IMPERFECT MOBILITY OF LABOR ACROSS SECTORS AND FISCAL TRANSMISSION*

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Abstract

This paper develops a two-sector open economy model with imperfect mobility of labor across sectors in order to account for time-series evidence on the aggregate and sectoral effects of a government spending shock. Using a panel of sixteen OECD countries over the period 1970-2007, our VAR evidence shows that a rise in government consumption i) increases hours worked and GDP and produces a simultaneous decline in investment and the current account, ii) increases non traded output relative to GDP and thus its output share (in real terms) and lowers the output share of tradables, and iii) causes both the relative price and the relative wage of non tradables to appreciate. While the second set of findings reveals that the government spending shock is biased toward non tradables and triggers a shift of resources for this sector, the third finding indicates the presence of labor mobility costs, thus preventing wage equalization across sectors. Turning to cross-country differences, empirically we detect a positive relationship between the magnitude of impact responses of sectoral output shares and the degree of labor mobility across sectors. Our quantitative analysis shows that our empirical findings for aggregate and sectoral variables can be rationalized as long as we allow for a difficulty in reallocating labor across sectors along with adjustment costs to capital accumulation. Finally, the model is able to generate a cross-country relationship between the degree of labor mobility and the responses of sectoral output shares which is similar to that in the data.

Keywords: Fiscal policy; Labor mobility; Investment; Relative price of non tradables; Sectoral wages.
JEL Classification: E22; E62; F11; F41; J31.

*We are grateful to Agustin Benetrix for sharing RATS codes and to Luisito Bertinelli who provided invaluable help at different stages of the paper. We thank Francisco Alvarez-Cuadrado, Stefan Schubert, and participants at the 18th Conference Theories and Methods of Macroeconomics, 13-14 February 2014, the seminar at the University of Rennes 1, 15 January 2015, and the Workshop 'Advances in Dynamic Macroeconomics', 17-21 May 2016, at the University of Bolzano, for valuable comments. Obviously, any remaining shortcomings are our owns.

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1 Introduction

Does a government spending shock affect the production sectors of an open economy uniformly? If not, how can we explain the heterogeneity in the sectoral effects of a rise in government consumption? Does the magnitude of the sectoral effects vary across countries and what factors cause such differences? Our paper provides an attempt to answer these questions by exploring empirically both the aggregate and the sectoral impacts of a government spending shock and calibrating an open economy version of the neoclassical model with tradables and non tradables. We find that the model is successful in replicating the evidence on the sectoral and aggregate effects of fiscal policy once we allow for imperfect mobility of labor across sectors along with capital installation costs. While these two features change the predictions of the model in a way that makes them consistent with our empirical findings on fiscal policy transmission, we find that the degree of labor mobility across sectors varies substantially across countries and is key to generating cross-country differences in the sectoral impact of a government spending shock.

Following the empirical work pioneered by Blanchard and Perotti [2002] on the identification of fiscal shocks in a VAR model, fiscal policy transmission has attracted considerable attention in the literature which has focused mainly on two issues. The first is the positive response of consumption to a rise in government spending, as exemplified in the papers by Gali, Lopez-Salido, and Vallès [2007], and Bilbiie [2011]. The second is related to factors determining the size of the aggregate fiscal multiplier. The theoretical study by Christiano, Eichenbaum, Rebelo [2011] shows that the fiscal multiplier is less than one in the neoclassical model, greater than one in a New-Keynesian model, as much as three times greater when the zero lower bound on the nominal interest binds. Despite the revival of interest in the fiscal policy tool and the vast existing literature on this subject, we believe that there is still a need to improve our understanding of fiscal transmission as the sectoral impact of fiscal shocks has received little attention in the literature.

The motivation for the analysis of the sectoral effects of a rise in government consumption is based on our panel VAR evidence which highlights two major findings. First, a government spending shock has a strong expansionary effect on hours worked and output in the non traded sector while the traded sector experiences a decline in hours worked and output. Moreover, non traded output increases relative to GDP (in real terms), thus raising the output share of non tradables while at the same time the output share of tradables falls. These findings suggest that the rise in government consumption is biased toward non traded goods and triggers a reallocation of resources toward this sector. Second, the extent of the positive impact on the share of non tradables and the size of the contraction in the share of tradables display a wide dispersion across OECD economies. In our paper, we propose an interpretation of cross-country differences in the magnitude of the sectoral impact of a government spending shock based on international differences in the degree of labor mobility across sectors.

In this regard, our study can be viewed as complementary to three papers which contrast the effects of fiscal policy on output across a number of country characteristics. Using a panel of 44 industrialized and developing countries, Ilzetzki, Mendoza, and Vegh [2013] find that fiscal multipliers increase with the level of development, decrease with the level of public debt, and are lower in countries which are more open to international trade, or operating under flexible exchange rate regimes. The last of these findings has been further explored by Born, Juessen and Müller [2013] who shed some light empirically on the fiscal transmission underlying this result and show that a New Keynesian small open economy model can account for the diversity of the size of government spending multipliers across exchange rate regimes. A third noteworthy work is the paper by Brinca, Holter, Krusell, Malafry [2016] who show both empirically and theoretically that there is a strong positive relationship across countries between the magnitude of fiscal multipliers and wealth inequality captured by the Gini index. While these papers focus only the aggregate fiscal multiplier, we analyze the factors determining the size of the sectoral fiscal multiplier along with the movement of sectoral output relative to GDP corresponding to sectoral output shares in real terms. By investigating the change in sectoral output relative to GDP, we filter the change in sectoral output arising from GDP growth and thus isolate the pure reallocation effect. Using a panel of 16 OECD countries over the period 1970-2007, we estimate a VAR model that includes sectoral variables by adopting the fiscal shock identifying assumption proposed by Blanchard and Perotti [2002]. We find empirically that non traded output increases by 0.7% of GDP on impact while the output share of non tradables rises initially by 0.35% of GDP. That is to say, non traded ouput would increase by 0.35% if GDP remained constant. Thus the reallocation of resources toward the non traded sector contributes to 50% of non traded output growth.

While a government spending shock generates a substantial reallocation of resources which significantly affects the relative size of sectors, our evidence also reveals that non traded wages increase sharply relative to traded wages. This empirical finding casts doubt over the assumption of perfect mobility of labor across sectors and rather suggests some difficulty in reallocating labor between sectors. To assess the extent of mobility costs, we estimate the elasticity of labor supply across sectors for each country in our sample which plays a pivotal role in our model. Estimating the panel VAR model for countries with a low and a high elasticity of labor supply across sectors, we find that non traded wages increase more relative to traded wages while hours worked (output) in tradables relative to non tradables fall less in countries where the elasticity is low. This corroborates our conjecture that in countries where mobility costs are higher, non traded firms wishing to produce more must pay much higher wages to attract workers. In order to emphasize the importance of mobility costs for fiscal transmission, we explore the cross-country relationship between the responses of sectoral output shares and the degree of labor mobility captured by the elasticity of labor supply across sectors. While the vast majority of the economies experience a rise (decline) in their output share of non tradables (tradables), we empirically detect a positive relationship between the size of the responses of sectoral output shares and the degree of labor mobility.

In order to account for the aggregate and the sectoral effects of a government spending shock, we put forward a variant of the two-sector open economy model with tradables and non tradables. Our setup has two distinct pivotal features. First, we consider a difficulty in reallocating labor across sectors. To generate imperfect mobility of labor, we assume limited substitutability in hours worked across sectors along the lines of Horvath [2000]. The advantage of such a modelling strategy is that the elasticity of substitution of labor across sectors that captures the degree of labor mobility can be estimated. An additional attractive feature is that it allows us to consider the range of all degrees of labor mobility across sectors, with perfect labor mobility emerging as a special case. Second, we assume that physical capital accumulation is subject to adjustment costs.

Calibrating the model to a representative OECD economy, we explore quantitatively the dynamic effects of a rise in government consumption by 1% of GDP biased toward non traded goods. We find that the time-series evidence on fiscal transmission can be rationalized provided we allow for both capital installation costs and imperfect mobility of labor across sectors. Regarding the aggregate effects, the baseline model is able to account for the rise in hours worked and GDP in the short-run along with the simultaneous decline in investment and the current account. Turning to the sectoral effects, the model is also successful in replicating the expansionary effect of a government spending shock on non traded labor and output, together with the appreciation in the relative price of non tradables and the rise in the non traded wage relative to the traded wage. Importantly, we find quantitatively that the rise in government consumption increases the output share of non tradables and lowers the relative size of the traded sector, and more so in countries with a higher degree of labor mobility across sectors. Our sensitivity analysis reveals that by imposing perfect mobility of labor and/or abstracting from capital installation costs, the model fails to account for both the aggregate and the sectoral effects of a government spending shock.

Given the success of our model in replicating the evidence, the final exercise we perform is to calibrate the model to match data from the 16 OECD countries regarding dimensions such as the non tradable content of labor, consumption, investment, government spending, and the elasticity of labor supply across sectors capturing the degree of labor mobility that we estimate for each economy in our sample. In line with the evidence, the countries experience a decline in the output share of tradables and a rise in the output share of non tradables which are more pronounced in countries with higher degree of labor mobility. We find quantitatively that impact responses of sectoral output shares to a government spending shock are sensitive to the degree of labor mobility, as they vary between 0.26% and 0.49% of GDP for non tradables when we move from the lowest to the highest value of the elasticity of labor supply across sectors. Although the model tends to understate changes in the relative size of sectors, it is able to generate a cross-country relationship between the responses of sectoral output shares and the degree of labor mobility that is similar to that in the data.

We contribute to the vast literature investigating fiscal transmission both empirically and theoretically by focusing on the sectoral impact which has so far received little attention. From an empirical point of view, one major finding is that the impact of government spending shocks is not uniform across sectors and generates a reallocation of labor toward the sector where the rise in public purchases is heavily concentrated. In this regard, like Ramey and Shapiro [1998], we emphasize the importance of the composition of government spending for understanding both the aggregate and the sectoral effects of a fiscal shock. In contrast to the authors who consider a rise in defense spending during a military buildup, which is heavily concentrated in the manufacturing sector, we investigate a rise in government consumption in 'normal times' and find that such a government spending shock leads to a sharp increase in the relative size of the non traded sector. This finding is in line with estimates documented by Monacelli and Perotti [2008] and Benetrix and Lane [2010] which reveal that an increase in government spending disproportionately benefits the non traded sector. In contrast to the authors who restrict their attention to sectoral outputs, we also analyze the effects on sectoral output shares along with the consequences for the labor markets of both sectors. Such an empirical investigation enables us to highlight the pivotal role of labor reallocation across sectors for fiscal transmission in open economies and to uncover a relationship between the magnitude of the sectoral impact of a fiscal shock and the degree of labor mobility across sectors.

From a theoretical point of view, we develop an open economy version of the neoclassical model with tradables and non tradables along the lines of Cordoba (de) and Kehoe [2000]. We extend their setup by considering elastic labor supply and limited substitutability in hours worked across sectors. Abstracting from physical capital accumulation, our model is tractable enough to deliver a number of analytical results that give a better understanding of the role of imperfect mobility of labor for fiscal transmission. In particular, by hampering the shift of labor toward non tradables, labor mobility costs trigger an excess demand in the non traded goods market caused by a rise in government consumption biased toward non tradables. The consecutive appreciation in the relative price of non tradables provides an incentive to produce and thus to hire more, which in turn increases the output share of non tradables. Our quantitative analysis reveals that this mechanism is key to reproducing the rise in the output share of non tradables estimated empirically. Furthermore, limited labor mobility is not sufficient, on its own, to account quantitatively for the evidence as capital installation costs contribute to magnifying the increase in the output share of non tradables. Intuitively, by mitigating the crowding out of investment, adjustment costs to capital accumulation amplifies the excess demand in the non traded goods market and thus the appreciation in the relative price. In this regard, our work can be viewed as close to the paper by Bouakez, Cardia and Ruge-Murcia [2011]. The authors show that imperfect labor mobility makes the predictions of the sticky-price model consistent with empirical evidence on the sectoral and aggregate effects of monetary policy shocks as long as a second feature, namely input-output interactions, is accounted for.

The remainder of the paper is organized as follows. In section 2, we establish panel VAR evidence on aggregate and sectoral effects of a government spending shock and then document an empirical relationship between the responses of sectoral output shares and the degree of labor mobility. In section 3, we develop an open economy version of the neoclassical model with a difficulty in reallocating labor across sectors. In section 4, we abstract from physical capital accumulation in order to derive a number of analytical results and to build up intuition on fiscal transmission with imperfect mobility of labor. In section 5, we report the results of our numerical simulations and assess the ability of the model to account for the evidence. In section 6, we summarize our main results and present our conclusions.

2 Stylized Facts on Fiscal Transmission

Recently, several studies have explored open economy aspects of the fiscal transmission mechanism on the basis of estimated vector autoregression (VAR) models in panel format, see e.g., Beetsma et al.[2008], Benetrix and Lane [2010], Corsetti, Meier and Muller [2012], Ilzetzki, Mendoza, and Vegh [2013]. However, little attention has been paid to the sectoral effects of a government spending shock, except for Benetrix and Lane [2010]. In this section, we thus revisit the time-series evidence on the aggregate and sectoral effects of government spending shocks. Because the sectoral impact of an expansionary fiscal shock varies considerably across the countries in our sample, we also contrast the effects of government spending shocks in economies with low and high workers' mobility costs and document an empirical relationship between the degree of labor mobility across sectors and the magnitude of the sectoral impact of a fiscal shock. We denote below the level of the variable in upper case and the logarithm in lower case.

2.1 VAR Model and Identification

In order to shed some light on fiscal transmission and guide our quantitative analysis, we estimate the VAR model in panel format on annual data. We consider a structural model with $k = 2$ lags in the following form:

$$AZ_{i,t} = \sum_{k=1}^{2} B_k Z_{i,t-k} + \epsilon_{i,t}, \tag{1}$$

where subscripts i and t denote the country and the year, respectively, $Z_{i,t}$ is the vector of endogenous variables, A is a matrix that describes the contemporaneous relation among the variables collected in vector $Z_{i,t}$, B_k is a matrix of lag specific own- and cross-effects of variables on current observations, and the vector $\epsilon_{i,t}$ contains the structural disturbances which are uncorrelated with each other.

Because the VAR model cannot be estimated in its structural form, we pre-multiply (1) by A^{-1} which gives the reduced form of the VAR model:

$$Z_{i,t} = \sum_{k=1}^{2} A^{-1} B_k Z_{i,t-k} + e_{it}, \tag{2}$$

where $A^{-1}B_k$ and $e_{it} = A^{-1}\epsilon_{it}$ are estimated by using a panel OLS regression with country fixed effects and country specific linear trends. To identify the VAR model and recover the government spending shocks, we need assumptions on the matrix A as the reduced form of the VAR model that we estimate contains fewer parameters than the structural VAR model shown in eq. (1).

To identify fiscal shock, we follow Blanchard and Perotti [2002] and assume that government spending is predetermined relative to the other variables in the VAR model. We thus adopt a Choleski decomposition in which government spending is ordered before the other variables so that the fiscal shock is exogenous. Technically, matrix A is thus lower-triangular. The identifying assumption holds as long as public spending does not respond to current output developments. As argued by Blanchard and Perotti [2002] who use quarterly data, typical fiscal policy conduct suggests that public spending cannot react contemporaneously to the state of the economy due to delays between current output observation and the implementation of fiscal measures. However, because our aim is to estimate the effects of public spending on a number of sectoral variables, quarterly data are not available for most of the countries, so we must use annual data. The potential problem is that Blanchard and Perotti's argument is not necessarily true when using annual data as some adjustment could be possible. To support our assumption, we estimated the same panel VAR model that includes aggregate variables which are available on a yearly and a quarterly basis. The responses of variables to an exogenous fiscal shock are similar whether we use annual or quarterly series as our estimates using quarterly data lie within the confidence interval of those obtained from yearly data.[1] Our results accord well with the conclusion reached by

[1] The results are included in a Technical Appendix available on request from the authors.

Born and Müller [2012] whose test reveals that the assumption that government spending is predetermined within the year cannot be rejected. Furthermore, we obtain results for aggregate variables which confirm those obtained by previous empirical studies using quarterly data. Moreover, as government spending does not include transfers (such as unemployment benefits), it is therefore much less likely to respond automatically to the other variables. Finally, the advantage of using annual data instead of quarterly series is that potential anticipation effects of policy changes are less likely to bias the estimates, as the identified shocks are more likely to be truly unanticipated.

2.2 Data Construction

Before presenting the VAR model, we briefly discuss the dataset we use. Our sample consists of a panel of 16 OECD countries: Australia (AUS), Austria (AUT), Belgium (BEL), Canada (CAN), Denmark (DNK), Finland (FIN), France (FRA), Ireland (IRL), Italy (ITA), Japan (JPN), the Netherlands (NLD), Norway (NOR), Spain (ESP), Sweden (SWE), the United Kingdom (GBR), and the United States (USA). Our sample covers the period 1970-2007 and contains annual observations.

As detailed in the next subsection, we consider a number of VAR specifications as we wish to shed some light on the reallocation of resources triggered by a fiscal shock that affects the relative size of sectors. Because their movements are strongly intertwined, we explore empirically both the aggregate and sectoral effects of government spending shocks. The former variables consist of government consumption (G_{it}), GDP (Y_{it}), private fixed investment (JE_{it}), current account (CA_{it}), labor (L_{it}), real consumption wage ($W_{C,it}$). All data are obtained from the OECD Economic outlook and OECD STAN database together with EU KLEMS database. For government final consumption expenditure, GDP, private investment (excluding residential investment), we use the volumes reported by the OECD. Aggregates G_{it}, Y_{it}, JE_{it} are deflated with their own deflators. We use hours worked to measure labor.[2] All quantities are scaled by the working age population and are measured in logs, except for the current account which is expressed as a fraction of GDP. The real consumption wage is the ratio of the nominal aggregate wage, W_{it}, to the consumption price index, $P_{C,it}$, and is measured in logs. The nominal wage is obtained by calculating the ratio of labor compensation to the number of hours worked. Details of data construction and the source of variables used in our estimate are given in Appendix A.

Because we also empirically explore the sectoral effects of fiscal transmission, we briefly describe how we construct time series at a sectoral level. Our sample covers the period 1970-2007 (except for Japan: 1974-2007), for eleven 1-digit ISIC-rev.3 industries. To split these eleven industries into traded and non traded sectors, we follow the classification

[2] Alternatively we use the number of employees as a measure of labor. All results remain almost unchanged.

suggested by De Gregorio et al. [1994]. Agriculture, hunting, forestry and fishing; Mining and quarrying; Total manufacturing; Transport, storage and communication are classified as traded industries. Following Jensen and Kletzer [2006], we updated the classification by De Gregorio et al. [1994] by treating Financial intermediation as a traded industry. Electricity, gas and water supply; Construction; Wholesale and retail trade; Hotels and restaurants; Real estate, renting and business services; Community, social and personal services are classified as non traded industries. Once industries have been classified as traded or non traded, series for sectoral value added in current (constant) prices are constructed by adding value added in current (constant) prices for all sub-industries in sector $j = T, N$. The same logic applies to constructing series for hours worked and labor compensation in the traded and the non traded sectors.[3]

We use the EU KLEMS [2011] and OECD STAN database which provide domestic currency series of value added in current and constant prices, labor compensation and employment (number of hours worked) at an industry level, from which we construct price indices, P_{it}^j, which correspond to sectoral value added deflators, and sectoral wage rates, W_{it}^j. The relative price of non tradables, P_{it}, is the ratio of the non traded value added deflator to the traded value added deflator (i.e., $P_{it} = P_{it}^N/P_{it}^T$). The relative wage, Ω_{it}, is the ratio of the non traded wage to the traded wage (i.e., $\Omega_{it} = W_{it}^N/W_{it}^T$).

2.3 VAR Specification

Because we wish to provide a better understanding of fiscal policy transmission in open economies we consider four specifications. The choice of variables is motivated in part by the variables discussed in the quantitative analysis. All quantities are measured in log and real terms (except for the current account), while prices and wages are logged:

- To explore the magnitude of the aggregate fiscal multiplier empirically, we consider a VAR model that includes in the baseline specification (log) government consumption, g_{it}, GDP, y_{it}, total hours worked, l_{it}, private fixed investment, je_{it}, the real consumption wage denoted by $w_{C,it}$. Our vector of endogenous variables, is given by: $z_{it} = [g_{it}, y_{it}, l_{it}, je_{it}, w_{C,it}]$. In the second specification we replace private investment with the current account expressed in percentage of GDP, ca_{it}.
- To investigate the magnitude of the sectoral fiscal multiplier, we consider a VAR model that includes value added at constant prices in sector j, y_{it}^j, hours worked in sector j,

[3] In contrast to De Gregorio et al. [1994] who treat "Financial intermediation" as non tradable, we classify this industry as tradable, following Jensen and Kletzer [2006]; our sensitivity analysis reveals that our conclusions hold whether "Financial intermediation" is classified as tradable or non tradable. The classification of items "Wholesale and Retail Trade", "Hotels and Restaurants", "Transport, Storage and Communication", "Real Estate, Renting and Business Services" may also display some ambiguity. In order to address this issue, we re-estimated the various VAR specifications for different classifications in which one of the above industries initially marked as tradable (non tradable resp.) is classified as non tradable (tradable resp.), all others industries staying in their original sector. Because results are very similar, to save space we do not present them and are therefore relegated to the Technical Appendix.

l_{it}^j, and the real consumption wage in sector j, $w_{C,it}^j$, defined as the sectoral nominal wage w_{it}^j divided by the consumption price index, $p_{C,it}$. Our vector of endogenous variables, is given by: $z_{it}^j = \left[g_{it}, y_{it}^j, l_{it}^j, w_{C,it}^j\right]$ with $j = T, N$.

- To estimate the change in sectoral output share which is defined as the excess of sectoral fiscal multiplier over the aggregate fiscal multiplier, we consider a VAR model where we divide sectoral value added at constant prices (labor) by GDP in order to filter the change in sectoral output (labor) arising from GDP (total hours worked) growth which allows us to isolate the 'pure' reallocation effect and thus gauge the importance of the shift of resources across sectors that affects their relative size. Denoting the output and labor share of sector j by $\nu_{it}^{Y,j} = y_{it}^j - y_{it}$ and $\nu_{it}^{L,j} = l_{it}^j - l_{it}$, respectively, our vector of endogenous variables, is given by: $z_{it}^{S,j} = \left[g_{it}, \nu_{it}^{Y,j}, \nu_{it}^{L,j}, w_{C,it}^j\right]$ with $j = T, N$.

- Finally, to investigate the relative price (p) and relative wage (ω) effects of a fiscal shock, we consider a VAR model where we replace sectoral quantities with the ratio of sectoral quantities for both the product and the labor market. Our vector of endogenous variables, is given by: $z_{it}^P = \left[g_{it}, y_{it}^T - y_{it}^N, p_{it}\right]$ and $z_{it}^W = \left[g_{it}, l_{it}^T - l_{it}^N, \omega_{it}\right]$, respectively.

2.4 Effects of Government Spending Shocks: VAR Evidence

We generated impulse response functions which summarize the responses of variables to an increase in government spending by 1 percentage point of GDP. Fig. 1-3 displays the estimated effects of a fiscal shock for our four alternative sets of specifications. The horizontal axis measures time after the shock in years and the vertical axis measures percentage deviations from trend. Government consumption, investment, the current account and GDP are measured in percentage points of total output relative to trend. Total labor, aggregate real consumption wage, sectoral real consumption wages, the relative price of non tradables and the relative wage are measured in percentage deviations from trend. Sectoral labor and sectoral labor share are both measured in percentage deviations of total hours worked from trend, while sectoral output and sectoral output share are both measured in percentage deviations of total output from trend. In each case, the solid line represents the point estimate, while the shaded area indicates 90% confidence bounds obtained by bootstrap sampling. Point estimates are shown in Panel A of Table 1 at a one year-, two-year and four-year horizon.

2.4.1 Aggregate Effects

We start with the aggregate effects of a government spending shock. Fig. 1 shows results for the first VAR model. The top left panel of Fig. 1 shows the endogenous response of government spending to an exogenous fiscal shock. The response of government consumption is hump-shaped, as it peaks after one year and then gradually declines; it shows a high level of persistence over time as it is about 8 years before the shock dies out. The impact on GDP is fairly moderate as the fiscal multiplier is about 0.5 and averages 0.29 during the first four years after the shock.[4] As shown in the last row, the dynamic adjustment of real GDP seems to mimic the dynamic adjustment of hours worked which increases on impact by 0.53% and declines after one year. In addition, we detect a moderate increase in the real consumption wage followed by a rapid decline. Its cumulative response over a two-year horizon is 0.6% approximately, and subsequently becomes negative.

