WIFO ■ WORKING PAPERS
664/2023

Production Structure, Tradability and Fiscal Spending Multipliers

Jesús Crespo Cuaresma
Christian Glocker

Production Structure, Tradability and Fiscal Spending Multipliers

Jesús Crespo Cuaresma, Christian Glocker

WIFO Working Papers 664/2023
July 2023

Abstract

We assess the role that nontradable goods play as a determinant of fiscal spending multipliers, making use of a two-sector model. While fiscal multipliers increase with the share of nontradable goods, an inverted U-shaped relationship exists between multiplier size and the import share. Employing an interacted panel VAR model for EU countries, we estimate the effect of the share of nontradable goods on fiscal spending multipliers. Our empirical results provide strong evidence for the predictions of the theoretical model. They imply that the drag of fiscal consolidations is on average smaller in countries with a low share of nontradable goods.

E-mail: jesus.crespo@wifo.ac.at, christian.glocker@wifo.ac.at

2023/1/W/0

Medieninhaber (Verleger), Hersteller: Österreichisches Institut für Wirtschaftsforschung
1030 Wien, Arsenal, Objekt 20 | Tel. (43 1) 798 26 01-0 | https://www.wifo.ac.at
Verlags- und Herstellungsort: Wien

PRODUCTION STRUCTURE, TRADABILITY AND FISCAL SPENDING MULTIPLIERS

JESÚS CRESPO CUARESMA[1,2,3,4,5] AND CHRISTIAN GLOCKER[4]

Abstract. We assess the role that nontradable goods play as a determinant of fiscal spending multipliers, making use of a two-sector model. While fiscal multipliers increase with the share of nontradable goods, an inverted U-shaped relationship exists between multiplier size and the import share. Employing an interacted panel VAR model for EU countries, we estimate the effect of the share of nontradable goods on fiscal spending multipliers. Our empirical results provide strong evidence for the predictions of the theoretical model. They imply that the drag of fiscal consolidations is on average smaller in countries with a low share of nontradable goods.

JEL codes: E23, E62, F41, C23

Keywords: Fiscal spending multiplier, Nontradable goods, Openness, DSGE model, Interacted panel VAR model

[1] *Vienna University of Economics and Business*; Vienna, Austria.
[2] *Wittgenstein Center for Demography and Global Human Capital*; Vienna, Austria.
[3] *International Institute of Applied Systems Analysis*; Laxenburg, Austria.
[4] *Austrian Institute of Economic Research*; Vienna, Austria.
[5] *CESifo*; Munich, Germany.

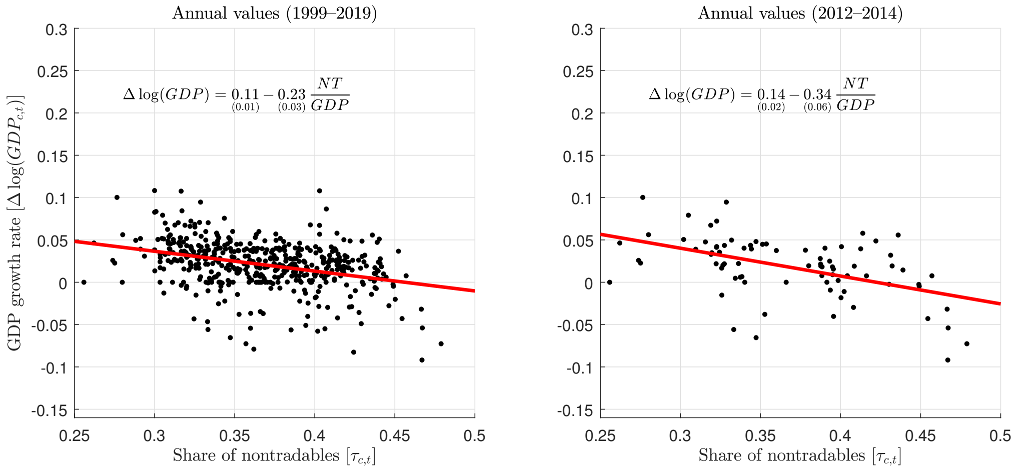
Financial support from the Anniversary Fund (Jubiläumsfonds, project number: 18466) of the Austrian National Bank (Oesterreichische Nationalbank—OeNB) is gratefully acknowledged. The authors would like to thank Josef Baumgartner, Maximilian Böck, Gabriel Felbermayr, Atanas Pekanov, Philipp Piribauer, Nawid Siassi, Pascal Towbin, Thomas Url and participants of the CEU-IHS-WIFO seminar on policy making, of the econ-seminar at the Technical University Vienna (TU Wien), and of the XXIII Conference on International Economics in Málaga, Spain. Excellent research assistance by Astrid Czaloun is gratefully acknowledged. Contact details: J. Crespo Cuaresma: *jcrespo@wu.ac.at*, C. Glocker: *christian.glocker@wifo.ac.at*.
This Version: July 2023.

1. Introduction

The goal of this study is to evaluate the role of the production structure for the size of fiscal spending multipliers. We are motivated in this respect by the experience of the euro zone, whose members pursued austerity programs in the aftermath of the global financial crisis (IMF, 2012, 2013). A remarkable aspect of these programs is the force with which it hit periphery countries, while at the same time almost bypassing core countries. The fact that some countries were hard hit while others less suggests that domestic factors internal to countries played a role. Most interesting in this regards is the observation that the extent of cross-country heterogeneity in the output contraction resembles surprisingly closely the extent of heterogeneity in the production structure (Friesenbichler and Glocker, 2019). This motivates the conjecture that the production structure may matter for the size of fiscal spending multipliers. A direct comparison of the share of nontradable goods to the GDP growth rate as in Figure 1 illustrates this conjecture empirically. While Cardi et al. (2020) find that shocks to government consumption tend to disproportionately affect the nontradable goods producing sector, the question arises as to whether the production structure matters for the overall size of fiscal spending multipliers rather than for particular sectors solely. Yet at an empirical and theoretical level, the systematic exploration on the role of the production structure for the size of fiscal spending multipliers is still vague.

The basic intuition for why the production structure may be an important factor to explain differences in fiscal spending multipliers over time and across countries is simple. Consider a two-sector decomposition of the production structure towards tradable and nontradable goods and services to this purpose. If a country produces mostly nontradables, a fiscal contraction gives rise to a large drop in domestic demand and hence in domestic production. On the other hand, if a country produces mostly tradables, a fiscal contraction implies a drop in domestic demand but is likely to exert only a small negative effect on domestic production. In this case, domestic producers can react to the fall in domestic demand simply by switching to exports and the drop in domestic production can be curbed as foreign demand stabilises the total demand for domestic goods. As a result, fiscal spending multipliers are likely to be higher in countries whose production structure is characterised by a high share of nontradable goods in total production, *ceteris paribus*. This effect is based on the notion that, for the case of nontradable goods, the potential of a compensatory effect by means of international trade is absent. The

FIGURE 1. Share of nontradable goods and GDP growth rates



Note: The sub-plots show the GDP growth rates (annual values) relative to the share of nontradable goods and services (sum of value added of all sectors producing nontradable goods and services relative to total value added) for the period 1999 until 2019 (left-hand side panel) and for the period of the European debt crisis (2012 until 2014, right-hand side panel). The sub-plot to the left omits data points which were classified as outliers (based on the Mahalanobis distance). The sub-plots are accompanied by estimated regression lines and equations, where the values in parenthesis are the standard deviations (based on the Newey–West robust covariance matrix estimator) of the estimated parameters.

production of tradables, in turn, can be very different to domestic demand: if tradable goods production exceeds its domestic demand, the rest can be exported – while when tradable goods production falls short of its domestic demand, imports cover the gap. The crucial structural element in this context is given by the ease with which producers can choose between domestic and foreign markets.

In order to address the question of how the composition of production affects the size of the fiscal multiplier, we consider a simple dynamic stochastic general equilibrium (DSGE) model to formalize our hypothesis and provide predictions that can be validated using data. The model comprises a small open economy set-up which includes a home country consisting of households, firms and a government, as well as a foreign country. The theoretical model implies that openness is determined by two parameters: it depends negatively on the share of nontradables and positively on the import share. Subsequently, two key conclusions in the context of fiscal spending can be drawn: (i) if a higher degree of openness is due to a lower share of nontradables, then fiscal spending multipliers decrease with the degree of openness; and (ii) if a higher degree of openness is due to a higher import share, then the effect of the degree of openness on the size of fiscal spending multipliers is ambiguous.

We evaluate empirically the predictions of our theoretical model using data for EU member states. We employ a Bayesian panel vector autoregressive (VAR) model, where we identify the effects of changes in government spending for different levels of the share of nontradables by means of an interaction term, as proposed by Towbin and Weber (2013). Our empirical findings confirm the implications of our theoretical setting. We find that fiscal spending shocks trigger a negligibly small response in output at low values of the share of nontradables, while the response for a high share of nontradables is significantly different from zero, large and persistent. For environments with a high value of the share of nontradables, fiscal spending shocks explain more than 17 percent in the variation of output, while that figure is below 4 percent for low values of the nontradable share. Furthermore, we find that the response of the trade balance decreases with the share of nontradables. The response is low and insignificant at high values of the share of nontradables, while at low levels the response is negative and highly significant. In addition, we find that the relative price of nontradable goods and services rises in response to an expansionary fiscal spending shock. The size of this response increases with the share of nontradables. All these results are in line with those derived from our theoretical model. We also find that fiscal spending multipliers decrease with the import share. The difference in the output response across low and high values of the import share is sizeable and supports theories of increased import leakage in response to a rise in fiscal spending, with negative fiscal spending multipliers for high values of the import share.

The key policy implication from our study is that the drag of fiscal consolidations is mitigated when the share of nontradable goods and services in total production is low. Conversely, if the intention behind the use of fiscal policy is to stabilize an economy in the wake of a recession, then the policy is likely to be most effective when the share of nontradables is large. From a policy perspective, this implies that the drag of fiscal consolidations is smaller in countries with a low share of nontradable goods, a result that may help to explain why European economies with a high share of nontradable goods experienced by far the largest drop in output in response to the fiscal consolidation in the wake of the European debt crisis.

Literature. Numerous studies have investigated the effect of government spending on output during the last two decades as surveyed by Ramey (2019). Our study is related to various strands of the literature. Most important in this respect are the contributions that focus on the production structure. In this context, Monacelli and Perotti (2008); Bénétrix and Lane (2010) show that an increase in government spending disproportionately benefits the nontradable goods producing sector. In contrast to the authors who restrict their attention to sectoral output or labour effects and thus do not investigate the reallocation effects, Cardi et al. (2020) analyse and rationalize the labour composition effect caused by shocks to government consumption. In a similar vein, Devereux et al. (2019) show that production network structures may play a central role in the propagation of fiscal shocks, particularly when wages are slow to adjust. The majority of contributions studying the impact of government spending on economic activity limits the scope to the analysis of the effect on aggregate demand and its various sub-components.

Our contribution is also related to the studies that focus on the composition of government spending. While most evaluate the role of government consumption and government investment in this respect, a few point towards the significant role of the government spending composition in terms of tradable and nontradable goods. In this respect, Schmitt-Grohé and Uribe (2013) argue that if fiscal policy targets nontraded industries, then a rise in government spending could potentially be an appropriate tool to stabilize output in non-exporting sectors. Cardi et al. (2020) stress that because changes in the sectoral value added and the sectoral share are positively correlated, raising the nontradable content of the government spending shock (or the degree of labour mobility across sectors) increases the fiscal multiplier for nontradables. Most importantly, at an aggregate level, a government spending shock produces a larger fiscal multiplier by targeting the sector that has the highest labour compensation share, which in most cases is the non-traded sector.

When considering a decomposition of the production structure into tradable and nontradable goods producing sectors, the role of openness emerges as a natural counterpart. Hence, the contributions which try to understand the effects of fiscal spending shocks in an open economy setting comprises the third important strand with which our study is related. The contributions in this strand are noticeably more numerous. Lane and Perotti (1998) document that an expansionary fiscal spending shock causes a contraction in exports and a deterioration of the trade balance for a group of OECD countries, especially under flexible exchange rates. Monacelli and Perotti (2010) and Ravn et al. (2012) conclude that an increase in government purchases produces output and consumption increases and a trade balance deterioration and that, in contrast to what would be expected, the fiscal shock also produces a real exchange rate depreciation. Corsetti et al. (2012) and Bénétrix and Lane (2013) document that for European countries a positive shock to government purchases produces an appreciation of the domestic currency. The potential importance of the interactions between fiscal policy and trade openness motivates an assessment of the role of cross-country production chains as a determinant of the size of fiscal spending multipliers, as well as of possible international spillovers of fiscal shocks. In this context, Corsetti and Müller (2007) show that the degree of openness does not alter the effects of government spending on output but affects its impact on private demand. The role of private demand is also emphasized in Born et al. (2013) in the context of the exchange rate regime. Born et al. (2013) find that government expenditure multipliers are significantly larger under fixed exchange rate regimes, reflecting the different response of private demand in the two regimes. Ilzetzki et al. (2013) analyse the determinants of differences in the size of fiscal multipliers across countries and show that, among others, the openness to trade is an important factor explaining the variation observed in fiscal multipliers across economies. More recently, Wierzbowska and Shibamoto (2018) identify net capital inflows and openness to trade as two of the most important determinants of fiscal policy effectiveness, while Cacciatore and Traum (2020) highlight that the domestic effectiveness of fiscal policy can be larger in economies which are more open to trade, irrespective of the trade balance dynamics. Finally, Born et al. (2021) stress the role of asymmetric effects in economies with fixed exchange rates: A fiscal expansion appreciates the real exchange rate but does not stimulate output. A fiscal contraction does not alter the exchange rate, but lowers output.

This overview highlights that even when aspects which are specific to open economies are taken into account, the focus in the literature is limited to demand-side variables such as imports and exports or balance of payments variables, while has been silent on the production structure in most cases. However, the role of the production structure emerges naturally in this context, since the composition of production matters for a country's degree of openness. Hence, it is also likely to play a role for the size of fiscal spending multipliers. We thus focus on structural factors related to the composition of tradable and nontradable goods and services (as opposed to cyclical ones, which tend to be at the centre of the discussion in the existing literature) as determinants of the response of output to fiscal shocks in open economies.

The paper is organized as follows. Section 2 discusses the empirical relationship between the share of nontradables, the degree of openness and the relative price of nontradables. Section 3 presents the theoretical model and derives the implications of variation in the sizes of the share of nontradables for macroeconomic responses to fiscal shocks.

The empirical analysis is carried out in Section 4, which also contains a discussion on the robustness of the results. Finally, Section 5 concludes.

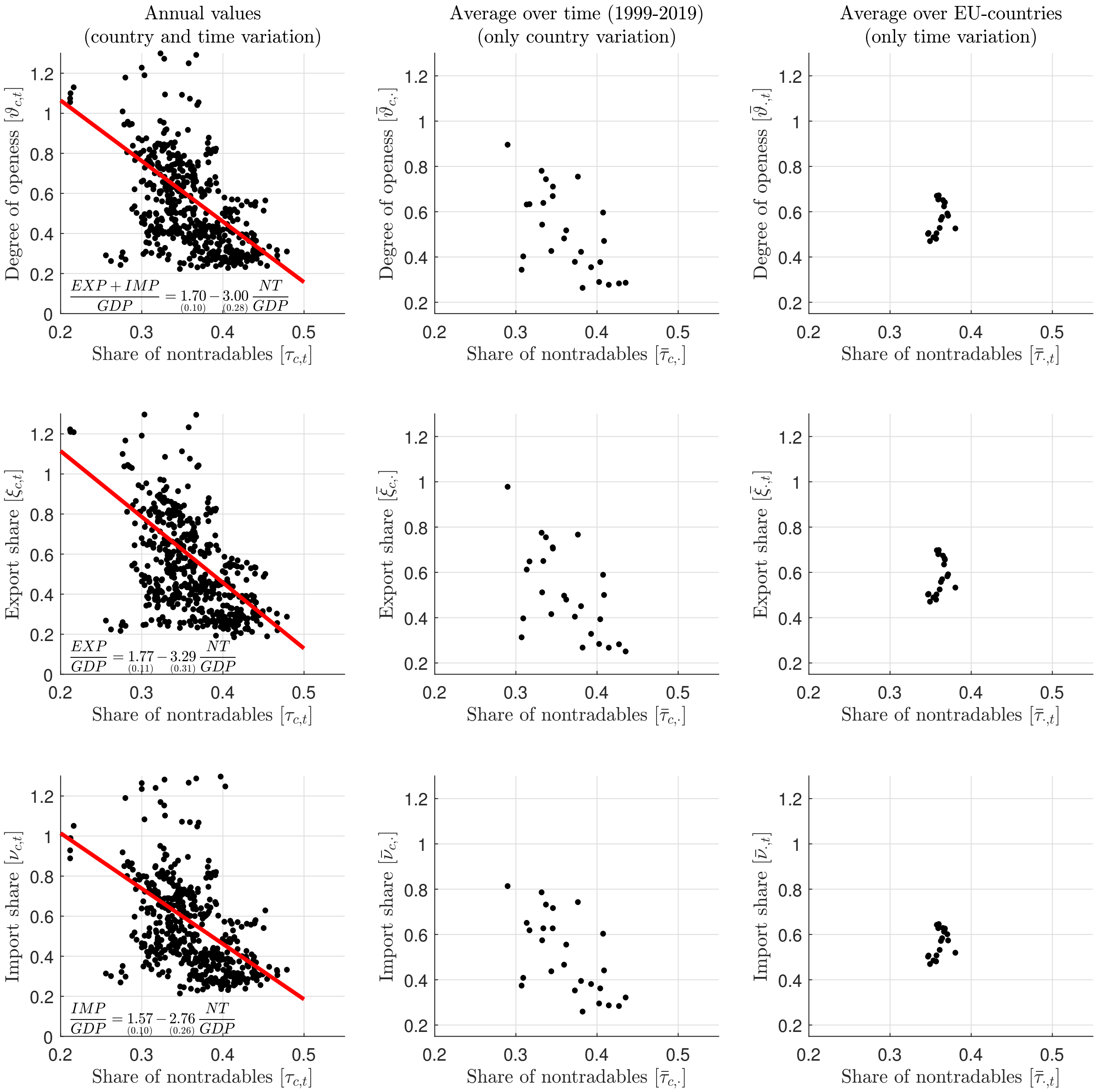
2. Nontradable goods, openness and relative prices – a look at the data

The theoretical literature on the composition of production relies on a neat division of goods and services into *tradables* and *nontradables*. Unfortunately, few real world goods and services fall unambiguously into one of these two categories. Hence, empirical work requires an operationalisation of the concept of tradability. We classify sectors according to their level of tradability making use of the work of Friesenbichler and Glocker (2019). Utilising input-output (IO) data within an approach that allows for changes in the classification of sectors over time, Friesenbichler and Glocker (2019) construct quarterly data for the share of nontradable goods in total production (τ, the value added of nontradable goods producing sectors relative to total value added) for the period ranging from 1999 to 2019.[1] Figure 2 shows the share of nontradable goods for the EU28 countries in relation to different measures of openness: (i) the sum of exports and imports relative to GDP multiplied by one half (ϑ), (ii) the export share (ξ), and (iii) the import share (ν). The sub-plots in the first column display the variation of the share of nontradables relative to different measures of openness for all EU countries and each year in the period 1999 - 2019. The share of nontradables ranges between 0.18 and 0.50 and presents thus far less variation than the degree of openness, which takes values that can be as low as 0.20 but also above unity. A clear negative relation between the share of nontradables and all measures of openness considered can be observed, pointing towards a strong co-movement of these variables and implying that a decrease in the share of nontradables by one percentage point is associated with an average increase in the degree of openness of around 3 percentage points.

Assuming that openness is a function of the share of nontradables, the negative co-movement depicted in Figure 2 allows to establish a function $\vartheta(\tau)$ with $\vartheta'(\tau) < 0$. Intuitively, the degree of openness is restricted by the composition of production: if the production structure of a country is confined exclusively to nontradable goods, its export ability is zero, which in turn naturally limits its degree of openness. However, a high share of tradables $(1 - \tau)$ does not necessarily imply a high export intensity. If a significant amount of tradable goods produced is consumed domestically, the export intensity can be low despite a high share of tradables. If, however, domestic demand for

[1] Further details on the dataset can be found in Section 4.3.

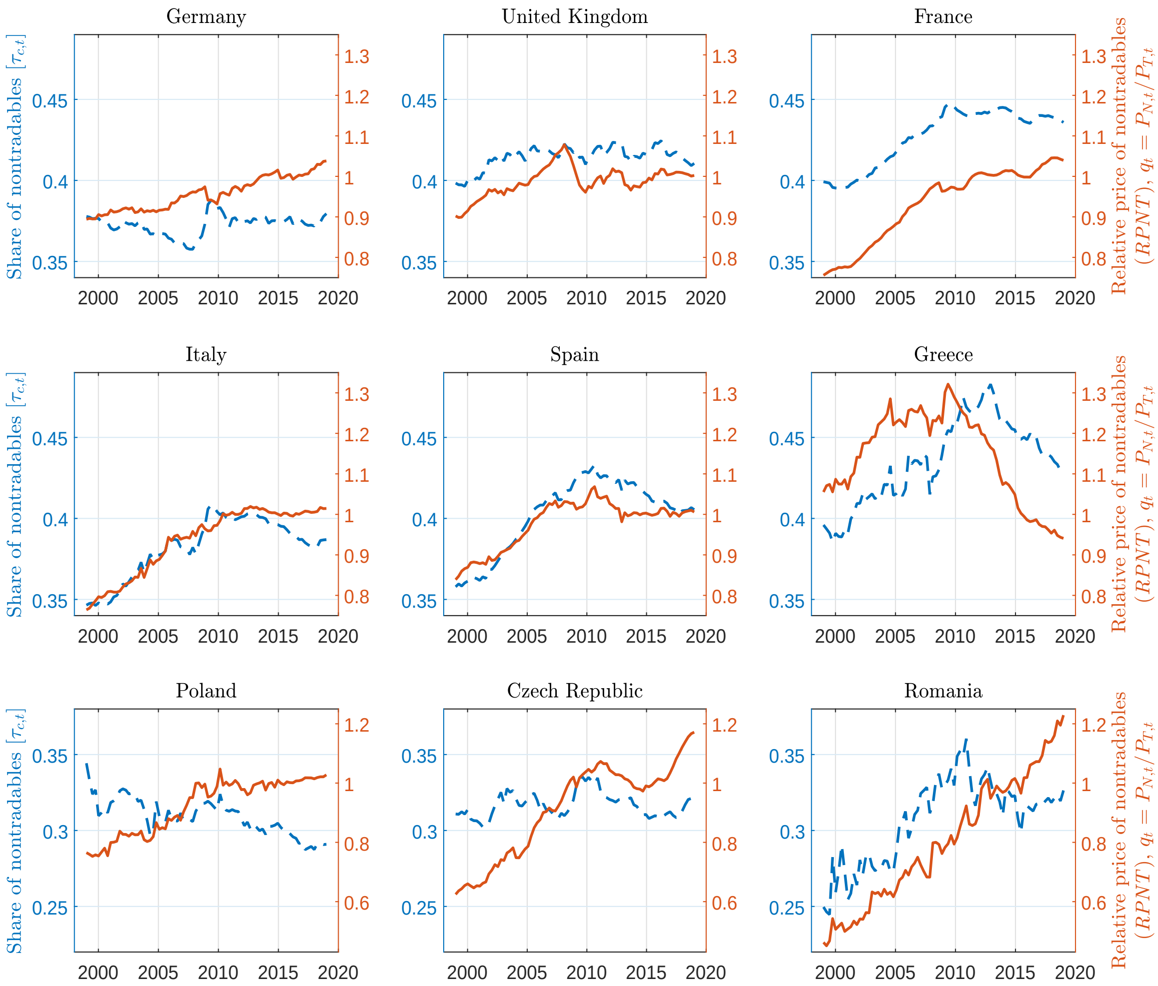
FIGURE 2. Nontradable goods share and degree of openness: EU28



Note: The sub-plots show the share of nontradable goods and services (sum of value added of all sectors producing nontradable goods and services relative to total value added) relative to different measures of openness across the rows. The sub-plots in the first column are accompanied by estimated regression lines and equations, where the values in parenthesis are the standard deviations (based on the Newey–West robust covariance matrix estimator) of the estimated parameters.

tradable goods falls short of supply, the excess supply could be easily provided to foreign markets. This simple assessment highlights the extent to which the share of tradable goods characterises a country's export potential. The sub-plots in the second column show the cross-country variation in the data, and those of the third column their variation over time. The variation over countries is sizeable and mimics the pattern observed in

FIGURE 3. The share of nontradables and their relative price: selected EU countries



Note: The blue dashed line shows the share of nontradable goods and services (left scale) and the orange solid line the relative price (right scale).

the full sample including variation across countries and over time. The variation over time is small in comparison to the cross-sectional variability.

