DOCUMENTOS DE ECONOMÍA Y FINANZAS INTERNACIONALES

Working Papers on International Economics and Finance

DEFI 18-03
Octubre 2018

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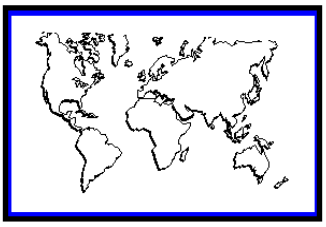

Asociación Española de Economía y Finanzas Internacionales
www.aeefi.com
ISSN: 1696-6376

A multi-country analysis of austerity policies in the European Union*

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Abstract

In this paper, we analyse the global effects, i.e., the effects on the world economy, from the austerity policies implemented in the European Union (EU) over the last years. Specifically, we simulate the effects of three alternative policies aimed to get a fall of one percentage point in the EU's government deficit to GDP ratio, through a decrease in the level of public spending, and increases in consumption and in labour taxes. We examine their effects on the main macroeconomic variables of seven regions of the world economy, i.e., the EU, the US, Japan, China, Asia-Pacific, Latin America and Rest of the World. The empirical methodology makes use of a computable general equilibrium (CGE) model, through an extension of the Global Trade Analysis Project (GTAP) model. The three policy measures led to contractionary effects on the EU's levels of activity, which were accompanied with changes in income distribution, always detrimental to labour. The effects on the rest of the world, however, were mostly negligible.

Keywords: Computable general equilibrium, Austerity policies, Global economy, European Union

JEL classification: C68, H62, H20, H50

* The authors acknowledge financial support from the Spanish Ministry of Economy, Industry and Competitiveness, through the projects ECO2016-78422-R (O. Bajo-Rubio) and ECO2017-86054-C3-2-R (A. G. Gómez-Plana).

1. Introduction

One of the most relevant after-effects of the global financial crisis that started in 2008 is the appearance of large fiscal imbalances in most advanced countries. As a consequence, a series of fiscal consolidation measures have been pursued in order to reduce the size of government deficits and the subsequent debt accumulation, so that the confidence of financial markets can be recovered, and the risk of sovereign default avoided.

The economic effects of these fiscal consolidation policies have been the subject of intensive research since the beginning of the crisis. An influential line of research in the first stages of the crisis claimed that, unlike the traditional "Keynesian" effects of fiscal policy, contractionary fiscal policies would provoke an expansionary effect on output. This result was explained in terms of the increased confidence of the private agents on government's solvency, leading to lower expected taxes in the next future. This is the literature on the so called "non-Keynesian" effects of fiscal policy, following the pioneering work of Giavazzi and Pagano (1990). The generality of these "non-Keynesian" effects of fiscal policy, however, has been put recently into question. In particular, some recent empirical studies using a novel methodology (i.e., identifying changes in fiscal policy motivated by the desire to reduce the budget deficit from historical documents) find that fiscal consolidations have a contractionary effect on economic activity, as expected from standard Keynesian models; see Romer and Romer (2010) and Guajardo, Leigh and Pescatori (2014). In addition, as shown by Auerbach and Gorodnichenko (2013), fiscal policy multipliers seem to be larger in recessions, which can be explained from several features that characterize depressed economies, such as the absence of supply constraints in the short run, and a binding zero lower bound on interest rates (DeLong and Summers, 2012). As a result, contractionary fiscal policies implemented during the crisis would have led to a permanent decline in output levels, as well as being unable to reduce debt to GDP ratios (Fatás and Summers, 2018).

Another relevant issue for the assessment of the effects of fiscal consolidations relates to their composition. Following previous contributions on this topic, Alesina and Ardagna (2010) concluded that, in the case of a fiscal consolidation, spending cuts are more effective than tax increases in order to stabilize the debt and avoiding a recession; whereas, for the case of a fiscal stimulus, the opposite result would hold, i.e., tax cuts are more expansionary than spending increases. Empirical support for these results has been provided by Alesina, Favero and Giavazzi (2015), who simulated the fiscal plans adopted by 16 OECD countries over a 30-year period (1978-2009) and found that spending-based fiscal consolidations were associated with minor and short-lived recessions; unlike tax-based consolidations, which led to deeper and longer recessions. The authors justified these results in terms of the confidence of investors, which recovers much sooner following a spending-based adjustment than a tax-based one. However, using a completely different methodology, Bajo-Rubio and Gómez-Plana (2015) simulated by means of a computable general equilibrium (CGE) model the effects of several alternative policy measures intended to reduce the Spanish government deficits, distinguishing between different types of taxes and expenditures. They found that the strongest negative effects on GDP and employment appeared in the case of an increase in the income tax, followed by spending cuts (especially in public education and, at a smaller extent, public health and public administration); in contrast, for indirect tax increases the negative effects on GDP and employment were milder.

On the other hand, especially in the member countries of the European Union (EU), the preferred way of implementing consolidation plans has been by reducing government spending, rather than increasing revenues. Leaving aside its ideological implications, this fact can be related to the standard result of the literature on fiscal policy and growth, which can be traced back to Barro (1991), of a negative and significant effect of the level of public consumption as a percentage of GDP (which would proxy government size) on the growth rate of a cross section of countries. This is justified on the grounds that a greater government intervention would distort the incentives systems, so that a higher government size would be associated with a lower productivity, and hence a lower growth. However, this effect did not appear robust to changes in the conditioning variables in the influential study of Levine and Renelt (1992). In addition, and even more important, it is not very clear why using government consumption as a proxy for the whole public expenditure. In particular, a model intended to analyse the effects of fiscal policy on growth should consider instead some other components of public spending more directly linked to growth, such as the government capital stock (directly, as an additional productive factor in the aggregate production function, and through its favourable effects on private capital's productivity), as well as public transfers that encourage accumulation and growth (as an externality in the aggregate production function); see Bajo-Rubio (2000).