Turning to the response of investment and the current account as shown in the second column of Fig. 1, the top panel indicates that investment is fairly unresponsive on impact which suggests the presence of installation costs, while the middle panel reveals that the current account moves into deficit in the short-run. The government spending shock leads to a protracted decline in investment which remains below trend while the current account recovers after two years and moves into surplus after about 5 years. As shown in Table 1, after four years, the cumulative decline in investment amounts to -1.29 percent of GDP while the current account deficit is substantial at -3.35 GDP percentage points.

< Please insert Figure 1 about here >

< Please insert Table 1 about here >

2.4.2 Sectoral Effects

We now discuss the sectoral effects of a government spending shock. In Fig. 2 we report results for the second VAR model. The first column shows responses for the traded sector while the second column displays results for the non traded sector. As shown in the first row, the response of government consumption to an exogenous fiscal shock is almost identical to that shown in Fig 1. The second row shows the dynamic adjustment of sectoral output. We find that a rise in government consumption has a strong expansionary effect on non traded output which increases significantly on impact by 0.70 percentage point of GDP, as reported in column 3 of Table 1, while its four-year horizon cumulative response is substantial at 1.88 percentage points of GDP. During the first four years after the shock, the non traded output multiplier of government spending averages at about 0.47 percentage point of GDP. In contrast, the traded sector displays a negative fiscal multiplier for the first four years as

[4] Like Ilzetzki, Mendoza, and Vegh [2013], we calculate the (aggregate or sectoral) multiplier at a k-year horizon by computing the ratio of the present value of the cumulative change in output to the present value of the cumulative change in government consumption:

$$\frac{\sum_{t=0}^{k}\left(1+r^{\star}\right)^{-t}\hat{y}_t}{\sum_{t=0}^{k}\left(1+r^{\star}\right)^{-t}\hat{g}_t},$$

where $r^{\star}$ is the world interest rate set to 4% to be consistent with the model calibration and $\hat{y}_t$ and $\hat{g}_t$ correspond to the percentage deviation of output and government consumption from trend in output units, respectively.

the government spending shock gives rise to a contraction in traded output which remains below trend. As shown in the third row of Fig. 2, higher non traded output is associated with a sharp increase in hours worked on impact while the traded sector experiences a gradual decline in labor for the first five years. In addition, the fourth row of Fig. 2 suggests that non traded firms pay higher real consumption wages in the short-run. In sum, our evidence shown in Fig. 2 reveals that the **government spending shock is strongly biased toward non tradable goods** as it benefits the non traded sector at the expense of the traded sector.

The first column of Fig. 3 enables us to gauge the contribution of the reallocation of inputs, labor especially, to the expansion of the relative size of the non traded sector. The first two rows show that the labor share of tradables declines by 0.27 percentage point of total labor while the reverse is true for non tradables. Since the response of sectoral labor share filters the change in sectoral labor arising from growth in total hours worked, our estimates thus suggest that over the first year, a government spending shock causes 0.27% of workers to shift from the traded to the non traded sector. Since non traded hours worked increase by 0.55% of total employment, 50% of non traded employment growth is the result of labor reallocation. As shown in the last two rows of the first column, fiscal shock lowers the output share of tradables significantly and substantially increases that of non tradables. Because changes in output shares indicate how much sectoral output would increase if GDP remained constant, they provide us with valuable information on the shift of inputs across sectors and the resulting changes in their relative size. Quantitatively, since non traded output rises by 0.7 percentage point of GDP while the output share of tradables rises by 0.35 percentage point of GDP, the shift of resources toward the non traded sector alone contributes to 50% of non traded output growth. Our second set of findings shown in Fig. 3 thus reveals that a government spending shock **generates a reallocation of labor that significantly affects the relative size of sectors**.

The second column of Fig. 3 enables us to shed some light on fiscal transmission. The last two rows support the conjecture that government spending shock is biased toward non traded goods as it causes the relative price of non tradables to appreciate significantly in the short-run and generates a decline in the ratio of traded output relative to non traded output. The first two rows show that the sharp decline in hours worked in the traded sector relative to the non traded sector is associated with a significant increase in non traded wages relative to traded wages. The positive response of the relative wage to a government spending shock casts doubt over the assumption of perfect mobility of labor that implies that sectoral wages will equalize and rather **reveals the presence of intersectoral labor mobility costs**.

$<$ Please insert Figures 2-3 about here $>$

2.5 Comparison with Previous Studies

Overall, our panel VAR evidence for aggregate variables is well in line with that reported in earlier studies. In particular, our estimate of an aggregate output multiplier of government spending being lower than one on impact accords well with earlier findings. For example, Corsetti et al. [2012], who use a panel of 17 OECD countries for the period 1975-2008, report an increase in aggregate output by about 0.7 percentage points on impact. As documented by Corsetti et al., an increase in government spending leads to a protracted decline in private investment. The fall in the current account following a rise in public purchases is also in line with earlier findings. Although the empirical literature commonly uses net exports, replacing the current account with the trade balance leads to similar results. Beetsma, Giuliodori and Klaassen [2008] report a fall in the trade balance by 0.5% of GDP for a panel of 11 Euro Area Members while Corsetti et al. [2012] document a decline in net exports on impact which is very similar to ours.

Regarding labor market variables, our evidence reveal that a government spending shock increases hours worked, a finding that again squares well with conventional wisdom and earlier empirical studies, see e.g., Pappa [2009], Ramey [2011]. While there is no debate in the literature about the empirical facts mentioned above, the response of the real wage to a government spending shock is not a clear-cut result. As summarized by Nekarda and Ramey [2011], the literature adopting Blanchard and Perotti's [2002] approach to identifying fiscal shock reports an increase in the real consumption wage while application of the 'narrative' approach reveals that real consumption wages tend to fall in response to military spending shocks, see e.g., Ramey [2011]. While we find a significant rise in the real consumption wage on impact, our panel VAR evidence indicates that it is followed by a rapid decline. In this regard, our result can be viewed as halfway between these two strands of literature applying different identification schemes to U.S. data.

To our knowledge, only Monacelli and Perotti [2008] and Benetrix and Lane [2010] conduct an empirical investigation of the sectoral impact of a government spending shock by differentiating the traded from the non traded sector. Both Monacelli and Perotti [2008] and Benetrix and Lane [2010] find empirically that a government spending shock increases both traded and non traded output, the latter sector increasing by a much larger amount. While our estimates corroborate this finding, we nevertheless find that traded output falls slightly on impact and remains below trend while the fiscal shock is in effect. Beyond the fact that the sample is different, this discrepancy could be attributed to the classification we adopt to split industries into traded and non traded sectors.[5] More specifically, Benetrix and Lane [2010] treat 'Transport, Storage and Communication' and 'Financial Intermediation'

[5] We use a panel of 16 OECD economies over 1970-2007 while Benetrix and Lane [2010] consider a sample of 11 EMU countries over 1970-2005 and Monacelli and Perotti [2008] restrict attention to the US, using quarterly data from 1954 to 2006.

as non traded rather than traded industries while Monacelli and Perotti [2008] refer to industries producing services as non tradables and thus take a different approach from ours.

2.6 Cross-Country Differences in the Sectoral Impact and Imperfect Mobility of Labor

One major empirical fact we established above is that the reallocation of resources toward the non traded sector is associated with a significant rise in non traded wages relative to traded wages.[6] The positive response of the relative wage to a government spending shock can be rationalized through the presence of workers' costs of switching sectors. Intuitively, following a rise in public purchases that are heavily concentrated in non traded industries, establishments in the non traded sector wish to increase their production to meet this additional demand. To attract workers, non traded firms must pay higher wages in order to cover their mobility costs, and all the more so as the difficulty in reallocating hours worked across sectors is more pronounced. In countries where workers' mobility costs are higher, we thus expect the positive response of the relative wage to a fiscal shock to be greater as non traded firms must pay much higher wages to increase hours worked. As the labor demand shifts along a steeper labor supply schedule in countries with greater mobility costs, the decline in relative hours worked in tradables is expected to be less pronounced. Since the traded sector experiences a lower labor outflow, the fall in traded output relative to non traded output should also be less (in absolute terms).

To gauge the importance of workers' mobility costs for fiscal transmission, we thus ask whether the positive response of the relative wage to a fiscal shock is more pronounced while the reallocation of labor is lower in countries where mobility costs are higher. To explore our conjecture empirically, we draw on Horvath [2000] and estimate the elasticity of labor supply across sectors for each country.[7] This parameter measures the extent to which workers are willing to reallocate their hours worked toward the non traded sector following a 1% increase in the relative wage. When the elasticity of labor supply across sectors is greater, workers' mobility costs are thus lower which in turn implies a higher degree of labor mobility. These workers' costs of switching sectors be interpreted as psychological costs when switching from one sector to another (see e.g., Dix-Carneiro [2014]), geographic mobility costs (see e.g., Kennan and Walker [2011]) or can be the result of sector-specific human capital (see e.g., Lee and Wolpin [2006]).

[6] This finding is in line with evidence documented by Artuç et al. [2010], Dix-Carneiro [2014], Lee and Wolpin [2006] who find substantial barriers to mobility and observe that wages are not equalized across sectors in the short run following both trade liberalization episodes and sector-biased technological change.

[7] In section 3, we develop a model with imperfect labor mobility. Along the lines of Horvath [2000], we generate a difficulty in reallocating labor across sectors by assuming limited substitutability in hours worked across sectors. One of the advantage of such a modelling strategy over alternatives is that it allows us to estimate the elasticity of substitution of labor across sectors for each country in our sample. Details about the empirical strategy can be found in Appendix B while details of derivation of the testable equation are provided in a Technical Appendix.

Building on our panel data estimates for the 16 OECD countries over the period 1970-2007, we split our sample into groups of 'high mobility' and 'low mobility' economies and re-estimate the sectoral effects for each of the two groups. The 'low mobility' economies are those for which the switching cost is above average for the sample. In order to provide some support for our measure of workers' mobility cost, we compute an intersectoral labor reallocation index in year t for each country i, denoted by $LR_{i,t}$, by calculating the average change between year t and $t-\tau$ in the amount of labor employed in sector j as a fraction of total employment:[8]

$$LR_{i,t}(\tau) = 0.5 \left[\sum_{j=T}^{N} \left| \frac{L_{i,t}^{j}}{\sum_{j=T}^{N} L_{i,t}^{j}} - \frac{L_{i,t-\tau}^{j}}{\sum_{j=T}^{N} L_{i,t-\tau}^{j}} \right| \right]. \tag{3}$$

We choose $\tau = 2$ to eschew year-to-year changes because of the low frequency changes in labor at that horizon and consider only differences over 2 years. As the values of the labor reallocation index, LR, increase, the fraction of workers who are working in a different sector in year t than in year $t-\tau$ is thus larger.[9]

While the third column of Fig. 3 contrasts the cumulative responses for the labor reallocation index, hours worked in tradables relative to non tradables, and the relative wage, the last two columns of Panel B of Table 1 show the point estimates for both sub-samples for selected horizons. Focusing first on cumulative responses displayed in the last column of Fig. 3 with the solid (dotted) line showing results for our sub-sample of countries which we classify as 'low mobility' ('high-mobility') economies, a government spending shock increases the reallocation of labor across sectors, although this is less pronounced for the 'low mobility' economies. Contrasting point estimates reported in columns 5 and 6 of Table 1, we find that the magnitude of the shift of labor in the 'low mobility' group is about five times less in first year. This finding thus lends credence to our measure of mobility costs. Importantly, in accordance with our conjecture, we find that the magnitude of the responses of the relative wage and relative hours worked of tradables are different across the sub-samples. As can be seen in the last row of Fig. 3, non traded wages increase substantially relative to traded wages for the 'low mobility' economies while the relative wage response for 'high mobility' countries is not statistically different from zero. The third row of Fig. 3 shows that the 'low mobility' economies experience a fall in relative hours worked of tradables which is less pronounced as labor supply is less elastic to the relative wage. Because the shift of labor toward the non traded sector is less, 'low mobility' economies also experience a smaller decline in output of tradables relative to non tradables as shown by point estimates reported in the last two columns of Table 1.

Overall, our results emphasize the importance of labor mobility for fiscal transmission.

[8] See e.g., Kambourov [2009] who computes the same labor reallocation index (3).

[9] When we estimate the response of the intersectoral labor reallocation index to a government spending shock, we replace hours worked in the traded sector in terms of hours worked in the non traded sector, $l_{it}^{T} - l_{it}^{N}$ with $LR(2)_{it}$ and thus consider the 'labor reallocation' specification that is given by: $z_{it}^{W} = [g_{it}, LR_{it}(2), \omega_{it}]$.

We now move a step further and explore the cross-country relationship between changes in the relative size of sectors and the magnitude of workers' costs of switching sectors. We estimate the same model as in eq. (2) but for a single country at a time.[10] Then in Fig. 4, we plot the impact responses of selected sectoral variables on the vertical axis against our measure of the degree of labor mobility, denoted ϵ, on the horizontal axis.[11] This exercise may be viewed as tentative as the sectoral effect of a government spending shock varies considerably across countries and there is substantial uncertainty surrounding point estimates given the relatively small number of observations available per country.

< Please insert Figure 4 about here >

The first column of Fig. 4 plots the point estimates for hours worked and output of tradables in terms of non tradables, respectively, against the respective country's degree of labor mobility. The trend line shows that hours worked and output of tradables tend to fall more relative to non tradables in countries where the elasticity of labor supply across sectors (i.e., ϵ) is higher. The second and third columns of Fig. 4 plot sectoral labor and sectoral output shares against the degree of labor mobility across sectors. The cross-country analysis highlights two major findings. First, as shown in the top panels, whether we use labor or output, almost all countries in our sample experience a fall in the relative size of the traded sector as impact responses from the VAR model are below the X-axis. The bottom panels reveal that the reverse is true for the non traded sector which benefits the reallocation of inputs. This evidence supports our earlier conjecture according to which government spending shock is biased toward non tradables as for the vast majority of OECD countries in our sample, the non traded sector expands while the traded sector shrinks. Second, as can be seen in the last two columns of Fig. 4, the top panels indicate that countries where workers have lower mobility costs experience a larger decline in the share of tradables while the bottom panels show that the relative size of non tradables increases more in these economies. In sum, our findings reveal that **the magnitude of the sectoral impact of a government spending shock increases with the degree of labor mobility across sectors**.

In the following, we develop a dynamic general equilibrium model with imperfect mobility of labor and capital installation costs in order to account for our evidence on fiscal transmission. We show that the model's predictions are consistent with the evidence on

[10] When estimating the responses of sectoral labor and sectoral output shares to a government spending shock for each country, we omit $w^j_{C,it}$ in order to economize some degrees of freedom; the vector of endogenous variables is thus $z^{S,j}_{it} = \left[g_{it}, \nu^{Y,j}_{it}, \nu^{L,j}_{it}\right]$. We also estimated the VAR model by including $\omega^j_{C,it}$ and find that the results are similar. When estimating the effects on the ratio of sectoral hours worked and sectoral outputs, the vectors of endogenous variables are identical to those specified for the whole sample, i.e., $z^{P,j}_{it} = \left[g_{it}, y^T_{it} - y^N_{it}, p_{it}\right]$ and $z^{W,j}_{it} = \left[g_{it}, l^T_{it} - l^N_{it}, \omega_{it}\right]$. We allow for two lags (i.e., $k = 2$ in eq. (1)), as we did for the panel data estimate.

[11] Because our panel data estimates are not statistically significant at 10% for Denmark and Norway, these two countries are removed from the cross-country analysis. If we include them, the conclusions are unaffected both qualitatively and qualitatively.

the aggregate and sectoral effects of fiscal shocks once we allow for these two features.

3 A Two-Sector Open Economy Model with Imperfect Mobility of Labor across Sectors

We consider a small open economy populated by a constant number of identical households and firms that have perfect foresight and live forever. The country is small in terms of both world goods and capital markets, and faces a given world interest rate, $r^\star$. One sector produces a traded good denoted by the superscript T which can be exported at no cost, invested and consumed domestically. A second sector produces a non traded good denoted by the superscript N which can be consumed domestically or invested. The traded good is chosen as the numeraire.[12] Time is continuous and indexed by t.

3.1 Households

At each instant the representative household consumes traded and non traded goods denoted by C^T and C^N, respectively, which are aggregated by means of a CES function:

$$C(t) = \left[\varphi^{\frac{1}{\phi}} \left(C^T(t)\right)^{\frac{\phi-1}{\phi}} + (1-\varphi)^{\frac{1}{\phi}} \left(C^N(t)\right)^{\frac{\phi-1}{\phi}}\right]^{\frac{\phi}{\phi-1}}, \tag{4}$$

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

The representative household supplies labor L^T and L^N in the traded and non traded sectors, respectively. To rationalize the rise in the non traded wage relative to the traded wage, we assume limited labor mobility across sectors. A shortcut to produce a difficulty in reallocating hours worked is to assume that workers experience a utility loss when shifting hours worked from one sector to another.[13] We follow Horvath [2000] and consider that hours worked in the traded and the non traded sectors are aggregated by means of a CES function:

$$L(t) = \left[\vartheta^{-1/\epsilon} \left(L^T(t)\right)^{\frac{\epsilon+1}{\epsilon}} + (1-\vartheta)^{-1/\epsilon} \left(L^N(t)\right)^{\frac{\epsilon+1}{\epsilon}}\right]^{\frac{\epsilon}{\epsilon+1}}, \tag{5}$$

and $0 < \vartheta < 1$ parametrizes the weight attached to the supply of hours worked in the traded sector and ϵ is the degree of substitutability in hours worked across sectors. When we let ϵ tend toward infinity, the special case of perfect labor mobility is obtained; in this configuration, eq. (5) reduces to $L = L^T + L^N$; because agents no longer experience a

[12] The price of the traded good is determined on the world market and exogenously given for the small open economy.

[13] An alternative way to break wage equalization across sectors is to consider a model with search unemployment along the lines of Alvarez and Shimer [2011]. In Bertinelli, Cardi and Restout [2016], we show that workers' costs of switching sectors, as reflected by a utility loss, are key to breaking wage equalization. Formally, such a utility loss shows up as long as we allow for an endogenous sectoral labor force participation decision where the elasticity of labor supply at the extensive margin plays exactly the same role as the elasticity of labor supply across sectors in the present model abstracting from search frictions. The authors show that search frictions on firms' hiring alone cannot generate on their own a change in the relative wage because the vacancy creation schedule shifts along a horizontal search decision schedule.

mobility cost and are thus willing to work in the sector that pays the highest wage, both sectors must pay the same wage. In contrast, hours worked are no longer perfect substitutes if $\epsilon < \infty$. As ϵ takes smaller values, workers experience a larger utility loss when shifting from one sector to another and thus the degree of labor mobility is lower.

The representative agent is endowed with one unit of time, she/he supplies a fraction $L(t)$ as labor, and consumes the remainder $l(t) \equiv 1 - L(t)$ as leisure. At any instant of time, households derive utility from their consumption and experience disutility from working. Assuming that the felicity function is additively separable in consumption and labor, the representative household maximizes the following objective function:[14]

$$U = \int_0^{\infty} \left\{ \frac{C(t)^{1-\frac{1}{\sigma_C}}}{1-\frac{1}{\sigma_C}} - \frac{L(t)^{1+\frac{1}{\sigma_L}}}{1+\frac{1}{\sigma_L}} \right\} e^{-\beta t} \mathrm{d}t, \tag{6}$$

where β is the discount rate, σ_C the intertemporal elasticity of substitution for consumption, and $\sigma_L > 0$ is the Frisch elasticity of labor supply or intertemporal elasticity of substitution for (aggregate) labor supply.

Factor income is derived by supplying labor $L(t)$ at a wage rate $W(t)$, and capital $K(t)$ at a rental rate $R(t)$. In addition, households accumulate internationally traded bonds, $B(t)$, that yield net interest rate earnings of $r^{\star}B(t)$. Denoting lump-sum taxes by $T(t)$, households' flow budget constraint states that real disposable income (on the RHS) can be saved by accumulating traded bonds, consumed, $P_C(t)C(t)$, or invested, $P_J(t)J(t)$:

$$\dot{B}(t) + P_C(t)C(t) + P_J(t)J(t) = r^{\star}B(t) + R(t)K(t) + W(t)L(t) - T(t), \tag{7}$$

where $P_C\left(P(t)\right)$ and $P_J\left(P(t)\right)$ are consumption and the investment price index, respectively, which are a function of the relative price of non traded goods, $P(t)$. The aggregate wage index, $W(t) = W\left(W^T(t), W^N(t)\right)$, associated with the labor index defined above (5) is:

$$W(t) = \left[\vartheta \left(W^T(t)\right)^{\epsilon+1} + (1-\vartheta)\left(W^N(t)\right)^{\epsilon+1}\right]^{\frac{1}{\epsilon+1}}, \tag{8}$$

where $W^T(t)$ and $W^N(t)$ are wages paid in the traded and the non traded sectors, respectively.

The investment good is (costlessly) produced using traded good and non traded good inputs according to a constant returns to scale function which is assumed to take a CES form:

$$J(t) = \left[\varphi_J^{\frac{1}{\phi_J}} \left(J^T(t)\right)^{\frac{\phi_J-1}{\phi_J}} + (1-\varphi_J)^{\frac{1}{\phi_J}} \left(J^N(t)\right)^{\frac{\phi_J-1}{\phi_J}}\right]^{\frac{\phi_J}{\phi_J-1}}, \tag{9}$$

where $0 < \varphi_J < 1$ is the weight of the investment traded input and ϕ_J corresponds to the elasticity of substitution between traded good and non traded good inputs. Installation of new investment goods involves increasing and convex costs, assumed quadratic, of net

[14] In the quantitative analysis we conduct in section 5, we show that relaxing the assumption of separability in preferences between consumption and labor merely affects the results.

investment. Thus, total investment $J(t)$ differs from effectively installed new capital, $I(t)$:

$$J(t) = I(t) + \frac{\kappa}{2}\left(\frac{I(t)}{K(t)} - \delta_K\right)^2 K(t), \tag{10}$$

where the parameter $\kappa > 0$ governs the magnitude of adjustment costs to capital accumulation, and $0 \leq \delta_K < 1$ is a fixed depreciation rate. Net investment gives rise to capital accumulation according to the dynamic equation:

$$\dot{K}(t) = I(t) - \delta_K K(t). \tag{11}$$

Households choose consumption, worked hours and investment in physical capital by maximizing lifetime utility (6) subject to (7) and (11) together with (10). Denoting by λ and Q' the co-state variables associated with (7) and (11), the first-order conditions characterizing the representative household's optimal plans are:[15]

$$C(t) = (P_C(t)\lambda)^{-\sigma_C}, \tag{12a}$$

$$L(t) = (W(t)\lambda)^{\sigma_L}, \tag{12b}$$

$$\frac{I(t)}{K(t)} = \frac{1}{\kappa}\left(\frac{Q(t)}{P_J(t)} - 1\right) + \delta_K, \tag{12c}$$

$$\dot{\lambda}(t) = \lambda(t)\left(\beta - r^\star\right), \tag{12d}$$

$$\dot{Q}(t) = \left(r^\star + \delta_K\right) Q(t) - \left\{R(t) + P_J(t)\frac{\kappa}{2}\left(\frac{I(t)}{K(t)} - \delta_K\right)\left(\frac{I(t)}{K(t)} + \delta_K\right)\right\}, \tag{12e}$$

and the transversality conditions $\lim_{t\to\infty} \lambda B(t)e^{-\beta t} = 0$, $\lim_{t\to\infty} Q(t)K(t)e^{-\beta t} = 0$. In an open economy model with a representative agent who has perfect foresight, a constant rate of time preference and perfect access to world capital markets, we impose $\beta = r^\star$ in order to generate an interior solution. Setting $\beta = r^\star$ into (12) yields $\lambda = \bar{\lambda}$. Eqs. (12a)-(12b) can be solved for consumption $C = C\left(\bar{\lambda}, P\right)$ and labor $L = L\left(\bar{\lambda}, W^T, W^N\right)$. A rise in the shadow value of wealth $\bar{\lambda}$ causes agents to cut their real expenditure and supply more labor. By raising the consumption price index, an appreciation in the relative price of non tradables drives down consumption. A rise in the sectoral wage W^j pushes up the aggregate wage index which provides an incentive to supply more labor.