In order to study differential price dynamics across the two classifications of goods and services, we aggregate the sectoral price deflators to obtain aggregate price indices for tradables ($P_{T,t}$) and nontradables ($P_{N,t}$), from which we establish a measure of the relative price of nontradable goods[2] (q_t, $RPNT$) as $q_t = P_{N,t}/P_{T,t}$. We display the relative price of nontradables jointly with the share of nontradables (τ_t) in Figure 3 for (i) Germany, United Kingdom and France, the three largest EU countries (first row), (ii) Italy, Spain and Greece, the three countries most affected by the European debt crisis

[2]Throughout the paper, we use the expression *relative price of nontradables*. It is useful to bear in mind that an increase in this relative price corresponds to a real appreciation.

of 2010-2013 (second row), and (iii) Poland, Czech Republic and Romania, the three largest Central and Eastern European (CEE) countries (third row).

Figure 3 highlights that the relative price of nontradables has increased almost uniformly across the countries depicted over the 1999 to 2019 period. The countries that depart from this pattern are those most affected by the European debt crisis. In particular, Greece experienced a strong decline in the relative price of nontradable goods. Secondly, most countries experienced both an increase in the relative price of nontradables and an increase in the relative size of the nontradable goods producing sector. Both findings are in line with the results put forward in De Gregorio et al. (1994a), where empirical evidence is presented concerning the fact that in the long run, most of the increase in the relative price of nontradables can be explained by the faster increase of total factor productivity in the tradable goods sector, which in turn conforms with the Balassa-Samuelson hypothesis.

This descriptive analysis of the data uncovers significant variation in the share of nontradable goods across EU countries, as well as in the relative price of nontradable goods. Our theoretical model and the empirical exercise concern the extent to which these structural differences shape the effectiveness of fiscal policy. In what follows, we tackle this issue theoretically in Section 3 and provide empirical evidence in Section 4.

3. The theoretical model

In order to gain an understanding of the linkages between the production structure and fiscal multipliers, we employ a DSGE model of a small open economy. The model is comprised by a home economy, consisting of households, firms, a government, and a foreign economy. We follow Sachs and Larrain (1993); Benigno and Thoenissen (2008); Dotsey and Duarte (2008); Schmitt-Grohé et al. (2019); Bussière et al. (2021) and assume that production takes place along two stages: intermediate goods and final goods. Intermediate goods production involves tradable and nontradable goods producers. Final goods producers merge tradable and domestic nontradable goods to a final good which is supplied to domestic households and the government. Households supply labour to firms in the tradable and nontradable sectors. We assume that international asset markets are incomplete, such that only a risk-free bond is traded. Hence, the wealth effect is borne by the home economy, which in turn implies that in response to an expansionary fiscal spending shock, labour input rises by more and the fall in the real wage will be larger than under the case of complete markets (see Corsetti and Müller, 2007; Beetsma and Giuliodori, 2011, for further details). Labour is assumed to be the only factor of production and is immobile across the two economies but mobile across the tradable and nontradable sectors.

3.1. **The production sectors.** There are four types of goods in the economy: (i) tradable (ii) nontradable, (iii) composite-tradable, and (iv) final goods. Final goods are obtained by combining domestic nontradable goods and composite-tradable goods. They are used only for serving domestic final goods demand, which is given by private and public consumption. Final goods are not traded across countries. Nontradable goods enter in the production process for the final goods directly and domestic tradable goods, in turn, enter final goods production only in the form of composite-tradable goods, which consist of domestic and foreign tradable goods. Trade between the two economies takes place exclusively in tradable goods.

3.1.1. *Tradable and nontradable goods producing firms.* Representative firms producing tradable and nontradable goods operate in perfectly competitive markets. They use labour and a sector-specific technology as production factors in a Cobb-Douglas production function. Firms in the nontradable sector produce $y_{N,t}$, which is supplied only to domestic producers of final goods. Firms producing tradable goods serve both domestic and foreign composite-tradable goods producers. They supply $y_{H,t}$ to domestic composite-tradable goods producers and $y^*_{H,t}$ to their foreign counterparts. Hence, the total supply of tradable goods is given by $y_{H,t} + y^*_{H,t}$.

The maximization problem of firms producing nontradable goods is given by $\max_{h_{N,t}} P_{N,t}y_{N,t} - w_t h_{N,t}$, subject to $y_{N,t} = A_N h^{\alpha}_{N,t}$, and for the tradable goods sector it is $\max_{h_{H,t}} P_{H,t}(y_{H,t} + y^*_{H,t}) - w_t h_{H,t}$, subject to $y_{H,t} + y^*_{H,t} = A_H h^{\alpha}_{H,t}$. w_t is the nominal wage rate per hour worked,[3] $h_{N,t}$ and $h_{H,t}$ are the overall hours worked in the two sectors and $P_{N,t}$ and $P_{H,t}$ are the prices of domestic nontradable and tradable goods. A_N and A_H are sector specific technology parameters. The first-order conditions of the respective maximization problems are given by

$$\frac{w_t}{P_{N,t}} = \alpha \frac{y_{N,t}}{h_{N,t}}, \qquad \frac{w_t}{P_{H,t}} = \alpha \frac{y_{H,t} + y^*_{H,t}}{h_{H,t}}. \tag{1}$$

3.1.2. *Composite-tradable and final goods producing firms.* The final good Y_t is produced using composite-tradable goods ($y_{T,t}$) and nontradable goods ($y_{N,t}$) according to the

[3]Since labour is assumed mobile across the two sectors, nominal (w_t) and real (w_t/P_t, where P_t is the price of final goods defined below) wages equalize in both sectors of production.

technology

$$Y_t = \left((1-\tau)^{\frac{1}{\kappa}} y_{T,t}^{\frac{\kappa-1}{\kappa}} + \tau^{\frac{1}{\kappa}} y_{N,t}^{\frac{\kappa-1}{\kappa}} \right)^{\frac{\kappa}{\kappa-1}}, \tag{2}$$

where κ is the elasticity of substitution between composite-tradable and nontradable goods and τ determines the share of nontradable goods used in the production of final goods. Composite-tradable goods are produced using both domestic ($y_{H,t}$) and foreign ($y_{F,t}$) tradable goods according to

$$y_{T,t} = \left((1-\nu)^{\frac{1}{\theta}} y_{H,t}^{\frac{\theta-1}{\theta}} + \nu^{\frac{1}{\theta}} y_{F,t}^{\frac{\theta-1}{\theta}} \right)^{\frac{\theta}{\theta-1}}, \tag{3}$$

where θ is the elasticity of substitution between domestic and foreign tradable goods and ν is the share of foreign tradable goods used in the production of composite-tradable goods. Final goods producers and producers of the composite-tradable goods operate in perfectly competitive markets and maximise their profits according to $\max_{y_{T,t},y_{N,t}} P_t Y_t - P_{T,t} y_{T,t} - P_{N,t} y_{N,t}$ and $\max_{y_{H,t},y_{F,t}} P_{T,t} y_{T,t} - P_{H,t} y_{H,t} - P_{F,t} y_{F,t}$, subject to equations (2) and (3). P_t and $P_{T,t}$ are the prices of final and composite-tradable goods and $P_{F,t}$ is the price of foreign tradable goods in terms of domestic currency units. We assume that the law of one price holds, so that $P_{F,t}$ depends on the price of foreign tradable goods expressed in foreign currency terms (P_F^*) and the nominal exchange rate (S_t): $P_{F,t} = S_t P_F^*$, with P_F^* being exogenous. The solution to the maximisation problem yields the following first order conditions, which characterise the demand functions for the input factors for production

$$y_{N,t} = \tau \left(\frac{P_{N,t}}{P_t} \right)^{-\kappa} Y_t, \tag{4}$$

$$y_{H,t} = (1-\tau)(1-\nu) \left(\frac{P_{H,t}}{P_{T,t}} \right)^{-\theta} \left(\frac{P_{T,t}}{P_t} \right)^{-\kappa} Y_t, \tag{5}$$

$$y_{F,t} = (1-\tau)\nu \left(\frac{P_{F,t}}{P_{T,t}} \right)^{-\theta} \left(\frac{P_{T,t}}{P_t} \right)^{-\kappa} Y_t. \tag{6}$$

The price indices for composite-tradable goods ($P_{T,t}$) and final goods (P_t) in line with the demand system of equations (4) - (6) are given by

$$P_{T,t} = \left((1-\nu) P_{H,t}^{1-\theta} + \nu P_{F,t}^{1-\theta} \right)^{\frac{1}{1-\theta}}, \qquad P_t = \left((1-\tau) P_{T,t}^{1-\kappa} + \tau P_{N,t}^{1-\kappa} \right)^{\frac{1}{1-\kappa}}. \tag{7}$$

3.2. **The household sector.** We consider a household sector that is comprised by a continuum of infinitely lived households. In a given period, households derive utility from consumption C_t and disutility from working by supplying h_t hours. Labour income is given by $w_t h_t$ (expressed in nominal terms) and (following Cardi et al., 2020), the instantaneous utility function is $u(C_t, h_t) = \log(C_t) - \frac{h_t^{1+\phi}}{1+\phi}$. Households can invest their savings in domestic nominal bonds B_t and foreign nominal bonds B_t^*, evaluated at the exchange rate S_t. To ensure stationarity, we assume that acquiring foreign bonds entails a holding cost equal to $\frac{\psi_B^*}{2}\left(\frac{S_t}{P_t}B_t^*\right)^2$. In addition to labour income, households receive gross interest payments on their holdings of domestic bonds, $i_{t-1}B_t$ and foreign bonds, $\bar{\imath}^* B_t^*$, dividends D_t from goods producing firms, and pay lump-sum taxes T_t to the government. The budget constraint is given by

$$
\begin{aligned}
P_t C_t + B_t + S_t B_t^* &= i_{t-1}B_{t-1} + \bar{\imath}^* S_t B_{t-1}^* + P_t(D_t - T_t) + \\
&\quad + w_t h_t - \frac{\psi_B^*}{2} P_t \left(\frac{S_t}{P_t} B_t^*\right)^2 .
\end{aligned} \tag{8}
$$

Households discount utility with a factor of β. They maximise their expected lifetime utility function $E_0 \sum_{t\geq 0} \beta^t u\left(C_t, h_t\right)$, subject to the budget constraint above, which leads to the following optimality conditions

$$1 = \beta E_t \left[\frac{C_t}{C_{t+1}} \frac{i_t}{P_{t+1}/P_t}\right], \tag{9}$$

$$1 + \psi_B^* \frac{S_t}{P_t} B_t^* = \bar{\imath}^* \beta E_t \left[\frac{C_t}{C_{t+1}} \frac{S_{t+1}/P_{t+1}}{S_t/P_t}\right], \tag{10}$$

$$\frac{w_t}{P_t} = h_t^{\phi} C_t, \tag{11}$$

where i_t and $\bar{\imath}^*$ denote gross interest rates on the domestic and foreign one-period bonds, respectively.

3.3. **The foreign economy.** We specify the demand of the foreign economy for tradable goods from the home economy in the form of the following (exogenously given) demand function

$$y_{H,t}^* = \nu^* \left(\frac{P_{H,t}}{S_t P_T^*}\right)^{-\theta^*} Y^*, \tag{12}$$

where θ^* is the elasticity of substitution between tradable goods in the home economy and the foreign economy within the production occurring in the *foreign* economy. Y^* is total final goods demand in the foreign economy and ν^* is the share of tradable goods from the home economy used in production in the foreign economy. Finally, P_T^* is the price index of the equivalent composite-tradable goods in the foreign economy. P_T^* and Y^* are assumed to be constant. From the point of view of the home economy, equation (12) is the export demand function and hence determines $y_{H,t}^*$.

3.4. **Equilibrium.** Labour market clearing gives rise to: $h_t = h_{N,t} + h_{H,t}$. Equilibrium in the goods market implies that the supply of final goods (Y_t) equals final goods demand. The latter arises from demand by households (C_t) and the government (G_t). Using the households' budget constraint, we find the following equilibrium condition for the final goods market

$$Y_t = C_t + G_t + \left[\frac{S_t}{P_t} \left(B_t^* - \bar{\imath}^* B_{t-1}^* - \frac{\psi_B^*}{2} P_t \left(\frac{S_t}{P_t} B_t^* \right)^2 \right) \right], \tag{13}$$

where the government budget constraint implies that $T_t = G_t$, with domestic bonds being in zero net supply. The term in parentheses in equation (13) captures the trade balance.

Finally, the model is closed by defining the balance of payments. The exports of the home economy are given by $P_{H,t} y_{H,t}^*$, and imports are equal to $P_{F,t} y_{F,t}$. Hence, the trade balance is equal to $P_{H,t} y_{H,t}^* - P_{F,t} y_{F,t}$ and the balance of payments identity is then given by

$$S_t \left(B_t^* - \bar{\imath}^* B_{t-1}^* \right) - \frac{\psi_B^*}{2} P_t \left(\frac{S_t}{P_t} B_t^* \right)^2 = P_{H,t} y_{H,t}^* - P_{F,t} y_{F,t}, \tag{14}$$

where, as before, $P_{F,t} = S_t P_F^*$.

3.5. **Solving the model.** We solve and simulate the model using a log-linear approximation around the symmetric steady state. We assume that in the steady state the trade balance is in equilibrium ($P_H y_H^* = P_F y_F$) and that foreign and domestic bonds are in zero net supply. We normalise P_F^*, P_T^* to unity and express all prices relative to P_t, which is used as the numéraire.

Government consumption (G_t) is assumed to satisfy[4] $\log(G_t) \sim N\left(\log\left(\bar{G}\right), \sigma_G^2\right)$ and we assume that the government balances its budget in each period by adjusting lump-sum taxes accordingly.

Since we characterise a nominal model, we need to specify a monetary policy rule. We assume that the monetary authority follows the strategy of setting the inflation of final goods to zero, so that $E_t P_{t+1}/P_t = 0$. We define $\epsilon_t = S_t P^*/P_t$ as the real exchange rate and the terms of trade (tot_t) as the relative price of imported goods, $\text{tot}_t = P_{F,t}/P_{H,t}$. In line with Section 2, we define the relative price of nontradables to tradables by $q_t = P_{N,t}/P_{T,t}$ and, since $P_{T,t}/P_{H,t} = (1-\nu+\nu(P_{F,t}/P_{H,t})^{1-\theta})^{1/(1-\theta)} = g(\text{tot}_t)$

[4]We relax the iid-assumption of government consumption spending shocks in the Online Appendix and observe that the results remain unchanged qualitatively.

with $g'(\cdot) > 0$, we have

$$q_t = \frac{q_{N,t}}{g(\mathrm{tot}_t)}, \tag{15}$$

where $q_{N,t} = P_{N,t}/P_{H,t}$ is the sectoral relative price of domestic goods, that is, a price measure of domestic nontradable goods relative to their tradable counterparts (see Monacelli and Perotti, 2010). We define $P_t/P_{T,t} = (1-\tau+\tau q_t^{1-\kappa})^{1/(1-\kappa)} = h(q_t)$ with $h'(\cdot) > 0$. Given the definition of the real exchange rate, we obtain

$$\epsilon_t \propto \frac{1}{h(q_t)}, \tag{16}$$

where the law of one price has been used and the foreign counterpart of $h(q_t)$ is constant. Hence, equations (15) and (16) identify a direct link between the relative price of nontradables (q_t), the terms of trade (tot_t) and the real exchange rate (ϵ_t). In other words, under the law of one price, movements in the terms of trade and the real exchange rate are proportional to those of the relative price of nontradables.[5]

3.6. **Nontradable goods and the degree of openness.** As Figure 2 shows, a negative relationship between the degree of openness and the share of nontradable goods can be observed in the data of EU countries. We assess to which extent the model is able to replicate this stylized fact by identifying the theoretical link between the degree of openness (ϑ) and the structural parameters of the model, with a particular focus on the behaviour in the steady state. The degree of openness considered in Section 2 can be defined in the model as

$$\vartheta_t = \frac{P_{H,t} y^*_{H,t} + P_{F,t} y_{F,t}}{2 P_t Y_t}. \tag{17}$$

The steady state version of the balance of payments identity given by equation (14) and the demand functions for the input factors for production in equations (4)–(6) give rise to the following equilibrium condition for the degree of openness

$$\vartheta = \nu(1-\tau). \tag{18}$$

Equation (18) identifies the structural parameters that determine the degree of openness: the degree of openness (ϑ) increases with the share of foreign goods used in the domestic production (ν) and decreases with the share of nontradable goods (τ). Since $1-\tau$ captures the share of tradable goods, equation (18) equivalently states that the degree

[5]For more analytical details of the model, see the Online Appendix.

of openness increases with the share of tradable goods. Hence, the model gives clear predictions about the particular way in which the degree of openness is restricted by the composition of production.

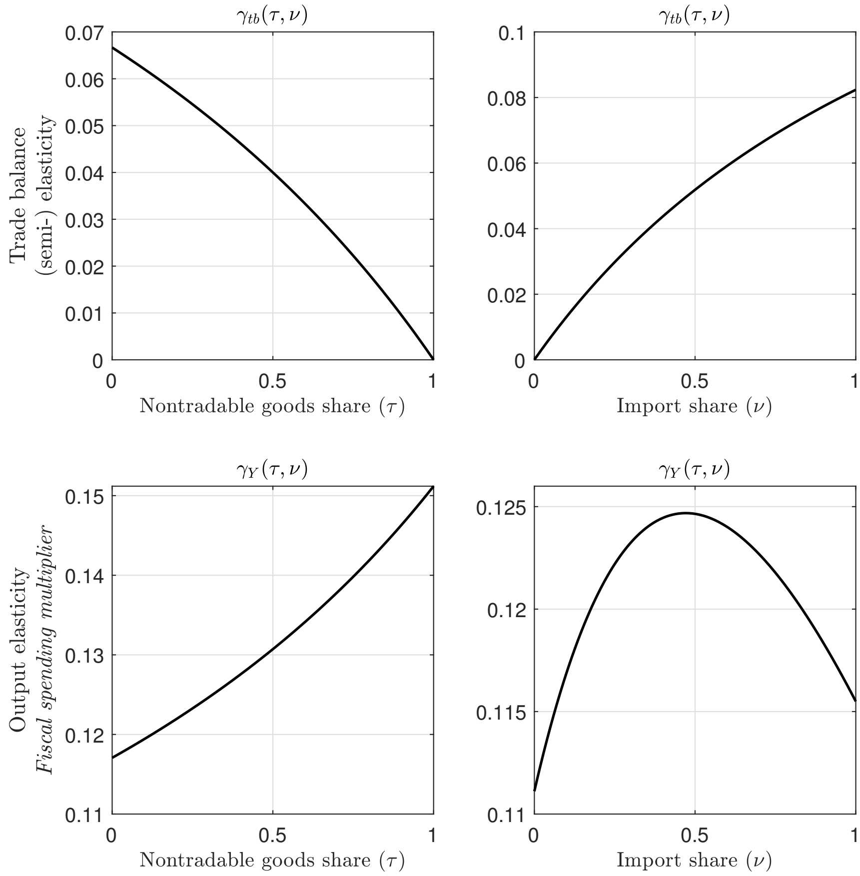
The share of foreign goods used in domestic goods production (ν) characterises the import intensity of an economy. Given the simplicity of our model, this share equals the import share, as only tradable goods are traded across countries, while the final good is not. This has to be kept in mind when interpreting ν as the import share. An increase therein implies a higher degree of openness as implied by equation (18). This parameter has traditionally been considered when studying the role of openness for fiscal spending multipliers (see for instance Corsetti and Müller, 2006, 2007, 2008; Monacelli and Perotti, 2010). Cacciatore and Traum (2020), for instance, use the trade share (the ratio of total trade to GDP) and show that this measure increases monotonically with the import share as implied also by equation (18). A different measure for openness is considered in Alcalá and Ciccone (2004), where a real measure of openness is introduced with the purpose of eliminating distortions due to cross-country differences in the relative price of nontradable goods within a context where the effects of trade are analysed on aggregate productivity.

Since the degree of openness is determined by both the import share and the share of nontradables, we assess the role of both parameters in shaping fiscal spending multipliers. From a theoretical point of view, the import share has been considered as an important determinant for the size of fiscal multipliers. However, the direction of its effect is not clear. On the one hand, trade integration theory predicts a downward trend in the size of government spending multipliers, as higher trade integration should increase the share of the government spending impulse that leaks abroad through higher imports. On the other hand, the appreciation of the terms of trade in response to an expansionary fiscal spending shock causes a positive wealth effect, which increases with the share of imported goods (see Corsetti and Müller, 2006). These opposing effects might explain why empirical studies have failed to identify a statistically significant role for the import share as a determinant of fiscal multipliers (see for instance Glocker et al., 2019).

3.7. **An analytical solution.** The solution of the log-linearized rational expectations DSGE model is given by

$$A_0(\tau,\nu)x_t = A_1(\tau,\nu)x_{t-1} + \Psi_0(\tau,\nu)z_t, \tag{19}$$

FIGURE 4. Influence of τ and ν on the trade balance and output



Note: The sub-plots show the sensitivity of $\gamma_{tb}(\tau,\nu)$ and $\gamma_Y(\tau,\nu)$ for different values of the share of nontradable goods (τ) and the import share (ν). The remaining parameters are fixed at the following values: $c_y = 0.7$, $\kappa = 0.5$, $\lambda = 0.5$; the two sub-plots in the first column consider variation over τ holding ν fixed at 0.5 while the two in the second column show the variation over ν holding τ fixed at 0.3.

where the vector x_t contains the endogenous variables and z_t the exogenous variables, with $z_t = \hat{G}_t$ in our particular case.[6] The matrix A_1 governs the dynamics among the endogenous variables, and the matrices A_0 and Ψ_0 govern the impact of the fiscal spending shock on the endogenous variables. The derivation of a tractable, analytical solution requires that we restrict ourselves to the special case of $\phi = \alpha = \theta^* = 1$, $\theta = \kappa$ and $\psi_B^* \to 0$. In this case, we find that the equilibrium law of motion reduces to $x_t = \Gamma_0(\tau,\nu)\hat{G}_t$ with $\Gamma_0(\tau,\nu) = A_0(\tau,\nu)^{-1}\Psi_0(\tau,\nu)$.[7] The matrix $\Gamma_0(\tau,\nu)$ gives rise to the

[6]Variables with a hat denote the percent deviation from the steady state and those with a tilde denote level deviations.
[7]See the details in the Online Appendix.

following equilibrium law of motion for the trade balance ($\widetilde{tb}_t$) and output ($\hat{Y}_t$)[8]

$$\widetilde{tb}_t = -\gamma_{tb}(\tau,\nu)\hat{G}_t, \qquad \hat{Y}_t = \gamma_Y(\tau,\nu)\hat{G}_t, \tag{20}$$

with $\gamma_{tb}(\tau,\nu) > 0$ and $\gamma_Y(\tau,\nu) > 0$. An intuitive understanding of the working of this model can be gained by considering the negative wealth effect caused by government spending, and in particular the negative Hicksian wealth effect on labour supply. The rise in government consumption raises expected future taxes, which induces a fall in private consumption. In turn, for any given level of the foreign interest rate ($\bar{\imath}^*$), the households' intertemporal first order conditions in equations (9) and (10) require an appreciation of the real exchange rate.[9] Since the Marshall-Lerner condition holds, the exchange rate appreciation brings about a deterioration of the trade balance, which is reinforced by higher import demand arising from the increase in domestic final goods demand.[10] This is captured by $d\widetilde{tb}_t/d\hat{G}_t = -\gamma_{tb}(\tau,\nu) < 0$, which is the (semi-)elasticity of the trade balance to fiscal spending.

In principle, the effect of an increase in fiscal spending on total output is ambiguous. Higher government spending raises output, but the decline in private consumption and the real appreciation (that causes a switch from domestic to foreign goods) both reduce output in the domestic economy. It is easy to see why output would tend to increase: private consumption and leisure are both normal goods, hence they both fall as a result of the negative wealth effect from higher expected taxation. As a consequence, the associated increase in employment raises output and leads to a positive fiscal multiplier.

Both reduced form parameters $\gamma_{tb}(\tau,\nu)$ and $\gamma_Y(\tau,\nu)$ are functions of the underlying structural parameters, and in particular of τ and ν. This allows us to assess the sensitivity of the trade balance and output to fiscal spending shocks with respect to different values of τ and ν. As shown in the Online Appendix, the two reduced form parameters satisfy

$$\frac{\partial\gamma_{tb}(\tau,\nu)}{\partial\tau} < 0, \qquad \frac{\partial\gamma_Y(\tau,\nu)}{\partial\tau} > 0, \tag{21}$$

$$\frac{\partial\gamma_{tb}(\tau,\nu)}{\partial\nu} > 0, \qquad \frac{\partial\gamma_Y(\tau,\nu)}{\partial\nu} \lesseqqgtr 0. \tag{22}$$

3.8. **The role of the share of nontradables and the import share.** The partial derivatives in equation (21) imply that a higher share of nontradables (τ) gives rise to a

[8]In case of $\psi_B^* > 0$, equation (20) characterises the impact response of the trade balance and output to the fiscal spending shock $\hat{G}_t$.

[9]This is shown analytically in the Online Appendix.

