. We also set γ_S to 0.9. We choose a higher value than for the baseline calibration because in section C.6, we document evidence indicating that this group of countries displays a significant higher persistence in consumption.

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, 0.12, 0.12, respectively. Other parameters are identical to those set for the representative economy except for η_Z^H and $\eta_Z^{W,H}$ and γ_S; 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 0.02 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: Detailed Description. 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 $L^H/L = 35\%$, a weight of tangible and intangible assets supply to the traded sector of $K^H/K = 40\%$ and $Z^H/Z = 58\%$, 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 $\omega_{G^H} = 86\%$ $(= P^H G^H/G^T)$, and we choose initial conditions so as trade is balanced, i.e., $\upsilon_{NX} = \frac{NX}{P^H Y^H} = 0$ with $NX = P^H X^H - C^F - I^F - G^F$. Because $u^{K,j} = u^{Z,j} = 1$ at the steady-state, four parameters related to capital ξ_1^H, ξ_1^N, and technology, χ_1^H, χ_1^N, adjustment cost functions are set to be equal to $R^{K,H}/P^H$, $R^{K,N}/P^N$, $R^{Z,H}/P^H$, $R^{Z,N}/P^N$, respectively.

Seventeen parameters are assigned values which are taken directly or estimated from our own data. We choose the model period to be one year. In accordance with column 28 of Table 32, 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 32, the shares of labor income in traded and non-traded value added, θ^H and θ^N, are set to 0.615 and 0.676, respectively, which leads to an aggregate LIS of 65%.

Building on our panel data estimates for the elasticity of labor supply across sectors, ϵ_L, we choose a value of 0.86 for this parameter which collapses to the country average of our estimates for the group $N = 7$, see section G.2. We have also estimated the degree of mobility of capital between sectors, ϵ_K, and choose a value of 0.16 which collapses to the country average of our estimates, see section G.3. Due to a lack of data, we cannot estimate the degree of mobility of intangible assets between sectors, ϵ_Z, and choose a value for this parameter which collapses the degree of mobility of physical capital, i.e., $\epsilon_Z = \epsilon_K = 0.16$. 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 0.53, see section G.4.

To determine the 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_Z^j) and the parameter ν_Z^j, i.e., $\gamma^j = \theta_Z^j \nu_Z^j$. By using the fact that $\nu_Z^H = 0.506$, and since $\theta_Z^H = 0.58$, we should set $\eta_Z^H = 0.87$. However, this value is not consistent with the markup μ^H which averages 1.50 for English-speaking and Scandinavian countries because $1 + \theta_Z^H \eta^H > 1.50$. To keep the differential between the markup μ^H and the degree of increasing returns to scale $1 + \theta_Z^H \eta^H$ positive, we set $\nu_Z^H = 0.78$ so that $1 + \theta_Z^H \nu_Z^H = 1.45 < \mu^H = 1.50$. 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 $1 - \theta_Z^H$) and the parameter $\nu_Z^{W,H}$, i.e., $\gamma^{W,H} = \left(1 - \theta_Z^H\right) \nu_Z^{W,H}$. We find an estimated value for the elasticity $\gamma^{W,H}$ of 0.223. By using the fact that $1 - \theta_Z^H = 0.42$, we thus choose a value of 0.53 for $\nu_Z^{W,H}$. When we turn to the non-traded sector, as shown in Table 27, we find that values for the elasticity γ^N and $\gamma^{W,N}$ average 0.062 and 0.053 once we ignore negative values which are not statistically significant. We thus set $\nu_Z^N = 0.098$ and $\eta_Z^{W,N} = 0.145$.

Nine parameters are taken from external research works. These values are identical to those chosen for a representative OECD economy except for the degree of habit persistence in consumption γ_S.

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. (31) 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 0.0045 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. We set the initial value for the CIT rate to the country average for English-speaking and Scandinavian countries, i.e., $\tau = 0.234$. To reproduce the dynamics of the international diffusion of innovation, we choose the same parameters as in the main text except for the long-run increase in the stock of R&D in tradables that we set to 2% instead of 1.6%.