Eq. (12c) can be solved for investment:

$$\frac{I(t)}{K(t)} = v\left(\frac{Q(t)}{P_J(t)}\right) + \delta_K, \quad v\left(.\right) = \frac{1}{\kappa}\left(\frac{Q(t)}{P_J(t)} - 1\right). \tag{13}$$

Equation (13) states that investment is an increasing function of Tobin's q, which is defined as the shadow value to the firm of installed capital, $Q(t)$, divided by its replacement cost, $P_J(t)$. For the sake of clarity, we drop the time argument below provided this causes no confusion.

[15] To derive (12c), we used the fact that $Q(t) = Q'(t)/\lambda$ which is the shadow value of capital in terms of foreign assets.

Once households have chosen aggregate consumption, they decide on its allocation between traded and the non traded goods according to the following optimal rule:

$$\left(\frac{1-\varphi}{\varphi}\right)\frac{C^T}{C^N} = P^{\phi}. \tag{14}$$

Applying Shephard's lemma (or the envelope theorem) yields consumption in non tradables, i.e., $C^N = \frac{\partial P_C}{\partial P} C = P_C' C$. Denoting the share of non traded goods in consumption expenditure by α_C, expenditure in non tradables and tradables is given by $PC^N = \alpha_C P_C C$ and $C^T = (1-\alpha_C) P_C C$, respectively.[16] The same logic applies to the allocation of aggregate investment expenditure; denoting the investment expenditure share on non tradables by α_J, the amounts spent on acquiring output from non tradables and tradables are $PJ^N = \alpha_J P_J J$ and $J^T = (1-\alpha_J) P_J J$, respectively.

Denoting the relative wage by $\Omega \equiv W^N/W^T$, workers allocate hours worked in the traded and the non traded sectors according to the following optimal rule:

$$\left(\frac{1-\vartheta}{\vartheta}\right)\frac{L^T}{L^N} = \Omega^{-\epsilon}, \tag{15}$$

where ϵ is the elasticity of labor supply across sectors as it measures the extent to which agents are willing to increase their hours worked in the non traded sector relative to the traded sector following a 1% rise in the relative wage. As ϵ takes higher values, workers experience lower mobility costs and thus demand a smaller increase in the relative wage to reallocate their hours worked toward the non traded sector; as a result, the degree of labor mobility across sectors increases. As for consumption, intra-temporal allocation of hours worked across sectors follows from Shephard's Lemma. We therefore obtain labor income from supplying hours worked in the non traded and the traded sectors, i.e., $W^N L^N = \alpha_L W L$ and $W^T L^T = (1-\alpha_L) WL$, with α_L being the share of non tradable labor revenue in the labor income.[17]

3.2 Firms

Each sector consists of a large number of identical firms which use labor, L^j, and physical capital, K^j, according to a constant returns to scale technology:

$$Y^j = Z^j \left(L^j\right)^{\theta^j} \left(K^j\right)^{1-\theta^j}, \tag{16}$$

where Z^j represents the TFP index which is introduced for calibration purposes only and θ^j corresponds to the labor income share in the value added of sector j. Firms lease capital from households and hire workers. They face two cost components: a capital rental cost equal to R, and wage rates in the traded and non traded sectors equal to W^T and W^N,

[16] Specifically, the non tradable content of consumption expenditure is given by $\alpha_C = \frac{(1-\varphi)P^{1-\phi}}{\varphi + (1-\varphi)P^{1-\phi}}$.

[17] Specifically, we have $\alpha_L = \frac{(1-\vartheta)\left(W^N\right)^{\epsilon+1}}{\left[\vartheta\left(W^T\right)^{\epsilon+1} + (1-\vartheta)\left(W^N\right)^{\epsilon+1}\right]}$.

respectively. Both sectors are assumed to be perfectly competitive and thus choose capital and labor by taking prices as given:

$$\max_{K^j, L^j} \Pi^j = \max_{K^j, L^j} \left\{ P^j Y^j - W^j L^j - R K^j \right\}. \tag{17}$$

Since capital can move freely between the two sectors, the value of marginal products in the traded and non traded sectors equalizes while costly labor mobility implies a wage differential across sectors:

$$Z^T \left(1-\theta^T\right) \left(k^T\right)^{-\theta^T} = P Z^N \left(1-\theta^N\right) \left(k^N\right)^{-\theta^N} \equiv R, \tag{18a}$$

$$Z^T \theta^T \left(k^T\right)^{1-\theta^T} \equiv W^T, \tag{18b}$$

$$P Z^N \theta^N \left(k^N\right)^{1-\theta^N} \equiv W^N, \tag{18c}$$

where $k^j \equiv K^j/L^j$ denotes the capital-labor ratio for sector $j = T, N$.

Aggregating over the two sectors gives us the resource constraint for capital:

$$K^T + K^N = K. \tag{19}$$

3.3 Government

The final agent in the economy is the government. Total government spending, G, falls on goods, G^N, produced by non traded firms and goods, G^T, produced by traded firms. Both components of government spending are determined exogenously. The government finances public spending by raising lump-sum taxes, T. As a result, Ricardian equivalence obtains and the time path of taxes is irrelevant for the real allocation. We may thus assume without loss of generality that government budget is balanced at each instant:

$$G = G^T + P G^N = T. \tag{20}$$

3.4 Model Closure and Equilibrium

To fully describe equilibrium, we impose goods market clearing conditions. The non traded goods market clearing condition requires that output is equalized with expenditure:[18]

$$Y^N \left(\bar{\lambda}, K, P\right) = C^N \left(\bar{\lambda}, P\right) + G^N + P_J' K \left[v\left(\frac{Q}{P_I}\right) + \delta_K + \frac{\kappa}{2} \left(v\left(\frac{Q}{P_I}\right)\right)^2 \right], \tag{21}$$

[18]Using the fact that $C^N = \frac{\partial P_C(P)}{\partial P} C$ and $C^T = \left(P_C - P P_C'\right) C$ and inserting the short-run solution for consumption yields: $C^N = C^N \left(\bar{\lambda}, P\right)$ and $C^T = C^T \left(\bar{\lambda}, P\right)$. Using the fact that $L^T = \frac{\partial W\left(W^T, W^N\right)}{\partial W^T} L$ and $L^N = \frac{\partial W\left(W^T, W^N\right)}{\partial W^N} L$, respectively, and inserting the short-run solution for labor yields $L^T = L^T \left(\bar{\lambda}, W^T, W^N\right)$ and $L^N = L^N \left(\bar{\lambda}, W^T, W^N\right)$. Plugging first the short-run solutions for L^T and L^N into the resource constraint for capital, (18a)-(18c) and (19) can be solved for sectoral capital-labor ratio $k^j = k^j \left(\bar{\lambda}, K, P\right)$ and sectoral wage $W^j = W^j \left(\bar{\lambda}, K, P\right)$ (with $j = T, N$). Inserting $k^T \left(\bar{\lambda}, K, P\right)$ into $R = Z^T \left(k^T\right)^{-\theta^T}$ allows us to solve for the return on domestic capital, i.e., $R = R\left(\bar{\lambda}, K, P\right)$. Inserting short-run solutions for sectoral capital-labor ratios and sectoral labor into production functions (16) allows us to solve for sectoral output: $Y^j = Y^j \left(\bar{\lambda}, K, P\right)$.

where we have substituted the optimal investment rule $v(.)$ given by (13). Eq. (21) can be solved for the relative price of non tradables:

$$P = P\left(\bar{\lambda}, K, Q, G^N\right). \tag{22}$$

It is worth mentioning that in contrast to the standard Rybczynski effect, as long as there is a difficulty in reallocating labor across sectors, a rise in the shadow value of wealth that increases labor supply or a rise in the stock of physical capital has an expansionary effect on non traded output, irrespective of sectoral capital intensities. As a result, the relative price of non tradables depreciates, i.e., $P_{\bar{\lambda}} < 0$ and $P_K < 0$. Conversely, a rise in the shadow value of installed capital, Q, which stimulates investment or an increase in government expenditure on non tradables, G^N, causes the relative price, P, to appreciate, i.e., $P_Q > 0$ and $P_{G^N} > 0$.

The adjustment of the open economy towards the steady state is described by a dynamic system which comprises two equations that form a separate subsystem in K and Q. The first equation corresponds to the non traded goods market clearing condition. The second equation is described by (12e) which equalizes the rates of return on domestic equities and foreign bonds, $r^\star$. The dynamic system reads as:[19]

$$\begin{aligned}
\dot{K} \equiv \Upsilon\left(K, Q, G^N\right) &= \frac{Y^N\left(K, P(.), \bar{\lambda}\right) - C^N\left(\bar{\lambda}, P(.)\right) - G^N}{P'_J\left(P(.)\right)} - \delta_K K \\
&- \frac{K}{2\kappa}\left[\frac{Q}{P'_J\left(P(.)\right)} - 1\right]^2, \qquad (23a)\\
\dot{Q} \equiv \Sigma\left(K, Q, G^N\right) &= \left(r^\star + \delta_K\right) Q - \left[R\left(K, P(.)\right) + P_J(P(.))\frac{\kappa}{2} v(.)\left(v(.) + 2\delta_K\right)\right], \qquad (23b)
\end{aligned}$$

where $P(.)$ is given by (22) and $R = R(K, P)$ is the return on domestic capital which is a decreasing function of physical capital and an increasing function of P, i.e., $R_K < 0$ and $R_P > 0$.

Regarding the allocation of government consumption in good $j = T, N$, we consider a rise in government consumption which is split between non tradables and tradables in accordance with their respective share in government expenditure which we denote by ω_{G^N} and $\omega_{G^T} \equiv 1 - \omega_{G^N}$, respectively; more specifically, denoting the long-term values with a tilde, we have in linearized form:

$$\tilde{P}\left(G^N(t) - \tilde{G}^N\right) = \omega_{G^N}\left(G(t) - \tilde{G}\right), \quad \left(G^T(t) - \tilde{G}^T\right) = \left(1 - \omega_{G^N}\right)\left(G(t) - \tilde{G}\right). \tag{24}$$

As detailed in section 5.1, since ω_{G^N} is substantial relative to ω_{G^T}, the rise in government consumption is biased toward non tradables.

Linearizing (23a) and (23b) in the neighborhood of the steady-state and using (24), we

[19] Using eq. (12c) and the fact that $J^N = P'_J J$ with $J = \dot{K} + \delta_K + \frac{K}{2\kappa}\left(\frac{Q}{P_I} - 1\right)^2$, leads to the accumulation equation for physical capital; inserting the optimal investment decision $v(.)$ given by eq. (13) into (12e) leads to the dynamic equation for the shadow price of installed capital (23b).

get in a matrix form:

$$\begin{pmatrix} \dot{K}(t) \\ \dot{Q}(t) \end{pmatrix} = \begin{pmatrix} \Upsilon_K & \Upsilon_Q \\ \Sigma_K & \Sigma_Q \end{pmatrix} \begin{pmatrix} K(t) - \tilde{K} \\ Q(t) - \tilde{Q} \end{pmatrix} + \begin{pmatrix} \varepsilon_K \\ \varepsilon_Q \end{pmatrix} \begin{pmatrix} G(t) - \tilde{G} \\ G(t) - \tilde{G} \end{pmatrix} \tag{25}$$

where the coefficients of the Jacobian matrix are partial derivatives of (23a) and (23b) evaluated at the steady-state, e.g., $\Upsilon_K = \frac{\partial \Upsilon}{\partial K}$, and the direct effects of an exogenous change in government spending on K and Q are described by $\varepsilon_K = \frac{\partial \Upsilon}{\partial G}$ and $\varepsilon_Q = \frac{\partial \Sigma}{\partial G}$, also evaluated at the steady-state.

To determine the solutions for physical capital and the shadow value of installed capital, we have to set the endogenous response of government spending to an exogenous fiscal shock. In order to account for the non monotonic pattern of the dynamic adjustment of government consumption in line with our evidence (see Figure 1(a)), we assume that the deviation of government spending relative to its initial value as a percentage of initial GDP is:

$$\frac{G(t) - \tilde{G}}{\tilde{Y}} = e^{-\xi t} - (1 - g)\, e^{-\chi t}, \tag{26}$$

where $g > 0$ parametrizes the magnitude of the exogenous fiscal shock, $\xi > 0$ and $\chi > 0$ parametrize the degree of persistence of the fiscal shock; as ξ and χ take higher values, government spending returns to its initial level more rapidly. More specifically, eq. (26) allows us to generate an inverted U pattern for the endogenous response of $G(t)$: if $\chi > \xi$, we have $\dot{G}(t) > 0$ following the exogenous fiscal shock and then government consumption declines after reaching a peak at some time t. As χ takes values closer to ξ, government spending reaches a peak more rapidly.

Denoting the negative eigenvalue by ν_1 and the positive eigenvalue by ν_2, applying standard method to solve systems of deterministic first order linear differential equations and making use of (26), the general solutions for K and Q can be written in a compact form:[20]

$$K(t) - \tilde{K} = X_1(t) + X_2(t), \quad Q(t) - \tilde{Q} = \omega_2^1 X_1(t) + \omega_2^2 X_2(t), \tag{27}$$

where ω_2^i is the element of the eigenvector associated with the eigenvalue ν_i (with $i = 1, 2$) and $X_1(t)$ and $X_2(t)$ are solutions which characterize the trajectory of physical capital and the shadow value of capital:

$$X_1(t) = e^{\nu_1 t} \left[\left(K_0 - \tilde{K} \right) + \Gamma_2 (1 - \Theta_2) - \Gamma_1 (1 - \Theta_1) \right] + \Gamma_1 \left(e^{-\xi t} - \Theta_1 e^{-\chi t} \right), \tag{28a}$$

$$X_2(t) = -\Gamma_2 \left(e^{-\xi t} - \Theta_2 e^{-\chi t} \right), \tag{28b}$$

where $\Gamma_i = -\frac{\Phi_i \tilde{Y}}{\nu_1 - \nu_2} \frac{1}{(\nu_i + \xi)}$, $\Phi_1 = (\Upsilon_K - \nu_2) + \Upsilon_Q \varepsilon_Q$, $\Phi_2 = (\Upsilon_K - \nu_1) + \Upsilon_Q \varepsilon_Q$, and $\Theta_i = (1 - g) \frac{\nu_i + \xi}{\nu_i + \chi}$ (with $i = 1, 2$). When the shock is permanent, $X_2(t) = 0$ while $X_1(t)$ reduces

[20] See e.g., Buiter [1984] who presents the continuous time adaptation of the method of Blanchard and Kahn. We find numerically that the determinant of the Jacobian matrix is negative for all parametrization, regardless of sectoral capital intensities. Since the number of predetermined variables (K) equals the number of negative eigenvalues, and the number of jump variables (Q) equals the number of positive eigenvalues, there is a unique one-dimensional convergent path towards the steady state.

to $e^{\nu_1 t}\left(K_0 - \tilde{K}\right)$. Because our objective is to account for VAR evidence, we restrict our attention to a temporary fiscal shock.

Using the fact that $RK + WL = Y^T + PY^N$ and inserting the market clearing condition for non tradables $Y^N = C^N + G^N + J^N$ into (7) gives the current account equation:

$$\dot{B} \equiv \Xi\left(B, K, Q, P(.), G\right) = r^\star B + Y^T\left(K, P(.)\right) - C^T\left(P(.)\right) - G^T - J^T, \tag{29}$$

where we substitute appropriate short-run static solutions along with $P(.)$ given by eq. (22). Using the fact that traded investment J^T can be written as $(1-\alpha_J) P_J J$ with $J = \frac{Y^N - C^N - G^N}{P_J'}$ and inserting the optimal investment decision (13), linearizing (29) around the steady state, substituting the solutions for $K(t)$ and $Q(t)$ given by (27), solving and invoking the transversality condition, yields the solution for traded bonds:

$$\begin{aligned} B(t) - \tilde{B} &= \frac{\omega_B^1}{\nu_1 - r^\star} e^{\nu_1 t} - \frac{\Xi_G \tilde{Y}}{\xi + r^\star}\left(e^{-\xi t} - \Theta' e^{-\chi t}\right) - \frac{N_1 \Gamma_1}{\xi + r^\star}\left(e^{-\xi t} - \Theta_1' e^{-\chi t}\right), \\ &+ \frac{N_2 \Gamma_2}{\xi + r^\star}\left(e^{-\xi t} - \Theta_2' e^{-\chi t}\right), \end{aligned} \tag{30}$$

where $\omega_B^1 = \left[\Xi_K + \Xi_Q \omega_2^1\right]\left[\left(K_0 - \tilde{K}\right) + \Gamma_2\left(1 - \Theta_2\right) - \Gamma_1\left(1 - \Theta_1\right)\right]$, with $\Xi_K = \frac{\partial \Xi}{\partial K}$, $\Xi_Q = \frac{\partial \Xi}{\partial Q}$, and $\Xi_G = \frac{\partial \Xi}{\partial G}$ evaluated at the steady-state, and $\Theta' = (1-g)\frac{r^\star + \xi}{r^\star + \chi}$, and $\Theta_i' = \Theta_i \frac{r^\star + \xi}{r^\star + \chi}$ (with $i = 1, 2$). To ultimately remain solvent, the open economy must satisfy the following condition:

$$\tilde{B} - B_0 = -\frac{\omega_B^1}{\nu_1 - r^\star} + \frac{\omega_B^2}{\xi + r^\star}, \tag{31}$$

where B_0 is the initial stock of traded bonds and $\omega_B^2 = \Xi_G \tilde{Y}\left(1 - \Theta'\right) + \left[\Xi_K + \Xi_Q \omega_2^1\right]\Gamma_1\left(1 - \Theta_1'\right) - \left[\Xi_K + \Xi_Q \omega_2^2\right]\Gamma_2\left(1 - \Theta_2'\right)$. As emphasized by Schubert and Turnovsky [2002], the assumption $\beta = r^\star$ implies that temporary policies have permanent effects. In this regard, eq. (31) determines the steady-state change of the net foreign asset position following a temporary fiscal expansion.

3.5 The Steady State

We now characterize the long-run equilibrium by using a graphical apparatus and discuss the steady-state effects of a temporary fiscal expansion. In order to avoid unnecessary complications, we normalize sectoral TFPs, i.e., Z^T and Z^N, to 1. Setting $\dot{Q} = \dot{K} = 0$ into (11) and (12e), we obtain equality between the marginal product of capital and the capital rental cost:

$$\tilde{R} \equiv \left(1 - \theta^T\right)\left(\tilde{k}^T\right)^{-\theta^T} = P_J\left(\tilde{P}\right)\left(\delta_K + r^\star\right), \tag{32}$$

where we use the fact that $\tilde{Q} = P_J\left(\tilde{P}\right)$. Since capital installation costs are absent in the long-run, the market clearing condition for non tradables (22) reduces to $\tilde{Y}^N = \tilde{C}^N + G^N + \tilde{I}^N$ with $\tilde{I}^N = P_J' \delta_K \tilde{K}$. Setting $\dot{B} = 0$ into (23a) and denoting net exports by $\tilde{NX}$, the market clearing condition for tradables can be written $\tilde{Y}^T = \tilde{C}^T + G^T + \tilde{I}^T + \tilde{NX}$. Combining the market clearing conditions for tradables and non tradables, and denoting by $\upsilon_{I^j} \equiv \tilde{I}^j/\tilde{Y}^j$ the ratio of investment to output in sector $j = T, N$, $\upsilon_{NX} \equiv \tilde{NX}/\tilde{Y}^T$ the ratio of net exports to traded output, yields:

$$\frac{\tilde{Y}^T \left(1 - \upsilon_{NX} - \upsilon_{I^T} - \upsilon_{G^T}\right)}{\tilde{Y}^N \left(1 - \upsilon_{I^N} - \upsilon_{G^N}\right)} = \frac{\tilde{C}^T}{\tilde{C}^N}, \tag{33}$$

where the allocation of aggregate consumption expenditure between traded and non traded goods follows from (14).

To characterize the steady state, we can either focus on the goods market or the labor market. We choose to concentrate on the former. The steady state is summarized graphically by two-schedules in the $(y^T - y^N, p)$-space, as shown in Figure 5. Combining the market clearing condition given by (33) with (14), and taking the logarithm yields the goods market equilibrium (GME henceforth) schedule:

$$\left(\tilde{y}^T - \tilde{y}^N\right)\Big|^{GME} = x + \phi\tilde{p} + \ln\frac{\left(1 - \upsilon_{I^N} - \upsilon_{G^N}\right)}{\left(1 - \upsilon_{NX} - \upsilon_{I^T} + \upsilon_{G^T}\right)}, \tag{34}$$

where $x = \ln\left(\frac{\varphi}{1-\varphi}\right)$. The GME-schedule is upward-sloping in the $(y^T - y^N, p)$-space with a slope equal to $1/\phi$. We assume that $\phi = 1$ so that the GME-schedule coincides with the 45° dotted line. When $\phi < 1$, the GME-equilibrium becomes steeper.

< Please insert Figure 5 about here >

The labor market equilibrium (LME henceforth) schedule is downward-sloping in the $(y^T - y^N, p)$-space since an increase in p allows non traded producers to pay higher wages, which in turn encourages workers to supply more labor in that sector and thus lowers traded output relative to non traded output. Formally, the LME-schedule is given by:[21]

$$\left(\tilde{y}^T - \tilde{y}^N\right)\Big|^{LME} = -\left[\epsilon + \left(\frac{1-\theta^T}{\theta^T}\right)(1+\epsilon)\right]\tilde{p} + \ln\Pi. \tag{35}$$

To begin with, a temporary fiscal shock has permanent effects on macroeconomic aggregates since the marginal utility of wealth must increase for the intertemporal solvency condition (31) to hold. The resulting negative wealth effect induces Ricardian agents to respond to higher tax burden by lowering consumption and increasing labor supply. Because the shock is temporary, households reduce savings, as they try to avoid a large reduction in consumption and/or a large increase in labor supply. The decline in private savings leads to a decumulation in both domestic capital and net foreign assets so that the open economy runs a current account deficit along the transitional path. Because interest receipts from traded bond holdings are reduced, the balance of trade must improve in the long-run. Higher demand for tradables increases traded output relative to non traded output and depreciates

[21] Using (18c) to determine the relative wage Ω, inserting the optimal allocation of aggregate labor supply across sectors (15) and production functions (16), using (32) and (18a) to eliminate the sectoral capital-labor ratios, yields the LME-schedule (35), where Π is a term composed of fixed parameters which is given by:

$$\Pi = \frac{\vartheta}{1-\vartheta}\left(r^\star + \delta_K\right)^{\left(\frac{\theta_T - \theta_N}{\theta_T\theta_N}\right)(1+\epsilon)} \frac{\left[\left(\theta_T\right)^{\epsilon\theta_T}\left(1-\theta_T\right)^{(1-\theta_T)(1+\epsilon)}\right]^{1/\theta_T}}{\left[\left(\theta_N\right)^{\epsilon\theta_N}\left(1-\theta_N\right)^{(1-\theta_N)(1+\epsilon)}\right]^{1/\theta_N}} > 0.$$

the relative price of non tradables. Graphically, as shown in Figure 5, the GME-schedule shifts to the right along the LME-schedule. Hence, traded output increases relative to non traded output while the relative price of non tradables falls in the long-run. In the next section, we discuss impact effects resulting from government spending shock.

4 Imperfect Mobility of Labor and the Transmission of Government Spending

In order to emphasize how a difficulty in reallocating labor across sectors modifies the fiscal transmission, we solve the model analytically by abstracting from physical capital.[22] Building on our panel VAR evidence which reveals that a rise in government consumption disproportionately benefits the non traded sector, we consider a rise in government consumption which is fully biased toward non tradables but discuss the consequences of an increase in G^T as well at the end of the section. As the shocks identified in the VAR literature are transitory, we focus the theoretical analysis on temporary increases in government spending. To avoid unnecessary complications, we solve the model by assuming that the endogenous response to an exogenous fiscal shock is governed by the following dynamic equation:

$$dG(t) = \tilde{Y} g e^{-\xi t}. \tag{36}$$

According to (36), government spending rises initially by g percentage points of GDP and declines monotonically at rate ξ.

Both sectors use labor as the sole input in a constant returns to scale technology, i.e., $Y^j = L^j$ with $j = T, N$. Because there is a difficulty in reallocating labor, sectoral wages do not equalize, i.e., $1 = W^T$ and $P = W^N$. The key equations characterizing optimal household behavior are given by first-order conditions described by (12a)-(12b) and (14)-(15). The market clearing conditions for non traded and traded goods read as $Y^N = C^N + G^N$ and $\dot{B} = r^\star B + Y^T - C^T - G^T$, respectively.