[10]The linearized/log-linearized trade balance is given by $\widetilde{tb}_t = \vartheta(\kappa\hat{\epsilon}_t - \hat{Y}_t)$. An exchange rate appreciation (i.e. a fall in $\hat{\epsilon}_t$) and the increase in domestic demand for final goods induce a decline in the trade balance.

lower sensitivity of the trade balance and a higher sensitivity of output to fiscal spending shocks. Fiscal spending multipliers therefore increase with the share of nontradables. The sub-plots in the first column in Figure 4 display the dependency of the reduced form parameters $\gamma_{tb}(\tau, \nu)$ and $\gamma_Y(\tau, \nu)$ on the share of nontradables.

In response to an increase in fiscal spending, the trade balance deteriorates. A higher share of nontradables implies a lower degree of openness, which mitigates the drop in the trade balance ($\partial\gamma_{tb}(\tau, \nu)/\partial\tau < 0$). As the drop in the trade balance decreases with τ, the rise in output hence increases with τ, which explains $\partial\gamma_Y(\tau, \nu)/\partial\tau > 0$.[11]

The intuition is the following.[12] The expansionary fiscal spending policy shock results in a negative wealth effect which triggers a drop in consumption and a rise labour supply. The negative wealth effect is shaped by (1) the terms-of-trade appreciation and (2) the increase in the relative price of nontradable goods. While the terms-of-trade appreciation attenuates the negative wealth effect, the increase in the relative price of nontradables exacerbates the negative wealth effect (since nontradable goods are now more expensive). In this context, τ and ν characterize the relative strength of the terms-of-trade appreciation and the relative price of nontradables on the wealth effect. A high τ results in a low degree of openness θ. As a consequence, the terms-of-trade appreciation has a weaker impact and the negative wealth effect is thus stronger. As a consequence, the drop in consumption and the rise in labour supply are more pronounced. Moreover, a high τ amplifies the impact of the relative price of nontradable goods which also exacerbates the negative wealth effect. Thus, both channels result in a unique effect between τ and the size of the negative wealth effect and hence the fiscal spending multiplier.

How does the model set-up – in particular, the production structure involving three levels (tradable and nontradable goods; composite-tradable goods and final goods) – matter for the previous results? To answer this question, we consider a simpler production structure where the final good (Y) is composed of tradable (y_H) and nontradable (y_N) goods only. This is achieved by setting the share of imported tradable goods used for the production of the composite-tradable good (y_T) equal to zero, which implies that $y_T = y_H$. It follows that $\gamma_Y = \frac{1-c_Y}{1+c_Y} \in (0, 1)$ and $\gamma_{tb} = 0$. Hence, despite a positive output response to a fiscal spending increase, the response is, however, independent of the share of nontradables in this case.

[11] Further simulations and discussions are provided in the Online Appendix.

[12] See also the Online Appendix for further details.

The sign of the partial derivative of the trade balance in equation (22) implies that the sensitivity of the trade balance to fiscal spending shocks increases with the import share (ν). This result is in line with a key finding of Corsetti and Müller (2006), Corsetti and Müller (2007) and Corsetti and Müller (2008), who argue that the effect of spending shocks on the trade balance is smaller if an economy is not very open to trade. The effect on output is, however, ambiguous. The sub-plots in the second column of Figure 4 highlight that there is an inverted U-shaped relationship between $\gamma_Y(\tau, \nu)$ and ν. Hence, a higher import share can either increase or decrease fiscal spending multipliers depending on the level of the import share itself.

A higher import share (ν) implies a weaker drop in consumption due to a wealth effect which arises from the terms of trade appreciation (which increases with ν). In contrast, the deterioration of the trade balance increases with the degree of openness and consequently with ν. Hence, output increases by less, when ν is large. These two opposing effects on output explain the inverted U-shaped pattern between ν and $\gamma_Y(\tau, \nu)$ depicted in Figure 4 and the ambiguous sign of $\partial\gamma_Y(\tau, \nu)/\partial\nu$ in equation (22).

3.9. **Key messages and extensions of the theoretical model.** Summarizing the main messages gained from our theoretical structure, the model predicts that (i) if a higher degree of openness is due to a lower share of nontradable goods, then fiscal spending multipliers decrease with the degree of openness and (ii) if a higher degree of openness is due to a higher import share, then the effect of the degree of openness on the size of fiscal spending multipliers is ambiguous.

We present further simulation results in the Online Appendix, where we provide a robustness check involving a more flexible calibration. Since most contributions in the context of fiscal multipliers utilize a Keynesian framework, we also consider a further extension of the model where we add (i) market power and countercyclical markups, and further extensions involving (ii) limited asset market participation, and, (iii) government consumption spending biased towards nontradables. Across all these extensions, we observe that the qualitative effect of the share of nontradables on the fiscal spending multiplier remains. Further details are provided in the Online Appendix.

4. The econometric model

We validate our theoretical model empirically by examining the conditional response to fiscal spending shocks in a panel of EU economies using an interacted panel vector-autoregressive (IPVAR) specification, as originally motivated[13] by Towbin and Weber (2013). The IPVAR model is employed to assess empirically how the matrices $A_0(\tau,\nu)$, $A_1(\tau,\nu)$, and $\Psi_0(\tau,\nu)$ of the system given by equation (19) depend on the two structural parameters of interest, τ and ν. We consider a first-order approximation of these matrix functions around the sample average of τ and ν, $\bar{\tau}$ and $\bar{\nu}$,

$$A_k(\tau,\nu) \approx A_k(\bar{\tau},\bar{\nu}) + \frac{\partial A_k}{\partial \tau}(\bar{\tau},\bar{\nu})(\tau-\bar{\tau}) + \frac{\partial A_k}{\partial \nu}(\bar{\tau},\bar{\nu})(\nu-\bar{\nu}), \quad \text{for } k \in \{0,1\} \tag{23}$$

and similarly for Ψ_0.

In contrast to the standard panel VAR (PVAR) model, in the IPVAR specification the regressors are not only covariates at various lags but also the interaction terms formed by these and the share of nontradables, as well as the import share. The response coefficients are thus allowed to change deterministically with the characteristics of the economy. In particular, the impulse response functions can be evaluated for varying constellations of τ and ν in order to validate empirically the theoretical results presented in the Online Appendix.

There are two potential limitations to the empirical approach adopted here. First of all, both the share of nontradable goods and the import share may be endogenous to the shocks hitting the economy. De Gregorio et al. (1994a), De Gregorio et al. (1994b) and Micossi and Milesi-Ferretti (1994), however, provide empirical evidence showing that demand shocks (to which fiscal spending contributes) trigger negligibly small changes in the share of nontradables in the short run. This evidence supports the assumption of the share of nontradables being exogenous to changes in government spending. We therefore ignore the possible endogeneity of the share of nontradables (and the import share) in our main specification, but provide an evaluation of its potential importance

[13]A series of recent papers have followed a similar approach, see Sa et al. (2014); Abbritti and Weber (2018); Glocker and Piribauer (2021); Boeck et al. (2022) among others

in the robustness analysis presented in the Online Appendix.[14] A second potential limitation is the linearity assumption embedded in the IPVAR specification used to mimic the approximation in equation (23). In principle, the assumption of linearity could be relaxed by considering various non-linear combinations of ν and τ in the IPVAR model. However, depending on the number of observations and parameters of interest in the estimation, over-fitting of the model becomes a problem in our setting, so we stick to linear specifications with interactions in this piece instead of assessing more complex non-linear parametrizations of the model.[15]

4.1. **Estimation.** We consider the following IPVAR model

$$A_0^c y_{c,t} = \Xi^c \zeta_t + \sum_{k=1}^{K} A_{k,t}^c y_{c,t-k} + \Psi_0^c e_{c,t} \tag{24}$$

where $y_{c,t}$ is a vector of endogenous variables and ζ_t is a vector of exogenous variables with coefficient matrix Ξ^c. K is the number of lags in the model. $e_{c,t}$ is assumed to be a Gaussian random vector of structural disturbances with mean zero and covariance matrix Σ^c. We analyse the role of the share of nontradables and the import share as mediators of the effect of (fiscal) shocks by allowing the coefficients of the A matrices to vary as follows

$$A_{k,t}^c = \bar{A}_k^c + \Lambda_{A,k}^{\tau,c} \tau_{c,t} + \Lambda_{A,k}^{\nu,c} \nu_{c,t} \tag{25}$$

where $k = 1, ..., K$ refers to the lag order and c denotes the countries. The representation corresponding to equation (23) is given by $A_{k,t}^c = A_k(\tau,\nu)$, $\bar{A}_k^c = A_k(\bar{\tau},\bar{\nu}) - (\partial A_k(\tau,\nu)/\partial\tau)\bar{\tau} - (\partial A_k(\tau,\nu)/\partial\nu)\bar{\nu}$, $\Lambda_{A,k}^{\tau,c} = \partial A_k(\tau,\nu)/\partial\tau$, and $\Lambda_{A,k}^{\nu,c} = \partial A_k(\tau,\nu)/\partial\nu$.

The IPVAR model is characterised by equations (24) and (25) (see Towbin and Weber, 2013; Sa et al., 2014, for further details). The representation of the IPVAR model corresponding to the solution of the DSGE model depicted in equations (19) and (25) is straightforward. In our empirical model, the interaction variables (τ_t and ν_t) in equation

[14] The finding is that using the share of nontradable goods as an additional endogenous variable, an increase in government spending by one percent induces an increase in the share of nontradable goods by 0.1 percentage points at the maximum. This reaction is not statistically different from zero even at the 16 percent credible interval (highest posterior density interval, HPDI). Moreover, given that the median of the share of nontradable goods across all EU countries is around 0.36 for the period 1999-2019, this result implies that the share of nontradables would increase to 0.361. This increase is negligibly small from a quantitative point of view. Similarly, we also find a statistically insignificant reaction of the import share.

[15] Such an analysis could be an interesting avenue of further research, eventually making use of shrinkage estimators in the framework of Bayesian VAR models.

(25) capture time variation in the share of nontradables and the import share. The interaction variables influence the dynamic relationship between the endogenous variables via the $\Lambda^{(\tau,\nu)}_{(A),k}$ coefficients. They can also affect the level of the variables via $\bar{A}_k$. In order to preserve degrees of freedom, we assume that the effect of the interaction variables on the intercept and slope coefficients ($\Lambda^{(\tau,\nu)}_{(A),k}$ and $\bar{A}_k$) is homogeneous across countries.[16]

The vector of endogenous variables y_t includes the log of GDP (Y_t) and of government consumption spending (G_t), both in real terms, the trade balance (tb_t), captured by the ratio of exports to imports, and the relative price of nontradable goods (q_t, $RPNT$). The vector of exogenous variables ζ_t includes a constant term and a measure for global real GDP and lags thereof to control for global conditions. We specifically focus on the effects of fiscal spending shocks on GDP, the trade balance and the relative price of nontradables.

All estimations are performed using a lag length of one, as suggested by the BIC. The model is estimated using Bayesian techniques as in Towbin and Weber (2013) and Sa et al. (2014). We use a natural-conjugate prior and draw all parameters jointly from the posterior. We sample 8,000 draws from the posterior distribution. After discarding the first 3,000, we are left with 5,000 draws for each parameter. We report the average responses across all of the countries in our sample. The average coefficient estimates are given by $A_{k,t} = \sum_{c=1}^{N} A^c_{k,t}/N$ for $k = 0, ..., K$ and $N = 28$. We compute impulse response functions using these average estimates and interpret them as responses in a typical EU country. This procedure yields the same regression coefficients as averaging country-by-country estimates, as proposed by Pesaran and Smith (1995).

4.2. **Identification.** We identify fiscal spending shocks by imposing a recursive identification based on the Cholesky decomposition of the reduced-form IPVAR shocks. We follow Beetsma et al. (2006), Crespo Cuaresma et al. (2011) and Capek et al. (2021) and assume that fiscal spending does not react contemporaneously to shocks arising from GDP, the trade balance or the relative price of nontradables in the system. These three variables are hence assumed to respond within the same quarter to the fiscal spending shock. This recursive structure is the most conventional strategy used to identify fiscal spending shocks in the established structural VAR literature.[17] It conforms with the identification approach proposed in Blanchard and Perotti (2002) since only government

[16]A set-up in line with this has also been considered in Towbin and Weber (2013); Sa et al. (2014); Abbritti and Weber (2018).

[17]See for instance the discussion in Capek and Crespo Cuaresma (2020).

spending shocks are considered and no tax shocks. We assess the sensitivity of the results with respect to this particular identification approach in the Online Appendix.

We utilize a recursive identification approach of fiscal spending shocks for two reasons. First, this approach is in line with recent studies that use panel VAR or country VAR methods to analyse the effects of fiscal policy (Beetsma and Giuliodori, 2011; Bénétrix and Lane, 2013; Almunia et al., 2014, to mention a few). Second, alternative identification approaches are too cumbersome to implement in our context. In particular, the event-study approach (Ramey and Shapiro, 1998; Ramey, 2011) has been applied only for the U.S. based on defence spending; this approach would be of limited suitability in our context as defence spending is negligibly small in most EU countries. Finally, the narrative approach (Romer and Romer, 2010; Guajardo et al., 2014) requires the availability of detailed legislative records in order to extract policy shocks.[18] Such approaches would require collecting detailed institutional information and data on fiscal spending plans for 28 countries for a sufficient long time horizon, thus rendering these approaches infeasible in our setting.

One potential drawback in the context of a recursive identification as considered in our case concerns the extent of unpredictability of changes in government spending from the point of view of a statistician. This might stand in contrast to economic agents, who might well have anticipated at least parts of the fiscal shock. One reason for this relates to the persistence between legislation and administration. Legal processes usually cause a time gap between the announcement and the implementation of a policy measure. A statistician, relying on the data a posteriori, would attach the implementation as starting point of the policy, while economic agents might have already reacted to the mere announcement of the policy change. Ignoring this aspect results into a potential underestimation of the effects of fiscal spending shocks. The role played by such anticipation effects is ultimately an empirical question. It abates with the extent of liquidity constrained households, which is indeed an important structural element for several EU countries, and with the share of consumption in GDP. EU countries are generally characterized by a low consumption share as compared to the US economy. Moreover, Mertens and Ravn (2010) highlight that a simple Cholesky decomposition delivers practically correct impulse responses for a large class of theoretical models even if shocks (they

[18]Kraay (2012) describes yet another approach whose applications are essentially limited to developing countries as it relies on two features unique to low-income countries: (1) borrowing from the World Bank and (2) spending on World Bank–financed projects. The resulting spending multipliers are small and reasonably precisely estimated to be in the vicinity of 0.5.

consider permanent spending shocks) were anticipated by the private sector. Not least, Born et al. (2020) that suggest that controlling for anticipation effects via forecast errors typically yields results very similar to recursive schemes. So fiscal foresight seems like more of a theoretical than a practical concern.

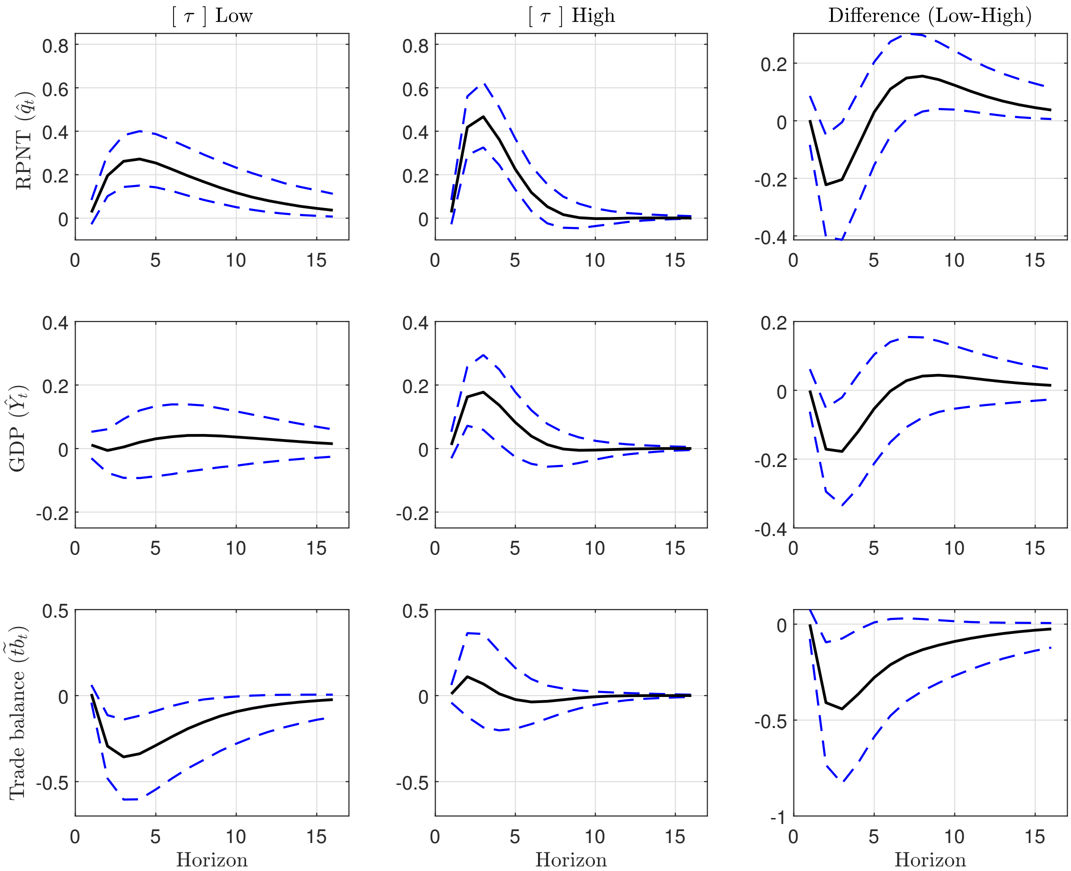
4.3. **Data.** We estimate the IPVAR model using (seasonally-adjusted) quarterly data from 1999Q1 to 2019Q4 for all EU countries (EU28). The data used to construct the quarterly measures for tradable and nontradable goods production, as well as for sectoral price deflators, are from the EUROSTAT database (further details are provided in Friesenbichler and Glocker, 2019). The variable used to identify the fiscal spending shocks at the country level is *Total final consumption expenditure of the general government* at constant prices (ESA 2010-code: P.3_S13), where prices of total final consumption of the general government are used as deflator. Our key variable of interest is output measured by means of *Gross domestic product at constant market prices* (ESA 2010-code: B.1*g), where the GDP deflator is used as price measure. The trade balance is defined as the ratio between exports (*Exports of goods and services at constant prices* (ESA 2010-code: P.6)) to imports (*Imports of goods and services at constant prices* (ESA 2010-code: P.7)). Additionally, we take into account a measure for the terms of trade, which is defined as the ratio of import to export prices and is constructed using the import and export price deflators for goods and services (*Price deflator exports of goods and services*, and *Price deflator imports of goods and services*). The definition of the terms of trade implies that a decrease is an appreciation.

The measure of world GDP (at constant prices and seasonally adjusted) for our global demand measure is sourced from the World Bank (Global Economic Monitor). Additional global variables used in our model are (i) global industrial production, (ii) the VIX index, aimed at capturing global uncertainty and (iii) the Brent oil price.[19]

4.4. **Results.** To address whether interactions with the share of nontradables and the import share affect the dynamics of the endogenous variables in the IPVAR model, we assess the posterior distribution of the impulse response functions (IRFs) at different levels of the interacting covariates and compute forecast error variance decompositions (FEVD). The impulse response functions are computed after fixing one of the interacting variables and varying the other between low and high values which we fix to

[19]Both series are retrieved from Macrobond. The series for global industrial production is from the CPB World Trade Monitor (Industrial Production excluding Construction, Monthly World, Import Weights, Calendar Adjusted, Seasonal Adjusted, Index).

FIGURE 5. Effects of a fiscal spending shock by share of nontradables



Note: The sub-plots in the first column depict IRFs and corresponding 95 percent posterior credible intervals, when the share of nontradable goods has a low level (below the 50th percentile). The sub-plots in the second column depict IRFs and 95 percent posterior credible intervals, when the share of nontradable goods has a high level (above the 50th percentile). The third column shows the difference of the two IRFs and the 95 percent credible interval.

the values of the 20th and 80th percentile of the sample distribution.[20] Specifically, the coefficient matrices for a typical country with a high share of nontradables are $A_{k,t}|_{\tau^{\text{High}}} = \sum_{c=1}^{N} A^c_{k,t}/N + \Lambda^{\tau}_{A,k} \cdot \tau^{\text{High}} + \Lambda^{\nu}_{A,k} \cdot \bar{\nu}$ for $k = 0, ..., K$ where $\bar{\nu}$ refers to the median of the import share observed across all EU28 countries. Analogously, the coefficient matrices for a typical country with a low share of nontradables is $A_{k,t}|_{\tau^{\text{Low}}} = \sum_{c=1}^{N} A^c_{k,t}/N + \Lambda^{\tau}_{A,k} \cdot \tau^{\text{Low}} + \Lambda^{\nu}_{A,k} \cdot \bar{\nu}$ for $k = 0, ..., K$. We proceed in the same fashion when evaluating the role of the import share in shaping the impulse response functions with the share of nontradables in this case held fixed.

[20]A similar approach is used by Towbin and Weber (2013), who consider the median and the 20th and 80th percentile of the sample distributions.

4.4.1. *Impulse response analysis.* Figures 5 and 6 present the impulse responses of GDP, the trade balance, and the relative price of nontradables to the fiscal spending shock for varying degrees of the share of nontradables and the import share. Each figure contains three columns: the first depicts IRFs and 95 percent credible intervals from the posterior when the relevant interaction term has a low level; the second column shows the IRFs when the interaction term has a high level; and the third column shows the difference of the two previous IRFs.[21] This allows to assess whether variations in the interaction terms have a significant impact on the dynamic adjustment to the shock.

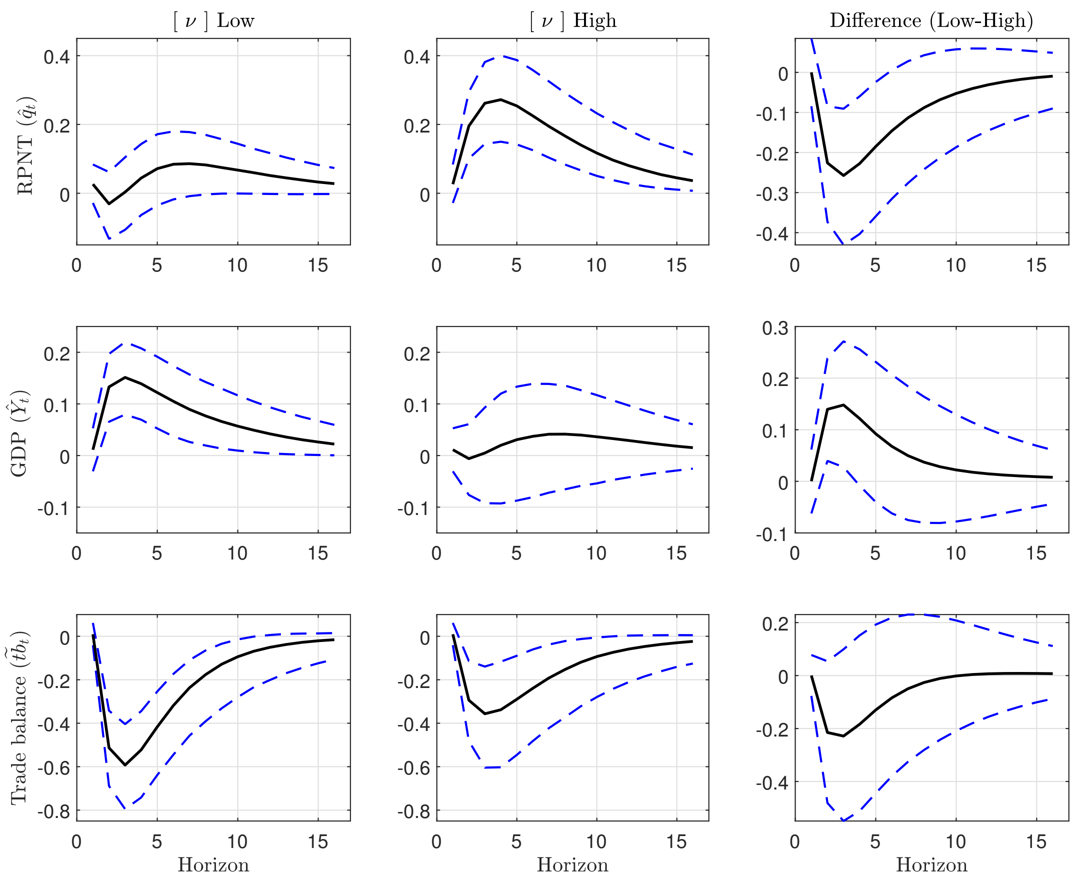
The figures show the effects after a one percent increase in government spending. In line with the implications of the theoretical model in Section 3, the expansionary shock causes a rise in GDP, an increase in the relative price of nontradables and a deterioration of the trade balance. The latter squares well with conventional wisdom and earlier empirical studies, supporting the notion of twin deficits, defined as a conditional positive correlation between budget and trade balance deficits (see for instance Monacelli and Perotti, 2010; Corsetti et al., 2012; Cacciatore and Traum, 2020). The strong reaction of the trade balance gives rise to significant cross-country spillover effects of fiscal spending shocks in the context of EU countries. This contrasts the findings put forth in Faccini et al. (2016), who document evidence in favour of the financial channel rather than the real channel in the case of the US economy. The increase in the relative price of nontradables gives rise to an appreciation. When using the terms of trade or the real effective exchange rate[22] instead, we also find evidence in favour of an appreciation. This is in line with the results documented in studies focusing on European countries such as Corsetti et al. (2012) or Bénétrix and Lane (2013), all of which document a real appreciation in response to expansionary spending shocks for several countries of the European Union.[23]

[21]The IRFs for low and high values of the interaction variable are correlated. We follow Abbritti and Weber (2018) and compute a test statistic using the impulse responses from draws of the posterior parameters. For each of the 5,000 draws, we compute the differences between the response of each variable to a fiscal spending shock under different values for the interaction term of interest. This yields a distribution of the difference between the responses, which can then be used to compute credible intervals. The IRFs for low and high values of a specific interaction variable can be considered statistically different to each other if the credible interval of their difference (shown in the third column) lies above or below zero.