Capital and technology utilization adjustment costs. Like for a representative OECD economy, we choose a value of $\xi_2^N = 0.2$ for the adjustment cost in the capital utilization rate for non-tradables. For tradables, we set $\xi_2^H = 0.4$ We choose a higher value for tradables ξ_2^H to account for the dynamics of $u^{K,H}(t)$ for English-speaking and Scandinavian countries. 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. To account for the dramatic technology improvement in the traded sector, we choose the adjustment cost for the technology utilization rate to be $\chi_2^H = 0.000001$ and assume that the costs of adjustment technology are prohibitive in the non-traded sector, i.e., we set $\chi_2^N = 100000$, because technology does not improve.

Continental European countries: Detailed Description. Parameters including φ, ι, ι_Z, φ^H, ι^H, ϑ_L, ϑ_K, ϑ_Z, δ_K, δ_Z, G, G^N, G^H must be set to target a tradable content of consumption and investment expenditure in tangible and intangible assets of $\alpha_C = 45\%$, $\alpha_J^K = 31\%$, $\alpha_J^Z = 62\%$, 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 $L^H/L = 36\%$, a weight of tangible and intangible assets supply to the traded sector of $K^H/K = 36\%$ and $Z^H/Z = 60\%$, 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 $\omega_{G^H} = 76\%$ $(= P^H G^H/G^T)$, 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.

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 32, the world interest rate, $r^\star$, which is equal to the subjective time

Table 32: 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
	(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	0.86	0.62	0.68	0.35	0.39	0.58
Cont. Europe	0.34	0.45	0.31	0.62	0.05	0.16	0.60	0.38	0.76	0.70	0.67	0.36	0.36	0.60
Sub-sample	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)
Eng. & Scand.	0.53	0.86	0.16	0.78	0.098	0.53	0.145	0.58	0.63	0.21	0.029	0.19	1.50	0.023
Cont. Europe	0.53	1.08	0.12	0.00	0.000	0.14	0.000	0.58	0.63	0.21	0.025	0.21	1.27	0.029

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 home content of government spending in traded goods; columns 10-11 show the labor income shares for tradables and non-tradables. Columns 12-15 display the hours worked share of tradables, the ratio of traded capital stock to the aggregate physical capital stock and the ratio of the stock of R&D of tradables to the aggregate stock of R&D. Columns show elasticities we have estimated empirically. ϕ is the elasticity of substitution between traded and non-traded goods in consumption; ϵ_L is the elasticity of labor supply across sectors; ϵ_K is the elasticity of capital supply across sectors; θ_Z^H (θ_Z^N) is the domestic component of traded (non-traded) technology and ν^H (ν^N) pins down the elasticity of the domestic component of technology w.r.t. the domestic stock of ideas in the traded (non-traded) sector while $\nu_Z^{W,H}$ ($\nu_Z^{W,N}$) 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 Consumption Price Index.

discount rate, β, is set to 2.89Table 32, 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 0.12 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 choose a value for this parameter which collapses the degree of mobility of capital, i.e., $\epsilon_Z = \epsilon_K = 0.12$. We keep ϕ unchanged at 0.53.

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 $\theta^H_Z = 0.58$, our estimates suggest that $\nu^{W,H}_Z = 0.14$. We set $\nu^H_Z = 0.001$ 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 27. For the non-traded sector, we set $\nu^N_Z = \nu^{W,N}_Z = 0.001$ in line with our estimates.

Nine parameters are taken from external research works. These values are identical to those chosen for a representative OECD economy, except for the degree of habit persistence in consumption which is set to $\gamma_S = 0.02$. First, we document evidence in section C.6 which reveals that consumption displays low persistence in continental Europe. When we regress the rate of change of consumption on its past value, the coefficient is not statistically significant. Havranek et al. [2017] report low values for γ_S for European countries. And we need to impose a low value for γ_S to generate the rise in consumption we estimate empirically.