4.1 Solving Analytically the Model

Substituting first (12a) into $C^N = \alpha_C \frac{P_C}{P} C$, (12b) and $W^N = P$ into $L^N = \alpha_L \frac{W}{W^N} L$, the market clearing condition for the non traded good can be rewritten as follows:

$$\frac{\alpha_L \bar{\lambda}^{\sigma_L} W^{1+\sigma_L}}{P} = \frac{\alpha_C P_C^{1-\sigma_C} \bar{\lambda}^{-\sigma_C}}{P} + G^N. \tag{37}$$

Totally differentiating (37), using the fact that $\hat{\alpha}_L = (1+\epsilon)(1-\alpha_L)\hat{P}$, $\hat{\alpha_C} = (1-\phi)(1-\alpha_C)\hat{P}$, $\hat{W} = \alpha_L \hat{P}$ and $\hat{P}_C = \alpha_C \hat{P}$, collecting terms, and denoting by a hat the percentage deviation relative to initial steady-state, the change in the relative price of non tradables is described by:

$$\hat{P} = \frac{-\left[\alpha_L \sigma_L + \alpha_C \omega_C \sigma_C\right]}{\Psi} \hat{\bar{\lambda}} + \frac{P dG^N}{Y} \Psi > 0, \tag{38}$$

[22] The implications of physical capital accumulation into the setup are discussed in the next section.

where we set $\Psi = \alpha_L \left[\epsilon \left(1-\alpha_L\right) + \sigma_L \alpha_L\right] + \omega_C \alpha_C \left[\left(1-\alpha_C\right)\phi + \alpha_C \sigma_C\right] > 0$ and we denote by $\omega_C = \frac{P_C C}{Y}$ consumption expenditure as a share of GDP; $\alpha_C = \frac{PC^N}{P_C C}$ and $\alpha_L = \frac{PY^N}{Y} = \frac{W^N L^N}{WL}$ correspond to the non tradable content of consumption expenditure and labor compensation, respectively;[23]

Substituting $L^T = \left(1-\alpha_L\right)\left(W\right)^{1+\sigma_L}\left(\bar{\lambda}\right)^{\sigma_L}$ and $C^T = \left(1-\alpha_C\right) P_C^{1-\sigma_C} \bar{\lambda}^{-\sigma_C}$ into the market clearing condition for traded goods leads to:

$$\dot{B}(t) = r^{\star} B(t) + \left(1-\alpha_L(t)\right) W(t)^{1+\sigma_L} \bar{\lambda}^{\sigma_L} - \left(1-\alpha_C(t)\right) P_C(t)^{1-\sigma_C} \bar{\lambda}^{-\sigma_C} - G^T. \tag{39}$$

Using the fact that both $\bar{\lambda}$ and G^T are constant over time, linearizing (39) in the neighborhood of the steady-state, substituting the law of motion of government spending (36), solving and invoking the transversality condition leads to the solution for $B(t)$:

$$B(t) - \tilde{B} = \frac{\Upsilon_G \tilde{Y}}{\xi + r^{\star}} g e^{-\xi t}, \tag{40}$$

consistent with the intertemporal solvency condition

$$\left(\tilde{B} - B_0\right) = -\frac{\Upsilon_G \tilde{Y}}{\xi + r^{\star}} g, \tag{41}$$

where $\Upsilon_G = \frac{\left[\left(1-\alpha_L\right)\alpha_L\left(\epsilon-\sigma_L\right) + \left(1-\alpha_C\right)\omega_C \alpha_C\left(\phi-\sigma_C\right)\right]}{\Psi} \gtrless 0$. The sign of the term Υ_G is ambiguous since $\epsilon \gtreqless \sigma_L$ and $\phi \gtreqless \sigma_C$. Intuitively, by pushing up the relative price of non tradables, higher government spending exerts two opposite effects on the current account. On the one hand, the appreciation in the relative price P raises the wage rate and the consumption price index which in turn leads workers to supply more labor in both sectors and to cut consumption expenditure. On the other hand, an increase in the relative price of non tradables encourages agents to substitute traded for non traded goods and to shift hours worked toward the non traded sector as the non traded wage increases. The former channel tends to improve the current account while the latter exerts a negative impact. Assuming $\epsilon > \sigma_L$ along with $\phi \simeq \sigma_C$, then we have $\Upsilon_G > 0$, so that the current account deteriorates following a temporary fiscal expansion, in line with our VAR evidence.

To determine the change in the equilibrium value of the marginal utility of wealth, we have to differentiate the market clearing condition (39) for the traded good evaluated at the steady-state (i.e., $\dot{B}(t) = 0$), using the fact that in the long-run government spending is restored to its initial level (i.e., $dG^N = 0$); next, inserting (41) into the resulting expression leads to the change in the equilibrium value of the marginal utility of wealth:

$$\hat{\bar{\lambda}} = \frac{\Psi \Upsilon_G}{\Gamma} \frac{r^{\star}}{\xi + r^{\star}} g > 0, \tag{42}$$

where $\Psi > 0$, $\Upsilon_G > 0$, $\xi > 0$, $g > 0$, and we set

$$\Gamma = \Psi \left\{\left[\left(1-\alpha_L\right)\sigma_L + \omega_C\left(1-\alpha_C\right)\sigma_C\right] + \left[\alpha_L \sigma_L + \omega_C \alpha_C \sigma_C\right]\Upsilon_G\right\} > 0. \tag{43}$$

[23] Because we abstract from physical capital and assume constant returns to scale technology, the non tradable content of labor compensation, $\frac{W^N L^N}{WL}$, coincides with the non tradable content of GDP, $\frac{PY^N}{Y}$.

4.2 Implications of Imperfect Mobility of Labor

What are the implications of imperfect mobility for fiscal transmission? As in a model that imposes perfect mobility of labor, a rise in government consumption produces an increase in the shadow value of wealth as taxes must be raised to balance the budget which reduces households' disposable income. It can be shown analytically that the term $\frac{\Psi\Upsilon_G}{\Gamma}$ in eq. (42) increases with the elasticity of labor supply across sectors, ϵ. Hence, as the difficulty in reallocating labor across sectors is reduced, a government spending shock further raises $\bar{\lambda}$, the largest increase being obtained when labor is perfectly mobile across sectors. Formally, if we let ϵ tend toward infinity, we have $\lim_{\epsilon\to\infty}\hat{\bar{\lambda}} = \frac{1}{\sigma_L+\omega_C\sigma_C}\frac{r^\star}{\xi+r^\star}g > 0$.[24] Intuitively, as discussed below, the relative price of non tradables is fixed when labor can move freely across sectors and thus does not influence private consumption; consequently, for the intertemporal solvency condition to hold, the rise in the shadow value of wealth must be greater.

The negative wealth effect encourages agents to work more and cut real expenditure. Because the decline in real expenditure is spread over the two goods, the rise in G^N more than offsets the fall in C^N. As long as there is a difficulty in reallocating labor, an excess demand arises in the non traded goods market, which in turn causes the relative price of non tradables to appreciate. Evaluating (37) at time $t = 0$, inserting (42), and using the fact that $\frac{\tilde{P}dG^N(0)}{\tilde{Y}} = \frac{dG(0)}{\tilde{Y}} = g > 0$, leads to the initial response of the relative price of non tradables:

$$\hat{P}(0) = \left\{1 - \frac{[\alpha_L\sigma_L + \omega_C\alpha_C\sigma_C]\,\Upsilon_G\Psi}{\Gamma}\frac{r^\star}{\xi + r^\star}\right\}\frac{g}{\Psi} > 0, \tag{44}$$

where the sign in braces is unambiguously positive since $0 < [\alpha_L\sigma_L + \omega_C\alpha_C\sigma_C]\frac{\Upsilon_G\Psi}{\Gamma} < 1$ and $0 < \frac{r^\star}{\xi+r^\star} < 1$. As the degree of labor mobility across sectors increases, a government spending shock results in a lower appreciation in the relative price of non tradables. The reason is that the shadow value of wealth, $\bar{\lambda}$, further increases. Hence, non traded output increases more while consumption falls by a larger amount. In a model imposing perfect mobility of labor across sectors (i.e., $\epsilon \to \infty$), the relative price of non tradables remains unaffected by a fiscal shock. Intuitively, a larger supply of non tradables triggered by the shift of labor toward the non traded sector allows to meet additional demand for non tradables so that the relative price is unchanged. Conversely, as long as there is a difficulty in reallocating labor across sectors, the rise in non traded output is not sufficent to meet the higher demand for non tradables. The subsequent excess demand for non tradables causes the relative price P to appreciate on impact, which provides an incentive to increase output and thus to hire more workers. This mechanism contributes to magnifying the sectoral impact of fiscal policy in a model with limited labor mobility.

To persuade workers who experience mobility costs to increase their hours worked in the non traded sector, non traded firms must pay higher wages. The subsequent shift of

[24] In a Technical Appendix, we show that $\lim_{\epsilon\to\infty}\frac{\Psi\Upsilon_G}{\Gamma} = \frac{1}{\sigma_L+\omega_C\sigma_C}$.

labor toward the non traded sector unambiguously raises hours worked in the non traded sector:[25]

$$\alpha_L \hat{L}^N(0) = \frac{\alpha_L\left[\epsilon\left(1-\alpha_L\right)+\alpha_L\sigma_L\right]}{\Psi}\left[1-\left(\alpha_L\sigma_L+\alpha_C\omega_C\sigma_C\right)\frac{\Psi\Upsilon_G}{\Gamma}\frac{r^\star}{\xi+r^\star}\right]g + \alpha_L\sigma_L\frac{\Psi\Upsilon_G}{\Gamma}\frac{r^\star}{\xi+r^\star}g > 0, \tag{45}$$

where the response of non traded labor is measured in percentage points of total labor. According to (45), the change in non traded labor is the result of two reinforcing effects. First, as shown by the first term on the RHS of (45), a fiscal shock tends to increase hours worked in the non traded sector by raising the wage in this sector (i.e., W^N), and all the more so the greater the elasticity of substitution between traded and non traded employment, ϵ. Second, as can be seen in the second term on the RHS of (45), which is positive, the negative wealth effect causes agents to supply more labor, which raises L^N in percent of total employment by an amount equal to α_L. If we let ϵ tend toward infinity, eq. (45) reduces to $\lim_{\epsilon\to\infty}\alpha_L\hat{L}^N(0) = \left[1-\frac{\alpha_C\omega_C\sigma_C}{\sigma_L+\omega_C\sigma_C}\frac{r^\star}{\xi+r^\star}\right]g > 0$. In order to be able to contrast the case of perfect labor mobility with the situation of limited labor mobility, it is useful to neutralize the effect of higher labor supply by setting $\sigma_L = 0$. In this case, we have $\alpha_L\hat{L}^N(0) = \frac{\alpha_L\epsilon(1-\alpha_L)}{\Psi}\left[1-\alpha_C\omega_C\sigma_C\frac{\Psi\Upsilon_G}{\Gamma}\frac{r^\star}{\xi+r^\star}\right]g > 0$. On the one hand, as ϵ takes higher values, the excess demand in the non traded goods market leads to a larger reallocation of labor toward the non traded sector. On the other hand, as labor mobility increases, the excess demand gets lower which mitigates the shift of hours worked toward the non traded sector. As discussed in the next section, our numerical results reveal that the latter effect predominates for large values of ϵ so that L^N rises more in the baseline scenario with limited labor mobility than if labor were perfectly mobile across sectors.

Traded labor falls or rises depending on whether labor mobility captured by ϵ is high or low:[26]

$$\left(1-\alpha_L\right)\hat{L}^T(0) = -\frac{\left(1-\alpha_L\right)\alpha_L\left(\epsilon-\sigma_L\right)}{\Psi}\left[1-\left(\alpha_L\sigma_L+\alpha_C\omega_C\sigma_C\right)\frac{\Psi\Upsilon_G}{\Gamma}\frac{r^\star}{\xi+r^\star}\right]g - \left(1-\alpha_L\right)\sigma_L\frac{\Psi\Upsilon_G}{\Gamma}\frac{r^\star}{\xi+r^\star}g \lesseqgtr 0. \tag{46}$$

According to (46), as long as $\epsilon > \sigma_L$, the initial reaction of traded labor to a fiscal shock is the result of two opposite effects. More precisely, the first term on the RHS of (46) captures the impact of increased non traded wages on L^T. On the one hand, a higher W^N causes a shift of labor away from the traded sector proportional to ϵ. On the other hand, the

[25]Substituting $L = \left(\bar{\lambda}W\right)^{\sigma_L}$ and $W^N = \frac{P}{\mu}$ into $L^N = \alpha_L\frac{W}{W^N}L$ leads to $L^N = \alpha_L\frac{\mu}{P}\left(W\right)^{1+\sigma_L}\bar{\lambda}^{\sigma_L}$. Totally differentiating, using the fact that $\hat{\alpha}_L = (\epsilon+1)\left(1-\alpha_L\right)\hat{P}$ and $\hat{W} = \alpha_L\hat{W}^N$ with $\hat{W}^N = \hat{P}$, one obtains $\hat{L}^N = \left[\epsilon\left(1-\alpha_L\right)+\alpha_L\sigma_L\right]\hat{P} + \sigma_L\hat{\bar{\lambda}}$. Evaluating at time $t = 0$, substituting (42) and (44), and collecting terms leads to eq. (45).

[26]Substituting $L = \left(\bar{\lambda}W\right)^{\sigma_L}$ and $W^T = 1$ into $L^T = \left(1-\alpha_L\right)\frac{W}{W^T}L$ leads to $L^T = \left(1-\alpha_L\right)\left(W\right)^{1+\sigma_L}\bar{\lambda}^{\sigma_L}$. Totally differentiating, using the fact that $\widehat{(1-\alpha_L)} = -\left(\epsilon+1\right)\alpha_L\hat{P}$ and $\hat{W} = \alpha_L\hat{P}$, one obtains $\hat{L}^T = -\alpha_L\left(\epsilon-\sigma_L\right)\hat{P} + \sigma_L\hat{\bar{\lambda}}$. Evaluating at time $t = 0$, substituting (42) and (44), and collecting terms leads to eq. (46).

subsequent increase in the aggregate wage provides an incentive to supply more labor, and all the more so the higher the value of σ_L. When $\epsilon > \sigma_L$, the former effect more than offsets the latter. Hence, as non traded wages go up, L^T falls. The second term on the RHS of (46) indicates that the negative wealth effect increases total hours worked, the traded sector receiving a share equal to $(1-\alpha_L)$. While the effect of a government spending shock on L^T is ambiguous, traded labor falls, in line with the evidence, as long as the elasticity of labor supply, σ_L, is not too high. If we let ϵ tend toward infinity, traded labor unambiguously declines; formally, we have $\lim_{\epsilon \to \infty} (1-\alpha_L)\, \hat{L}^T(0) = -\left[1 - \frac{\sigma_L + \alpha_C \omega_C \sigma_C}{\sigma_L + \omega_C \sigma_C} \frac{r^\star}{\xi + r^\star}\right] g < 0$. Thus, when workers' costs of switching sectors are nil, labor must be shifted toward the non traded sector to meet additional demand. In contrast, if labor is weakly mobile across sectors, L^T merely falls or even rises as workers' mobility costs put upward pressure on the aggregate wage which magnifies the positive response of labor supply, thus making the rise in non traded labor large enough to meet increased demand for non tradables.

Because $Y^j = L^j$, eqs. (45) and (46) measure the fiscal multiplier on impact for non tradables and tradables, respectively. The magnitude of sectoral fiscal multipliers depend on four parameters: the degree of labor mobility captured by ϵ, the degree of persistence of the fiscal shock, ξ, the elasticity of labor supply, σ_L, and the non tradable content of consumption expenditure, α_C. Since we discuss the implications of ϵ for sectoral output shares below, we focus first on the other three parameters. As the values of ξ increase, government spending reverts to its initial level more rapidly, which mitigates the present value of the necessary tax increases and thus moderates the rise in $\bar{\lambda}$. Hence, excess demand in the non traded goods market is higher so that the relative price P appreciates by a larger amount, which further increases the non traded output multiplier and drives down the traded output multiplier of government spending. When agents are more willing to supply labor, the positive response of total hours worked to a rise in government spending is amplified. Higher L is split between both sectors and thus raises both sectoral fiscal multipliers. In contrast, raising the non tradable content of consumption expenditure, α_C, increases the fiscal multiplier for tradables (which thus becomes less negative) and lowers the fiscal multiplier for non tradables (which becomes less positive). Intuitively, at the final steady-state, net exports must be greater for the open economy to be solvent. To improve the balance of trade in the long-run, output of tradables must be higher while consumption in tradables must be lower. Because the share of tradables in the economy is lower, the marginal utility of wealth must increase by a larger amount to lower consumption in tradables and thus increase net exports. As the negative wealth effect is stronger, the excess of demand for non tradables and thus the appreciation in the relative price P is smaller, which mitigates the shift of resources toward the non traded sector.

In section 2, we documented a positive relationship between the magnitude of the sectoral impact of a government spending shock and the degree of labor mobility across sectors. In the data, the sectoral impact is measured by the initial response of the sectoral output share. This is calculated as the growth differential in GDP units between sectoral value added at constant prices and real GDP denoted by Y_R. Totally differentiating non traded output and real GDP, the latter being equal to overall labor compensation WL with $L = \left(\bar{\lambda}W\right)^{\sigma_L}$, and evaluating at time $t = 0$ leads to the impact response of the output share of non tradables in real terms:[27]

$$\alpha_L \left(\hat{Y}^N(0) - \hat{Y}_R(0)\right) = \alpha_L \left(1 - \alpha_L\right) \epsilon \hat{P}(0) > 0, \tag{47}$$

where $\hat{P}(0)$ is given by eq. (44). According to (47), the appreciation in the relative price of non tradables and the subsequent increase in non traded wages leads to a shift of labor toward the non traded sector. While higher non traded output relative to real GDP increases its relative size, a rise in the parameter ϵ exerts two opposite effects on the magnitude of the positive response of the output share of non tradables. On the one hand, as the parameter ϵ on the RHS of (47) takes higher values, more labor shifts toward the non traded sector, thus amplifying the positive response of the output share of non tradables. On the other hand, as mentioned above, the negative wealth effect turns out to be greater as labor becomes more mobile across sectors; as a result, increased labor mobility mitigates the excess demand in the non traded goods market and thus the appreciation in the relative price of non tradables as reflected in smaller values of $\hat{P}(0) > 0$. While we find analytically that raising ϵ may amplify or mitigate the impact response of the output share of non tradables, it is most likely that the relationship between the two variables displays an inverted U-shaped pattern; more specifically, it is clear that the positive influence of increased labor mobility is large when ϵ is initially small since in this case $\hat{P}(0) > 0$ is high.[28] Conversely, the positive influence on the output share of increased labor mobility gets much lower if ϵ is initially high because $\hat{P}(0) > 0$ is low. As the traded sector experiences a labor outflow, its expression is exactly the opposite of (47), and thus the relative size of the traded sector

[27] Real GDP is the sum of value added at constant prices, i.e., $Y_R = Y^T + \tilde{P}Y^N$ where $\tilde{P}$ corresponds to the initial steady-state value for the relative price of non tradables. Using the fact that $Y_R = WL$, totally differentiating real GDP and inserting $\hat{L} = \sigma_L \hat{\bar{\lambda}} + \sigma_L \hat{W}$ with $\hat{W} = \alpha_L \hat{P}$, leads to $\hat{Y}_R = \sigma_L \hat{\bar{\lambda}} + \alpha_L \sigma_L \hat{P}$. Using the fact that $\hat{Y}^N = \left[\epsilon \left(1 - \alpha_L\right) + \alpha_L \sigma_L\right] \hat{P} + \sigma_L \hat{\bar{\lambda}}$, multiplying the growth differential between non traded output and real GDP (i.e., $\hat{Y}^N - \hat{Y}_R$) by α_L and evaluating at time $t = 0$ leads to eq. (47).

[28] Formally, differentiating (47) w.r.t. ϵ leads to:

$$\begin{aligned} \frac{\partial \alpha_L \left(\hat{Y}^N(0) - \hat{Y}_R(0)\right)}{\partial \epsilon} &= \alpha_L \left(1 - \alpha_L\right) \hat{P}(0) + \left(1 - \alpha_L\right) \epsilon \frac{\partial \hat{P}(0)}{\partial \epsilon}, \\ &= \hat{P}(0) \alpha_L \left(1 - \alpha_L\right) \left[1 - \frac{\alpha_L \left(1 - \alpha_L\right) \epsilon}{\Psi}\right] \\ &- \alpha_L \left(1 - \alpha_L\right) \epsilon \frac{g}{\Psi} \left[\alpha_L \sigma_L + \omega_C \alpha_C \sigma_C\right] \frac{r^\star}{\xi + r^\star} \frac{\partial \frac{\Psi \Upsilon_G}{\Gamma}}{\partial \epsilon} \gtrless 0, \end{aligned}$$

where $\frac{\partial \frac{\Psi \Upsilon_G}{\Gamma}}{\partial \epsilon} > 0$. The first term on the RHS of the above equation shows that the output share of non tradables further increases on impact when the degree of labor mobility captured by ϵ is higher. Conversely, the second term on the RHS reflects the fact that as ϵ increases, the shadow value of wealth rises further which in turn moderates the increase in the relative price of non tradables. While the sign of the above expression is ambiguous, the former effect is low when ϵ takes high values because $\hat{P}(0) > 0$ in front of the first term on the RHS is small so that the latter effect may predominate in this case.

declines following a rise in government consumption. In the same way as for non tradables, raising ϵ exerts two opposite effects on the impact response of the output share of tradables.

In the special case of perfect mobility of labor, the initial response of the output share of non tradables can be rewritten as follows:[29]

$$\lim_{\epsilon \to \infty} \alpha_L \left(\hat{Y}^N(0) - \hat{Y}_R(0) \right) = \left[1 - \left(\frac{\alpha_L \sigma_L + \alpha_C \omega_C \sigma_C}{\sigma_L + \omega_C \sigma_C} \frac{r^\star}{\xi + r^\star} \right) \right] g > 0. \tag{48}$$

As mentioned above, the magnitude of the rise in the output share of non tradables can be smaller with perfect mobility of labor than if labor mobility were limited. Intuitively, while workers can costlessly shift hours worked from one sector to another, because the shadow value of wealth has to increase more to drive down consumption as the consumption price index is fixed, excess demand in the non traded goods market is less. The latter influence may offset the former. This ambiguity will be addressed numerically.

How does the real consumption wage react to a fiscal shock? Because the traded wage must stick to the marginal product of labor, i.e., $W^T = 1$, W^T remains unchanged. In contrast, the non traded wage increases by the same proportion as the relative price of non tradables, i.e., $\hat{W}^N = \hat{P}$; it follows that a fiscal shock unambiguously raises the relative wage (i.e., $\Omega \equiv W^N/W^T$). Higher non traded wages increase the aggregate wage W in proportion to the non tradable content of labor compensation, i.e., $\hat{W} = \alpha_L \hat{P}$. Differentiating W/P_C, using the fact that $\hat{P}_C = \alpha_C \hat{P}$, the initial response in the real consumption wage is given by:

$$\mathrm{d}\left(\frac{W}{P_C} \right)(0) = \frac{W}{P_C} \left(\alpha_L - \alpha_C \right) \hat{P}(0) > 0. \tag{49}$$

As long as the non tradable content of labor compensation α_L is higher than the non tradable content of consumption expenditure α_C, the rise in the aggregate wage index more than offsets the increase in the consumption price index so that a fiscal shock raises initially the real consumption wage W/P_C, in line with the evidence.

We turn to the adjustment of the net foreign asset position. Following a temporary fiscal shock, agents decumulate financial wealth in order to avoid a large reduction in consumption and/or a large increase in labor supply. The decline in private savings triggers a current account deficit along the transitional path, whether labor is perfectly mobile across sectors or not. Differentiating (40) with respect to time leads to the current account in percentage of GDP:

$$\frac{\dot{B}(t)}{\tilde{Y}} = -\Upsilon_G \frac{\xi}{\xi + r^\star} g e^{-\xi t} < 0, \tag{50}$$

where $\Upsilon_G > 0$.

[29] First inserting (44) into eq. (47), letting ϵ tend toward infinity and applying l'Hôpital's rule that implies that $\lim_{\epsilon \to \infty} \frac{\Psi \Upsilon_G}{\Gamma} = \frac{1}{\sigma_L + \omega_C \sigma_C}$ together with $\lim_{\epsilon \to \infty} \frac{\alpha_L (1-\alpha_L)}{\Psi} = 1$ gives eq. (48).