[22]Data for the real effective exchange rate are taken from the database of the Bank for International Settlements (BIS).

[23]Our empirical results align with findings put forth for the US economy. Müller (2008) finds evidence for an appreciation of the terms of trade in response to an increase in government spending. Furthermore, the finding that the relative price of nontradables declines in response to a rise in government spending conforms with the evidence put forth in Monacelli and Perotti (2008).

Figure 6. Effects of a fiscal spending shock by import share



Note: The sub-plots in the first column depict IRFs and corresponding 95 percent posterior credible intervals, when the import share has a low level (below the 50th percentile). The sub-plots in the second column depict IRFs and corresponding 95 percent posterior credible intervals, when the import share has a high level (above the 50th percentile). The third column shows the difference of the two IRFs and the corresponding 95 percent confidence bands.

The size and persistence of the responses, however, differ markedly across different constellations of the share of nontradables and the import share. Considering Figure 5, which shows the role of the share of nontradables, we observe that a low value of the variable implies a modest positive reaction in GDP in response to the fiscal expansion. In contrast, the reaction in GDP is large and significant once the share of nontradables is high. Hence, as indicated by the third column in Figure 5 the difference between these two IRFs is negative and significantly different from zero. As for the trade balances responses, deteriorating in both cases, the reaction is larger once the share of nontradables is low. Finally, the relative price of nontradables rises, with a larger reaction the higher the share of nontradables is. These findings are in line with the predictions of the DSGE model outlined in Section 3.7. Although the theoretical implications merely give rise to a small, though unambiguous effect of the share of nontradables on the IRFs, the IPVAR model indicates sizeable differences.

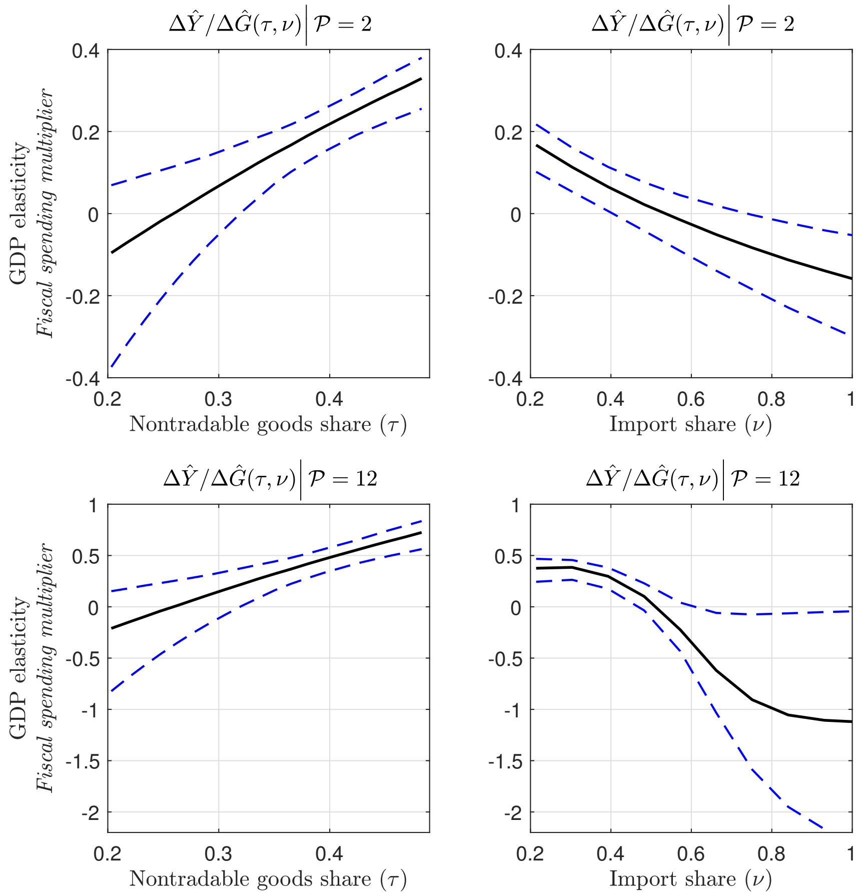
Figure 6 exemplifies the role of the import share in shaping the effects of fiscal spending shocks. As can be seen in the sub-plots of the first row, the reaction in GDP is strongly dependent on the import share, with smaller rises in GDP corresponding to larger shares of imported goods. This is in line with the theoretical implications stated previously and implies that the government spending impulse that leaks abroad through higher imports dominates the positive wealth effect arising from the appreciation of the terms of trade. The difference of the IRFs for low and high values of the import share is sizeable and amounts to nearly 0.15 percentage points. Considering the effects on trade, we observe a deterioration in the trade balance for both low and high values of the import share. The IRFs are significantly different from zero and display a high degree of inertia. While the estimates indicate a statistically significant reaction in the trade balance for both high and low values of the import share, the third column in Figure 6 highlights that the difference is not statistically different from zero. Finally, we find that the reaction of the relative price of nontradables rises with the size of the import share. In particular, when the import share is high, the increase in the relative price of nontradables is significantly different from zero for a comparably long time span. In contrast to that, at low levels of the import share, the relative price does not show any significant reaction. The difference in the IRFs for low and high values of the import share is correspondingly negative. This again conforms with the theoretical predictions and emphasizes the important role of the import share in shaping the responses to fiscal spending shocks.

The choice of values chosen for the interaction variables in the IRFs is to some extent arbitrary. As the impulse response functions of the IPVAR model are functions of τ and ν, we can thus display the fiscal spending multiplier for output over the whole distribution of the share of nontradables and the import share. We do so by considering the following definition of the fiscal spending multiplier

$$\frac{\Delta \hat{Y}}{\Delta \hat{G}}(\tau, \nu) = \frac{\sum_{i=1}^{\mathcal{P}} \mathrm{IRF}_i^{\log Y}(\tau, \nu)}{\sum_{j=1}^{\mathcal{P}} \mathrm{IRF}_j^{\log G}(\tau, \nu)}, \tag{26}$$

where $\mathrm{IRF}_t^{\log Y}(\tau, \nu)$ and $\mathrm{IRF}_t^{\log G}(\tau, \nu)$ denote the impulse response functions of output (Y) and government spending (G) to a fiscal spending shock over the horizon $\mathcal{P}$. We

Figure 7. Influence of τ and ν on the output multiplier



Note: The sub-plots show the sensitivity of the output (GDP) ($\Delta Y/\Delta G(\tau,\nu)$) multiplier for different values of the share of nontradable goods (τ) and the import share (ν) as identified by the IPVAR model. The sub-plots show the median jointly with a 95 percent credible interval.

focus on short run and medium run multipliers[24] and choose $\mathcal{P} = 2$ and $\mathcal{P} = 12$ quarters to this purpose. The results are shown in Figure 7 and can be compared with the fiscal spending multiplier for output of the DSGE model as depicted in Figure 4 and formally given by $d\hat{Y}_t/d\hat{G}_t = \gamma_Y(\tau,\nu)$ as implied by equation (20). The two sub-plots on the left-hand side in Figure 7 show that the output multiplier increases with the share of nontradables in the short and the medium run. The multiplier is significantly different

[24]The fiscal spending multiplier is given by $\gamma_Y(\tau,\nu)$ in equation (20) which is an elasticity and relates the percentage change in output to a percentage change in government spending: $\frac{\Delta\hat{Y}_t}{\Delta\hat{G}_t} = \gamma_Y(\tau,\nu)$, where $\hat{Y}_t$ and $\hat{G}_t$ denote relative deviations in case of the DSGE model and the IPVAR model as of equation (26). Noting that $\hat{Y}_t = \Delta Y_t/Y_{(t)} = \Delta\log(Y_t)$ and $\hat{G}_t = \Delta G_t/G_{(t)} = \Delta\log(G_t)$ gives rise to $\Delta Y_t = \frac{\gamma_Y(\tau,\nu)}{g_y}\cdot\Delta G_t$, where $g_y = Y/G$ is the government spending share in output. The term $\gamma_Y(\tau,\nu)/g_y$ satisfies $\gamma_Y(\tau,\nu)/g_y > \gamma_Y(\tau,\nu)$ and is the most commonly used form of the fiscal spending multiplier as it allows the assess the change in output in response to a change in government spending in monetary units. We, instead, continue working with percentage changes and elasticities for the multiplier, especially since in the course of the panel data set, we find a large heterogeneity of g_y across countries and the choice of g_y is thus arbitrary.

from zero in each case when the share of nontradables is above 0.3. Below this value, fiscal spending shocks do not trigger significant effects on output. For high values of the share of nontradables, the IPVAR model gives rise to a fiscal spending multiplier of around 0.4 in the short and of around 0.7 in the medium run.

The two sub-plots on the right-hand side in Figure 7 display the fiscal spending multiplier as a function of the import share. In the short run, the multiplier is positive and significant for values of the import share below 0.4. Moreover, the multiplier is negative and significant for values of the import share above 0.8. For values of the import share between 0.4 and 0.8, the fiscal spending shocks do not trigger statistically significant effects on output. The medium run multiplier displays a high degree of non-linearity. This conforms with the theoretical evidence provided in Section 3.7 and Figure 4. The multiplier settles at values around 0.4 for low values of the import share and around -1.1 for high values.[25]

Turning to the literature, in a review of 41 studies, Mineshima et al. (2014) found that first-year government spending multipliers – derived from DSGE simulations and SVAR models developed since the early 1990s – in advanced economies range from 0.3 to 1.3 in "normal times." These multipliers represent the change in output (ΔY_t) resulting from a discretionary change in government consumption spending (ΔG_t). To compare these values with our estimates, we need to adjust our estimates by dividing by the average share of government consumption spending in output across EU countries, which is 0.20 (average across EU-28 countries and time, 1999-2019). With a view to Figure 7, the GDP elasticity with respect to government consumption spending at the average (across countries and time) value of the share of non-tradables ($\bar{\tau} = 0.37$) is equal to 0.18; from this we can obtain an average value of the fiscal spending multiplier of $0.18/0.2 = 0.8$. This value is similar in magnitude to those reported by Mineshima et al. (2014); Batini et al. (2014); Guo et al. (2023), among others, for "normal times." Auerbach et al. (2022) document significantly higher values for the COVID-19 recession period.

4.4.2. *Forecast error variance decomposition.* Table 1 reports the results for the forecast error variance decomposition of the IPVAR model along two dimensions: (i) for different horizons (two, four and eight quarters) and (ii) for different values of the share of nontradables and the import share. Fiscal spending shocks explain a low fraction of the

[25]Various robustness checks are provided in the Online Appendix, where we assess the role of other factors that have been found important in shaping the output response to fiscal spending shocks (see Capek and Crespo Cuaresma, 2020, for further details).

Table 1. Forecast error variance decomposition

	GDP		*Trade balance*		*RPNT*	
Horizon	Low	High	Low	High	Low	High
Share of nontradable goods τ						
2	0.3	7.2	3.9	0.9	4.4	20.5
4	1.2	16.1	12.1	2.5	17.0	43.1
8	3.7	17.7	17.9	3.6	28.7	45.3
12	5.1	17.8	19.1	3.7	31.7	45.2
Share of imported goods ν						
2	4.7	0.3	10.1	4.0	0.4	4.4
4	12.1	1.4	19.1	13.3	1.2	17.1
8	16.6	3.8	25.9	19.4	3.4	28.8
12	18.3	4.8	26.4	22.5	4.6	31.2

The values refer to the median of the corresponding posterior distribution of the IPVAR model. *RPNT* refers to the relative price of nontradable goods and *Horizon* is measured in *quarters*. The columns *Low* and *High* refer to values of the interaction terms below and above the 50th percentile of the cross-country distribution in the share of nontradables (τ) and the import share (ν) used for the computation of the forecast error variance decomposition.

variance of GDP when the horizon considered is short and the share of nontradables is low. In contrast, they explain up to 17 percent at horizons of eight quarters when the share of nontradables is high. A different picture emerges when the import share is considered. The importance of fiscal spending shocks in explaining fluctuations in GDP still increases with the horizon but decreases with the import share.

A different pattern arises for the trade balance. While the share of explained variance decreases with the share of nontradable goods, it also decreases with the import share which is at odds with the theoretical model; however, the difference of the FEVD is not (statistically) different from zero.[26] Finally, fiscal spending shocks explain a comparably large fraction of the fluctuations in the relative price of nontradables. For high values of τ, fiscal spending shocks explain up to 45 percent of the fluctuations at the two year horizon, highlighting the role of demand shocks in shaping domestic price dynamics. The high degree of inertia in changing the relative size of the two sectors explains this result. For a significant change in the share of nontradable to tradable goods production to occur, a shift is required in the input factors to production, which takes time. As an

[26]The peculiar response of the trade balance strongly depends on its composition. If only goods exports and imports are used to construct the trade balance, then an expansionary fiscal policy shock causes a stronger reaction in the trade balance when ν is large, which is in line with our theoretical results. Given the fact that for many, especially smaller, EU countries, services imports and services exports are of particular importance, we take them fully into account in our measure of the trade balance.

immediate consequence, the short run effect of the fiscal stimulus is characterised by a significant rise in relative prices of nontradable goods.

4.5. **Discussion.** Our key finding is that countries with a high share of tradable goods production can mitigate the adverse effects of a contraction in domestic demand by switching to increased exports. However, there are barriers to this in terms of administrative procedures, transport costs and the like. In this case, producers may not be able to choose easily between domestic and foreign markets. Selling goods on foreign markets involves different administrative procedures and costs compared to the domestic market. This difference may impede a smooth transition to foreign markets in the event of a contraction in domestic demand. These practical considerations can make it difficult for producers to choose between domestic and export markets. While EU legislation is particularly concerned with removing barriers to trade (especially within the EU), this does not apply to trade with non-EU countries.

In addition to this, in order to expand foreign market presence in response to a contraction in domestic demand, it is crucial that there is a demand for the country's goods abroad - what does a country produce relative to what is demanded abroad? Measures of import-export similarity (Linnemann and Beers, 1988) can potentially provide valuable guidance in identifying the foreign markets to target. These measures offer insights that can facilitate the selection process. However, this remains an empirical question and is beyond the scope of our contribution. Apart from this, the ability of a country to offset a fall in domestic demand by increasing exports depends not only on the goods it produces (tradables versus nontradables), but also on the existence of external demand. When global demand is weak, it becomes much more difficult to offset the decline in domestic demand through an export-led approach.[27]

5. Conclusion

In this contribution, we assess the role of the production structure in shaping fiscal spending multipliers. To this purpose, we decompose the production of goods and services into tradable and nontradable goods and services. Since the concept of tradability is inherently related to the openness of an economy, we also consider the import share

[27]We have ignored the potential increase in risk spreads in response to a debt-financed fiscal expansion, as well as the long-term costs associated with deleveraging - both in the theoretical and the empirical model. While these are aspects that have been important in the context of the European debt crisis, they are likely to mitigate the size of the fiscal expansion, but also the size of the multiplier, leading to a relatively mild overall impact on output; see (Riera-Crichton et al., 2015; Heimberger, 2023).

as an additional mediator between fiscal shocks and output responses. Our two-sector small open economy model highlights that the degree of openness is determined uniquely by the import share and the share of nontradable goods. Considering the response to shocks in fiscal spending, the model delivers two key conclusions: First, if a higher degree of openness is due to a lower share of nontradable goods, fiscal spending multipliers decrease with the degree of openness. Furthermore, if a higher degree of openness is due to a higher import share, then the effect of the degree of openness on the size of fiscal spending multipliers is ambiguous.

We validate the model empirically by means of an interacted panel VAR model which is estimated using data for EU countries. The results provide strong evidence for the fact that fiscal spending multipliers increase with the share of nontradable goods. For high values, the IPVAR model estimates an average short run output multiplier of 0.4. In line with other studies, we find that fiscal spending multipliers decrease with the import share, which conforms with the theory of increased import leakage in response to a rise in fiscal spending.

Overall, our results suggest that the impact of fiscal spending on the economy depends crucially on the share of nontradable goods and services produced, and hence on the structure of production. From a policy perspective, this implies that the drag of a fiscal consolidation is smaller in countries with a low share of nontradables, a result that may help explain why European economies with a high share of nontradables experienced by far the largest output declines in response to the fiscal consolidation in the wake of the European debt crisis. Our contribution thus helps to explain why some EU countries were hit hard by the fiscal consolidation while others were less affected. The key factor is the structure of production, which in turn determines a country's export capacity.

References

Abbritti, Mirko, and Sebastian Weber (2018) 'Reassessing the role of labor market institutions for the business cycle.' *International Journal of Central Banking* 14(1), 1–34

Alcalá, Francisco, and Antonio Ciccone (2004) 'Trade and productivity.' *Quarterly Journal of Economics* 119(2), 613–646

Almunia, Miguel, Agustín Bénétrix, Barry Eichengreen, Kevin H. O'Rourke, and Gisela Rua (2014) 'From great depression to great credit crisis: similarities, differences and lessons.' *Economic Policy* 25(62), 219–265

Auerbach, Alan, Yuriy Gorodnichenko, Peter B. McCrory, and Daniel Murphy (2022) 'Fiscal multipliers in the covid19 recession.' *Journal of International Money and Finance* 126, 102669

Batini, Nicoletta, Luc Eyraud, Lorenzo Forni, and Anke Weber (2014) 'Fiscal multipliers: Size, determinants, and use in macroeconomic projections.' IMF Technical Notes and Manuals 2014/004, International Monetary Fund, October

Beetsma, Roel, and Massimo Giuliodori (2011) 'The effects of government purchases shocks: Review and estimates for the EU.' *Economic Journal* 121(550), 4–32

Beetsma, Roel, Massimo Giuliodori, and Franc Klaassen (2006) 'Trade spill-overs of fiscal policy in the European Union: A panel analysis.' *Economic Policy* 21(48), 639–687

______ (2008) 'The effects of public spending shocks on trade balances in the European Union.' *Journal of the European Economic Association* 6(2-3), 414–423

Bénétrix, Agustín, and Philip Lane (2010) 'Fiscal shocks and the sectoral composition of output.' *Open Economies Review* 21, 335–350

______ (2013) 'Fiscal shocks and the real exchange rate.' *International Journal of Central Banking* 9(3), 6–37

Benigno, Gianluca, and Christoph Thoenissen (2008) 'Consumption and real exchange rates with incomplete markets and non-traded goods.' *Journal of International Money and Finance* 27(6), 926–948

Berka, Martin, Michael B. Devereux, and Charles Engel (2018) 'Real exchange rates and sectoral productivity in the Eurozone.' *American Economic Review* 108(6), 1543–1581

Blanchard, Olivier, and Roberto Perotti (2002) 'An Empirical Characterization of the Dynamic Effects of Changes in Government Spending and Taxes on Output.' *The Quarterly Journal of Economics* 117(4), 1329–1368

Boeck, Maximilian, Jesús Crespo Cuaresma, and Christian Glocker (2022) 'Labor market institutions, fiscal multipliers, and macroeconomic volatility.' CESifo Working Paper Series 9749, CESifo, 4

Born, Benjamin, Falko Juessen, and Gernot J. Müller (2013) 'Exchange rate regimes and fiscal multipliers.' *Journal of Economic Dynamics and Control* 37(2), 446–465

Born, Benjamin, Francesco D'Ascanio, Gernot J. Müller, and Johannes Pfeifer (2021) 'Mr. Keynes Meets the Classics: Government Spending and the Real Exchange Rate.' ifo Working Paper Series 352, ifo Institute - Leibniz Institute for Economic Research at the University of Munich, 3

Born, Benjamin, Gernot J. Müller, and Johannes Pfeifer (2020) 'Does austerity pay off?' *The Review of Economics and Statistics* 102(2), 323–338

Bussière, Matthieu, Aikaterini E. Karadimitropoulou, and Miguel A. León-Ledesma (2021) 'Current account dynamics and the real exchange rate: Disentangling the evidence.' *Macroeconomic Dynamics* 25(1), 28–58

Cacciatore, Matteo, and Nora Traum (2020) 'Trade flows and fiscal multipliers.' NBER Working Papers 27652, National Bureau of Economic Research, Inc, August

Capek, Jan, and Jesús Crespo Cuaresma (2020) 'We just estimated twenty million fiscal multipliers.' *Oxford Bulletin of Economics and Statistics* 82(3), 483–502

Capek, Jan, Jesús Crespo Cuaresma, Johannes Holler, and Philip Schuster (2021) 'Fiscal multipliers in a small open economy: the case of Austria.' *Oxford Bulletin of Economics and Statistics*

Cardi, Olivier, Romain Restout, and Peter Claeys (2020) 'Imperfect mobility of labor across sectors and fiscal transmission.' *Journal of Economic Dynamics and Control* 111(C), 1–35

Corsetti, Giancarlo, and Gernot Müller (2006) 'Twin deficits: squaring theory, evidence and common sense.' *Economic Policy* 21(48), 597–638

______ (2007) 'International dimensions of fiscal policy transmission.' 2007 Meeting Papers 726, Society for Economic Dynamics, January

______ (2008) 'Twin deficits, openness, and the business cycle.' *Journal of the European Economic Association* 6(2-3), 404–413

Corsetti, Giancarlo, André Meier, and Gernot Müller (2012) 'What determines government spending multipliers?' *Economic Policy* 27(72), 521–565

Crespo Cuaresma, Jesús, Markus Eller, and Aaron Mehrotra (2011) 'The economic transmission of fiscal policy shocks from Western to Eastern Europe.' *Focus on European Economic Integration* 1(2), 44–68

De Gregorio, Jose, Alberto Giovannini, and Holger Wolf (1994a) 'International evidence on tradables and nontradables inflation.' *European Economic Review* 38(6), 1225–1244

De Gregorio, Jose, Alberto Giovannini, and Thomas Krueger (1994b) 'The behavior of nontradable-goods prices in Europe: Evidence and interpretation.' *Review of International Economics* 2(3), 284–305

Devereux, Michael, Karine Gente, and Changhua Yu (2019) 'Production network and international fiscal spillovers.' Working Papers halshs-02179890, HAL, June

Dotsey, Michael, and Margarida Duarte (2008) 'Nontraded goods, market segmentation, and exchange rates.' *Journal of Monetary Economics* 55(6), 1129–1142

Faccini, Renato, Haroon Mumtaz, and Paolo Surico (2016) 'International fiscal spillovers.' *Journal of International Economics* 99(C), 31–45

Forni, Mario, and Luca Gambetti (2014) 'Sufficient information in structural VARs.' *Journal of Monetary Economics* 66(C), 124–136

Fragetta, Matteo, and Emanuel Gasteiger (2014) 'Fiscal foresight, limited information and the effects of government spending shocks.' *Oxford Bulletin of Economics and Statistics* 76(5), 667–692

Frenkel, Jacob A., and Assaf Razin (1985) 'Government spending, debt, and international economic interdependence.' *Economic Journal* 95(379), 619–636

Friesenbichler, Klaus S., and Christian Glocker (2019) 'Tradability and productivity growth differentials across EU Member States.' *Structural Change and Economic Dynamics* 50, 1–13

Galí, Jordi, J. David López-Salido, and Javier Vallés (2007) 'Understanding the effects of government spending on consumption.' *Journal of the European Economic Association* 5(1), 227–270

Glocker, Christian, and Pascal Towbin (2015) 'Reserve requirements as a macroprudential instrument - Empirical evidence from Brazil.' *Journal of Macroeconomics* 44(C), 158–176

Glocker, Christian, and Philipp Piribauer (2021) 'Digitalization, retail trade and monetary policy.' *Journal of International Money and Finance* 112, 102340

Glocker, Christian, Giulia Sestieri, and Pascal Towbin (2019) 'Time-varying government spending multipliers in the UK.' *Journal of Macroeconomics* 60(C), 180–197

Guajardo, Jaime, Daniel Leigh, and Andrea Pescatori (2014) 'Expansionary Austerity? International Evidence.' *Journal of the European Economic Association* 12(4), 949–968