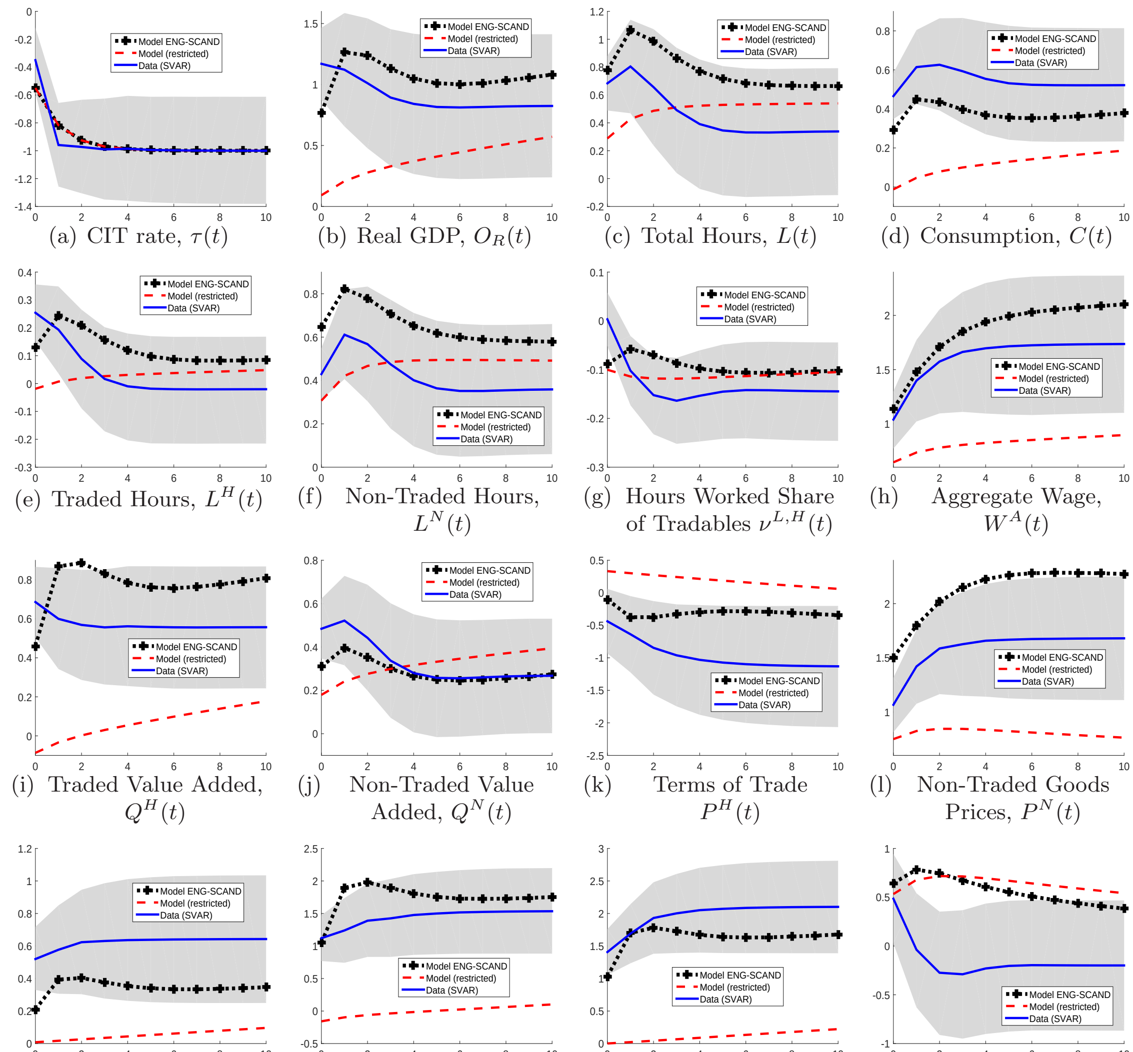
Setting the dynamics for endogenous response of domestic corporate income tax and international R&D spillover. We have to choose values for three parameters in eq. (31) to reproduce the dynamics from the VAR model for $\tau(t)$. First, we normalize the steady-state variation in the domestic corporate income tax rate to 1 percentage point, i.e., $d\tau = -0.01$. We choose a value of 0.00559 for $x_T = d\tau(0) - d\tau$ and a value of 0.5 for ξ_T so as to reproduce the estimated response of τ from the VAR model. We set the initial value for the CIT rate to the country average for continental European countries, i.e., $\tau = 0.209$. To reproduce the dynamics of the international diffusion of innovation, we choose the same parameters as in the main text.