4.3 Implications of a Rise in Public Purchases of Tradables

What are the implications of a rise in government consumption in tradables? Just as after a rise in G^N, an increase in public purchases of traded goods produces a negative wealth effect that encourages agents to lower consumption and supply more labor, both of which being split across sectors. The subsequent decline in consumption in non tradables and the higher hours worked in the non traded sector trigger an excess supply of non tradables, leading to a depreciation in the relative price of non tradables. As a result, labor shifts toward the traded sector. Thus, the output share of non tradables unambiguously declines while the rise in G^T pushes up the output share of tradables. In the special case where $\sigma_C = \phi = 1$, the non traded sector experiences a fall in labor as long as $\epsilon > \sigma_L$.[30] In contrast, the government spending shock, which is fully biased toward traded goods, has an expansionary effect on hours worked in the traded sector through the combined influence of the negative wealth effect and the reallocation of labor toward this sector. While L^T increases and C^T unambiguously declines, the rise in G^T leads to a current account deficit when the fiscal shock is in effect. Finally, because the aggregate wage falls in proportion to the non tradable content of labor compensation, α_L, the real consumption wage declines as long as $\alpha_L > \alpha_C$. In sum, with the exception of the current account deficit, the predictions of the model are at odds with the data when the rise in government consumption is fully biased toward traded goods.

In conclusion, the open economy version of the model can account for the evidence on the aggregate and sectoral effects of a government spending shock as long as public purchases are heavily concentrated on non tradables and labor is imperfectly mobile across sectors. In the following, we analyze numerically the implications of physical capital accumulation and show that the model can account for the evidence quantitatively as long as we allow for limited labor mobility along with capital adjustment costs.

5 Quantitative Analysis

In this section, we analyze quantitatively the effects of a temporary and unanticipated rise in government consumption. For this purpose we solve the model described in section 3 numerically.[31] First we discuss parameter values before turning to the short-term consequences of higher government consumption.

[30]Formally, the response of non traded labor is the result of two opposite effects. On the one hand, higher labor supply triggered by the negative wealth effect increases hours worked in the non traded sector. On the other hand, the depreciation in the relative price of non tradables and the consecutive shift of labor toward the traded sector exerts a negative impact on L^N. Assuming $\sigma_C = \phi = 1$, the latter effect more than offsets the former and thus a rise in G^T drives down hours worked in the non traded sector.

[31]Technically, the assumption $\beta = r^\star$ requires the joint determination of the transition and the steady state.

5.1 Calibration

To calibrate our model, we estimated a set of parameters so that the initial steady state is consistent with the key empirical properties of a representative OECD economy. Our sample covers the sixteen OECD economies in our dataset. Our reference period for the calibration corresponds to the period 1990-2007.[32] Since we calibrate a two-sector model with tradables and non tradables, we pay particular attention to ensure that the non tradable content of the model matches the data. Table 4 summarizes our estimates of the non tradable content of GDP, employment, consumption, gross fixed capital formation, government spending, labor compensation, and gives the share of government spending on the traded and non traded goods in their respective sectoral output, the shares of labor income in output in both sectors, for all countries in our sample. Moreover, columns 12-14 of Table 4 display investment expenditure and government spending as a percentage of GDP together with the labor income share, respectively, for the whole economy. To capture the key properties of a typical OECD economy, chosen as the baseline scenario, we take unweighted average values, as shown in the last line of Table 4. Some of the parameter values can be taken directly from the data, but others like φ, φ_J, ϑ, δ_K together with initial conditions (B_0, K_0) need to be endogenously calibrated to fit a set of aggregate and sectoral ratios.[33] We choose the model period to be one year and therefore set the world interest rate, $r^\star$, which is equal to the subjective time discount rate, β, to 4%.

In light of our discussion above, ϵ plays a key role in fiscal transmission. The degree of labor mobility captured by ϵ is set to 0.75, in line with the average of our estimates shown in the last line of Table 4.[34] Our estimates display a sharp dispersion across countries and we therefore conduct a sensitivity analysis with respect to this parameter. Excluding the estimates of ϵ for Denmark and Norway which are not statistically significant at 10%, estimates of ϵ range from a low of 0.22 for the Netherlands to a high of 1.39 for the U.S. and 1.64 for Spain.[35] Hence, we allow for ϵ to vary between 0.22 and 1.64 in the sensitivity analysis.

Building on our panel data estimates, the elasticity of substitution ϕ between traded

[32] The choice of this period was dictated by data availability for all countries in the sample.

[33] As detailed in a Technical Appendix, the steady-state can be reduced to four equations which jointly determine P (and thus α_C and α_J), Y^T/Y^N (and thus $\frac{L^N}{L}$), K/Y (and thus $\omega_J = \frac{P_J I}{Y}$) and $\upsilon_B = \frac{r^\star B}{Y^T}$ (and thus $\upsilon_{NX} = \frac{NX}{Y^T}$ where we denote net exports by NX). Among the 19 parameters that the model contains, 15 have empirical counterparts while the remaining 4, i.e., φ, φ_J, ϑ, δ_K together with initial conditions (B_0, K_0) must be set in order to match $\alpha_C = \frac{PC^N}{P_C C}$, $\alpha_J = \frac{PI^N}{P_J I}$, $\frac{L^N}{L}$, $\omega_J = \frac{P_J I}{Y}$, and $\upsilon_{NX} = \frac{NX}{Y^T}$ with $NX = Y^T - C^T - G^T - I^T$.

[34] Since estimates of ϵ for Denmark and Norway are not statistically significant at a standard threshold, the values are left blank and we set ϕ to 0.75 which corresponds to the average value. To estimate ϵ, we closely follow Horvath [2000]. We first derive a testable equation by combining first-order conditions for labor supply and labor demand. Details of the derivation of the equation we explore empirically can be found in the Technical Appendix. We next run the regression of the sectoral employment growth arising from labor reallocation across sectors on the ratio of labor compensation in that sector to overall labor compensation, see Appendix B.

[35] Horvath [2000] finds an estimate for ϵ of one for the United States by considering 36 sectors over the period 1948-1985.

and non traded goods is set to 0.77 in the baseline calibration since this value corresponds to the average of estimates shown in the last line of column 15 of Table 4.[36] The weight of consumption in non tradables $1-\varphi$ is set to 0.51 to target a non-tradable content in total consumption expenditure (i.e., α_C) of 53%, in line with the average of our estimates shown in the last line of column 2. We assume that the utility for consumption is logarithmic and thus set the intertemporal elasticity of substitution for consumption, σ_C, to 1.[37] In our baseline parametrization, we set intertemporal elasticity of substitution for labor supply σ_L to 0.4, in line with evidence reported by Fiorito and Zanella [2012], but conduct a sensitivity analysis with respect to this parameter. The weight of labor supply to the non traded sector, $1-\vartheta$, is set to 0.68 to target a non-tradable content of labor compensation of 66%, in line with the average of our estimates shown in the last line of column 6 of Table 4.

In order to assess to what extent our results depend on the assumption of separability in preferences between consumption and labor, we also consider a more general specification for preferences. The functional form is taken from Shimer [2011]:

$$\frac{C^{1-\sigma}V(L)^{\sigma}-1}{1-\sigma}, \quad \text{if} \quad \sigma \neq 1, \quad V(L) \equiv \left(1+(\sigma-1)\frac{\sigma_L}{1+\sigma_L}L^{\frac{1+\sigma_L}{\sigma_L}}\right). \tag{51}$$

These preferences are characterized by two crucial parameters: σ_L is the Frisch elasticity of labor supply, and $\sigma > 0$ determines the substitutability between consumption and leisure; if $\sigma > 1$, the marginal utility of consumption increases in hours worked. In contrast, setting $\sigma = 1$ implies that preferences are separable in consumption and labor, as in (6). When we investigate the implications of non separability in preferences, we set $\sigma = 2$ while keeping other parameters unchanged.

We now describe the calibration of production-side parameters. We assume that physical capital depreciates at a rate δ_K of 6% to target an investment-to-GDP ratio of 21% (see column 12 of Table 4). The shares of sectoral labor income in output take two different values depending on whether the traded sector is more or less capital intensive than the non traded sector. If $k^T > k^N$, labor income shares in the traded (θ^T) and the non traded sector (θ^N) are set to 0.58 and 0.68, respectively, which correspond roughly to the averages for countries with $k^T > k^N$.[38] Such values, i.e., $\theta^T = 0.58$ and $\theta^N = 0.68$, give an aggregate labor income share of 64%, in line with the average value shown in the last line of column 14 of Table 4. When $k^N > k^T$, we use reverse but symmetric values, i.e., $\theta^T = 0.68$ and

[36]The average value is calculated by excluding estimates for Italy which are negative.

[37]We choose $\sigma_C = 1$ to be consistent with the general specification for preferences (51). Whereas in the baseline model, we assume separability in preferences between consumption and labor, we also allow for non separability when we conduct a sensitivity analysis. When we let $\sigma = 1$ in eq. (51), preferences turn out to be separable in consumption and labor, i.e., $\ln C(t) - \frac{1}{1+\frac{1}{\sigma_L}}L(t)^{1+\frac{1}{\sigma_L}}$, where instantaneous utility derived from consumption is logarithmic.

[38]Table 4 gives the labor share of sector j θ^j (with $j = T, N$) for the sixteen OECD countries in our sample. The values we have chosen for θ^T and θ^N correspond roughly to the averages for countries with $k^T > k^N$.

$\theta^N = 0.58$. In line with our evidence shown in the last column of Table 4, we assume that traded firms are 28 percent more productive than non traded firms; hence we set Z^T and Z^N to 1.28 and 1 respectively. We choose an elasticity of substitution, ϕ_J, between J^T and J^N of 1, in accordance with the empirical findings documented by Bems [2008] for OECD countries. The weight of non traded investment $(1-\varphi_I)$ is set to 0.64 to target a non-tradable content of investment expenditure of 64%. We choose the value of parameter κ so that the elasticity of I/K with respect to Tobin's q, i.e., Q/P_J, is equal to the value implied by estimates in Eberly, Rebelo, and Vincent [2008]. The resulting value of κ is equal to 17.[39]

We set government spending on non traded goods G^N and traded goods G^T so as to yield a non tradable share of government spending, ω_{G^N}, of 90%, and government spending as a share of GDP to 20%. The ratios G^T/Y^T and G^N/Y^N are 5% and 29% in the baseline calibration.

We choose initial conditions for B_0 and K_0 so that trade is initially balanced. Since net exports are nil and $\frac{P_J I}{Y} = 21\%$ and $\frac{G}{Y} = 20\%$, the accounting identity according to which GDP is equal to the sum of the final uses of goods and services, leads to a consumption-to-GDP ratio of $\frac{P_C C}{Y} = 59\%$.[40] It is worthwhile mentioning that the non tradable content of GDP is endogenously determined by the non tradable content of consumption, α_C, investment, α_J, and government expenditure, ω_{G^N}, along with the consumption-to-GDP ratio, ω_C, and the investment-to-GDP ratio, ω_J. More precisely, dividing the non traded good market clearing condition, i.e., $Y^N = C^N + G^N + I^N$, by Y leads to the non tradable content of GDP:

$$\frac{PY^N}{Y} = \omega_C\alpha_C + \omega_J\alpha_J + \omega_{G^N}\omega_G = 63\%, \tag{52}$$

where $\omega_C = 59\%$, $\alpha_C = 53\%$, $\omega_J = 21\%$, $\alpha_J = 64\%$, $\omega_{G^N} = 90\%$, and $\omega_G = 20\%$. According to (52), the ratios we target are consistent with a non tradable content of GDP of 63% found in the data, as reported in the last line of column 1 of Table 4.

In order to capture the endogenous response of government spending to exogenous fiscal shock, we assume that the dynamic adjustment of government consumption is governed by eq. (26). In the quantitative analysis, we set $g = 0.01$ so that government consumption increases by 1 percentage point of initial GDP. To calibrate ξ and χ that parametrize the shape of the dynamic adjustment of government consumption along with its persistence, we proceed as follows. Because $G(t)$ peaks after one year, we have $\frac{dG(1)}{Y} = \left[e^{-\xi} - (1-g)\,e^{-\chi}\right] = g' > g$ with $g' = 0.011265$ and $\frac{\dot{G}(1)}{Y} = -\left[\xi e^{-\xi} - \chi\,(1-g)\,e^{-\chi}\right] = 0$. Solving the system gives us $\xi = 0.408$ and $\chi = 0.415$. While government purchases fall on both non traded, G^N, and traded goods, G^T, our VAR evidence suggests that the rise in government con-

[39]Eberly, Rebelo, and Vincent [2008] run the regression $I/K = \alpha + \beta\,.\ln(q)$ and obtain a point estimate for β of 0.06. In our model, the steady-state elasticity of I/K with respect to Tobin's q is $1/\kappa$. Equating $1/\kappa$ to 0.06 gives a value for κ of 17.

[40]Remember that $J = I$ at the steady-state.

sumption is strongly biased toward non traded goods because the relative size of the non traded sector increases significantly. When we simulate the model, we thus consider a rise in government consumption by 1 percentage point of GDP which is split between non tradables and tradables in accordance with their respective share in government expenditure at 90% and 10%, respectively.[41]

As the baseline scenario, we take the model with imperfect mobility of labor across sectors, capital adjustments costs and separability in preferences between consumption and labor. In our baseline calibration we set $\epsilon = 0.75$, $\sigma_L = 0.4$, $\kappa = 17$, $\theta^T = 0.58$, $\sigma = 1$, but we also conduct a sensitivity analysis with respect to these four parameters by setting alternatively: ϵ to 0.22 and 1.64, σ_L to 1, κ to 0, σ to 2, and the labor income share θ^T to 0.68. In order to contrast our results with those obtained when imposing perfect mobility of labor across sectors, we let ϵ tend toward infinity.

5.2 Results

Before analyzing in detail the role of imperfect mobility of labor in shaping the dynamics of the open economy in response to a government spending shock, we recall the set of observations established in section 2. Our first set of findings indicates that a rise in government spending produces a simultaneous decline in investment and the current account, raises both hours worked and GDP and increases the real consumption wage on impact. The second set of findings relates to the sectoral impact. We find that a government spending shock increases non traded output significantly, causes the relative price of non tradables to appreciate along with the relative wage, and leads to a reallocation of resources toward the non traded sector, thus increasing its relative size at the expense of the traded sector.

Table 2 shows the simulated impact effects of an exogenous and unanticipated increase in government consumption by 1 percentage point of GDP while column 1 shows impact responses from our VAR model for comparison purposes.[42] Column 4 shows results for the baseline model which we contrast with those obtained when we impose perfect mobility of labor (i.e., we set $\epsilon \to \infty$) and abstract from capital installation costs (i.e., we set $\kappa = 0$) as well. Other columns give results for alternative scenarios discussed below. While in Table 2, we restrict our attention to impact responses, in Fig. 6 and 7 we show the dynamic adjustment to an increase in government consumption by 1% of GDP. Figures show the model predictions together with the respective VAR evidence. In each panel, the solid blue line displays the point estimate of the VAR model, with the dotted blue lines indicating 90%

[41] It is worthwhile mentioning that there is a threshold for the allocation of the rise in government consumption between tradables and non tradables which leaves the relative price of non tradables and thus the sectoral output shares unaffected. We find numerically that a rise in government consumption by 1% of GDP which is split between non tradables and tradables in the following proportions, $\bar{\omega}_{G^N} = 16.5\%$ and $\bar{\omega}_{G^T} = 83.5\%$ does not affect the relative size of sectors.

[42] For reasons of space, we do not show long-run effects since we believe that their interpretation is secondary.

confidence bounds. The solid black line shows the transitional paths obtained in a model with imperfect mobility of labor and capital adjustment costs. To gauge the importance of labor mobility across sectors for fiscal transmission, we contrast our baseline case featuring imperfect mobility with the perfect mobility case shown by the dashed black line. It is worth mentioning that the endogenous response of government spending to an exogenous fiscal shock that we generate theoretically in Figure 6(a) by specifying the law of motion (26) reproduces the dynamic adjustment from the VAR model remarkably well as the black line and the blue line cannot be differentiated.

5.2.1 Aggregate Effects

We begin with the aggregate effects of a government spending shock shown in panels A and B of Table 2. Contrasting the numerical results reported in columns 2 and 4 with the evidence shown in column 1, whether we assume perfect or imperfect mobility of labor, both models tend to understate the responses of real GDP and hours worked. However, the model performance improves with imperfect mobility of labor as the rise in GDP by 0.19% lies within the confidence interval, as shown in Figure 6(b). The reason is that with imperfect mobility of labor, the existence of workers' costs of switching sectors puts upward pressure on non traded wages and thus on the aggregate wage. This then amplifies the positive response of hours worked which increases on impact by 0.30% instead of 0.11% when the mobility cost is absent. Because agents supply more labor, real GDP rises by a larger amount as long as there is a difficulty in reallocating labor. While the real consumption wage is unaffected on impact when we let ϵ tend toward infinity, a government spending shock generates a rise in the wage rate which more than offsets the increase in the consumption price index and thus pushes up the real consumption wage by 0.07% in the baseline model where $\epsilon = 0.75$.

Turning to the dynamic adjustment of investment and the current account displayed in Fig. 6(d) and 6(f), a model assuming perfect mobility and abstracting from capital installation costs dramatically overstates the decline in investment and predicts a current account surplus in the short-run, contrary to the evidence. Because capital-labor ratios are fixed, the return on domestic capital remains unchanged as well. The substantial decline in private savings generates such a physical capital decumulation that the current account moves into surplus. In contrast, as long as we relax the assumption of perfect mobility of labor, the neoclassical model is able to produce the crowding out of investment along with the current account deficit in the short-run, as shown in column 7 of Table 2 where we abstract from capital installation costs to isolate the role of limited labor mobility. Intuitively, as long as there is a difficulty in reallocating labor across sectors, the capital-labor ratio falls in the traded sector as the workers' mobility costs moderate the shift of labor. Thus, the return on domestic capital increases, which in turn mitigates the fall in investment and produces a current account deficit. However, the model tends to overstate the crowding-out of investment and to understate the decline in the current account. In contrast, as shown in column 4, when we allow for capital installation costs along with imperfect mobility of labor, the model predicts a current account deficit of 0.34% of GDP, which accords well with our estimate, by further mitigating the decline in investment. We then ask whether both capital adjustments costs and imperfect mobility of labor are essential to account for the evidence. To answer this, column 3 considers a scenario where we assume that physical capital accumulation is subject to installation costs while hours worked are perfect substitutes across sectors. The model predicts a rise in investment instead of a decline and considerably overstates the current account deficit found in the data: while the shadow price of investment, Q, increases as in a model assuming imperfect mobility of labor, the rise in the investment price index, P_J, is not large enough to drive down Tobin's q. As will become clear below, perfect mobility of labor implies that the relative price of non tradables merely appreciates, thus hampering the increase in P_J.

Contrasting the model's predictions with VAR evidence in Fig. 6, the simulated responses lie within the confidence interval along the transitional adjustment, with the exception of the real consumption wage. Although quite stylized, the model is able to account for the time-series evidence on the aggregate effects of a government spending shock as long as we allow for both capital installation costs and a difficulty in reallocating labor.

< Please insert Table 2 about here >

< Please insert Figures 6-7 about here >

5.2.2 Sectoral Effects

Turning to the sectoral impact of a rise in government consumption, the baseline model can account reasonably well for the dynamic adjustment of the non traded sector and somewhat less well for the traded sector. Panels C and D of Table 2 show impact responses of labor and product market variables, respectively, while in Fig. 7, we report the model predictions together with the VAR evidence of selected sectoral variables.

Focusing first on impact responses, column 2 of Table 2, shows that a model assuming perfect mobility of labor fails to account for the evidence along a number of dimensions. More specifically, comparing the VAR evidence reported in column 1 with simulated impact effects, we find that a model abstracting from workers' mobility costs understates the expansionary effect of a government spending shock on non traded output, cannot generate an appreciation in the relative price of non tradables along with the rise in the non traded wage relative to the traded wage, and substantially understates the changes in sectoral output shares.

In contrast, as displayed in column 4, the performance of the neoclassical model improves as long as we allow for imperfect mobility of labor. To begin with, the baseline model which considers costs of switching sectors can account for the rise in the relative wage. Intuitively, because government spending is biased toward non tradables, non traded firms are encouraged to produce and thus to hire more to meet additional demand. As workers experience intersectoral mobility costs, non traded firms must pay higher wages to attract workers which raises the relative wage, Ω, by 1.44% as shown in the sixth line of panel C.

Because labor shifts toward the non traded sector, the baseline model predicts a rise in hours worked of non tradables by 0.44% which accords will the evidence shown in column 1. Labor reallocation pushes up non traded output by 0.50%, the response being almost double that obtained with perfect labor mobility (see column 2). The reason is twofold. First, the capital-labor ratio in the non traded sector increases as workers are reluctant to shift their hours worked across sectors. Second, because the aggregate wage increases when we allow for imperfect mobility of labor, workers supply more labor which further raises output in the non traded sector since it is relatively more labor intensive. While the baseline model is able to account pretty well for impact responses of hours worked and output of non tradables, it tends to somewhat overstate the contraction in hours worked and output of tradables which are fairly muted according to VAR evidence.

As long as there is a difficulty in reallocating labor across sectors, excess demand shows up in the non traded goods market. As a result, the price of non traded goods relative to traded goods appreciates by 0.88%, as shown in the fourth line of panel D. The appreciation in the relative price triggers a reallocation of resources toward the non traded sector, raising its output share by 0.38% of GDP, while that of tradables falls by exactly the same amount. As we move from column 5 to column 6 of Table 2, the utility loss resulting from the shift from one sector to another is reduced. As shown analytically in section 4, a rise in the degree of labor mobility exerts two opposite effects on sectoral output shares: while workers are more willing to shift across sectors, the relative price of non tradables appreciates less which mitigates the incentive for labor reallocation. We find numerically that raising the elasticity of labor supply across sectors, ϵ, from 0.22 to 1.64 amplifies the rise in the output share of non tradables from 0.26% to 0.49% of GDP, in accordance with our evidence documented in section 2.6. Thus, the former effect more than offsets the latter.[43]

Turning to the adjustment of sectoral variables following a government spending shock as shown in Fig. 7, the dynamics of the relative price and the relative wage are captured fairly well by the model. As government spending falls and is restored to its initial level, excess demand in the non traded goods market is reduced, which depreciates the relative price of non tradables along the transitional path, as shown in Fig. 7(a). Decreasing prices

[43]However, the latter influence may predominate if the values of ϵ are higher because the relative price merely appreciates in this case. In the polar case where ϵ tends toward infinity, the output share of non tradables increases by only 0.24%, a value that is much smaller than the estimated response of 0.35% of GDP.

of non tradables relative to tradables encourage non traded firms to reduce hours worked and thus to lower output, in line with the evidence in Fig. 7(h) and 7(g). Because non traded wages fall relative to traded wages during the transitional adjustment, as shown in Fig. 7(b), labor is reallocated toward the traded sector, which recovers gradually, while both hours worked and output remain below their initial levels for almost ten years. As shown in Fig. 7(e) and 7(d), the model tends to somewhat understate the contraction of labor and the output of tradables in the medium run.[44]

In order to further highlight the performance of the baseline model with imperfect mobility of labor and capital installation costs, it is useful to analyze the dynamic adjustment of sectoral variables when these two features are absent. The dotted line in Fig. 7 displays the model predictions if we let ϵ tend toward infinity, while the parameter governing the magnitude of adjustment cost, κ, is set to zero. First, a model assuming $\epsilon \to \infty$ and setting $\kappa = 0$ predicts a flat temporal path for the relative wage and the relative price which conflict with the evidence. Second, it substantially understates the impact responses of sectoral output shares while the simulated responses for the baseline model accord well with the evidence. Intuitively, the relative price of non tradables appreciates when ϵ takes intermediate values, which in turn amplifies the shift of capital toward the non traded sector. Third, the model imposing perfect mobility of labor considerably overstates the changes in sectoral output shares along the transitional path. The reason is that the capital stock falls sharply in the short-run and then recovers rapidly after two years, resulting in sharp changes in the relative size of sectors due to the Rybczynski effect.

5.2.3 Sensitivity Analysis

To gauge the relative role of limited labor mobility and capital adjustment costs, we also report results from two restricted versions of the model where one of the two features is, respectively, shutdown. Column 3 of Table 2 shows the predictions of a model imposing perfect mobility of labor along with capital installation costs while column 7 reports impact responses from a model assuming imperfect mobility while setting $\kappa = 0$.[45] Both models fail to account for the responses of sectoral output shares to a government spending shock. While introducing capital installation costs restore transitional dynamics for the relative price of non tradables, the restricted model where labor is perfectly mobile across sectors considerably overstates the responses of sectoral output shares. Intuitively, workers no longer experience a mobility cost and thus are willing to shift their whole time to the sector that pays the highest wage. As a result, sectoral labor and thus sectoral output

[44]The explanation is intuitive: the baseline model underpredicts the decumulation of physical capital along the transitional path while the traded sector is more capital intensive.