Guo, Fei, Isabel Kit-Ming Yan, Tao Chen, and Chun-Tien Hu (2023) 'Fiscal multipliers, monetary efficacy, and hand-to-mouth households.' *Journal of International Money and Finance* 130, 102743

Heimberger, Philipp (2023) 'Public debt and r-g risks in advanced economies: Eurozone versus standalone.' *Journal of International Money and Finance* 136, 102877

Ilzetzki, Ethan, Enrique G. Mendoza, and Carlos A. Végh (2013) 'How big (small?) are fiscal multipliers?' *Journal of Monetary Economics* 60(2), 239–254

IMF (2012) 'Euro Area Policies : Staff Report for the 2012 Article IV Consultation with Member Countries.' Country Report 12/181, International Monetary Fund (IMF), 7

——— (2013) 'Euro Area Policies : 2013 Article IV Consultation.' Country Report 13/231, International Monetary Fund (IMF), 7

Kraay, Aart (2012) 'How large is the Government Spending Multiplier? Evidence from World Bank Lending.' *The Quarterly Journal of Economics* 127(2), 829–887

Lane, Philip R., and Roberto Perotti (1998) 'The trade balance and fiscal policy in the OECD.' *European Economic Review* 42(3-5), 887–895

Linnemann, Hans, and Cees van Beers (1988) 'Measures of export-import similarity, and the Linder hypothesis once again.' *Weltwirtschaftliches Archiv* 124(3), 445–457

Mertens, Karel, and Morten O. Ravn (2010) 'Measuring the impact of fiscal policy in the face of anticipation: A structural VAR approach.' *Economic Journal* 120(544), 393–413

Micossi, Stefano, and Gian Maria Milesi-Ferretti (1994) 'Real exchange rates and the prices of nontradable goods.' IMF Working Papers 94/19, International Monetary Fund, February

Mineshima, Aiko, Marcos Poplawski-Ribeiro, and Anke Weber (2014) 'Size of Fiscal Multipliers.' In *Post-crisis Fiscal Policy,* ed. C. Cottarelli, P. Gerson, and A. Senhadji (The MIT Press)

Monacelli, Tommaso, and Roberto Perotti (2008) 'Openness and the sectoral effects of fiscal policy.' *Journal of the European Economic Association* 6(2-3), 395–403

——— (2010) 'Fiscal policy, the real exchange rate and traded goods.' *Economic Journal* 120(544), 437–461

Müller, Gernot J. (2008) 'Understanding the dynamic effects of government spending on foreign trade.' *Journal of International Money and Finance* 27(3), 345–371

Obstfeld, Maurice, and Kenneth Rogoff (1995) 'Exchange rate dynamics redux.' *Journal of Political Economy* 103(3), 624–660

Pesaran, M. Hashem, and Ron Smith (1995) 'Estimating long-run relationships from dynamic heterogeneous panels.' *Journal of Econometrics* 68(1), 79–113

Ramey, Valerie A. (2011) 'Identifying government spending shocks: It's all in the timing.' *The Quarterly Journal of Economics* 126(1), 1–50

——— (2019) 'Ten years after the financial crisis: What have we learned from the renaissance in fiscal research?' *The Journal of Economic Perspectives* 33(2), 89–114

Ramey, Valerie A., and Matthew D. Shapiro (1998) 'Costly capital reallocation and the effects of government spending.' *Carnegie-Rochester Conference Series on Public Policy* 48(1), 145–194

Ravn, Morten O., Stephanie Schmitt-Grohé, and Martín Uribe (2012) 'Consumption, government spending, and the real exchange rate.' *Journal of Monetary Economics* 59(3), 215–234

Riera-Crichton, Daniel, Carlos A. Vegh, and Guillermo Vuletin (2015) 'Procyclical and countercyclical fiscal multipliers: Evidence from oecd countries.' *Journal of International Money and Finance* 52, 15–31

Romer, Christina D., and David H. Romer (2010) 'The Macroeconomic Effects of Tax Changes: Estimates Based on a New Measure of Fiscal Shocks.' *American Economic Review* 100(3), 763–801

Rotemberg, Julio J. (1982) 'Monopolistic price adjustment and aggregate output.' *Review of Economic Studies* 49(4), 517–531

Sa, Filipa, Pascal Towbin, and Tomasz Wieladek (2014) 'Capital inflows, financial structure and housing booms.' *Journal of the European Economic Association* 12(2), 522–546

Sachs, Jeffrey, and Felipe Larrain (1993) *Macroeconomics in the Global Economy* (Prentice Hall)

Schmitt-Grohé, Stephanie, and Martin Uribe (2013) 'Downward nominal wage rigidity and the case for temporary inflation in the eurozone.' *Journal of Economic Perspectives* 27(3), 193–212

Schmitt-Grohé, Stephanie, and Martín Uribe (2016) 'Downward nominal wage rigidity, currency pegs, and involuntary unemployment.' *Journal of Political Economy* 124(5), 1466–1514

Schmitt-Grohé, Stephanie, Martín Uribe, and Michael Woodford (2019) *International macroeconomics* Textbook Manuscript (Columbia University)

Towbin, Pascal, and Sebastian Weber (2013) 'Limits of floating exchange rates: The role of foreign currency debt and import structure.' *Journal of Development Economics* 101(C), 179–194

Wierzbowska, Agata, and Masahiko Shibamoto (2018) 'Cross-country evidence on determinants of fiscal policy effectiveness: The role of trade and capital flows.' *Applied Economics* 50(32), 3493–3514

Appendix A. Details and extensions of the theoretical model

The following sections provide further details on the theoretical model. These concern the equations describing the equilibrium, details on the model solution, evaluations based on a more general calibration and extensions involving nominal rigidities, government consumption biased towards nontradables and limited asset market participation.

A.1. **Log-linearised equations.** The following equations describe the equilibrium of the model in log-linearised form as referred to in the main text. Variables with a hat denote the percent deviation from the steady state and those with a tilde denote level deviations. Let $\bar{x}$ be the steady state value of some variable x_t, then the two notations are linked as follows: $\tilde{x}_t = \bar{x} \cdot \hat{x}_t$ with $\hat{x}_t = dx_t/\bar{x}$. The price index for final goods (P_t) is used as numéraire. For relative prices ($P_{T,t}/P_t$, $P_{H,t}/P_t$, $P_{N,t}/P_t$, w_t/P_t, S_t/P_t and $P_{N,t}/P_{T,t}$) the log-deviation is the same as the absolute deviation (denoted by $\pi_{T,t}$, $\pi_{H,t}$, $\pi_{N,t}$, ω_t, ϵ_t, and q_t), since the steady state value is set to unity.

Production

- Tradable and nontradable goods production

$$\hat{y}_{N,t} = \alpha \hat{h}_{N,t}, \quad (1-\nu)\hat{y}_{H,t} + \nu \hat{y}^*_{H,t} = \alpha \hat{h}_{H,t},$$

  where $y_H/(y_H + y^*_H) = 1 - \nu$ as implied by the demand functions put forth in the main text.

- Labour demand

$$\begin{aligned} \omega_t - \pi_{N,t} &= \hat{y}_{N,t} - \hat{h}_{N,t}, \\ \omega_t - \pi_{H,t} &= (1-\nu)\hat{y}_{H,t} + \nu \hat{y}^*_{H,t} - \hat{h}_{H,t}. \end{aligned}$$

- Final and composite-tradable goods production

$$\begin{aligned} \hat{y}_{T,t} &= (1-\nu)\hat{y}_{H,t} + \nu \hat{y}_{F,t} \qquad \text{with} \qquad \nu = y_F/y_T, \\ \hat{Y}_t &= (1-\tau)\hat{y}_{T,t} + \tau \hat{y}_{N,t} \qquad \text{with} \qquad \tau = y_N/Y. \end{aligned}$$

Price index

- Composite-tradable goods prices

$$\pi_{T,t} = (1-\nu)\pi_{H,t} + \nu \hat{\epsilon}_t.$$

Households

- Consumption-saving decision

$$E_t\hat{C}_{t+1} - \hat{C}_t = \hat{r}_t,$$

where the (gross) real rate of interest r_t is given by: $\hat{r}_t = \hat{\imath}_t - E_t\pi_{t+1}$.

- Uncovered interest parity condition

$$\hat{r}_t + \psi_B^* \tilde{B}_t^* = E_t\left(\hat{\epsilon}_{t+1} - \hat{\epsilon}_t\right),$$

where $\bar{B}^* = 0$, that is, in the steady state foreign bonds are in zero net supply and $\epsilon = S_t/P_t$ is the real exchange rate.[28]

- Labour supply

$$\hat{h}_t = \frac{1}{\phi}\left(\omega_t - \hat{C}_t\right).$$

Market clearing

- Domestic demand for nontradable, domestic and foreign tradable goods

$$\begin{aligned} \hat{y}_{N,t} - \hat{Y}_t &= -\kappa\pi_{N,t}, \\ \hat{y}_{H,t} - \hat{Y}_t &= (\theta - \kappa)\pi_{T,t} - \theta\pi_{H,t}, \\ \hat{y}_{F,t} - \hat{Y}_t &= (\theta - \kappa)\pi_{T,t} - \theta\hat{\epsilon}_t. \end{aligned}$$

- Foreign demand for domestic tradable goods

$$\hat{y}_{H,t}^* = \theta^*\left(\hat{\epsilon}_t - \pi_{H,t}\right).$$

- Labour market

$$\hat{h}_t = (1-\lambda)\hat{h}_{H,t} + \lambda\hat{h}_{N,t} \qquad \text{with} \qquad \lambda = h_N/h.$$

- Final goods market

$$\hat{Y}_t = c_y\hat{C}_t + (1-c_y)\hat{G}_t + \tilde{B}_t^* - \bar{\imath}^*\tilde{B}_{t-1}^*.$$

- Balance of payments

$$\tilde{B}_t^* = \bar{\imath}^*\tilde{B}_{t-1}^* + y_H^*\left(\hat{y}_{H,t}^* + \pi_{H,t}\right) - y_F\left(\hat{y}_{F,t} + \hat{\epsilon}_t\right),$$

where $y_F = y_H^* = \nu(1-\tau)$ and the steady state value of Y is normalized to unity.

Policy

- Fiscal policy

$$\hat{G}_t \sim N(0, \sigma_G^2).$$

[28]An increase in ϵ implies a depreciation of the currency of the *home* economy in real terms.

A.2. **Solving the model.** In order to obtain a tractable analytical solution, we impose that $\alpha = \phi = \theta^* = 1$, $\theta = \kappa$ and $\psi_B^* \to 0$.

Using the equations for (i) final and composite-tradable goods production, (ii) composite-tradable goods prices and (iii) domestic demand for nontradable, domestic and foreign tradable goods, implies

$$\omega_t = \pi_{N,t} = \pi_{H,t} = -\gamma_1 \hat{\epsilon}_t,$$

with $\gamma_1 = \frac{(1-\tau)\nu}{1-\nu(1-\tau)} > 0$. From this we then get $\text{tot}_t = \hat{y}^*_{H,t} = (1+\gamma_1)\hat{\epsilon}_t$, $\tilde{y}^*_{H,t} = \nu(1-\tau)(1+\gamma_1)\hat{\epsilon}_t$, $\pi_{T,t} = (\nu - \gamma_1(1-\nu))\hat{\epsilon}_t$, $\hat{q}_t = -\nu(1+\gamma_1)\hat{\epsilon}_t$ and

$$\hat{Y}_t = \frac{-1}{1-\nu(1-\lambda)} \left(\hat{C}_t + (\gamma_1 + \gamma_2)\hat{\epsilon}_t \right),$$

with $\gamma_2 = \nu(1-\lambda)(1+\gamma_1(1-\kappa)) + \gamma_1\kappa > 0$. From the system of demand equations we have: $\hat{y}_{H,t} - \hat{Y}_t = \kappa\gamma_1\epsilon_t$, $\hat{y}_{N,t} - \hat{Y}_t = \kappa\gamma_1\hat{\epsilon}_t$, $\hat{y}_{F,t} - \hat{Y}_t = -\kappa\hat{\epsilon}_t$, and for the trade balance we get $\widetilde{tb}_t = \vartheta\left(\kappa\hat{\epsilon}_t - \hat{Y}_t\right)$. Using the goods market equilibrium, the balance of payments identity and the previous equation for $\hat{Y}_t$, we obtain

$$\gamma_4 \hat{C}_t + \gamma_5 \hat{\epsilon}_t = -\gamma_6 \hat{G}_t, \tag{27}$$

with

$$\begin{aligned}
\gamma_4 &= \frac{1}{1-\nu(1-\lambda)} + \frac{c_y}{1+\nu(1-\tau)} > 0, \\
\gamma_5 &= \frac{\gamma_1+\gamma_2}{1-\nu(1-\lambda)} + \frac{\kappa\nu(1-\tau)}{1+\nu(1-\tau)} > 0, \\
\gamma_6 &= \frac{1-c_y}{1+\nu(1-\tau)} > 0.
\end{aligned}$$

Equation (27) and the two intertemporal optimality conditions can be put into a matrix system as follows

$$\tilde{A}_{-1} E_t\left[\tilde{x}_{t+1}\right] + \tilde{A}_0 \tilde{x}_t = \tilde{\Psi}_0 \hat{G}_t \quad \text{with} \quad \hat{G}_t \sim N(0, \sigma_G^2), \tag{28}$$

with

$$\tilde{x}_t = \begin{bmatrix} \hat{C}_t \\ \hat{\epsilon}_t \end{bmatrix}, \quad \tilde{A}_{-1} = \begin{bmatrix} 1 & -1 \\ 0 & 0 \end{bmatrix}, \quad \tilde{A}_0 = \begin{bmatrix} -1 & 1 \\ \gamma_4 & \gamma_5 \end{bmatrix}, \quad \tilde{\Psi}_0 = \begin{bmatrix} 0 \\ -\gamma_6 \end{bmatrix}. \tag{29}$$

We solve for the rational expectations solution by using the *method of undetermined coefficients*. For this we define and impose the equilibrium law of motion $\tilde{x}_t = \Gamma\hat{G}_t$. The solution for Γ is given by $\Gamma = \tilde{A}_0^{-1}\tilde{\Psi}_0$, which implies that

$$\begin{bmatrix} \hat{C}_t \\ \hat{\epsilon}_t \end{bmatrix} = -\tilde{\gamma} \begin{bmatrix} 1 \\ 1 \end{bmatrix} \hat{G}_t, \tag{30}$$

with $\tilde{\gamma} = \frac{\gamma_6}{\gamma_4+\gamma_5} > 0$. From this it follows that

$$\widetilde{tb}_t = -\gamma_{tb}(\tau,\nu)\hat{G}_t \tag{31}$$

$$\hat{Y}_t = \gamma_Y(\tau,\nu)\hat{G}_t, \tag{32}$$

with $\gamma_{tb}(\tau,\nu) = \nu(1-\tau)(\kappa\tilde{\gamma} + \gamma_Y(\tau,\nu)) > 0$ and $\gamma_Y(\tau,\nu) = \frac{1+\gamma_1+\gamma_2}{1-\nu(1-\lambda)}\tilde{\gamma} > 0$, which simplifies to $\gamma_{tb}(\tau,\nu) = (1-c_y)\nu(1-\tau)(1+(1-\kappa)(1-\lambda)\nu+\kappa)/\eta$ and $\gamma_Y(\tau,\nu) = (1-c_y)(1+\nu(1-\lambda+\kappa(1-\tau)(1-(1-\lambda)\nu)))/\eta$, with $\eta = c_y((\lambda-1)\nu+1)(\nu(\tau-1)+1)-(2\kappa-1)(\lambda-1)\nu^2(\tau-1)-\nu(2\kappa(\tau-1)+\lambda+\tau-2)+1$. We observe that

$$\begin{aligned}
\frac{\partial\gamma_{tb}(\tau,\nu)}{\partial\tau} &= -\frac{(1-c_y)\nu((1-c_y)(1-\lambda)\nu+c_y+1)((1-\kappa)(1-\lambda)\nu+\kappa+1)}{[\,\cdot\,]^2} < 0,\\
\frac{\partial\gamma_Y(\tau,\nu)}{\partial\tau} &= \frac{(1-c_y)\nu(1-c_y+(1+c_y)(1-\lambda)\nu)(1+\kappa+(1-\kappa)(1-\lambda)\nu)}{[\,\cdot\,]^2} > 0,\\
\frac{\partial\gamma_Y(\tau,\nu)}{\partial\nu} &= \frac{(1-\nu(1-\lambda))\frac{\partial}{\partial\nu}[\tilde{\gamma}(1+\gamma_1+\gamma_2)]+\tilde{\gamma}(1+\gamma_1+\gamma_2)(1-\lambda)}{[\,\cdot\,]^2} \lesseqgtr 0,\\
\frac{\partial\gamma_{tb}(\tau,\nu)}{\partial\nu} &\propto \left(1+\frac{\nu}{\tilde{\gamma}}\frac{\partial\tilde{\gamma}}{\partial\nu}+\frac{\nu(1-\kappa)(1-\lambda)}{1+\kappa+\nu(1-\kappa)(1-\lambda)}\right)(1-\nu(1-\tau))(1-\nu(1-\lambda))\\
&\quad +\nu\left[(1-\tau)(1-\nu(1-\lambda))+(1-\lambda)(1-\nu(1-\tau))\right] > 0.
\end{aligned}$$

The ambiguity in the sign of $\partial\gamma_Y(\tau,\nu)/\partial\nu$ arises from $\frac{\partial}{\partial\nu}[\tilde{\gamma}(1+\gamma_1+\gamma_2)] = (1+\gamma_1+\gamma_2)\frac{\partial\tilde{\gamma}}{\partial\nu}+\tilde{\gamma}\left(\frac{\partial\gamma_1}{\partial\nu}+\frac{\partial\gamma_2}{\partial\nu}\right)$. Since $\partial\gamma_1/\partial\nu > 0$, $\partial\gamma_2/\partial\nu > 0$ and $\partial\tilde{\gamma}/\partial\nu < 0$, the first term is negative, while the second is positive, thus rendering the sign of $\partial\gamma_Y(\tau,\nu)/\partial\nu$ uncertain. Concerning the last derivative, $\partial\gamma_{tb}(\tau,\nu)/\partial\nu > 0$, despite $\partial\tilde{\gamma}/\partial\nu < 0$ – since the positive terms dominate throughout across a wide range of reasonable values of the structural parameters, the sign of the expression is unambiguous.

A.3. **A quantitative assessment based on simulations.** As an extension to the analysis hitherto, we assess the sensitivity of the coefficient matrices $A_k(\tau,\nu)\ \forall\ k \in \{0,1\}$ and $\Psi_0(\tau,\nu)$ within a more general calibration of the structural parameters of the model. We distinguish two scenarios where we set the share of nontradable goods (τ) equal to 0.3 and 0.5, respectively. In each scenario, the import share ν is fixed at 0.5; hence the degree of openness (ϑ) in the steady state equals 0.35 and 0.25 respectively.

Given that our focus is on the role of openness in the international transmission of fiscal spending shocks, we do not calibrate our model to a particular economy. Instead, we consider a continuum of values for the degree of openness. Table 2 lists the details of the calibration exercise. The specific values chosen are standard in the literature

Table 2. Calibration

Ident.	Value	Description	Range
α	1.0	Labour share in production	$[0.5 - 1.0]$
κ	0.3	Elasticity of substitution between tradable and nontradable goods	$(0.0 - 2.0]$
θ, θ^*	2.0	Substitution between domestic and foreign goods in the home (θ) and foreign (θ^*) economy	$(0.0 - 5.0]$
λ	0.5	Share of total hours worked in the nontradable sector	$[0.2 - 0.8]$
β	0.985	Discount factor	$[0.950 - 0.995]$
ϕ	3.0	Inverse of the Frisch labour supply elasticity	$(0.0 - 5.0]$
ψ_{B^*}	0.02	Adjustment costs for net foreign assets	$[0.001 - 0.1]$
c_y	0.70	Private household consumption share in output	$[0.50 - 0.90]$
ρ_g	0.80	Inertia of government spending shock (AR(1)-parameter)	$[0.40 - 0.98]$
The following parameters only concern the model extensions of Section A.5.			
σ	6.0	Elasticity of substitution between final goods	
ϕ_P	1.0	Adjustment cost for nominal rigidities	
ϕ_π	1.5	Monetary policy reaction to inflation rate	
The following parameters only concern the model extensions of Section A.6.			
λ	0.25	Share of non-Ricardian households	
The following parameters only concern the model extensions of Section A.7.			
τ_c	0.4	Share of nontradables in household consumption (C_t)	
τ_g	0.8	Share of nontradables in government consumption (G_t)	
κ_c	0.6	Elasticity of substitution between tradable and nontradable goods in household consumption (C_t)	
κ_g	0.1	Elasticity of substitution between tradable and nontradable goods in government consumption (G_t)	

(Benigno and Thoenissen, 2008; Dotsey and Duarte, 2008; Schmitt-Grohé and Uribe, 2016).

Figure 8 displays the responses of output and several other variables to an expansionary fiscal spending shock. Output increases, private consumption declines, the relative price of nontradable goods increases, the terms of trade and the real exchange rate appreciate[29]

[29]The Mundell-Fleming model also predicts an appreciation of the (real) exchange rate, as long as the increase in fiscal spending is debt financed. If it is financed through lump-sum taxes, the (real) exchange rate could also depreciate (see Frenkel and Razin, 1985). This follows from assuming an exogenous money supply. With lump-sum taxes increasing, disposable income and hence demand for domestic money falls and the (real) exchange rate depreciates. Similarly, in Obstfeld and Rogoff (1995) the nominal exchange rate depreciates in response to an increase in domestic fiscal spending because of a fall in money demand (assuming that purchasing power parity holds).

and the trade balance deteriorates. The responses vary with the size of the share of nontradable goods (τ). Our results show that the impact response is representative for the direction of the change in the adjustment mechanism induced by different sizes of the share of nontradables.[30]

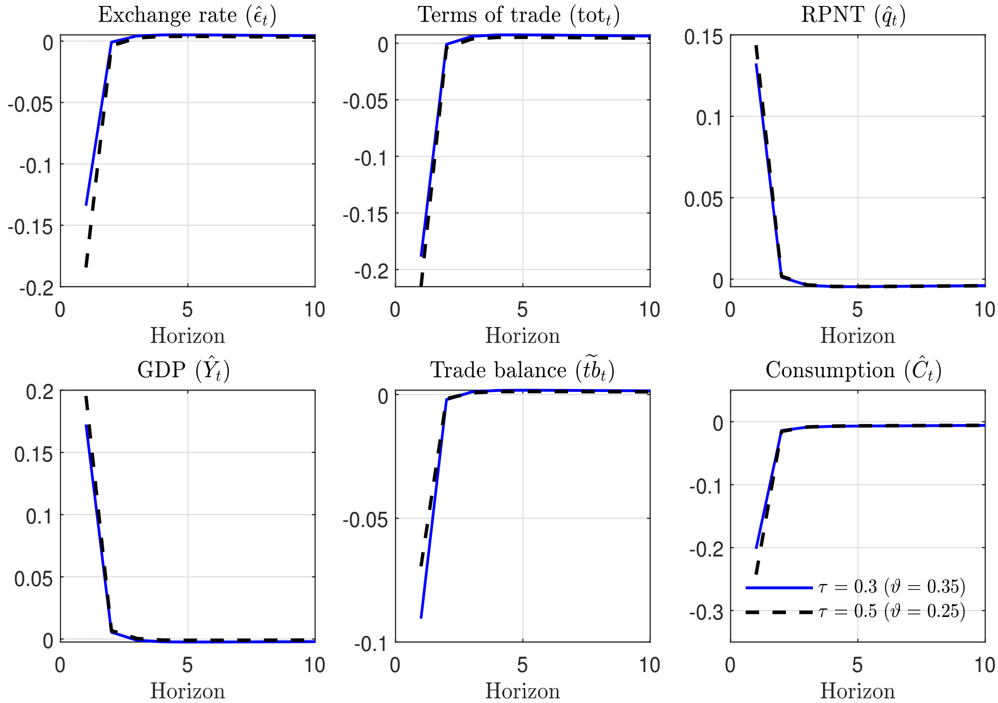
As discussed in the main text, the degree of openness is determined by two structural parameters: the share of nontradable goods (τ) and the import share (ν). We now turn to consider the role of both parameters in shaping the effects of fiscal spending shocks. We simulate the model over a wide range of different values for the structural parameters. To this purpose we attach a uniform distribution to each parameter and define upper and lower bounds as indicated in the fourth column (*Range*) in Table 2. We simulate the model 2000 times and show the difference of the impact responses for the following two scenarios (i) $\tau = 0.3$ and $\tau = 0.5$ with ν fixed at 0.5 and (ii) $\nu = 0.5$ and $\nu = 0.3$ with τ fixed at 0.3. The first scenario is depicted in the upper sub-plot in Figure 9, and the second in the lower one.[31] The boxplots show the difference in the impact response. Considering the output response ($\hat{Y}_t$) in the upper sub-plot as an example, we notice that it is negative throughout due to the fact that the impact response of output with a low share of nontradable goods ($\tau = 0.3$) is systematically smaller than that with a high share ($\tau = 0.5$) The negative range of values in this particular plot replicates the difference in the impact responses shown in Figure 8 and described in the analytic discussion in the main text for a more flexible set of calibrations.