Capital utilization and technology adjustment costs. In contrast to English-speaking and Scandinavian countries, we find that continental European countries increase significantly and persistently the intensity in the use of tangible assets $u^{K,j}(t)$. To account for the responses of $u^{K,H}(t)$ and $u^{K,N}(t)$, we set the adjustment cost in the capital utilization rate, i.e., ξ^j_2. to $\xi^H_2 = \xi^N_2 = 0.08$. For the technology utilization rate, we assume prohibitive adjustments costs and set $\chi^H_2 = \chi^N_2 = 10000$ because technology does not improve in the group of continental European countries after a CIT cut.

I.4 More Numerical Results for Sub-Group of Countries

Dynamic Responses. For reasons of space, in the main text i.e., in Fig. 4, we focus on a restricted set of variables. In this Appendix, we provide more numerical results. Fig. 30 shows numerical results for the group of countries made up of English-speaking and Scandinavian economies. The solid blue line displays point estimate from the VAR model with shaded areas indicating 68% confidence bounds; the thick dotted black line with crosses displays model predictions in the baseline scenario which are contrasted with the dashed red lines which show 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 and we assume that domestic firms are not exposed to foreign technology. Fig. 31 shows numerical results for the group of continental European countries by differentiating the predictions of the flexible wage model and higher habit persistence $\gamma_S = 0.7$ (dashed red lines) from those of the sticky wage model and no habit persistence in consumption $\gamma_S = 0.02$ (black lines with squares).

Impact and Long-Run Effects. To have a sense of the contribution of each ingredient



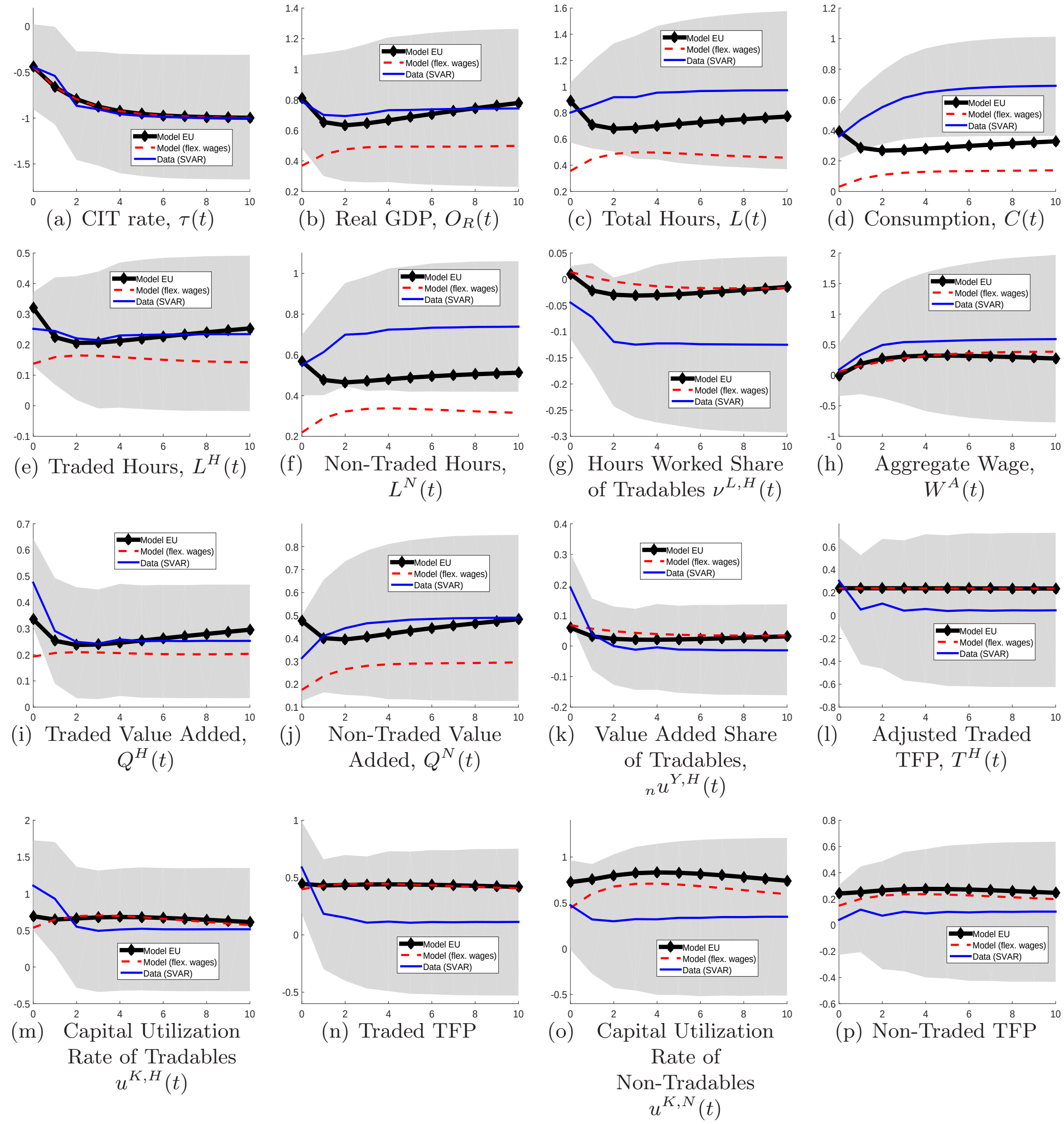
(a) CIT rate, $\tau(t)$ (b) Real GDP, $O_R(t)$ (c) Total Hours, $L(t)$ (d) Consumption, $C(t)$