[45]To save space we develop intuition regarding the implications of imperfect mobility of labor and capital adjustment costs by restricting attention to impact responses. In a Technical Appendix, we contrast the dynamic adjustment from baseline model with the responses from the restricted model where one of the two features is shut down.

become unrealistically sensitive to a change in relative price, thus leading to a change in the sectoral output share which is about twice what is estimated empirically, as can be seen in column 3. In contrast, as reported in column 7, a model assuming imperfect mobility of labor while abstracting from capital installation costs tends to substantially understate the responses of sectoral output shares. As investment is crowded out by a larger amount than if capital were subject to adjustment costs, the excess demand in the non traded goods market is lower so that the relative price appreciates less, resulting in smaller shifts of labor and capital toward the non traded sector. In sum, to generate a sectoral impact of a government spending shock that is similar to that in the data, we have to allow for adjustment costs to physical capital accumulation along with imperfect mobility of labor across sectors.

Columns 8 and 9 show results when the elasticity of labor supply, σ_L, is set to 1, and σ is set to 2, respectively. As can be seen in column 8, raising σ_L from 0.4 to 1 amplifies the rise in hours worked triggered by the negative wealth effect and the increase in the aggregate wage, which further raises real GDP. Because larger labor supply benefits both sectors, hours worked (and subsequently output) increase more in the non traded sector while employment (and subsequently output) falls less in the traded sector. Since the non traded sector is more labor intensive, the rise in non traded labor is somewhat more pronounced. However, responses of sectoral output shares are almost unchanged compared with those obtained from the baseline model as the relative price of non tradables appreciates by a smaller amount, thus mitigating the shift of capital toward the non traded sector. Numerical results shown in column 9 indicate that non separability in preferences between consumption and labor amplifies the rise in the real consumption wage while hours and real GDP increase less. Additionally, the open economy runs a larger current account deficit. Intuitively, because non separability in preferences between consumption and labor increases the disutility from working, agents are less willing to supply labor while demanding higher wages. Because consumption increases with the aggregate wage, agents lower their expenditure less. Thus, private savings decline further, which in turn amplifies the decline in the current account. As the crowding out of private consumption is less, the relative price of non tradables appreciates by a larger amount, thus amplifying the responses of sectoral output shares. While the extension of the baseline model to non separability in preferences somewhat improves its performance in reproducing the responses of several sectoral variables, the extended model tends to substantially overstate the contraction in the traded sector and to overpredict the rise in the relative wage. In contrast, all simulated impact responses from the baseline model assuming separability in preferences lie within the confidence interval.

Finally, in the last two columns of Table 2, we investigate whether our conclusions hold if we assume a non traded sector that is more capital intensive than the traded sector.

While the predictions of the model are very sensitive to sectoral labor income shares if we let ϵ tend toward infinity, results are almost unaffected for the baseline model whether $\theta^T < \theta^N$ or $\theta^T > \theta^N$. As shown in column 10, the model imposing perfect mobility of labor fails to account for the evidence along a number of dimensions. In particular, the simulated responses of sectoral output shares are more than four times greater than those reported from the VAR model. The reason is that imposing perfect mobility makes labor and thus sectoral output highly sensitive to a change in relative price. Because investment is crowded in, the subsequent excess demand in the non traded goods market causes the relative price of non tradables to appreciate, thus leading to dramatic changes in the relative size of sectors. Since the model's predictions reported in column 11 are similar to those shown in column 4, they do not merit further comment.

5.3 Cross-Country Differences in Sectoral Impact: Taking the Model to Data

We have shown above that the performance of the neoclassical model in replicating the evidence related to fiscal transmission improves as long as we allow for imperfect mobility of labor and capital adjustment costs. We now move a step further and assess the ability of the model to generate a similar cross-country relationship between the degree of labor mobility and changes in the relative size of sectors to that in the data.

To compute numerically the impact responses of sectoral output shares to a government spending shock, we calibrate our model to match key characteristics of the 16 OECD economies in our sample, including the share of non traded hours worked to total hours worked, the non tradable content of consumption, investment and public expenditure, investment- and government spending-to-GDP ratios, and the degree of labor mobility across sectors. Table 4 summarizes the country-specific data for non tradable and GDP component shares. The elasticity of labor supply across sectors, ϵ, which plays a pivotal role in fiscal transmission, is set in accordance with our estimates shown in the last column of Table 4. As mentioned in section 5.1, φ, φ_J, ϑ, δ_K together with initial conditions (B_0, K_0) need to be endogenously calibrated to target α_C, α_J, L^N/L, ω_J along with $\upsilon_{NX} = NX/Y^T$ where $NX = Y^T - C^T - G^T - J^T$ corresponds to net exports. The remaining parameters are set to their empirical counterparts. Some parameters, such as the elasticity of labor supply, σ_L, and κ governing the magnitude of adjustment costs to physical capital accumulation, along with the world interest rate, are however kept constant for all countries. While we explore the sectoral effects of a rise in government consumption by 1% of GDP (i.e., g is set to 0.01) for each country in our sample, to be consistent with the calibration to a representative OECD economy described in section 5.1, we assume that the increase in public purchases is split between non tradables and tradables in accordance with their respective shares in government spending, i.e., ω_{G^N} and $1 - \omega_{G^N}$, respectively, where ω_{G^N}

is set in accordance with its country-specific value shown in column 4 of Table 4, except for Australia and Ireland.[46]

< Please insert Figures 8-9 about here >

To explore the cross-country relationship quantitatively, we first plot in Fig. 8 the simulated responses of sectoral output shares on the vertical axis against the degree of labor mobility captured by the parameter ϵ on the horizontal axis. Restricting our attention to countries where the rise in government consumption is biased toward non tradables, impact changes in non traded output relative to real GDP range from 0.26% of GDP for the Netherlands to 0.49% of GDP for Spain. Fig. 8(a) and 8(b) also show that these differences in the responses of sectoral output shares are correlated with the measure of the degree of labor mobility across sectors. As ϵ takes higher values, countries with a higher degree of labor mobility experience a larger decline in the relative size of the traded sector and a larger increase in the relative size of the non traded sector. These results thus reveal that **the sectoral impact of fiscal policy increases with the degree of labor mobility**, which accords with our evidence. Quantitatively, as we move along the trend line shown in Fig. 8(a), our model predicts that a country with a low degree of labor mobility as captured by a value of ϵ of 0.2 will experience a decline in the output share of tradables of 0.2% of GDP, while a country with a higher degree of labor mobility as captured by a value of ϵ of 1.2 will face a fall by 0.4% of GDP, a decline which is twice as strong. Hence, **cross-country differences in the degree of labor mobility generate a substantial dispersion in the sectoral impact of fiscal policy**.

In Fig. 9, we contrast the cross-country relationship from the calibrated baseline model shown by the solid blue line with the cross-country relationship from the VAR model shown by the solid black line. When we calibrate our model to cross-country data, we obtain a correlation between the responses of sectoral output shares and the measure of the degree of labor mobility of -0.206 for tradables ($t - stat = -2.238$) and 0.206 for non tradables ($t - stat = 2.238$). While it tends to understate the changes in the relative size of sectors since the cross-country relationship is higher for tradables and lower for non tradables, the model is able to generate a cross-country relationship between the responses of sectoral output shares and the degree of labor mobility which is quite similar to that in the data.

6 Conclusion

While the literature analyzing fiscal transmission mainly focuses on the aggregate effects of a rise in government consumption, our empirical results reveal that the impact of fiscal

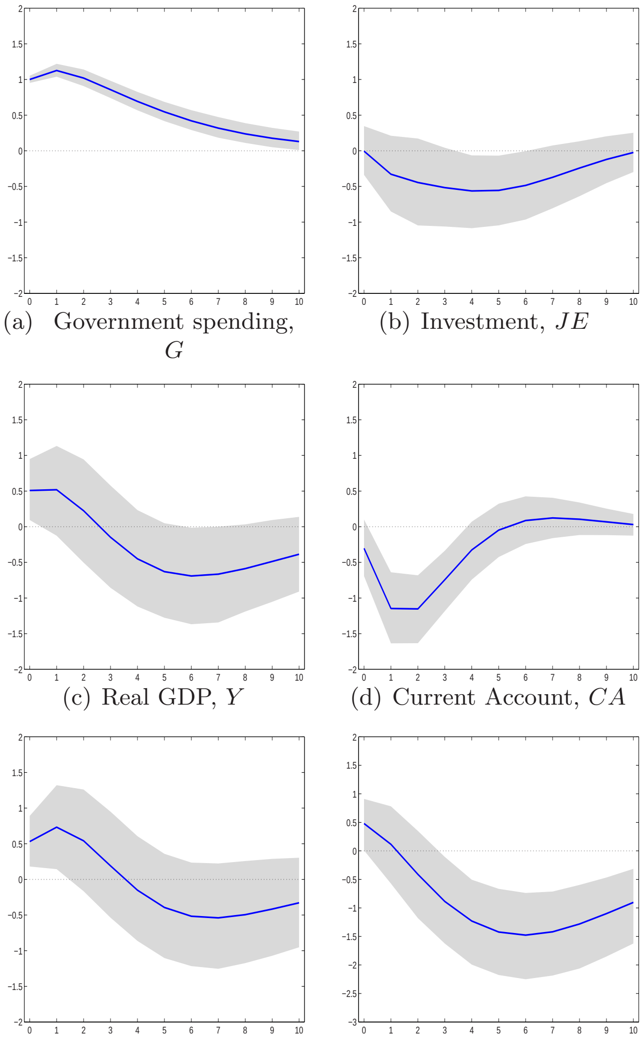
[46]For Australia and Ireland, we find empirically that the output share of tradables increases on impact while the relative size of the non traded sector declines. To be consistent with empirical evidence, we consider a rise in public purchases which is fully biased toward tradables. It is worthwhile mentioning that at the initial steady-state, we set the non tradable content of government spending, ω_{G^N}, to 0.90% and 0.89% for Australia and Ireland, respectively, in accordance with the shares reported in column 4 of Table 4.

policy varies significantly between sectors and across countries. Using a panel of 16 OECD countries over the period 1970-2007, we find empirically for the whole sample that a government spending shock has an expansionary effect on hours worked and output of non tradables, whereas it gives rise to contractions in hours worked and output of tradables. Such a finding along with the appreciation in the relative price of non tradables suggests that public purchases are biased toward non traded goods. Importantly, non traded output increases substantially relative to GDP (in real terms) while the reverse is true for the traded sector. This evidence thus highlights the fact that resources are shifted toward the non traded sector, with the reallocation of inputs contributing to 50% of non traded output growth. If labor were freely mobile across sectors, sectoral wages would equalize. However, we find empirically that non traded wages increase substantially relative to traded wages, thus suggesting the presence of labor mobility costs across sectors. Contrasting the sectoral impact across the economies in our sample, the output share of non tradables (in real terms) rises for the vast majority of the economies while its magnitude varies sharply across countries. Estimating the elasticity of labor supply across sectors for each country, we find that impact responses of output shares for tradables and non tradables are more pronounced in countries with lower mobility costs.

To rationalize our panel VAR evidence, we develop a two-sector open economy model with imperfect mobility of labor across sectors and adjustment costs to physical capital accumulation. As in Horvath [2000], agents cannot costlessly reallocate hours worked from one sector to another. Because mobility is costly in utility terms, workers demand higher wages in order to compensate for their cost of switching sectors. Abstracting first from capital accumulation, we find analytically that the model can account for our evidence as long as the rise in public purchases is biased toward non traded goods while the elasticity of labor supply across sectors takes finite values. In contrast, if we let the elasticity of labor supply across sectors tend toward infinity, both the relative price and the relative wage of non tradables remain unaffected. Turning to the sensitivity of the sectoral impact of a fiscal shock to the degree of labor mobility, our analytical results suggest a non monotonic relationship between the elasticity of labor supply across sectors and the magnitude of impact responses of sectoral output shares.

Calibrating the model to a representative OECD economy and considering a rise in government consumption biased toward non tradables, we find quantitatively that the open economy version of the neoclassical model with tradables and non tradables can account for the panel VAR evidence as long as we allow for imperfect mobility of labor across sectors together with adjustment costs to physical capital accumulation. The first feature mitigates the shift of labor toward the non traded sector and hence the subsequent increase in the supply of non tradables. The second feature moderates the crowding out of investment, resulting in a much smaller decline in private demand for tradables. Put together, these two ingredients trigger an excess demand for non tradables. The resulting appreciation in the relative price is key to generating a shift of hours worked and capital which generates a rise (a fall) in the output share of non tradables (tradables) by an amount that accords well with the data. We show that each of these features contributes to magnifying the aggregate and sectoral effects of a rise in government consumption. In contrast, the restricted version of the model where one of the two features is shut down fails to account for the evidence along a number of dimensions.

The final exercise we perform is to calibrate our baseline model with a difficulty in reallocating labor and costly capital accumulation to each OECD economy in our sample. Our numerical results reveal that international differences in the degree of labor mobility generate a large dispersion in the responses of sectoral output shares to a government spending shock: changes in the relative size of sectors are twice as strong in the country with the highest degree of labor mobility than in the economy with the lowest labor mobility. Finally, we find quantitatively that the model reproduces pretty well the cross-country relationship between the degree of labor mobility and the responses of sectoral output shares that we estimate empirically.



(a) Government spending, G

(b) Investment, JE

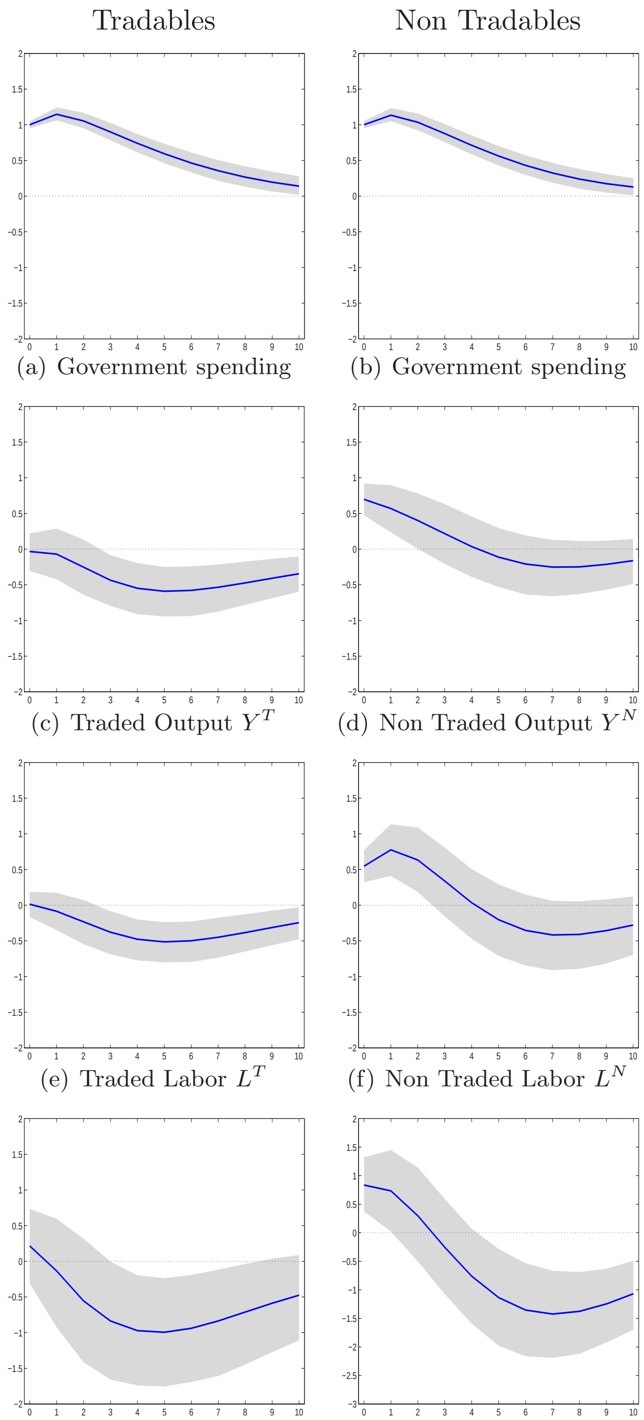
(c) Real GDP, Y

(d) Current Account, CA

(e) Labor, L

(f) Real Consumption Wage, W/P_C

Figure 1: Effects of Unanticipated Government Spending Shock on Aggregate Variables. Notes: Exogenous increase of government consumption by 1% of GDP. Aggregate variables include GDP (constant prices), total hours worked, private fixed investment, the current account and the real consumption wage. Horizontal axes indicate years. Vertical axes measure percentage deviation from trend in output units (government spending, GDP, investment, current account), percentage deviation from trend in labor units (total hours worked), percentage deviation from trend (real consumption wage). Results for baseline specification are displayed by solid lines with shaded area indicating 90 percent confidence bounds obtained by bootstrap sampling; sample: 16 OECD countries, 1970-2007, annual data.



(a) Government spending (b) Government spending

(c) Traded Output Y^T (d) Non Traded Output Y^N

(e) Traded Labor L^T (f) Non Traded Labor L^N

(g) Real Consumption Wage in Tradables W^T/P_C (h) Real Consumption Wage in Non Tradables W^N/P_C

Figure 2: Effects of Unanticipated Government Spending Shock on Sectoral Variables. Notes: Exogenous increase of government consumption by 1% of GDP. Sectoral variables include sectoral valued added at constant prices, sectoral hours worked, and real consumption sectoral wages. Horizontal axes indicate years. Vertical axes measure percentage deviation from trend in output units (sectoral output), percentage deviation from trend in labor units (sectoral labor), percentage deviation from trend (real consumption sectoral wages). Results for baseline specification are displayed by solid lines with shaded area indicating 90 percent confidence bounds obtained by bootstrap sampling; sample: 16 OECD countries, 1970-2007, annual data.

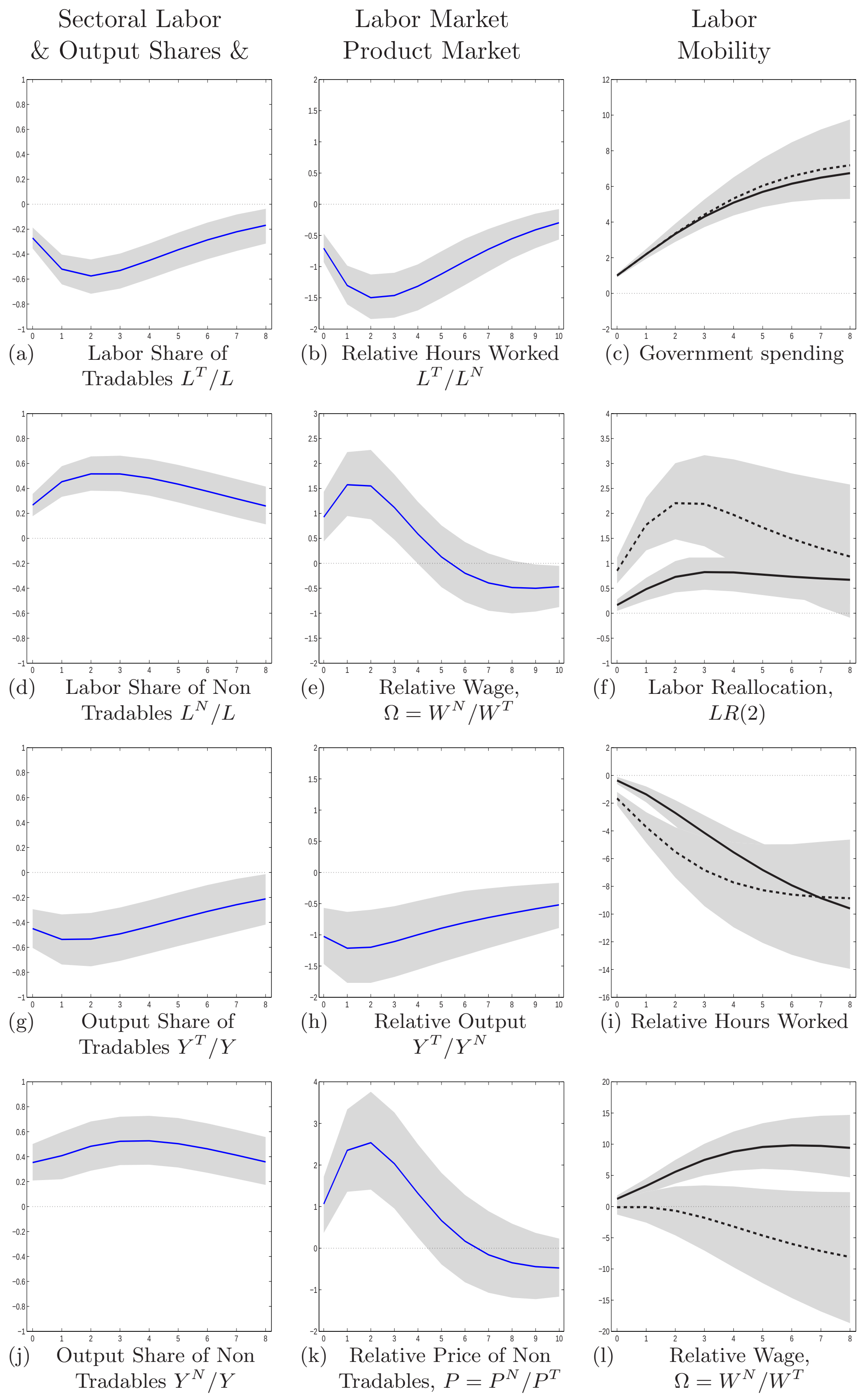
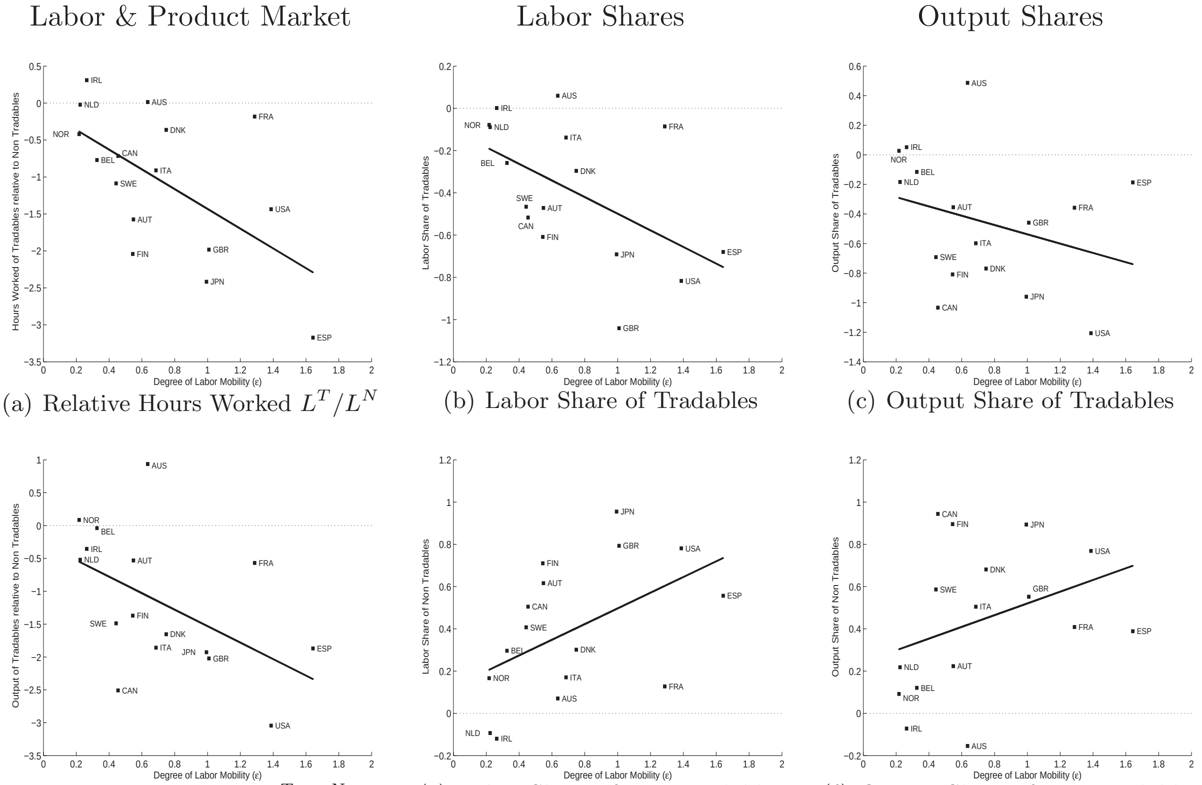


Figure 3: Effects of Unanticipated Government Spending Shock on Sectoral Composition and Reallocation. Notes: Exogenous increase of government consumption by 1% of GDP. Horizontal axes indicate years. Vertical axes measure percentage deviation from trend in output units (sectoral output, sectoral output shares), percentage deviation from trend in labor units (sectoral labor, sectoral labor shares, intersectoral labor reallocation index), deviations from trend (ratio of traded value added to non traded value added, ratio of hours worked of tradables to hours worked of non tradables), and percentage deviation from trend (relative price, relative wage). Results for baseline specification are displayed by solid lines with shaded area indicating 90 percent confidence bounds obtained by bootstrap sampling. The third column shows the cumulative responses of government spending, labor reallocation across sectors, hours worked of tradables in terms of non tradables, and the relative wage in countries where the mobility of labor is low (solid line) and high (dashed line); sample: 16 OECD countries, 1970-2007, annual data.