The upper sub-plot in Figure 9 highlights that the impact response of output varies considerably with τ. This is crucially driven by the effects of τ on the trade balance, consumption and labour supply. We discuss them in what follows. In response to an increase in fiscal spending, the trade balance deteriorates. The size of the drop depends on the degree of openness (ϑ) and hence on τ. A higher value of τ implies a lower degree of openness, which mitigates the drop in the trade balance. This is indicated by the negative box of the trade balance in the upper sub-plot in Figure 9 and shown formally by $\partial\gamma_{tb}(\tau,\nu)/\partial\tau < 0$ in the main text. While the drop in the trade balance decreases with τ, the rise in output in response to the expansionary fiscal spending shock increases with

[30]Alternatively, computing cumulative responses gives similar results.

[31]We draw values for the structural parameters shown in Table 2. For a particular draw, we solve the model for $\tau = 0.3$ and compute impulse response functions. For the same draw we also solve the model using $\tau = 0.5$ – in both cases holding ν fixed at 0.5. The difference in the impact values of the impulse response functions is depicted in Figure 9. By this procedure we can uniquely attach the difference in the impact response to changes in τ, while at the same time allowing for flexibility in the model calibration. We carry out the same exercise for the import share (ν), keeping τ fixed.

Figure 8. Impulse response functions to an expansionary fiscal spending shock



Note: The figure shows the impulse response functions to a one percent rise in government spending. A decline in the real exchange rate (ϵ_t) and the terms of trade (tot_t) refers to an appreciation in each case. *RPNT* refers to the *relative price of nontradable goods* ($q_t = P_{N,t}/P_{T,t}$).

τ. The reaction of consumption is determined by the wealth effects arising from (i) the expected higher future taxation, (ii) the terms of trade appreciation and (iii) the increase in the relative price of nontradables. As shown formally in Appendix A.4, the effects of the latter two depend on τ: the terms of trade appreciation attenuates the decline in consumption as imports become relatively cheaper and this effect decreases with τ. The rise in the relative price of nontradables reinforces the decline in consumption and this effect increases with τ. Hence, the sensitivity of consumption with respect to τ is unambiguous: a higher share of nontradables attenuates the positive wealth effect from the terms of trade appreciation and reinforces the negative wealth effect of higher nontradable goods prices. This implies that the drop in consumption increases with τ, as captured in the upper sub-plot of Figure 9. This, in turn, implies that the rise in output in response to the expansionary fiscal spending shock is likely to decrease with τ, a result that stands in contrast to the effects arising for the trade balance. This apparent puzzle can be solved easily. First of all, the effect of τ on the trade balance outweighs the one on consumption, as indicated in the upper sub-plot of Figure 9. In addition, since consumption and leisure are normal goods, the intratemporal first order condition gives rise to an increase in labour supply when consumption declines. Since the drop in consumption increases with τ, we equivalently have that the increase in labour supply rises with τ. This finally motivates an unambiguous effect on output and confirms the sign of $\partial\gamma_Y(\tau,\nu)/\partial\tau > 0$.

The implications are different when we consider the role of the import share (ν) in shaping the response of output, as indicated in the lower sub-plot of Figure 9. As indicated by equation (35) in the Appendix, the wealth effect due to the terms of trade appreciation increases with ν. Moreover, the wealth effect arising from the increase of the relative price of nontradables does not depend on ν. Hence, a higher ν implies a weaker drop in consumption,[32] which is depicted in the effects of consumption in the lower sub-plot in Figure 9.[33]

The deterioration of the trade balance increases with the degree of openness and consequently with ν. Hence, output increases by less, when ν is large. These two opposing effects on output explain the inverted U-shaped pattern between ν and $\gamma_Y(\tau,\nu)$ shown in the main text and the ambiguous sign of $\partial\gamma_Y(\tau,\nu)/\partial\nu$. The results of the main text are thus also present within a more flexible calibration environment.

Summing up, our model predicts that (i) if a higher degree of openness is due to a lower share of nontradable goods, then fiscal spending multipliers decrease with the degree of openness and (ii) if a higher degree of openness is due to a higher import share, then the effect of the degree of openness on the size of fiscal spending multipliers is ambiguous.

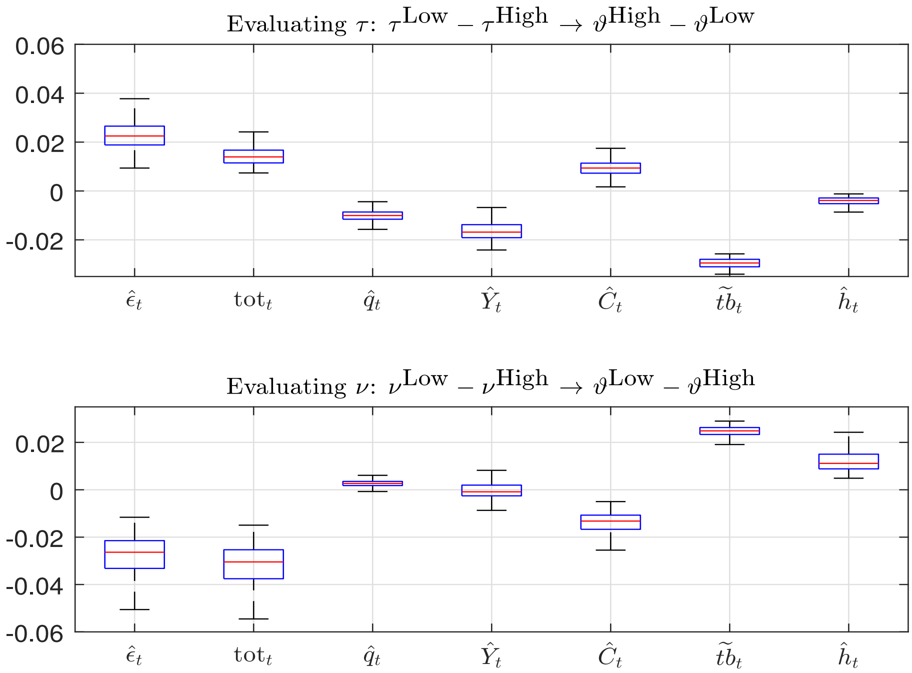
A.4. **The terms of trade, relative productivity and the intertemporal margin.** In this section we elaborate on the extent to which openness alters the transmission mechanism of fiscal spending shocks because movements in the terms of trade and relative sector prices trigger substitution effects in consumption along the intertemporal margin. To evaluate this, we turn to the intertemporal consumption optimality equation, which determines the optimal consumption/saving decision. Denoting the marginal utility of consumption by λ_t, optimality requires the following to hold

$$\lambda_t = \beta E_t\left[\lambda_{t+1}R_t^C\right], \tag{33}$$

[32] Corsetti and Müller (2008) and Monacelli and Perotti (2010) show that this result also applies within a New Keynesian framework, i.e. when allowing for nominal rigidities.

[33] Note that the intertemporal first order conditions for households imply that a drop in consumption is accompanied with an exchange rate appreciation. To the extent that the drop in consumption in response to an increase in fiscal spending declines with ν, the appreciation of the real exchange rate and the terms of trade is weaker the higher ν is, a result which is in line with the conclusions of Corsetti and Müller (2007).

Figure 9. Differences of impact responses to an expansionary fiscal spending shock



Note: The figure shows the difference of the impact responses to a fiscal spending increase for different degrees of openness (ϑ). In the upper sub-plot the degree of openness changes with the share of nontradable goods (τ). In the lower sub-plot, changes in the degree of openness stem from changes in the import share (ν). The boxes refer to the variation of the difference in the impact response for different calibrations of the remaining structural parameters.

where $R_t^C = \frac{i_t}{P_{t+1}/P_t}$ measures the consumption-based real interest rate. Note that in the competitive equilibrium, we have that for the sectoral relative price of domestic goods

$$q_{N,t} = \frac{P_{N,t}}{P_{H,t}} = \tilde{a}_{H,t} = -\text{MRT}_t(y_N, y_H), \tag{34}$$

where $\tilde{a}_{H,t} = \tilde{A}_{H,t}/\tilde{A}_{N,t}$ is the relative labour productivity in the sector producing tradable goods and $\tilde{A}_{H,t} = \alpha(y_{H,t} + y^*_{H,t})/h_{H,t}$ and $\tilde{A}_{N,t} = \alpha y_{N,t}/h_{N,t}$ are the (time-varying) labour productivities in the tradable and nontradable sectors, while $\text{MRT}_t(y_N, y_H)$ refers to the marginal rate of transformation between the production of tradable and nontradable goods.[34] Assuming a symmetric equilibrium with $\theta \to 1$ and $\kappa \to 1$, then the consumption-based real interest rate is given by

$$R_t^C = \frac{i_t}{P_{H,t+1}/P_{H,t}} \left(\frac{\text{tot}_t}{\text{tot}_{t+1}}\right)^{\vartheta} \left(\frac{q_{N,t}}{q_{N,t+1}}\right)^{\tau} = \frac{i_t}{P_{H,t+1}/P_{H,t}} \left(\frac{\text{tot}_t}{\text{tot}_{t+1}}\right)^{\vartheta} \left(\frac{\tilde{a}_{H,t}}{\tilde{a}_{H,t+1}}\right)^{\tau}. \tag{35}$$

[34]Using the two production functions for tradable and nontradable goods yields the following production possibility frontier (PPF):
$y_{N,t} = A_N \left[h_t - \left((y_{H,t} + y^*_{H,t})/A_H\right)^{1/\alpha}\right]^{\alpha}$.

Equation (35) establishes a direct link between the consumption-based real interest rate (R_t^C), the change in the terms of trade and the change in the relative productivity in the tradable goods sector. Let us first consider the case of $\alpha = 1$. It follows that $\tilde{a}_{H,t} = A_H/A_N$, due to the equations describing firms' labour demand with the consequence that $\tilde{a}_{H,t} = \bar{\tilde{a}}_H$ and $q_{N,t} = \bar{q}_N \; \forall \; t$. This reduces equation (35) to an expression linking the consumption-based real interest rate to the terms of trade only. If the terms of trade appreciate on impact and then gradually return to their pre-shock level, we have $(\text{tot}_t/\text{tot}_{t+1}) < 1$, i.e. in response to the initial drop the terms of trade increase over time back to the steady state. As a result, a terms of trade appreciation which is gradually reversed, will *ceteris paribus* induce a lower consumption-based real interest rate. This effect is stronger, the more open an economy is: the terms of trade elasticity of R_t^C is given by $\vartheta = \nu(1-\tau)$. Hence, both a higher import share (ν) and a lower share of nontradable goods (τ) increase the elasticity of R_t^C with respect to the terms of trade. Intuitively, better terms of trade today imply a lower price of today's consumption basket, as imported goods are cheaper. Put differently, the appreciation of the terms of trade attenuates the negative wealth effect of higher future taxation in response to the rise in fiscal spending. This attenuation increases with the import share and decreases with the share of nontradables.

When allowing for $\alpha \in [0, 1)$, the term $(q_{N,t}/q_{N,t+1})$ enters equation (35) with elasticity τ. In response to the expansionary fiscal spending shock, the relative price of nontradable goods increases. This gives rise to $(q_{N,t}/q_{N,t+1}) > 1$, i.e. in response to the initial rise the relative price of nontradable goods decreases over time back to the steady state. Considering again equation (35), an increase in the relative price of nontradable goods which is gradually reversed, will *ceteris paribus* induce a higher consumption-based real interest rate. This effect is stronger, the larger the share of nontradable goods, as the elasticity of the relative price of nontradable goods is given by τ. Intuitively, a higher relative price of nontradables implies a higher price of today's consumption basket, as nontradable goods are more expensive. Hence, the rise in nontradable goods prices reinforces the negative wealth effect of higher future taxation in response to the rise in fiscal spending.

The latter argument can also be viewed from the perspective of productivity, which introduces a *Balassa-Samuelson effect*. To see this, note that, as implied by equation (34), an increase in the relative price of nontradables ($q_{N,t}$) *ceteris paribus* leads to an increase in the relative labour productivity of the tradable goods sector ($\tilde{a}_{H,t}$) –

the positive co-movement of labour productivity of the tradable goods sector and the relative price of nontradable goods characterises the essence of the *Balassa-Samuelson effect*. Equation (35) contains the change in relative labour productivity of the tradable sector $(\tilde{a}_t/\tilde{a}_{t+1})$, which enters with elasticity τ. Relative labour productivity growth in the tradable goods sector increases in response to the expansionary fiscal spending shock. This gives rise to $(\tilde{a}_{H,t}/\tilde{a}_{H,t+1}) > 1$, i.e. in response to the initial rise the relative labour productivity of the tradable sector decreases over time back to the steady state. Hence, an increase in relative labour productivity of the tradable sector which is gradually reversed, will *ceteris paribus* induce a higher consumption-based real interest rate. This effect is stronger the larger the share of nontradable goods, as the elasticity of the relative labour productivity of the tradable sector is given by τ. Intuitively, higher relative labour productivity of the tradable goods sector implies a higher relative price of nontradable goods. This in turn induces final goods producing firms to substitute nontradable goods by tradable goods. Part of the increased demand for tradables will be satisfied by higher imports. As a consequence the trade balance deteriorates and results in a drop in net foreign assets, which gives rise to a negative wealth effect. This reinforces the negative wealth effect of higher future taxation in response to the rise in fiscal spending.

The Balassa-Samuelson effect works in an opposite direction to the terms of trade effect in this context. The sole remaining question addresses the inequality $(\tilde{a}_{H,t}/\tilde{a}_{H,t+1}) > 1$ – why does relative labour productivity in the tradable sector rise in response to an increase in fiscal spending? Intuitively, the expansionary fiscal spending shock increases final goods demand (Y_t), which in turn raises demand for nontradable $(y_{N,t})$ and tradable goods $(y_{T,t})$ alike. The higher demand for tradables can partly be compensated by higher imports $(y_{F,t})$. In contrast to that, the higher demand for nontradables can only be met by higher domestic production of nontradables. This requires a reallocation of production input factors, in this case, a reallocation of labour from the tradable to the nontradable sector. Hence, the excessive relative demand for nontradables implies that $q_{N,t}$ (and q_t) rise. The relative drop in labour in the tradable goods sector, despite an increase in demand for tradables, implies that relative labour productivity in the tradable sector $(\tilde{a}_{H,t})$ increases. In equilibrium, the adjustment in both of them is of equal size, satisfying $q_{N,t} = \tilde{a}_{H,t}$. The structural adjustment of the economy requires thus a shift not only in production, but also in relative prices. Assuming balanced trade initially, the increase in fiscal spending brings about three effects: (i) an increase in public and private consumption relative to income, (ii) a real exchange rate appreciation, meaning in this context, a rise in P_N/P_H (and in P_N/P_T), and (iii) a shift in production from tradable goods to nontradable goods.

A.5. **Extension 1: Nominal rigidities – Market power and countercyclical markups.** While a neo-classical set-up, as considered in the main text, is commonly considered when analysing the effects of fiscal policy, it misses one important element. In particular, in the neo-classical set-up, the expansionary effect of higher government spending on output results from the wealth effect on leisure. This channel has been viewed critically especially also because it is unrelated to Keynesian arguments based on increases in private demand that are aggravated by the slow (rather than fast) increase in prices in response to an expansionary fiscal spending shock. Against this background, we now consider an extension of the model of the main text that features sticky rather than flexible prices. We confine the extent of price stickiness to the final goods prices (P_t).

Final goods producers buy domestic intermediate goods ($y_{T,t}$ and $y_{N,t}$) directly from intermediate goods producing firms and sell the final composite good (Y_t) to the government and to the households. We assume that there is a continuum of final goods producers indexed by $i \in [0,1]$. They are perfectly competitive in their input markets and monopolistically competitive in their output market. Their price setting is subject to nominal rigidities. We first analyse the demand for their output, then we turn to their technology, and finally we describe their profit maximization problem.

Demand for final goods varieties comes from multiple sources. Let j be an individual purchaser of final goods (government and private households). Then his demand $Z_t(j)$ is for a CES composite of final goods varieties i, with elasticity of substitution σ

$$Z_t(j) = \left(\int_0^1 \left(Z_t(j,i)\right)^{\frac{\sigma-1}{\sigma}} di \right)^{\frac{\sigma}{\sigma-1}} \tag{36}$$

with associated demands

$$Z_t(j,i) = \left(\frac{P_t(i)}{P_t} \right)^{-\sigma} Z_t(j) \tag{37}$$

where $P_t(i)$ is the price of variety i of final goods output, and P_t is the aggregate final goods price level given by

$$P_t = \left(\int_0^1 \left(P_t(i)\right)^{1-\sigma} di \right)^{\frac{1}{1-\sigma}} \tag{38}$$

Furthermore, the total demand facing a producer of final goods output variety i can be obtained by aggregating over all sources of demand j. We obtain

$$Z_t(i) = \left(\frac{P_t(i)}{P_t}\right)^{-\sigma} Z_t \tag{39}$$

where $Z_t(i)$ and Z_t remain to be specified by way of market clearing conditions for final goods output. The price markup is given by $\mu = \sigma/(\sigma - 1)$.

The **technology** of final goods producers is given by a CES production function as in the main text that uses nontradables $y_{N,t}$ and composite-tradables $y_{T,t}$ with a share coefficient for nontradables of τ and an elasticity of substitution κ

$$Y_t(i) = \left((1-\tau)^{\frac{1}{\kappa}} y_{T,t}(i)^{\frac{\kappa-1}{\kappa}} + \tau^{\frac{1}{\kappa}} y_{N,t}(i)^{\frac{\kappa-1}{\kappa}}\right)^{\frac{\kappa}{\kappa-1}}, \tag{40}$$

Final goods producing firms are subject to quadratic price adjustment costs $G_{P,t}(i)$ in line with the approach of sticky prices á la Rotemberg (1982). They are quadratic in price levels, whereby deviations of the actual inflation rate from the inflation target $\bar{\pi}$ are costly. Compared to the Calvo price setting assumption, such adjustment costs have the advantage of greater analytical tractability. We have

$$G_{P,t}(i) = \frac{\phi_P}{2} Y_t \left(\frac{P_t(i)}{P_{t-1}(i)} - \bar{\pi}\right)^2 \tag{41}$$

We also consider an extension where the extent of nominal rigidity emerges from inflation inertia, that is, higher order price stickiness. To this purpose we consider a quadratic inflation adjustment cost $G_{P,t}(i)$ which is quadratic in the rate of inflation rather than the price levels. We consider the following functional form

$$G_{P,t}(i) = \frac{\phi_P}{2} Y_t \left(\frac{\frac{P_t(i)}{P_{t-1}(i)}}{\frac{P_{t-1}}{P_{t-2}}} - 1\right)^2 \tag{42}$$

In what follows, we consider the implications of both forms of modelling nominal rigidities. Final goods firms maximize the present discounted value of dividends which are given by

$$D_t(i) = P_t(i)Y_t(i) - P_{T,t}y_{T,t}(i) - P_{N,t}y_{N,t}(i) - P_t G_{P,t}(i) \tag{43}$$

The **optimization problem** of each final goods producing firm is

$$\max_{P_t(i), y_{T,t}(i), y_{N,t}(i)} E_t \left[\sum_{s=0}^{\infty} \Lambda_{t,t+s} D_{t+s}(i)\right] \tag{44}$$

subject to the definition of dividends (43), the demand for final goods of producer i given by equation (39), the production function (40) and nominal adjustment costs (41) or (42).

We write out the profit maximization problem of a representative final firm in Lagrangian form. We introduce a multiplier λ_t^c for the market-clearing condition $Y_t(i) = Z_t(i)$ which gives rise to $\left((1-\tau)^{\frac{1}{\kappa}} y_{T,t}(i)^{\frac{\kappa-1}{\kappa}} + \tau^{\frac{1}{\kappa}} y_{N,t}(i)^{\frac{\kappa-1}{\kappa}}\right)^{\frac{\kappa}{\kappa-1}} = \left(\frac{P_t(i)}{P_t}\right)^{-\sigma} Z_t$. The variable λ_t^c equals the nominal marginal cost of producing one more unit of final good i. Optimization gives rise to the following optimality condition for the input demand

$$\frac{y_{N,t}(i)}{y_{T,t}(i)} = \frac{\tau}{1-\tau}\left(\frac{P_{N,t}}{P_{T,t}}\right)^{-\kappa} \tag{45}$$

Equation (45) implies that the input ratio of nontradables $y_{N,t}(i)$ and composite-tradables $y_{T,t}(i)$ will be identical across final goods producers and equal to the aggregate nontradables/composite-tradables ratio. The real marginal costs λ_t^c/P_t of firm i are given by

$$\frac{\lambda_t^c}{P_t} = \tau\left(\frac{P_{N,t}}{P_t}\right)^{1-\kappa} + (1-\tau)\left(\frac{P_{T,t}}{P_t}\right)^{1-\kappa} \tag{46}$$

Finally, we take the first order condition with respect to $P_t(i)$ and then impose symmetry by setting $P_t(i) = P_t$ and $Y_t(i) = Y_t$ because all firms face an identical problem. Then we obtain

$$\begin{aligned} \frac{\sigma-1}{\phi_P}\left(\mu\frac{\lambda_t^c}{P_t} - 1\right) &= \pi_t(\pi_t - \bar{\pi}) - \\ & E_t\left[\Lambda_{t,t+1}\frac{P_{t+1}}{P_t}\frac{Y_{t+1}}{Y_t}\pi_{t+1}\left(\pi_{t+1} - \bar{\pi}\right)\right] \end{aligned} \tag{47}$$

in case adjustment cost function (41) is used and we defined $\pi_t = P_t/P_{t-1}$ as the (gross) inflation rate. For the adjustment cost function (42) we obtain

$$\begin{aligned} \frac{\sigma-1}{\phi_P}\left(\mu\frac{\lambda_t^c}{P_t} - 1\right) &= \left(\frac{\pi_t}{\pi_{t-1}}\right)\left(\frac{\pi_t}{\pi_{t-1}} - 1\right) - \\ & E_t\left[\Lambda_{t,t+1}\frac{P_{t+1}}{P_t}\frac{Y_{t+1}}{Y_t}\left(\frac{\pi_{t+1}}{\pi_t}\right)\left(\frac{\pi_{t+1}}{\pi_t} - 1\right)\right] \end{aligned} \tag{48}$$

A.5.1. *The log-linearized equations.* We consider a log-linear approximation of the additional equations around the symmetric steady state. As in Section A.1 of the Appendix, we assume that P_t is the numéraire with a value in the steady state equal to unity. We assume that the target (gross) inflation rate $\bar{\pi}$ is unity too. This gives rise to the following two versions of the Phillips relation in case of adjustment cost functions (41) and (42)

$$\pi_t = \beta E_t \pi_{t+1} + \frac{\phi_P}{\sigma}\pi_{\lambda^c,t} \tag{49}$$

and

$$\pi_t = \frac{\beta}{1+\beta} E_t \pi_{t+1} + \frac{1}{1+\beta} \pi_{t-1} + \frac{\phi_P}{\sigma(1+\beta)} \pi_{\lambda^c,t} \tag{50}$$

where $\pi_{\lambda^c,t} = \lambda_t^c / P_t$ is real marginal costs. The log-linearized version of equations (45) and (46) are given by

$$\hat{y}_{N,t} - \hat{y}_{T,t} = -\kappa \left(\pi_{N,t} - \pi_{T,t} \right) \tag{51}$$

and

$$\pi_{\lambda^c,t} = (1-\kappa) \left(\pi_{N,t} - \pi_{T,t} \right) \tag{52}$$

where we used the definition of relative prices as put forward in Section A.1 of the Appendix. Finally we introduce a monetary policy rule of the following form

$$i_t = \bar{\imath} + \phi_\pi \pi_t \tag{53}$$

where $\phi_\pi > 1$ captures the monetary authority's reaction in the nominal interest rate i_t with respect to the inflation rate π_t.

A.5.2. *Implications of the nominal rigidities.* To see how the presence of nominal rigidities affects the transmission of fiscal spending shocks, and, in particular, how nominal rigidities trigger real effects, we use equation (49) and combine it with equations (51) and (52). This gives rise to the following

$$\pi_t = \beta E_t \pi_{t+1} + \frac{\phi_P (1-\kappa)}{\sigma \kappa} \left(\hat{y}_{N,t} - \hat{y}_{T,t} \right) \tag{54}$$

and equivalently in case of equation (50). Hence, the presence of inertia in the adjustment of final goods prices impairs the adjustment in the input factors ($\hat{y}_{T,t}$ and $\hat{y}_{N,t}$) and hence in intermediate goods prices ($\pi_{N,t}$ and $\pi_{T,t}$). Given that $\kappa < 1$, we have that real marginal costs ($\pi_{\lambda^c,t}$) rise in response to the expansionary fiscal spending shock. This in turn triggers a drop in the price markup. The counter-cyclical behaviour of the markup is at the core in the extension with nominal rigidities compared to the frictionless set-up of the model in the main text. Intuitively, the counter-cyclical markup introduces a wedge between firms' marginal product of labour and households' marginal rate of substitution. An increase in government purchases raises employment and, under standard assumptions, lowers the marginal product of labour. Thus, it follows that consumption must drop if the markup does not change. However, a drop in the markup in response to a fiscal expansion renders feasible a simultaneous increase in employment and consumption (see Galí et al., 2007, for further details).