(e) Traded Hours, $L^H(t)$ (f) Non-Traded Hours, $L^N(t)$ (g) Hours Worked Share of Tradables $\nu^{L,H}(t)$ (h) Aggregate Wage, $W^A(t)$

(i) Traded Value Added, $Q^H(t)$ (j) Non-Traded Value Added, $Q^N(t)$ (k) Terms of Trade $P^H(t)$ (l) Non-Traded Goods Prices, $P^N(t)$

(m) Adjusted Aggregate TFP, $T^A(t)$ (n) Traded TFP, $\text{TFP}^H(t)$ (o) Adjusted Traded TFP, $T^H(t)$ (p) Capital Utilization Rate of Non-Tradables $u^{K,N}(t)$

Figure 30: Theoretical vs. Empirical Responses Following a 1 ppt Permanent CIT Cut in English-speaking and Scandinavian Countries. Notes: Adjusted TFP means utilization-adjusted-TFP. The solid blue line displays point estimate from the VAR model with shaded areas indicating 68% confidence bounds; the thick dotted black line with crosses displays model predictions in the baseline scenario; the dashed red lines show 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 $\nu_Z^{W,j} = 0$).



(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-Traded Hours, $L^N(t)$ (g) Hours Worked Share of Tradables $\nu^{L,H}(t)$ (h) Aggregate Wage, $W^A(t)$

(i) Traded Value Added, $Q^H(t)$ (j) Non-Traded Value Added, $Q^N(t)$ (k) Value Added Share of Tradables, ${}_n u^{Y,H}(t)$ (l) Adjusted Traded TFP, $T^H(t)$

(m) Capital Utilization Rate of Tradables $u^{K,H}(t)$ (n) Traded TFP (o) Capital Utilization Rate of Non-Tradables $u^{K,N}(t)$ (p) Non-Traded TFP

Figure 31: Theoretical vs. Empirical Responses Following a 1 ppt Permanent CIT Cut in continental European Countries. Notes: Adjusted TFP means utilization-adjusted-TFP. The solid blue line displays point estimate from the VAR model with shaded areas indicating 68% confidence bounds; the thick dotted black line with crosses displays model predictions in the baseline scenario; the dashed red lines show the predictions of a restricted version of the baseline model where we allow for flexible wages in both sectors (i.e., we set $\phi_W^j = 0$) and set habit persistence in consumption γ_S to 0.7 which is the value chosen in the baseline calibration.