Table 1: Responses to Government Spending Shock: Point Estimates

		A. Aggregate and Sectoral Effects					**B. Low Vs. High Labor Mobility**		
Variables	Horizon	Aggregate (1)	Tradables (2)	Non Tradables (3)	Variables	Horizon	All sample (4)	Low Mobility (5)	High Mobility (6)
Gov. spending	1	1.000*	1.000*	1.000*	Relative Labor	1	−0.705*	−0.346*	−1.770*
	2	2.127*	2.147*	2.134*	(L^T/L^N)	2	−2.007*	−1.303*	−3.972*
	4	4.004*	4.099*	4.044*		4	−4.968*	−3.950*	−7.299*
Output	1	0.508*	−0.033	0.697*	Relative Output	1	−1.025*	−0.674*	−1.936*
	2	1.026	−0.103	1.266*	(Y^T/Y^N)	2	−2.240*	−1.764*	−3.405*
	4	1.103	−0.792	1.882*		4	−4.547*	−4.293*	−5.389*
Labor	1	0.531*	0.014	0.547*	Mobility Indicator	1	0.304*	0.163*	0.851*
	2	1.263*	−0.071	1.323*	$(LR(2))$	2	0.754*	0.482*	1.772*
	4	1.994	−0.683	2.295*		4	1.110*	0.824*	2.191*
Real Wage	1	0.480*	0.215	0.835*	Relative Wage	1	0.939*	1.320*	−0.687
	2	0.595	0.080	1.569*	(W^N/W^T)	2	2.667*	3.603*	−1.307
	4	−0.703	−1.313	1.610		4	5.222*	7.683*	−5.248
Investment	1	−0.004							
	2	−0.332							
	4	−1.293							
Current Account	1	−0.303							
	2	−1.450*							
	4	−3.346*							

Notes: Horizon measured in year units. * denote significance at 10% level. Standard errors are bootstrapped with 10000 replications. The last three columns report, for selected horizons and samples, the cumulative responses of relative labor, relative output, the intersectoral labor reallocation index and relative wage to an increase in government spending by 1% of GDP. The response of relative labor (relative output resp.) is estimated from a 3-variable VAR that includes government spending, relative labor (relative output), L^T/L^N (Y^T/Y^N), and the relative wage of non tradables (relative price of non tradables), W^N/W^T (P^N/P^T). Finally, the response of labor reallocation (LR) is estimated from a 3-variable VAR that includes government spending, the intersectoral labor reallocation index, $LR(2)$, and the relative wage of non tradables, W^N/W^T.



(a) Relative Hours Worked L^T/L^N (b) Labor Share of Tradables (c) Output Share of Tradables

(d) Relative Output Y^T/Y^N (e) Labor Share of Non Tradables (f) Output Share of Non Tradables

Figure 4: Effect of Government Spending Shocks on Sectoral Composition against the Degree of Labor Mobility across Sectors. Notes: Figure 4 plots impact responses of traded hours worked relative to non traded hours worked, traded output relative to non traded output, sectoral labor and sectoral output shares. Impact responses shown in the vertical axis are obtained by running a VAR model for each country and are expressed in percentage point. Horizontal axis displays the elasticity of labor supply across sectors, ϵ, which captures the degree of labor mobility across sectors; panel data estimates for ϵ are taken from column 16 of Table 4.

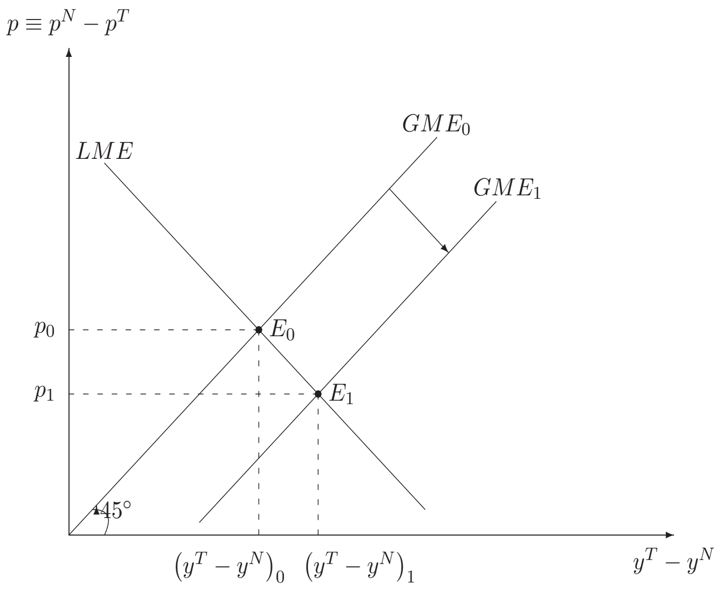
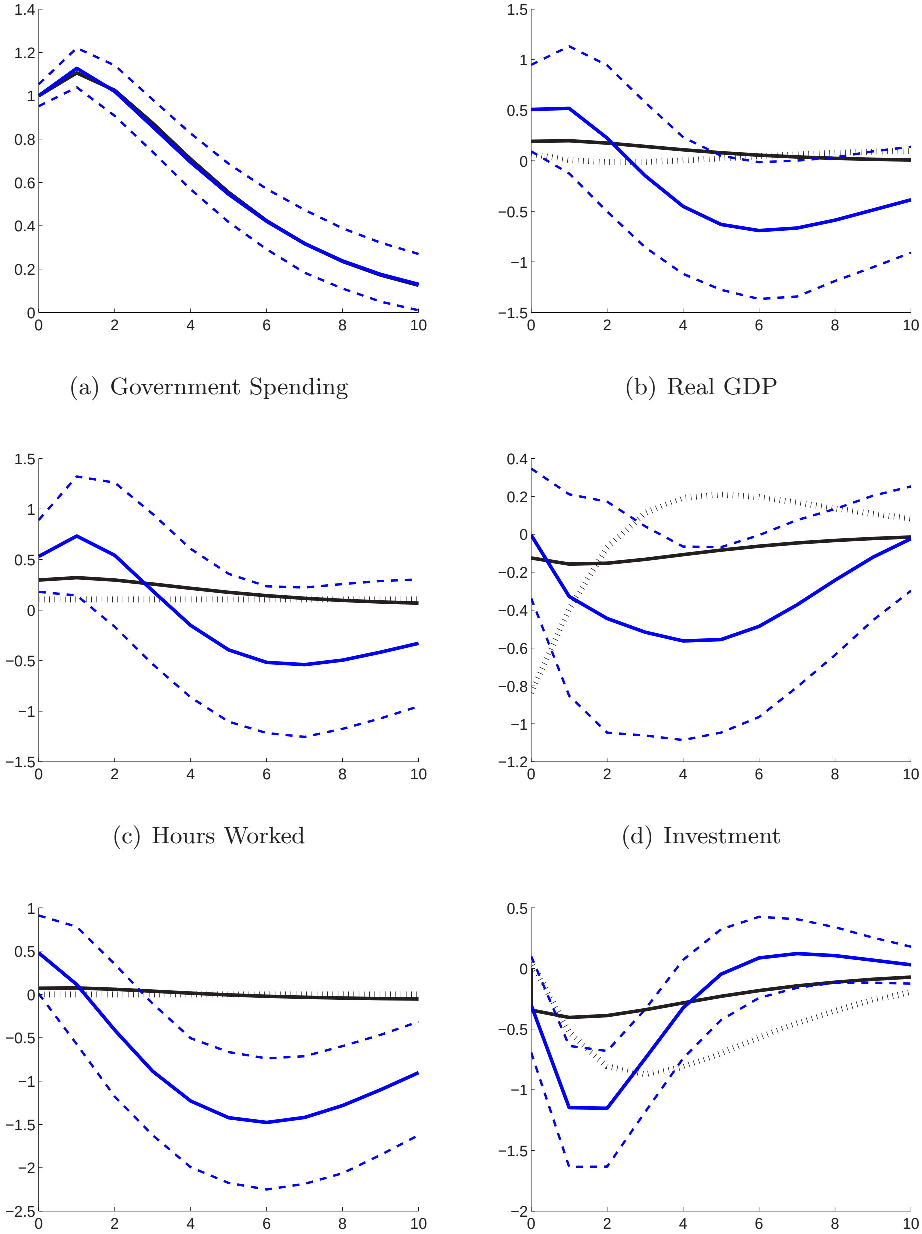


Figure 5: Steady-State Effects of an Unanticipated Temporary Rise in Government Spending in the $(y^T - y^N, p)$-space.

Table 2: Impact Responses of Aggregate and Sectoral Variables to of a Rise in Government Consumption (in %)

	Data	$1-\theta^T > 1-\theta^N$								$1-\theta^T < 1-\theta^N$	
		Perf. Mob.		Bench	Mobility		No Adj. Cost.	Lab. supply	Non sep.	Perf. Mob.	IML
		$(\kappa=0)$	$(\kappa=17)$	$(\epsilon=0.75)$	$(\epsilon=0.22)$	$(\epsilon=1.64)$	$(\kappa=0)$	$(\sigma_L=1)$	$(\sigma=2)$	$(\epsilon=\infty)$	$(\epsilon=0.75)$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
A.Impact: GDP & Components											
Real GDP, $dY_R(0)$	0.51	0.07	0.09	0.19	0.22	0.16	0.15	0.34	0.17	0.00	0.16
Investment, $dI(0)$	-0.01	-0.84	0.04	-0.13	-0.17	-0.08	-0.41	-0.14	-0.14	1.49	-0.22
Current account, $dCA(0)$	-0.30	0.06	-0.75	-0.34	-0.22	-0.46	-0.12	-0.29	-0.50	-2.49	-0.35
B.Impact: Labor & Real Wage											
Labor, $dL(0)$	0.53	0.11	0.15	0.30	0.34	0.25	0.24	0.53	0.27	0.00	0.25
Real consumption wage, $d\left(W/P_C\right)(0)$	0.48	0.00	0.07	0.07	0.08	0.06	0.05	-0.04	0.12	-0.30	-0.05
C.Impact: Sectoral Labor											
Traded labor, $dL^T(0)$	0.01	-0.20	-0.68	-0.14	0.02	-0.29	-0.09	-0.04	-0.19	-1.94	-0.17
Non traded labor, $dL^N(0)$	0.54	0.30	0.83	0.44	0.32	0.55	0.33	0.57	0.45	1.95	0.42
Traded wage, $d\left(W^T/P_C\right)(0)$	0.22	0.00	0.07	-0.89	-1.18	-0.61	-0.65	-0.91	-1.00	-0.30	-0.96
Non traded wage, $d\left(W^N/P_C\right)(0)$	0.83	0.00	0.07	0.55	0.69	0.42	0.38	0.43	0.66	-0.30	0.54
Relative labor, $d\left(L^T/L^N\right)(0)$	-0.71	-0.53	-1.86	-0.52	-0.19	-0.86	-0.36	-0.50	-0.59	-5.83	-0.60
Relative wage, $d\left(W^N/W^T\right)(0)$	0.93	0.00	0.00	1.44	1.87	1.03	1.02	1.33	1.66	-0.00	1.49
Labor share of tradables, $d(L^T/L)(0)$	-0.27	-0.23	-0.74	-0.24	-0.09	-0.38	-0.17	-0.23	-0.27	-1.94	-0.27
Labor share of non tradables, $d(L^N/L)(0)$	0.27	0.23	0.74	0.24	0.09	0.38	0.17	0.23	0.27	1.94	0.27
D.Impact: Sectoral Output											
Traded output, $dY^T(0)$	-0.03	-0.22	-0.72	-0.31	-0.19	-0.43	-0.21	-0.24	-0.37	-1.87	-0.31
Non traded output, $dY^N(0)$	0.70	0.28	0.82	0.50	0.41	0.59	0.37	0.58	0.55	1.87	0.47
Relative output, $d\left(Y^T/Y^N\right)(0)$	-1.03	-0.62	-3.16	-0.97	-0.64	-1.30	-0.64	-0.97	-1.07	-4.93	-0.88
Relative price, $dP(0)$	1.06	0.00	0.02	0.88	1.13	0.64	0.62	0.79	1.02	0.08	1.01
Output share of tradables, $d(Y^T/Y_R)(0)$	-0.45	-0.24	-0.76	-0.38	-0.26	-0.49	-0.27	-0.37	-0.44	-1.87	-0.37
Output share of non tradables, $d(Y^N/Y_R)(0)$	0.35	0.24	0.76	0.38	0.26	0.49	0.27	0.37	0.44	1.87	0.37

Notes: Effects of an unanticipated and temporary exogenous rise in government consumption by 1% of GDP. Panels A,B,C,D show the initial deviation in percentage relative to steady-state for aggregate and sectoral variables. Market product (aggregate and sectoral) quantities are expressed in percent of initial GDP while labor market (aggregate and sectoral) quantities are expressed in percent of initial total hours worked; θ^T and θ^N are the labor income share in the traded sector and non traded sector, respectively; ϵ measures the degree of substitutability in hours worked across sectors and captures the degree of labor mobility; σ_L is the Frisch elasticity of labor supply; κ governs the magnitude of adjustment costs to capital accumulation; σ determines the substitutability between consumption and leisure when preferences are non separable. In our baseline calibration (labelled 'Bench'), we set $\theta^T = 0.58$, $\theta^N = 0.68$, $\epsilon = 0.75$, $\phi = 0.77$, $\sigma_L = 0.4$, $\kappa = 17$, $\sigma = 1$. In column 11 ('IML' means Imperfect Mobility of Labor), we keep the same calibration as the baseline, except for θ^T and θ^N which are set to 0.68 and 0.58, respectively.



(a) Government Spending

(b) Real GDP

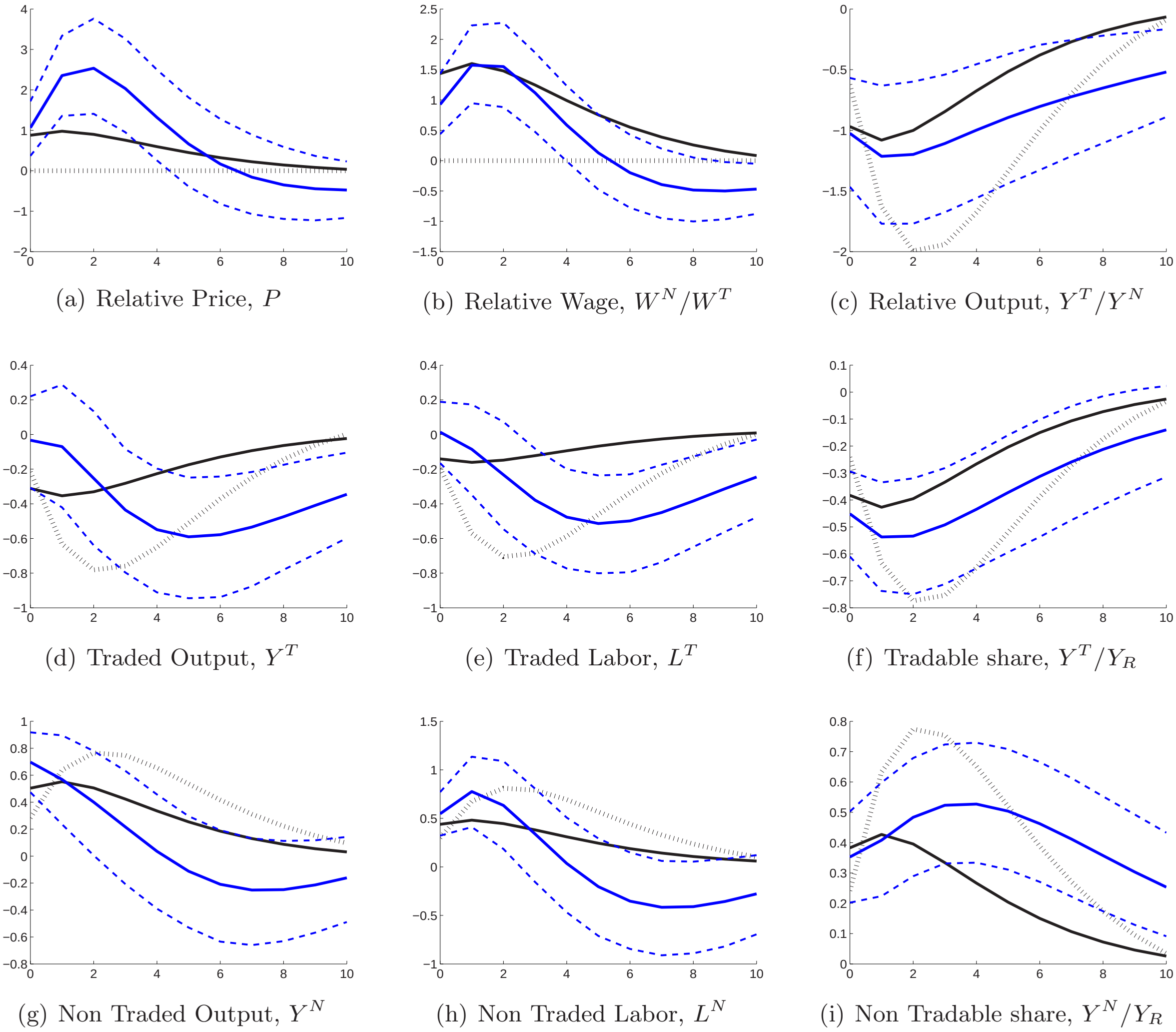
(c) Hours Worked

(d) Investment

(e) Aggregate Real Wage

(f) Current Account

Figure 6: Dynamic Adjustment of Aggregate Variables to Unanticipated Government Spending Shock. Notes: Solid blue line displays point estimate of VAR model with dotted blue lines indicating 90% confidence bounds; the solid black line displays model predictions in the baseline scenario with imperfect mobility of labor across sectors ($\epsilon = 0.75$) and capital installation costs ($\kappa = 17$) while the dotted black line shows predictions of the model imposing perfect mobility of labor ($\epsilon \to \infty$) and abstracting from capital adjustment costs ($\kappa = 0$).

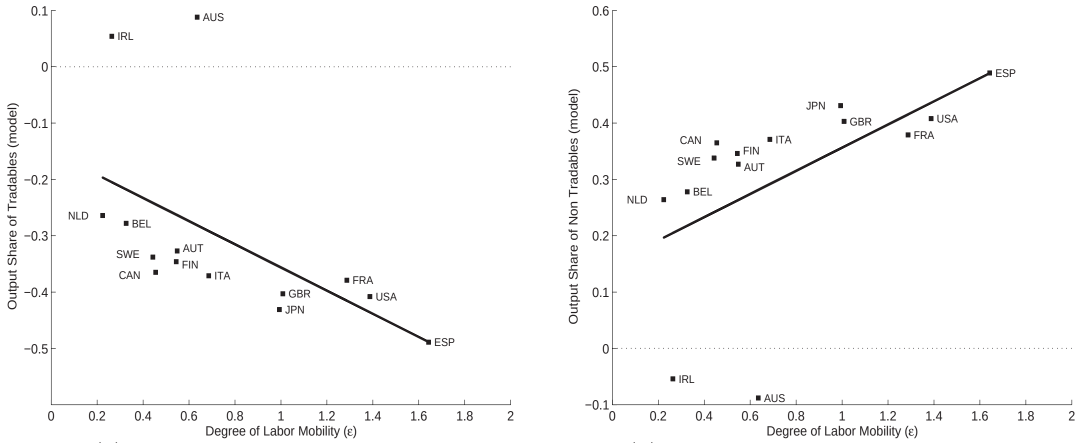


(a) Relative Price, P (b) Relative Wage, W^N/W^T (c) Relative Output, Y^T/Y^N

(d) Traded Output, Y^T (e) Traded Labor, L^T (f) Tradable share, Y^T/Y_R

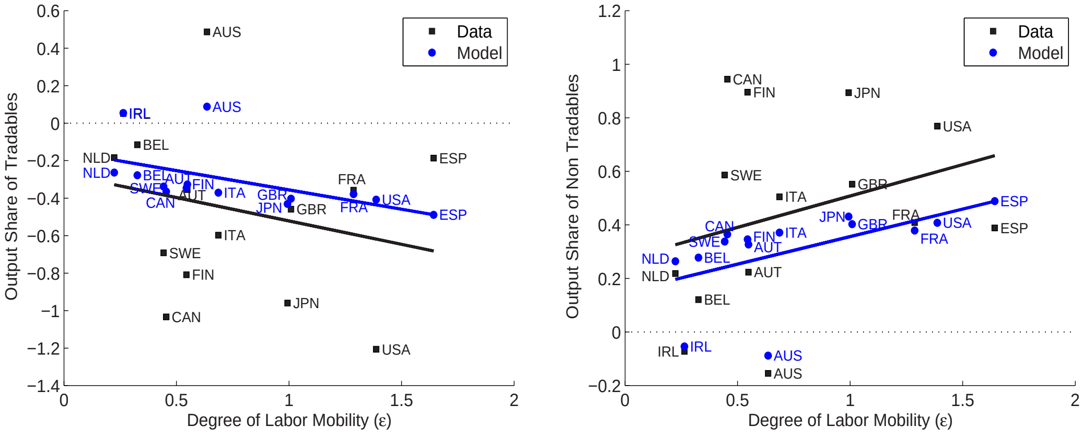
(g) Non Traded Output, Y^N (h) Non Traded Labor, L^N (i) Non Tradable share, Y^N/Y_R

Figure 7: Dynamic Adjustment of Sectoral Variables to Unanticipated Government Spending Shock. Notes: Solid blue line displays point estimate of VAR with dotted blue lines indicating 90% confidence bounds; the solid black line displays model predictions in the baseline scenario with imperfect mobility of labor across sectors ($\epsilon = 0.75$) and capital installation costs ($\kappa = 17$) while the dotted black line shows predictions of the model imposing perfect mobility of labor ($\epsilon \to \infty$) and abstracting from capital adjustment costs ($\kappa = 0$).



(a) Output Share of Tradables (b) Output Share of Non Tradables

Figure 8: Cross-Country Relationship between the Responses of Sectoral Output Shares to Government Spending shock and the Degree of Labor Mobility across Sectors. Notes: Horizontal axes displays panel data estimates of the elasticity of labor supply across sectors, ϵ, taken from the last column of Table 4, which captures the degree of labor mobility across sectors. Vertical axes report simulated impact responses from the baseline model with imperfect mobility of labor across sectors and adjustments costs to capital accumulation.



(a) Output Share of Tradables (b) Output Share of Non Tradables

Figure 9: Cross-Country Relationship from Simulated Responses vs. Cross-Country Relationship from VAR Estimates. Notes: Horizontal axes displays panel data estimates of the elasticity of labor supply across sectors, ϵ, taken from the last column of Table 4, which captures the degree of labor mobility across sectors. Vertical axes report simulated responses from the baseline model (blue circles) and impact responses from the VAR model (black squares).

A Data Description for Empirical Analysis

Coverage: Our sample consists of a panel of 16 countries: Australia (AUS), Austria (AUT), Belgium (BEL), Canada (CAN), Denmark (DNK), Finland (FIN), France (FRA), Ireland (IRL), Italy (ITA), Japan (JPN), the Netherlands (NLD), Norway (NOR), Spain (ESP), Sweden (SWE), the United Kingdom (GBR) and the United States (USA). The period is running from 1970 to 2007, except for Japan (1974-2007).