The reaction of the monetary authority comprises an important additional element in this context: a high degree of nominal rigidities leads to a smaller increase in the real interest rate in response to the higher inflation rate induced by the fiscal expansion (this depends crucially on the reaction of monetary policy[35]); as a result consumption declines by less (or even reacts positively), which in turn aggravates the positive effect on output. Hence, when prices are fully flexible, consumption is always crowded out in response to a rise in government spending, independently of the degree of persistence of the latter. The size of the response of output is increasing in the degree of price rigidities, which emerges as a result of a stronger multiplier effect on consumption.

Given this, we assess the role of the share of nontradables and the import share in this context. Details on the calibration of the additional parameters (ϕ_π, ϕ_P and σ) are provided in Section A.3 of the Appendix. Figures 10 and 11 show the impulse response functions for various variables along the rows. The effects are shown for (i) the flexible price scenario (baseline set-up as outlined in the main text), (ii) a model version based on sticky prices in line with equations (41) and (49), and, (iii) a model version based on a higher extent of price stickiness in line with equations (42) and (50); the scenarios are depicted along the columns. In each case, the model calibrations are exactly the same, except that the latter two versions contain nominal frictions.

Considering first the implications of variations in the share of nontradables (τ) as shown in Figure 10, the presence of nominal rigidities does not change the central conclusions drawn in the main text. In the presence of nominal rigidities, the reaction of consumption is stronger. This effect is augmented once the share of nontradables is high as explained in detail in Section A.4. As a result, the fiscal spending multiplier turns out highest when nominal frictions are present and the share of nontradables is high. The extent of nominal rigidities is of particular importance in this case: when comparing the two forms of modeling nominal rigidities, the version with sticky inflation (right column in Figure 10) triggers effects in output which exceed those of the other two model versions. Hence when the share of nontradables is high, the extent of nominal rigidities augments the effects of fiscal spending shocks additionally.

With a view to the import share, Figure 11 highlights the consequences when nominal rigidities are present. In this case, the output effects triggered by fiscal spending shocks

[35]In models with sticky prices like ours, the central bank can approximate arbitrarily well the flexible price equilibrium allocation by following an interest rate rule that responds with sufficient strength to changes in inflation. Hence, an increase in ϕ_P affects the output and consumption multipliers in a way qualitatively similar to an increase in the extent of price rigidity/flexibility.

decreases with the size of the import share, confirming the results put forth in the main text. In addition to this, the size of the output effects in response to the fiscal spending rise increases with the extent of nominal rigidities. The effect thereof crucially depends on the reaction of consumption.

Hence, the key implications put forth in the main text apply also when nominal rigidities are present. Even more, the latter strongly augments the effects of the former giving rise to high fiscal spending multipliers when nominal rigidities are high and the degree of openness is low which applies with either a high share of nontradable goods or low share of imported goods (or both).

A.6. **Extension 2: Limited asset market participation.** Galí et al. (2007) show how the interaction of rule-of-thumb consumers with sticky prices and deficit financing can account for the existing evidence on the effects of government spending. In this context, rule-of-thumb consumers are characterized by limited asset market participation which implies that they lack any ability of smoothing their consumption profile; as a consequence, they spend (consume) each period all of their income. This rule-of-thumb results in a consumption pattern that strongly aligns with wage income. This gives rise to a positive consumption response in the wake of an expansionary fiscal spending shock. We again consider the baseline model and the extension solely concerns the private household sector. We add to the Ricardian consumers as outlined in the baseline model non-Ricardian consumers as second household type with a share given by ξ.

The consumers outlined in the baseline model are now referred to as *Ricardian* consumers and their consumption is henceforth denoted by c_t^r (same for their labour supply h_t^r). Rule-of-thumb households are assumed to behave in a "hand-to-mouth" fashion, fully consuming their current labour income. Their period utility is given by $u(c_t^{nr}, h_t^{nr})$ and they are subject to the budget constraint $c_t^{nr} = \frac{w_t}{P_t} h_t^{nr} + T_t^{nr}$. Aggregate consumption and employment are given by a weighted average of the corresponding variables for each consumer type. Formally, $C_t = \xi c_t^{nr} + (1-\xi) c_t^r$, $h_t = \xi h_t^{nr} + (1-\xi) h_t^r$. It is further assumed that the labour market is characterized by a structure which gives rise to wages being negotiated in a centralized manner by an economy-wide union with firms.

The panels in the second column in Figures 12 and 13 shows the results of the extension of the model with non-Ricardian consumers and compares them to the baseline model. The simulations are based on a share of one-half of non-Ricardian households ($\xi = 0.5$). As can be seen, the size of the output effect in response to an increase in government

FIGURE 10. Expansionary fiscal spending shock: the role of the share of nontradables in the wake of nominal rigidities

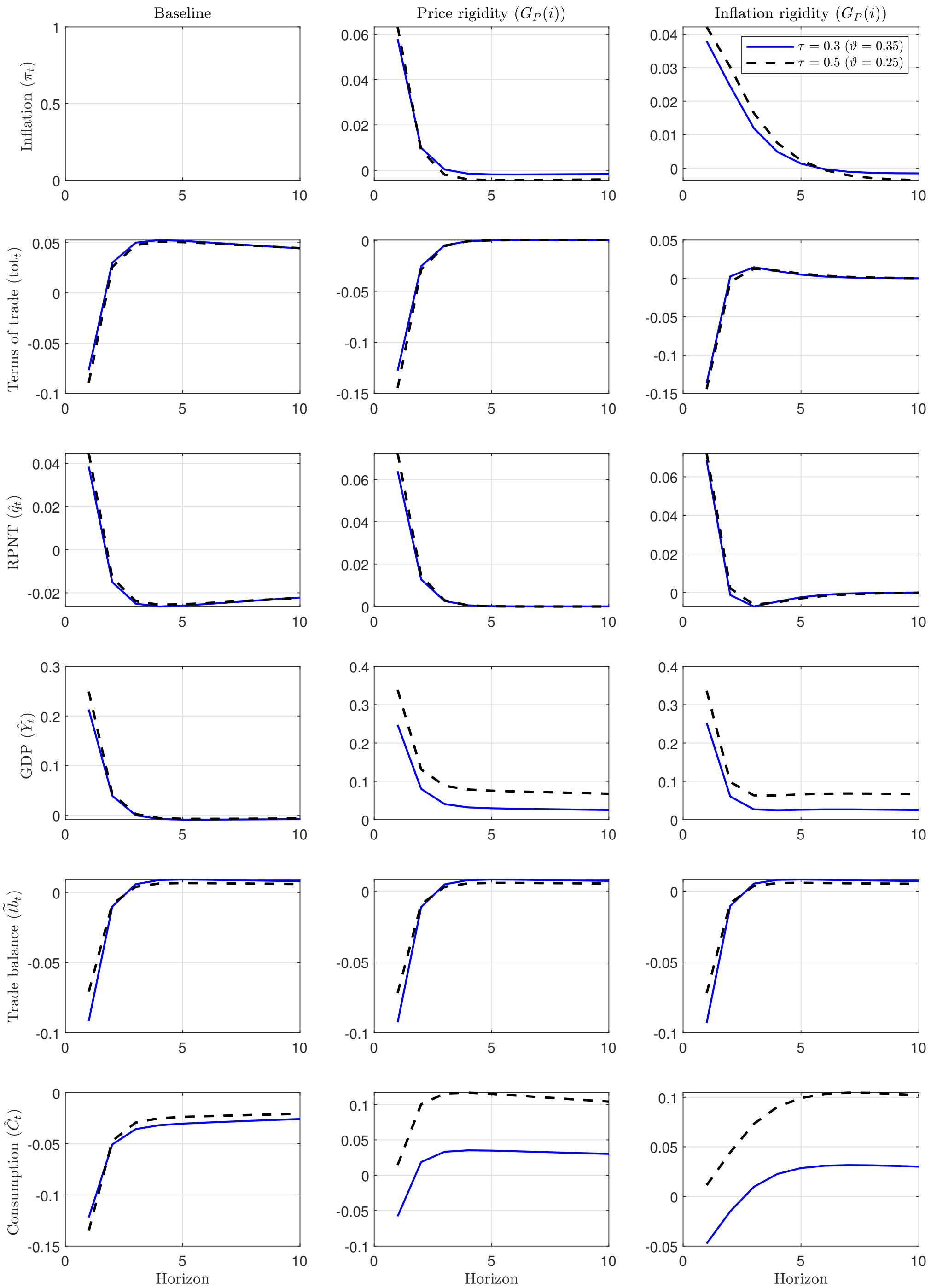
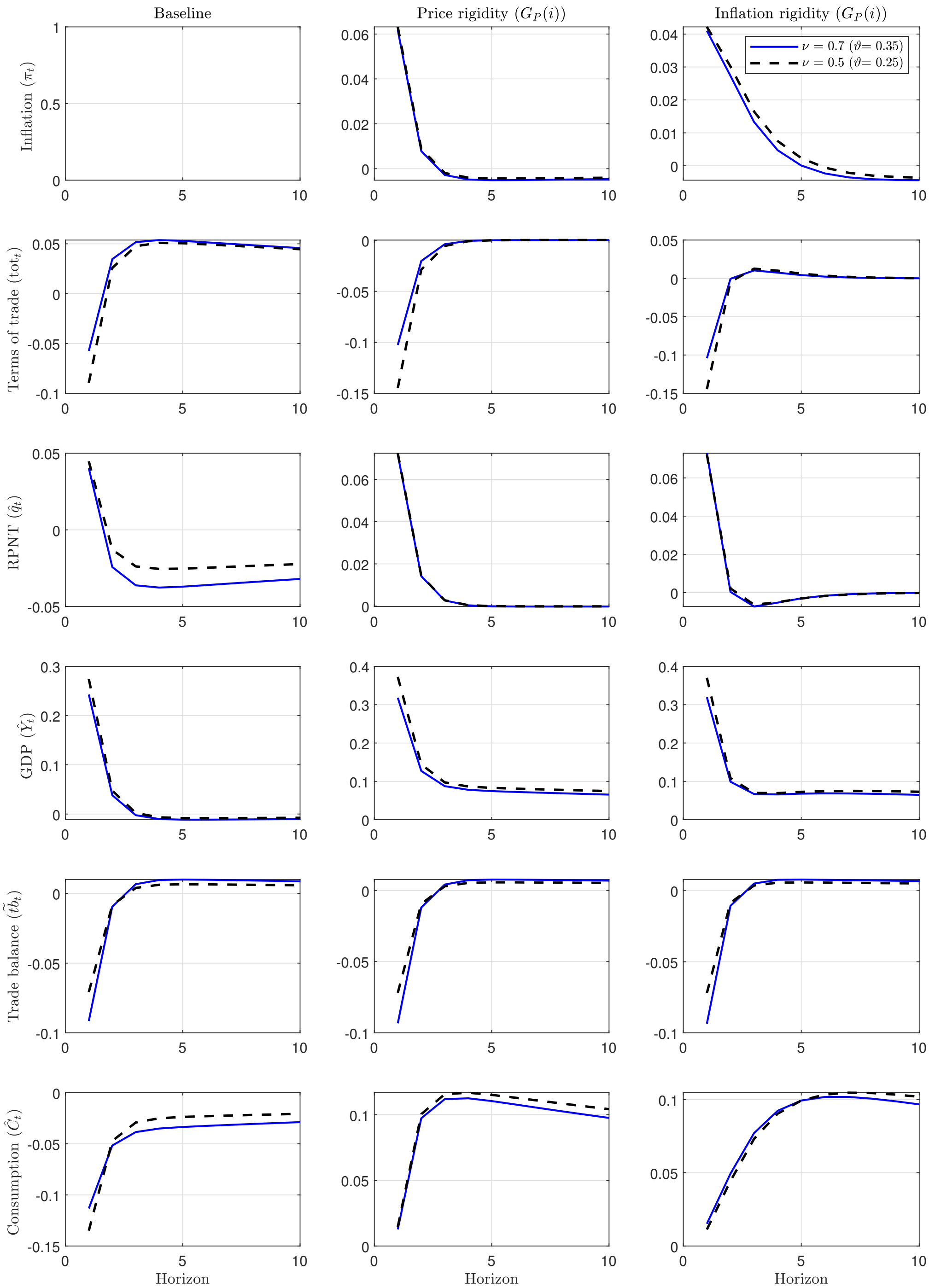


FIGURE 11. Expansionary fiscal spending shock: the role of the import share in the wake of nominal rigidities



spending still rises with the share of nontradables. This applies to both the output and employment multipliers, but also for household consumption. The reason for the higher multiplier throughout is due to the different reaction of consumption. In the baseline model, consumption declines owing to the negative wealth effect that comes along with the (deficit financed) increase in fiscal spending. The (absolute) size of the decline is, however, decreasing in the share of non-Ricardian households (ξ), reflecting the offsetting role of rule-of-thumb behaviour on the conventional negative wealth and intertemporal substitution effects triggered by the fiscal expansion. The results hence illustrate the amplifying effects of the introduction of rule-of-thumb consumers. To sum up, the positive relation of the fiscal spending multiplier with the share of nontradables still applies. Even more, the positive relation now turns out even stronger than in the baseline model.

A.7. **Extension 3: Nontradables bias in government consumption.** Corsetti and Müller (2006); Cardi et al. (2020); Born et al. (2021) point out the bias of government consumption towards nontradables. According to Eurostat, compensation of employees (D3 in Table gov_10a_exp) accounts for about 10 percent of GDP and therefore already for roughly 50 percent of government spending. Consequently, the share of nontradables in government spending is bigger than the largest country-year observation for the overall share of nontradables. We now assess this empirical bias towards nontradables of government consumption for the general validity of our results.

We omit the final goods production function on the production side of the theoretical model and introduce a consumption aggregator C_t instead which depends on consumers' demand for tradables $c_{T,t}$ and nontradables $c_{N,t}$ as follows

$$C_t = \left((1-\tau_c)^{\frac{1}{\kappa_c}} c_{T,t}^{\frac{\kappa_c - 1}{\kappa_c}} + \tau_c^{\frac{1}{\kappa_c}} c_{N,t}^{\frac{\kappa_c - 1}{\kappa_c}} \right)^{\frac{\kappa_c}{\kappa_c - 1}}, \tag{55}$$

where τ_c and κ_c are the share of nontradables consumed, the elasticity of substitution and the individual demand functions are given by

$$c_{N,t} = \tau_c \left(\frac{P_{N,t}}{P_t} \right)^{-\kappa_c} C_t, \tag{56}$$

$$c_{T,t} = (1-\tau_c) \left(\frac{P_{T,t}}{P_t} \right)^{-\kappa_c} C_t, \tag{57}$$

and the consumption deflator P_t is given by

$$P_t = \left((1-\tau_c) P_{T,t}^{1-\kappa_c} + \tau_c P_{N,t}^{1-\kappa_c} \right)^{\frac{1}{1-\kappa_c}} \tag{58}$$

Figure 12. Expansionary fiscal spending shock: the role of non-Ricardian households and a nontradables' bias in government spending

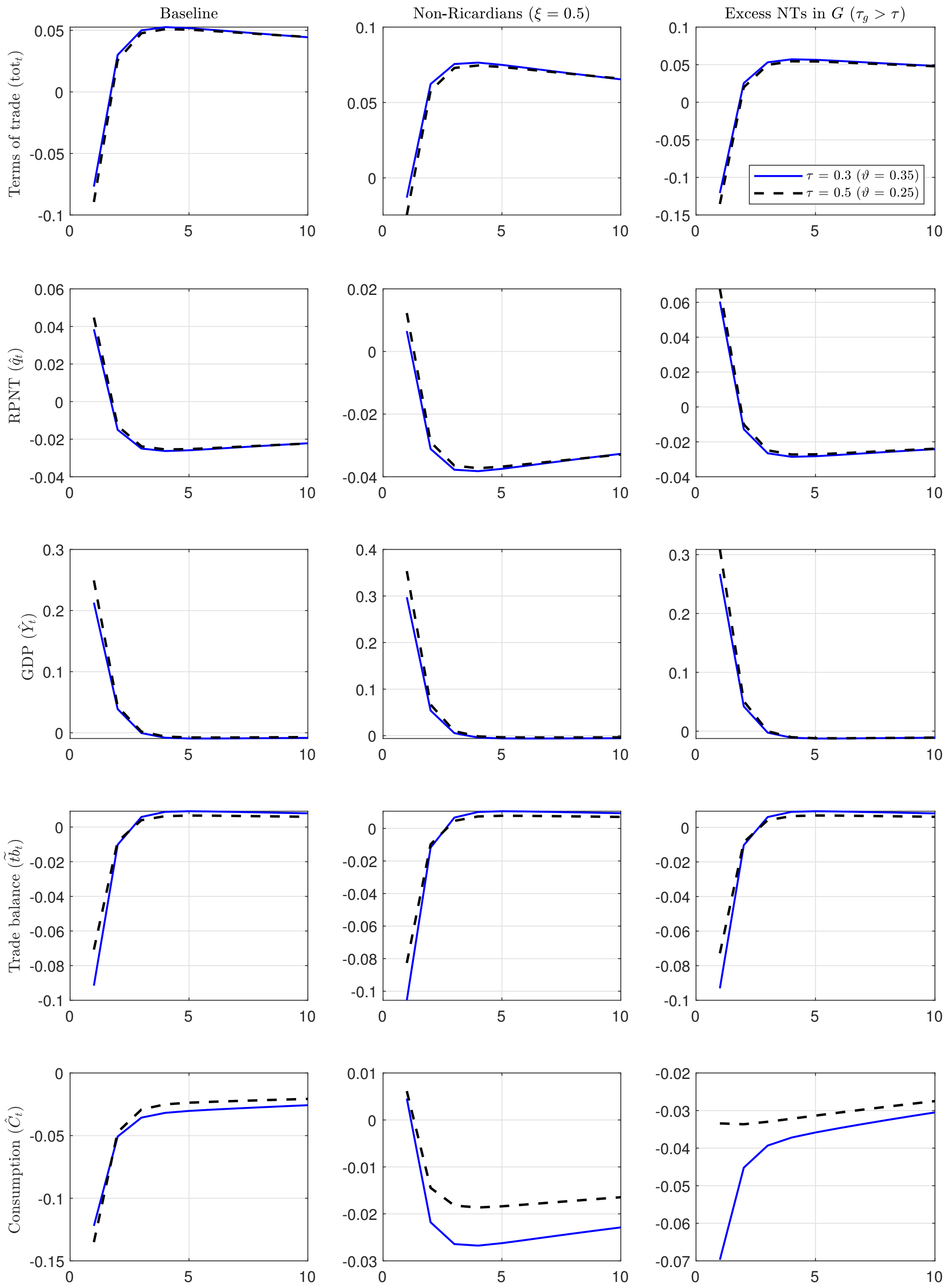
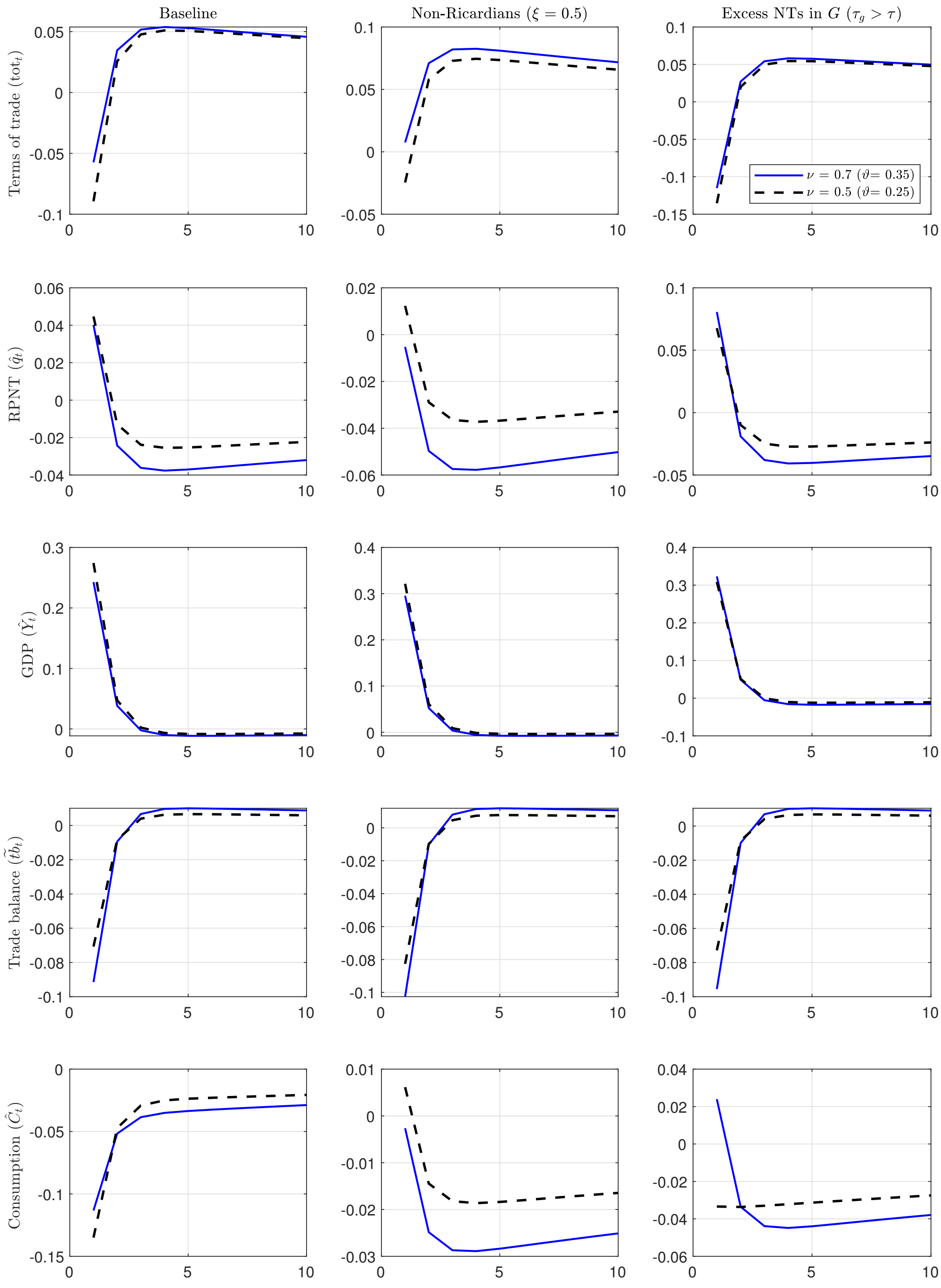


FIGURE 13. Expansionary fiscal spending shock: the role of non-Ricardian households and a nontradables' bias in government spending



The household budget constraint and the first order conditions are still given by the corresponding equation in the main text. In a similar form as private household consumption C_t, also government consumption G_t is now assumed to be composed of tradable and nontradable goods, $g_{T,t}$ and $g_{N,t}$, in the following form

$$G_t = \left((1-\tau_g)^{\frac{1}{\kappa_g}} g_{T,t}^{\frac{\kappa_g-1}{\kappa_g}} + \tau_g^{\frac{1}{\kappa_g}} g_{N,t}^{\frac{\kappa_g-1}{\kappa_g}}\right)^{\frac{\kappa_g}{\kappa_g-1}} \tag{59}$$

where τ_g and κ_g are the share of nontradables consumed by the government and the elasticity of substitution between tradables and nontradables. The individual demand functions are given by

$$g_{N,t} = \tau_g \left(\frac{P_{N,t}}{P_{G,t}}\right)^{-\kappa_g} G_t, \tag{60}$$

$$g_{T,t} = (1-\tau_g) \left(\frac{P_{T,t}}{P_{G,t}}\right)^{-\kappa_g} G_t, \tag{61}$$

and the government consumption deflator $P_{G,t}$ is given by

$$P_{G,t} = \left((1-\tau_g)P_{T,t}^{1-\kappa_g} + \tau_g P_{N,t}^{1-\kappa_g}\right)^{\frac{1}{1-\kappa_g}} \tag{62}$$

The overall level of government consumption G_t still satisfies the stochastic properties outlined in the main text. Finally, the goods market equilibrium relation is now given by

$$Y_t = C_t + \frac{P_{G,t}}{P_t} G_t + \left[\frac{S_t}{P_t}\left(B_t^* - \bar{\imath}^* B_{t-1}^* - \frac{\psi_B^*}{2} P_t \left(\frac{S_t}{P_t} B_t^*\right)^2\right)\right] \tag{63}$$

where the government budget constraint implies that $T_t = G_t$, with domestic bonds being in zero net supply and aggregate production Y_t is given by

$$Y_t = \frac{P_{T,t}}{P_t} y_{T,t} + \frac{P_{N,t}}{P_t} y_{N,t} \tag{64}$$

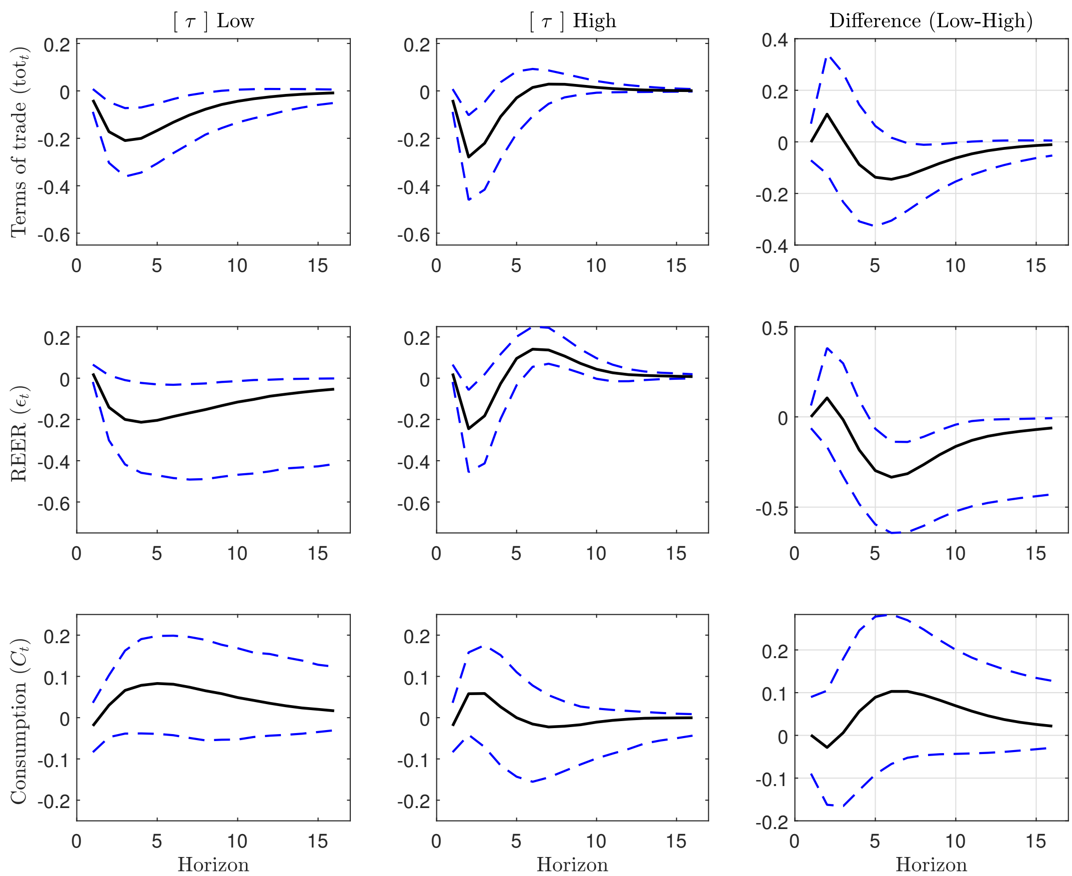
which can be log-linearized to $\hat{Y}_t = \tau\left(\hat{y}_{N,t} + \pi_{N,t}\right) + (1-\tau)\left(y_{T,t} + \pi_{T,t}\right)$, where $\tau = y_N/Y$. Finally, the model is closed by defining the balance of payments.