to the performance of the baseline model when we perform a country-split, we show impact and long-run effects in Table 33 by contrasting the predictions of the baseline model with the predictions of restricted variants. 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 $\gamma_S = 0.02$ 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 33. 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. In Table 34, we decompose the contribution of the accumulation of the stock of knowledge, international R&D spillovers and the technology utilization rate. An endogenous $u^{Z,j}(t)$ contributes 47% to the technology improvement on impact while it accounts for 45% of the increase in utilization-adjusted-TFP in the long-run. International R&D spillovers account for 53% of productivity gains on impact and 29% over a ten-year horizon. The contribution of the increase in the stock of knowledge stands at 13% at $t = 10$.

Hours worked. Despite the fact that technology merely improves in continental European countries, hours worked increase significantly in the data by 0.80% on impact and 0.97% 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 0.65% 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 0.02 dramatically amplifies the rise in hours in the long-run from 0.37% (see column 11) to 0.77%. 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.

Table 33: 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)
Corp. Inc. Tax, $d\tau(t)$	-0.35	-0.55	-1.00	-1.00	-0.44	-0.44	-0.44	-0.44	-1.00	-1.00	-1.00	-1.00
A. Hours												
Total hours, $dL(t)$	0.68	0.78	0.34	0.66	0.80	0.89	0.65	0.36	0.97	0.77	0.37	0.46
Non-traded hours, $dL^N(t)$	0.43	0.65	0.36	0.58	0.55	0.57	0.43	0.22	0.74	0.51	0.34	0.32
B. Technology Improvement												
Adjustd Agg. TFP, $dT^A(t)$	0.52	0.21	0.64	0.35	0.04	0.08	0.09	0.08	0.01	0.08	-0.07	0.08
Adjusted Traded TFP, $dT^H(t)$	1.41	1.03	2.10	1.68	0.30	0.24	0.24	0.24	0.04	0.23	-0.13	0.23
C. Consumption												
Consumption, $dC(t)$	0.47	0.29	0.52	0.38	0.36	0.39	0.20	0.03	0.69	0.33	0.10	0.14

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 0.02.

Table 34: Effects of a Permanent CIT Cut by 1 ppt on Technology: A Decomposition of Impact and Long-Run Effects in English-speaking and Scandinavian Countries

	Impact ($t = 0$) and Long-run ($t = 10$) Theoretical Responses		
	No $u^{Z,j}$ and $\nu_Z^{W,j} = 0$	No $u^{Z,j}$	$\chi_2^j < \infty$ and $\nu_Z^{W,j} > 0$
	(1)	(2)	(3)
A. Technology $t = 0$			
Utilization-Adjusted-Traded-TFP, $dT^H(t)$	0.00	0.55	1.03
Decomposition (in %)			
Contribution $dZ^{W,H}(t)$			53%
Contribution $du^{Z,H}(t)$			47%
Utilization-Adjusted-Aggregate-TFP, $dT^A(t)$	0.01	0.08	0.21
B. Technology $t = 10$			
Utilization-Adjusted-Traded-TFP, $dT^H(t)$	0.22	0.70	1.68
Decomposition (in %)			
Contribution $dZ^{W,H}(t)$			29%
Contribution $du^{Z,H}(t)$			45%
Utilization-Adjusted-Aggregate-TFP, $dT^A(t)$	0.10	0.07	0.35

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 and B show the deviation in percentage relative to steady-state for traded and economy-wide utilization-adjusted-TFP. Panel A shows the impact effects at time $t = 0$ while panel B show long-run effect at time $t = 10$. Column 1 displays the effects when we shut down the technology utilization rate (i.e., we let $\chi_2^j \to \infty$) and we abstract form international R&D spillovers (i.e., we set $\nu_Z^{W,j} = 0$). In column 2, we allow for international R&D spillovers (i.e., $\nu_Z^{W,j} > 0$) but keep on shutting down $u^{Z,j}(t)$. Column 3 shows results for the baseline model when we allow for both international R&D spillovers and an endogenous technology utilization rate (i.e., $\chi_2^j < \infty$).

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