Sources: Our primary sources for sectoral data are the OECD and EU KLEMS databases. We use the EU KLEMS [2011] sectoral database (the March 2011 data release, available at `http://www.euklems.net`) which provides for all countries of our sample with the exceptions of Canada and Norway annual data for eleven 1-digit ISIC-rev.3 industries. For Canada and Norway, sectoral data are taken from the Structural Analysis (STAN) database provided by the OECD [2011]. In addition, expenditure aggregates are obtained from the Economic Outlook Database provided by the Organisation for Economic Cooperation and Development [2012b].

The eleven 1-digit ISIC-rev.3 industries are classified as tradables or non tradables. To do so, we adopt the classification proposed by De Gregorio et al. [1994]. Following Jensen and Kletzer [2006], we have updated this classification by treating "Financial Intermediation" as a traded industry. We construct traded and non traded sectors as follows (EU KLEMS codes are given in parentheses):

- **Traded Sector**: "Agriculture, Hunting, Forestry and Fishing" (AtB), "Mining and Quarrying" (C), "Total Manufacturing" (D), "Transport, Storage and Communication" (I) and "Financial Intermediation" (J).
- **Non Traded Sector**: "Electricity, Gas and Water Supply" (E), "Construction" (F), "Wholesale and Retail Trade" (G), "Hotels and Restaurants" (H), "Real Estate, Renting and Business Services" (K) and "Community Social and Personal Services" (LtQ).

Once industries have been classified as traded or non traded, for any macroeconomic variable X, its sectoral counterpart X^j for $j = T, N$ is constructed by adding the X_k of all sub-industries k classified in sector $j = T, N$ as follows $X^j = \sum_{k \in j} X_k$.

Relevant to our work, the EU KLEMS and OECD STAN databases provide data, for each industry and year, on value added at current and constant prices, permitting the construction of sectoral deflators of value added, as well as details on labor compensation and employment data, allowing the construction of sectoral wage rates. In the VAR models, with the exception of the current account, all quantity variables are in log levels and scaled by the working age population (15-64 years old), while price deflators and wage rates are in natural logs. Source: OECD ALFS Database for the working age population. We describe below the construction for the sectoral data employed in Section 2 (mnemonics are given in parentheses):

- **Sectoral output**, Y^j: sectoral value added at constant prices in sector $j = T, N$ (VA_QI). Sources: EU KLEMS and OECD STAN databases.
- **Relative output**, Y^T/Y^N: ratio of traded value added at constant prices to non traded value added at constant prices.
- **Sectoral output share**, $\nu^{Y,j}$: ratio of value added at constant prices in sector j to GDP at constant prices, i.e., $Y^j/(Y^T + Y^N)$ for $j = T, N$.
- **Relative price of non tradables**, P: ratio of the non traded value added deflator to the traded value added deflator, i.e., $P = P^N/P^T$. The sectoral value added deflator P^j for sector $j = T, N$ is calculated by dividing value added at current prices (VA) by value added at constant prices (VA_QI) in sector j. Sources: EU KLEMS and OECD STAN databases.
- **Sectoral labor**, L^j: total hours worked by persons engaged in sector j (H_EMP). Sources: EU KLEMS and OECD STAN databases.
- **Relative labor**, L^T/L^N: ratio of hours worked in the traded sector to hours worked in the non traded sector.
- **Sectoral labor share**, $\nu^{L,j}$: ratio of hours worked in sector j to total hours worked, i.e., $L^j/(L^T + L^N)$ for $j = T, N$.
- **Sectoral real consumption wage**, W^j/CPI: nominal wage in sector j divided by the consumer price index (CPI). Source: OECD Prices and Purchasing Power Parities for the consumer price index. The sectoral nominal wage W^j for sector $j = T, N$ is calculated by dividing labor compensation in sector j (LAB) by total hours worked by persons engaged (H_EMP) in that sector. Sources: EU KLEMS and OECD STAN databases.
- **Relative wage**, Ω: ratio of the nominal wage in the non traded sector W^N to the nominal wage in the traded sector W^T, i.e., $\Omega = W^N/W^T$.

- **Labor reallocation index**, LR: measures the fraction of workers who are working in year t in a different sector than in year $t-2$ and is computed as:

$$LR_t(2) = 0.5 \sum_{j=T}^{N} \left| \frac{L_t^j}{\sum_{j=T}^{N} L_t^j} - \frac{L_{t-2}^j}{\sum_{j=T}^{N} L_{t-2}^j} \right|.$$

Data for labor (H_EMP), used to compute LR, are taken from EU KLEMS and OECD STAN databases.

In the following, we provide details on data construction for aggregate variables (mnemonics are in parentheses):

- **Government spending**, G: real government final consumption expenditure (CGV). Source: OECD Economic Outlook Database.
- **Gross domestic product**, Y: real gross domestic product (GDPV). Source: OECD Economic Outlook Database.
- **Private investment**, JE: real private non-residential gross fixed capital formation (IBV). Source: OECD Economic Outlook Database.
- **Current account**, CA: ratio of the current account to the gross domestic product at current prices (CBGDPR). Source: OECD Economic Outlook Database.
- **Labor**, L: total hours worked by persons engaged (H_EMP). Sources: EU KLEMS and OECD STAN databases.
- **Real consumption wage**, W/CPI: nominal wage divided by the consumer price index (CPI). Source: OECD Prices and Purchasing Power Parities for the consumer price index. The nominal wage is calculated by dividing labor compensation (LAB) by total hours worked by persons engaged (H_EMP). Sources: EU KLEMS and OECD STAN databases.

Government spending, investment and GDP variables are deflated with their own deflators.

B Data for Calibration

Table 4 shows the non tradable content of GDP, consumption, investment, government spending, labor and labor compensation. In addition, it gives information about the share of government spending on the traded and non traded goods in the corresponding sectoral value added and the sectoral labor income shares. The column 11 shows the ratio of labor productivity of tradables to labor productivity of non tradables as we we use labor productivity to approximate technological change. Columns 12 to 14 display investment-to-GDP ratio and government spending in % of GDP and the labor income share, respectively, for the whole economy. Our sample covers the 16 OECD countries mentioned in Section A. Our reference period for the calibration corresponds to the period 1990-2007. The choice of this period has been dictated by data availability. Columns 15 and 16 report estimates for the elasticity of substitution in consumption between traded and non traded goods, ϕ, and the elasticity of labor supply across sectors, ϵ. In the following, statistics for the sample as a whole represent (unweighted) averages of the corresponding variables among the group.

To calculate the non tradable share of output, labor and labor compensation, we split the eleven industries into traded and non-traded sectors by adopting the classification proposed by De Gregorio et al. [1994] and updated by Jensen and Kletzer [2006]. Details about data construction for sectoral output and sectoral labor are provided in section A. We calculate the non-tradable share of labor compensation as the ratio of labor compensation in the non traded sector (i.e., $W^N L^N$) to overall labor compensation (i.e., WL). Sources: EU KLEMS [2011] and STAN databases. Data coverage: 1990-2007 for all countries. The non tradable content of GDP, labor and labor compensation, shown in columns 1, 5 and 6 of Table 4, average to 63%, 67% and 66% respectively.

To split consumption expenditure (at current prices) into consumption in traded and non traded goods, we made use of the Classification of Individual Consumption by Purpose (COICOP) published by the United Nations (Source: United Nations [2011]). Among the twelve items, the following ones are treated as consumption in traded goods: "Food and Non-Alcoholic Beverages", "Alcoholic Beverages Tobacco and Narcotics", "Clothing and Footwear", "Furnishings, Household Equipment" and "Transport". The remaining items are treated as consumption in non traded goods: "Housing, Water, Electricity, Gas and Fuels", "Health", "Communication", "Recreation and Culture", "Education", "Restaurants and Hotels". Because the item "Miscellaneous Goods and Services" is somewhat problematic, we decided to consider it as both tradable (50%) and non tradable (50%) with equal shares. Data coverage: 1990-2007 for AUS, AUT, CAN, DNK, FIN, FRA, GBR, ITA, JPN, NLD, NOR and USA, 1993-2007 for SWE and 1995-2007 for BEL, ESP and IRL. The non-tradable share of consumption shown in column 2 of Table 4 averages to 53%.

To calculate the non tradable share of investment expenditure, we follow the methodology proposed by Burstein et al. [2004] who treat "Housing", "Other Constructions" and "Other Products" as non-tradable investment and "Products of Agriculture, Forestry, Fisheries and Aquaculture", "Metal Products and Machinery", "Transport Equipment" as tradable investment expenditure. Source: OECD Input-Output database [2012a]. Data coverage: 1990-2007 for AUT, CAN, ESP, FIN, GBR, IRL, JPN, NLD, and NOR, 1990-2006 for DNK, FRA, ITA and USA, and 1993-2007 for SWE. Data are not available for AUS and BEL. Non tradable share of investment shown in column 3 of Table 4 averages to 64%, in line with estimates provided by Burstein et al. [2004] and Bems [2008].

Sectoral government expenditure data (at current prices) were obtained from the Government Finance Statistics Yearbook (Source: IMF [2011]) and the OECD General Government Accounts database (Source: OECD [2012b]). Adopting Morshed and Turnovsky's [2004] methodology, the following four items were treated as traded: "Fuel and Energy", "Agriculture, Forestry, Fishing, and Hunting", "Mining, Manufacturing, and Construction", "Transport and Communications". Items treated as non traded are: "Government Public Services", "Defense", "Public Order and Safety", "Education", "Health", "Social Security and Welfare", "Environment Protection", "Housing and Community Amenities", "Recreation Cultural and Community Affairs". Data coverage: 1990-2007 for BEL, DNK, FIN, GBR, IRL, ITA, JPN, NOR and USA, 1990-2006 for CAN, 1995-2007 for AUT, ESP, FRA, NLD and SWE. Data are not available for AUS. The non tradable component of government spending shown in column 4 of Table 4 averages to 90%. Government spending on traded and non traded goods in % of the corresponding sectoral output, i.e., G^T/Y^T and G^N/Y^N, respectively, is shown in columns 7 and 8 of Table 4. They average 5% and 30%, respectively.

The labor income share for sector j denoted by θ^j is calculated as the ratio of labor compensation of sector j to value added of sector j at current prices. Sources: EU KLEMS [2011] and STAN databases. Data coverage: 1990-2007 for all countries. As shown in columns 9 and 10 of Table 4, θ^T and θ^N average 0.60 and 0.67, respectively. When $k^T > k^N$, the shares of labor income average 0.58 and 0.67 for the traded and the non traded sector, respectively, while if $k^N > k^T$, θ^T and θ^N average 0.70 and 0.64, respectively. In addition, column 14 of Table 4 gives the aggregate labor income share which averages 0.64 in our sample.

Column 11 of Table 4 displays the ratio of labor productivity in tradables to labor productivity in non tradables (Z^T/Z^N) averaged over the period 1990-2007. To measure labor productivity in sector $j = T, N$, we divide value added at constant prices in sector j (VA_QI) by total hours worked by persons engaged (H_EMP) in that sector. Sources: EU KLEMS [2011] and STAN databases. Data coverage: 1990-2007 for all countries. As shown in column 11, the traded sector is in average 28 percent more productive than the non traded sector for the whole sample.

Columns 12 and 13 of Table 4 display gross capital formation and final consumption expenditure of general government as a share of GDP, respectively. Source: OECD National Accounts Database. Data coverage: 1990-2007 for all countries.

Column 1 of Table 3 shows our estimates of the elasticity of labor supply across sectors, ϵ, while columns 2-3 show our estimates of the elasticity of substitution in consumption between traded and non traded goods, ϕ. We detail our empirical strategy to estimate these two parameters.

Along the lines of Horvath [2000], we derive a testable equation by combining optimal rules for labor supply and labor demand and estimate ϵ by running the regression of the worker inflow in sector $j = T, N$ of country i at time t arising from labor reallocation across sectors computed as $\hat{l}^j_{i,t} - \hat{l}_{i,t}$ on the relative labor's share percentage changes in sector j, $\hat{\beta}^j_{i,t}$:[47]

$$\hat{l}^j_{i,t} - \hat{l}_{i,t} = f_i + f_t + \gamma_i \hat{\beta}^j_{i,t} + \nu^j_{i,t}, \tag{53}$$

where we denote logarithm in lower case and the deviation from initial steady-state by a hat; $\nu^j_{i,t}$ is an i.i.d. error term; country fixed effects are captured by country dummies, f_i, and common macroeconomic shocks by year dummies, f_t. The LHS term of (53) is calculated as the difference between changes (in percentage) in hours worked in sector j, $\hat{l}^j_{i,t}$, and in total hours worked, $\hat{l}_{i,t}$. The RHS term β^j corresponds to the fraction of labor's share of output accumulating to labor in sector j. Denoting by $P^j_t Q^j_t$ output at current prices in sector $j = T, N$ at time t, β^j_t is computed as $\frac{\xi^j P^j_t Q^j_t}{\sum_{j=N}^T \xi^j P^j_t Q^j_t}$ where ξ^j is labor's share in output in sector $j = T, N$ defined as the ratio of the compensation of employees to output in the jth sector, averaged over the period 1971-2007.[48] Because hours worked are aggregated by means of a CES function, total hours percentage change $\hat{l}_{i,t}$ is calculated as a weighted average of sectoral employment percentage changes, i.e., $\hat{l}_t = \sum_{j=N}^T \beta^j_{t-1} \hat{l}^j_t$. The parameter we are interested in, the degree of substitutability of hours worked across sectors, is given by $\epsilon_i = \gamma_i/(1-\gamma_i)$. In the regressions that follow, the parameter γ_i is alternatively assumed

[47] Details of derivation of the equation we explore empirically can be found in a Technical Appendix.

[48] As Horvath [2000], we use time series for output instead of value added so that our estimates can be compared with those documented by the author.

to be identical across countries when estimating for the whole sample ($\gamma_i = \gamma_{i'} \equiv \gamma$ for $i \neq i'$) or to be different across countries when estimating ϵ for each economy ($\gamma_i \neq \gamma_{i'}$ for $i \neq i'$). Data are taken from the EU KLEMS [2011] and STAN databases, and the sample includes the 16 OECD countries mentioned above over the period 1971-2007 (except for Japan: 1975-2007). Table 3 reports empirical estimates that are consistent with $\epsilon > 0$. All values are statistically significant at 10%, except for Denmark and Norway.[49]

To estimate the elasticity of substitution in consumption, ϕ, between traded and non traded goods, we first derive a testable equation by inserting the optimal rule for intra-temporal allocation of consumption (14) into the goods market equilibrium which gives $\frac{C^T}{C^N} = \frac{Y^T - NX - G^T - I^T}{Y^N - G^N - I^N} = \left(\frac{\varphi}{1-\varphi}\right) P^{\phi}$ where $NX \equiv \dot{B} - r^{\star} B$ is net exports, I^j and G^j are investment in physical capital and government spending in sector j, respectively. Isolating $\left(Y^T - NX\right)/Y^N$ and taking logarithm yields $\ln\left(\frac{Y^T - NX}{Y^N}\right) = \alpha + \phi \ln P$. Adding an error term μ, we estimate ϕ by running the regression of the (logged) output of tradables adjusted with net exports at constant prices in terms of output of non tradables on the (logged) relative price of non tradables:

$$\ln\left(\frac{Y^T - NX}{Y^N}\right)_{i,t} = f_i + f_t + \alpha_i t + \phi_i \ln P_{i,t} + \mu_{i,t}, \tag{54}$$

where f_i and f_t are the country fixed effects and time dummies, respectively. Because the term $\alpha \equiv \ln \frac{\left(1-\upsilon_{G^N}-\upsilon_{I^N}\right)}{\left(1-\upsilon_{G^T}-\upsilon_{I^T}\right)} + \ln\left(\frac{\varphi}{1-\varphi}\right)$ is composed of ratios, denoted by υ_{G^j} and υ_{I^j}, of G^T (G^N) and I^T (I^N) to $Y^T - NX$ (Y^N) and hence may display a trend over time, we add country-specific linear trends, as captured by $\alpha_i t$.[50]

Instead of using time series for sectoral value added, we can alternatively make use of series for sectoral labor compensation by inserting the first-order condition equating the marginal revenue of labor and the sectoral wage, i.e., $\frac{\theta^j P^j Y^j}{L^j} = W^j$, into the goods market clearing condition. Eliminating Y^j, denoting by $\gamma^T = \left(W^T L^T - \theta^T P^T NX\right)$ and $\gamma^N = W^N L^N$, and taking logarithm yields $\ln\left(\frac{\gamma^T}{\gamma^N}\right) = \eta + \phi \ln P$ where η is a term composed of both preference (i.e., φ) and production (i.e., θ^j) parameters, and (logged) ratios of G^T (G^N) and I^T (I^N) to $W^T L^T - \theta^T P^T NX$ $(W^N L^N)$. We estimate ϕ by exploring alternatively the following empirical relationship:

$$\ln\left(\gamma^T/\gamma^N\right)_{i,t} = g_i + g_t + \sigma_i t + \phi_i \ln P_{i,t} + \zeta_{i,t}, \tag{55}$$

where g_i and g_t are the country fixed effects and time dummies, respectively, and we add country-specific trends, as captured by $\sigma_i t$, because η is composed of ratios that may display a trend over time.

Time series for sectoral value added at constant prices, labor compensation, and the relative price of non tradables are taken from EU KLEMS [2011] and STAN databases (see Section A). Net exports correspond to the external balance of goods and services at current prices taken from OECD Economic Outlook Database. To construct time series for net exports at constant prices, NX, data are deflated by the value added deflator of traded goods P_t^T.

Since LHS terms of (54) and (55) and relative price of non tradables display trends, we ran unit root and then cointegration tests. Having verified that these two assumptions are empirically supported, we estimate the cointegrating relationships by using fully modified OLS (FMOLS) procedure for cointegrated panel proposed by Pedroni [2000], [2001]. FMOLS estimates of (54) and (55) are reported in the second and the third column of Table 3 respectively. As a reference model, we consider eq. (54) which gives an estimate for the whole sample of $\phi = 0.66$. This value is roughly halfway between estimates documented by cross-section studies, notably Stockman and Tesar [1995] who find a value for ϕ of 0.44 and Mendoza [1995] who reports an estimate of 0.74.

[49] In a Technical Appendix, we address one potential econometric issue. While $\beta^j_{i,t}$ (i.e., the RHS term in eq. (53)) is constructed independently from the dependent variable (i.e., the LHS term in eq. (53)), if the labor's share is (almost) constant over time and thus is close from the average ξ^j, an endogeneity problem may potentially show up. Our empirical results reveal that for the majority of the countries in our sample, the dependent variable does not Granger-cause the explanatory variable.

[50] Because an endogeneity problem of relative prices may potentially affect our econometric results, we ran Granger causality tests. Our empirical results reveal that for the majority of the countries in our sample, the dependent variable does not Granger-cause the explanatory variable. Our results show that one can consider the regressor in eq. (54) as exogenous with respect to the dependent variable.

Table 3: Estimates of the Elasticity of Labor Supply across Sectors (ϵ) and the Elasticity of Substitution in Consumption between Tradables and Non Tradables (ϕ)

Country	Labor Mobility (ϵ)	Elasticity of Substitution (ϕ)	
	eq. (53)	eq. (54)	eq. (55)
	$\hat{\epsilon}_i$	$\hat{\phi}_i^{FMOLS}$	$\hat{\phi}_i^{FMOLS}$
AUS	0.635^a (3.55)	0.268^a (2.99)	0.409^b (2.52)
AUT	0.548^a (2.66)	0.986^a (3.09)	1.413^a (4.99)
BEL	0.326^b (2.51)	0.070 (0.41)	0.795^a (4.99)
CAN	0.454^a (3.41)	0.391^a (3.74)	0.582^a (5.53)
DNK	0.150 (1.46)	2.071^a (2.95)	1.323^a (2.93)
ESP	1.642^a (3.02)	0.783^a (4.96)	0.413^b (2.04)
FIN	0.544^a (3.62)	1.072^a (8.57)	1.421^a (8.12)
FRA	1.287^b (2.44)	0.937^a (6.22)	1.038^a (5.25)
GBR	1.008^a (3.79)	0.477^a (9.64)	1.164^a (14.07)
IRL	0.264^a (3.18)	0.374^c (1.71)	0.158 (0.35)
ITA	0.686^a (2.84)	-0.308 (-1.60)	-0.187 (-0.98)
JPN	0.993^a (2.87)	0.654^a (2.98)	0.676^a (4.33)
NLD	0.224^b (1.97)	0.709^b (2.33)	0.428 (1.18)
NOR	0.097 (1.49)	0.979^a (9.72)	2.056^a (13.66)
SWE	0.443^a (3.61)	0.356^a (4.02)	0.900^a (7.23)
USA	1.387^a (2.59)	0.668^a (2.81)	0.799^b (2.02)
Whole Sample	0.479^a (12.16)	0.656^a (16.13)	0.837^a (14.16)
Countries	16	16	16
Observations	1178	605	605
Data coverage	1971-200	1970-2007	1970-2007
Country fixed effects	yes	yes	yes
Time dummies	yes	yes	yes
Time trend	no	yes	yes

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

Table 4: Data to Calibrate the Two-Sector Model (1990-2007)

Countries	Non tradable Share						G^j/Y^j		Labor Share		Product.	Aggregate ratios			Elasticities	
	Output	Consump.	Inv.	Gov. Spending	Labor	Lab. comp.	G^T/Y^T	G^N/Y^N	θ^T	θ^N	Z^T/Z^N	I/Y	G/Y	Labor Share	ϕ	ϵ
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
AUS	0.63	0.56	n.a.	n.a.	0.68	0.67	n.a.	n.a.	0.55	0.66	1.30	0.25	0.18	0.62	0.27	0.64
AUT	0.64	0.52	0.62	0.90	0.64	0.64	0.05	0.27	0.65	0.66	1.05	0.24	0.19	0.65	0.99	0.55
BEL	0.65	0.53	n.a.	0.91	0.68	0.66	0.06	0.30	0.65	0.67	1.28	0.21	0.22	0.66	0.80	0.33
CAN	0.63	0.54	0.67	0.91	0.69	0.67	0.05	0.30	0.53	0.63	1.32	0.20	0.20	0.59	0.39	0.45
DNK	0.66	0.54	0.60	0.94	0.68	0.68	0.05	0.36	0.63	0.70	1.17	0.20	0.26	0.68	2.07	-
ESP	0.64	0.54	0.72	0.88	0.66	0.67	0.06	0.24	0.60	0.66	1.18	0.25	0.18	0.64	0.78	1.64
FIN	0.58	0.53	0.68	0.89	0.63	0.63	0.06	0.34	0.59	0.73	1.47	0.20	0.22	0.67	1.07	0.54
FRA	0.70	0.51	0.69	0.94	0.69	0.68	0.05	0.31	0.70	0.64	1.05	0.19	0.23	0.66	0.94	1.29
GBR	0.64	0.52	0.58	0.93	0.70	0.65	0.04	0.29	0.70	0.73	1.54	0.17	0.20	0.72	0.48	1.01
IRL	0.52	0.52	0.69	0.89	0.62	0.62	0.04	0.28	0.46	0.69	1.83	0.22	0.17	0.58	0.37	0.26
ITA	0.64	0.46	0.57	0.91	0.63	0.62	0.05	0.27	0.71	0.64	1.00	0.21	0.19	0.67	-	0.69
JPN	0.63	0.57	0.63	0.86	0.64	0.65	0.06	0.22	0.57	0.63	0.96	0.26	0.16	0.61	0.65	0.99
NLD	0.65	0.53	0.63	0.90	0.70	0.69	0.07	0.32	0.60	0.70	1.38	0.21	0.23	0.67	0.71	0.22
NOR	0.54	0.49	0.67	0.88	0.66	0.67	0.06	0.34	0.38	0.65	1.44	0.22	0.21	0.52	0.98	-
SWE	0.64	0.56	0.55	0.92	0.68	0.67	0.06	0.39	0.63	0.71	1.42	0.18	0.27	0.68	0.36	0.44
USA	0.69	0.63	0.64	0.90	0.73	0.69	0.05	0.20	0.61	0.63	1.12	0.19	0.16	0.62	0.67	1.39
Mean	0.63	0.53	0.64	0.90	0.67	0.66	0.05	0.30	0.60	0.67	1.28	0.21	0.20	0.64	0.77	0.75

Notes: G^j/Y^j is the share of government spending in good j in output of sector j; θ^j is the share of labor income in value added at current prices of sector $j = T, N$; Z^T/Z^N corresponds to the ratio of labor productivity of tradables to labor productivity of non tradables. I/Y is the investment-to-GDP ratio and G/Y is government spending as a share of GDP.

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