We assume that $\tau = \tau_c < \tau_g$ and $\kappa_c > \kappa_g$ for simplicity. The remaining parameters are unchanged and provided in Table 2. We again log-linearize the extended model for the purpose of solving it and simulate a rise in government spending. We focus and the extent to which higher values of τ, that is, the share of nontradables in production, shape the results while at the same time we now assess the sensitivity of the results with respect to the nontradables bias of government consumption. The results are shown in the right-hand side panels in Figure 12 for the nontradables share (τ) and in Figure 13 for the import share (ν). As can be seen, the size of the output reaction is noticeably larger compared to the baseline model where the nontradables goods bias in government consumption is absent. Most importantly, however, is the finding that the output reaction in response to a rise in fiscal spending is exacerbated by the share of nontradables. This emerges on the back of a weaker drop in the trade balance and household consumption and highlights the role of the composition in government spending in shaping the size of fiscal spending multipliers.

Appendix B. Further details on the empirical results

This section provides further empirical results of the IPVAR model. We focus, among others, on the role of omitted variables, the specification of the model and the exogeneity assumption of the share of nontradables and the import share which are used as interaction variables in the main specification.

Figure 14. Effects of a fiscal spending shock by share of nontradables – additional variables



Note: The sub-plots in the first column depict IRFs and corresponding 95 percent credible interval when the share of nontradables has a low level (below the 50th percentile). The sub-plots in the second column depict IRFs and corresponding 95 percent credible interval when the share has a high level (above the 50th percentile). The third column shows the difference of the two IRFs and the corresponding 95 percent credible interval.

B.1. **Omitted variables.** Separate Ljung-Box tests on the residual time series cannot reject the null hypothesis that they follow processes which are uncorrelated over time. However, it is still possible that omitted variables matter for the results. To check whether the identified fiscal spending shock is correlated with other (omitted) variables, we first assess the changes in the results when additional variables are added to the IPVAR model, and secondly, we follow Glocker and Towbin (2015) and compute correlations of the estimated structural disturbance with variables that a large class of general equilibrium models suggests as being jointly generated by various shocks.

Concerning the first point, we extend the IPVAR model by variables which have been found important within the transmission channel of fiscal spending shocks. These are, among others, real private household consumption spending,[36] the terms of trade and the real effective exchange rate. We add each variable individually to the IPVAR model. The responses of these additional variables in the expanded model after an expansionary fiscal spending shock are displayed in Figure 14. The sub-plots show the IRFs for different sizes of the share of nontradables (first and second column) and the difference between them (third column). We find that the expansionary fiscal spending shock triggers a sizeable appreciation of the real effective exchange rate (ϵ_t) and the terms of trade (tot_t). This result is in line with Beetsma et al. (2008) and Berka et al. (2018). Berka et al. (2018) argue that real effective exchange rates in countries of the Eurozone closely reflect differences in the relative prices of nontradables across countries.[37] The appreciation is accompanied by an initial drop and a subsequent rise in consumption, which is, however, not statistically different from zero.[38] Considering the third column, the reaction of consumption does not appear to depend on the particular size of the share of nontradables.

As regards the second aspect, in line with Glocker and Towbin (2015) we compute correlations up to six leads and lags between the shock and the growth rate of local stock market indexes, the stock market index of the Eurozone (EURO STOXX 50), the implied volatility index of the EURO STOXX 50 (VSTOXX), the cyclical component of

[36]Data are taken from the EUROSTAT database: *Actual individual final consumption of households at constant prices* (ESA 2010-code: P.41), where the consumption deflator is used as price measure.

[37]Additionally, Berka et al. (2018) provide evidence that the appreciation of real exchange rates in the countries of the Eurozone also reflects differences in the relative productivity levels in the tradable versus nontradable sectors, which – together with the relative price of nontradables – conforms with the Balassa-Samuelson hypothesis.

[38]When using investment (Gross Fixed Capital Formation) instead of consumption, we observe a small increase, which is, however, only marginally significant. This confirms the results in Beetsma et al. (2006).

the (logged) oil price obtained after applying the Christiano-Fitzgerald filter, monetary policy interest rates, short term government bond interest rates, inflation rates captured by means of the GDP deflator and employment. The cross-correlations indicate that none of the omitted variables correlates significantly with the structural shock.[39]

B.2. **Robustness checks of the empirical model.** In this section we provide the results of further robustness checks. We assess the stability of our baseline results along two dimensions. The first addresses extensions of the specification of the IPVAR model, the second the identification and the third the truly exogenous part. We consider extensions in the form of linear and quadratic trend specifications, different lag lengths, employing the interaction variables as additional individual regressors and changing the identification. As regards the latter, we consider the following: ordering GDP as first (*Cholesky (ver.1)*) and as third variable (*Cholesky (ver.2)*) – in the baseline results, GDP is ordered as second variable. Finally, to address fiscal foresight (or the limited information problem) as discussed in Fragetta and Gasteiger (2014), we follow the idea of the procedure of Forni and Gambetti (2014) and consider truly forward looking variables in the the VAR specification. To this purpose we extend the baseline specification for the yield curve (*Fiscal Foresight*). We provide the results of these exercises only for the output response displayed in Figures 15 and 16.

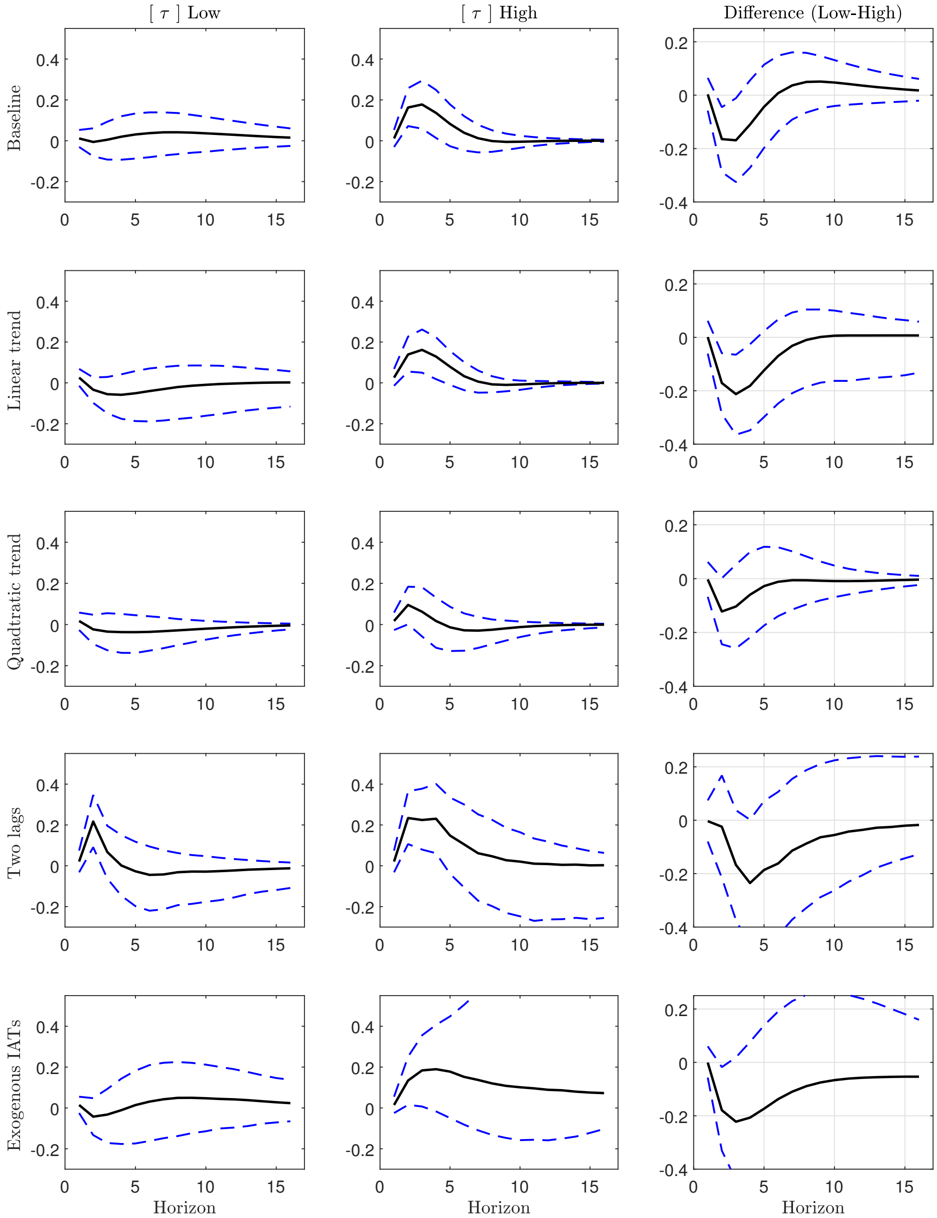
Concerning the exogenous variables part, we consider several extensions in form of additional variables being used in the vector y_t^G. Specifically, we consider the VIX index and the oil price as additional endogenous variables. In addition, we also assess our results when using global industrial production instead of global GDP. The results are provided only for the output response and are shown in Figure 17.

None of the extensions changes our baseline results. In all cases, we observe that the effect of an increase in government spending on output increases with the share of nontradable goods. The difference between low and high values of the share of nontradables is in most cases significantly different from zero.

As a further robustness check in this context, we assessed the role of the exchange rate regime. Standard textbook-models highlight that fiscal spending multipliers are larger in case of a fixed-exchange rate regime. Against this background we constructed an exchange rate dummy variable for each country (flexible or fixed exchange rate; Eurozone membership is classified as fixed exchange rate) to assess the role of the exchange

[39]The statistical importance of the cross-correlations has been judged by means of the upper and lower limits of an asymptotic 95 percent confidence tunnel for the null hypothesis of no cross-correlation.

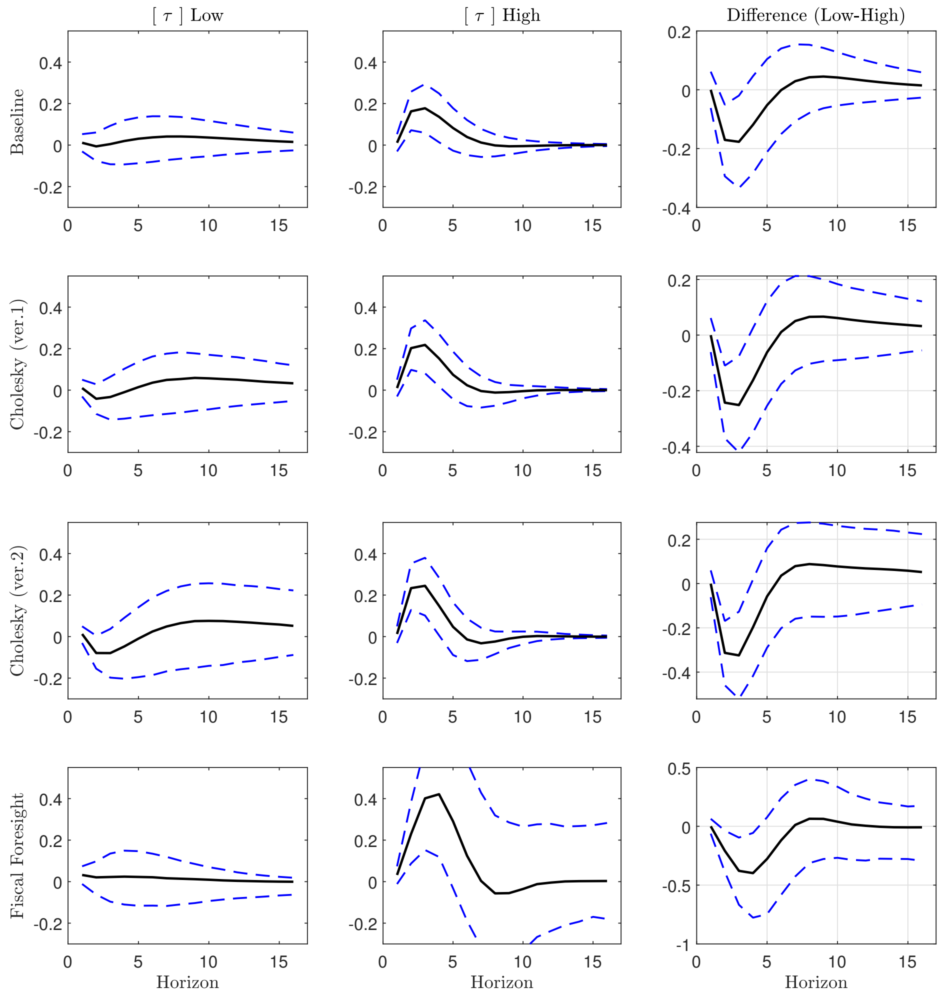
FIGURE 15. Extensions 1: Effects of a fiscal spending shock on GDP



Note: The sub-plots show the IRFs of GDP to an expansionary government consumption shock for low and high levels of the share of nontradables τ (panels in the first and second column) and the difference thereof (right-hand side panels). The IRFs are shown for different specifications of the IPVAR model where the IRFs of the baseline specification (panels in the first row) are compared to the following extensions of the baseline specification: linear and quadratic time-trend (panels in the second and third rows), different lag-length (panels in the fourth row) and the interaction variables also added as exogenous variables (*Exogenous IATs*, panels in the fifth row).

rate regime on our results (see Towbin and Weber, 2013, for details on this). The results of this extension are in line with our baseline results. This is primarily due to the fact

FIGURE 16. Extensions 2: Effects of a fiscal spending shock on GDP

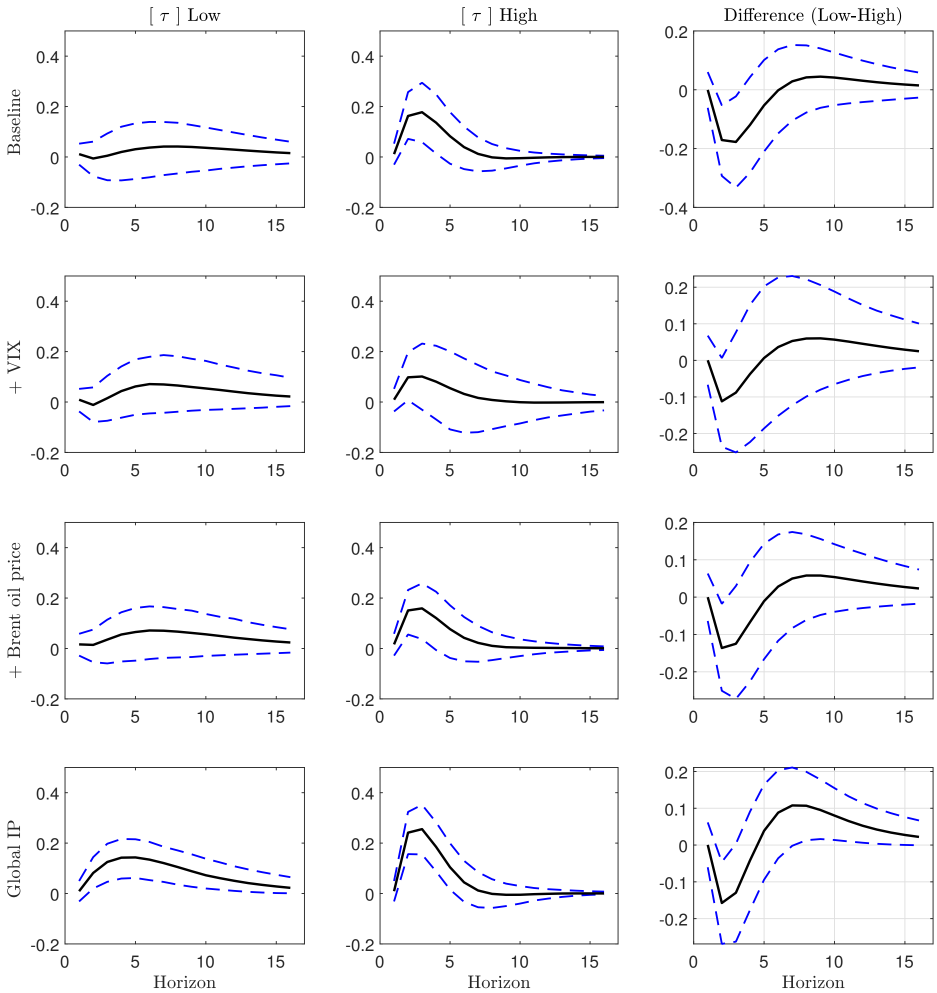


Note: The sub-plots shows the IRFs of GDP to an expansionary government consumption shock for low and high levels of the share of nontradables τ (panels in the first and second column) and the difference thereof (right-hand side panels). The IRFs are shown for different specifications of the IPVAR model where the IRFs of the baseline specification (panels in the first row) are compared to the following extensions of the baseline specification with a focus on the identification of the government consumption shock: different orderings of the endogenous variables in the IPVAR model where *Cholesky (ver.1)* and *Cholesky (ver.2)* order GDP as first and third variable (panels in the second and third rows) while in the baseline results, GDP is ordered as second variable; finally, *Fiscal Foresight* (panels in the fourth row) considers the limited information problem as discussed in Fragetta and Gasteiger (2014) and we follow the idea of the procedure of Forni and Gambetti (2014) and extend the baseline specification for the yield curve.

that the coefficients of the exchange rate dummy variables are rather small for nearly all countries and statistically not significantly different from zero in all cases.

B.2.1. *On the exogeneity assumption of the share of nontradables.* As a further robustness check, we estimate a panel VAR (PVAR) model without interaction terms, but using the share of nontradable goods as an additional endogenous variable. The vector

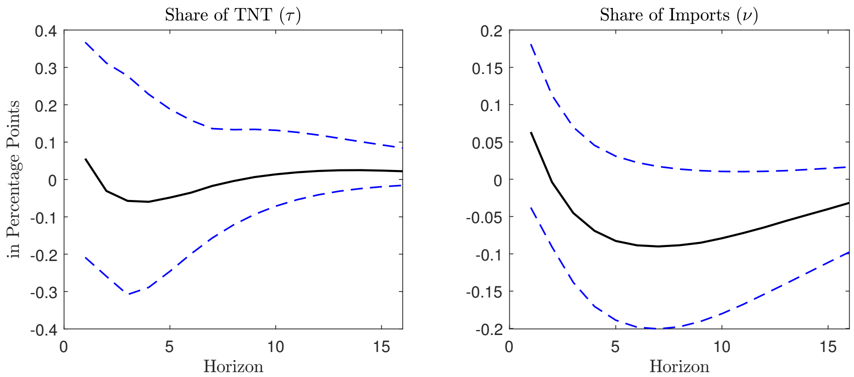
FIGURE 17. Extensions 3: Effects of a fiscal spending shock on GDP



Note: The sub-plots shows the IRFs of GDP to an expansionary government consumption shock for low and high levels of the share of nontradables τ (panels in the first and second column) and the difference thereof (right-hand side panels). The IRFs are shown for different specifications of the IPVAR model where the IRFs of the baseline specification (panels in the first row) are compared to the following extensions of the baseline specification with a focus on the exogenous variables: we add the VIX index (panels in the second row), the (in logarithmic terms) Brent oil price (panels in the third row) and finally we substitute the global industrial production index from the baseline specification with global GDP (panels in the fourth row).

y_t is now five-dimensional. We estimate the PVAR model and simulate the effects of an increase in fiscal spending. The results can provide insights as regards the plausibility in using the share of nontradables as exogenous variable in the baseline results. We let the share of nontradable goods enter the PVAR model as *fast* variable, i.e. changes in government spending are allowed to have an immediate effect on the share of nontradables, though not the other way around. We find that an increase in government spending by one percent induces an increase in the share of nontradable goods by 0.1 percentage points at the maximum. Given that the median of the share of nontradable

Figure 18. Examining the exogeneity assumption



Note: The sub-plots show the IRFs of the share of nontradables (left) and the import share (right) to an expansionary government consumption shock in a model without interaction terms. The panels show the median and the 68 percent credible interval.

goods across all EU countries is around 0.36 for the period 1999-2019, this result implies that the share of nontradables would increase to 0.361. This increase is negligibly small from a quantitative point of view. Moreover, the response is statistically not significantly different from zero as indicated by the 68-percent error bands. The simulations shown in the main text use a low and a high percentile of the distribution of the share of nontradables, which implies a share of nontradable goods equal to 0.32 in the first and 0.4 in the second case. Hence, we consider these results in favor of our baseline specification, which utilizes the share of nontradables as an interaction variable, which in turn implies that this share is exogenous to fiscal spending shocks.

B.2.2. *On the exogeneity assumption of the import share.* As a final robustness check, we examine the exogeneity assumption of the import share in the IPVAR model. This assessment resembles the one of Section B.2.1 where the focus was on the share of nontradables. The IPVAR model as specified in the main text uses the import share as an interaction variable. In this context, it is assumed that the import share is exogenous with respect to fiscal spending shocks. The plausibility of this assumption can be examined empirically by using the import share as an additional endogenous variable rather than as an exogenous (or interaction) variable. This implies that the vector of endogenous variable y_t in the model is now five-dimensional (government consumption spending, relative price of nontradable goods, GDP, the trade balance and the import share). This gives rise to a PVAR model rather than an IPVAR model. We estimate the PVAR model and simulate the effects of an increase in fiscal spending. The results can provide insights as regards the plausibility in using the import share as exogenous variable in the baseline results. We let the import share enter the PVAR model as *fast* variable, i.e. changes in government consumption spending are allowed to have an immediate effect on the import share, though not the other way around. We find that an increase in government spending by one percent induces an increase in the import share by 0.05 percentage points initially followed by a decline. However, most importantly, the response is statistically not significantly different from zero as indicated by the 68-percent error bands. Hence, we consider these results in favour of our baseline specification, which utilizes the import share as an interaction variable, which in turn implies that this share is exogenous to fiscal spending shocks.