In fact, over a long-term viewpoint, consolidation strategies based on cutting public expenditure items such as education, health care, R&D or public investments might harm future growth prospects (European Commission, 2012). For all these reasons, and even more in the current context of credit supply restrictions, fiscal adjustments should be gradual, and rely also on increases in government revenues in addition to spending cuts, in order to not dampen future growth (Baldacci, Gupta and Mulas-Granados, 2015). And all this would be particularly relevant since, as emphasized by Reinhart and Rogoff (2009), the decrease in public revenues due to the subsequent recession is the main reason behind the higher government deficits associated with financial crises.

Our aim in this paper will be to analyse the global effects, i.e., the effects on the world economy, from the austerity policies implemented in the EU over the last years. As is well known, faced to the increase in government deficits in most EU countries following the financial crisis that started in 2008, the EU authorities have endorsed the implementation of fiscal consolidation strategies, known as austerity policies. While only partially successful in reducing government deficits, such austerity policies have resulted in deepening the recession in most EU countries (De Grauwe and Ji, 2013). Specifically, we will simulate the effects of three alternative policies aimed to get a fall of one percentage point in the EU's government deficit to GDP ratio, through a decrease in the level of public spending, an increase in consumption taxes, and an increase in labour taxes; and examine their effects on the main macroeconomic variables of seven regions of the world economy, i.e., the EU, the US, Japan, China, Asia-Pacific, Latin America and Rest of the World. The empirical methodology will make use of a CGE model, through an extension of the Global Trade Analysis Project (GTAP) model. This methodology allows obtaining the consequences of changes in a particular variable on the whole economy under analysis, as well as the specific effects across the different productive sectors. Thus, the

potential of CGE models lies in their ability to integrate micro and macro elements (Devarajan and Robinson, 2005).

The rest of the paper is organized as follows. A brief description of the model is provided in Section 2. The data and calibration process are discussed in Section 3. The results from the simulations are presented in Section 4. Section 5 concludes.

2. The model

The model is an extension of Lanz and Rutherford (2016), based on GTAP9inGAMS (where GAMS stands for General Algebraic Modeling System, i.e., a high-level modeling system for mathematical programming and optimization), and is a static, multi-region CGE model. The centrepiece of GTAP is the GTAP Data Base, a global data base representing the world economy, which contains complete bilateral trade information, transport and protection linkages. The last release, namely, the GTAP 9 Data Base (Narayanan, Aguiar and McDougall, 2015), includes 140 regions and 57 sectors, taking 2004, 2007 and 2011 as reference years. This paper presents a version describing seven open economies (regions), disaggregated in fifteen productive sectors, one private representative consumer and a public sector for each region, and three primary factors (i.e., labour, capital and natural resources). The listing of the world regions and sectors appears in Table 1, and their correspondence with the GTAP 9 Data Base can be seen in Appendix I.

Table 1. Regions and sectors

Regions	Sectors
European Union	Agricultural products
United States	Chemical industry
Japan	Motor vehicles
China	Other transport equipment
Latin America	Machinery and equipment
Asia-Pacific	Electronic equipment
Rest of the World	Other industry
	Construction
	Trade
	Transport and communications
	Financial intermediation
	Business services
	Recreational services
	Government services
	Other services

The extension of the model performed in this paper is as follows:

(1) The original version of GTAP9inGAMS has one representative agent for each country or region. The model developed here splits the representative agent into public and private agents, extending the equations, and using National Accounts and other data sources to assign the corresponding micro and macro variables.

(2) Public expenditure and public savings are modelled as independent and

endogenous variables. The original GTAP9inGAMS assumes exogenous aggregate public expenditure while national savings are exogenous and public and private savings are aggregated.

(3) There is unemployment at regional level. It must be noted that due to the high unemployment rate in some regions, instead of using the common assumption of full employment in labour markets, the model includes unemployment in a way derived from the wage curve models.

(4) The trade balance is endogenous at regional level, unlike GTAP9inGAMS where it is assumed to be exogenous.

Next, we will present a brief description of the model, and the full set of equations is presented in Appendix II. The core equations of the standard GTAP9inGAMS model can be found in Lanz and Rutherford (2016).

Equilibrium conditions

The equilibrium of the model is a set of prices and an allocation of goods and factors. It involves the simultaneous solution of three sets of equations:

- Zero-profit conditions for firms.
- Market clearing in goods, natural resources and capital markets.
- Constraints on income balance (total revenue must equal total expenditure), labour market (that includes unemployment), and macroeconomic closure of the model.

Production

Production is based on a technology characterized by a nested CES-Leontief structure of intermediate inputs and factors. The firms' decision problem is to maximise profits subject to the technology constraints, obtaining the unit cost functions, which are further used in the zero-profit conditions. In turn, the demands for factors and intermediate inputs are obtained from Shephard's lemma on cost functions, and then used in the market-clearing equations. Firms show constant returns to scale in their technologies and follow a competitive pricing rule, with free entry and exit of firms. Two sectors (i.e., Agricultural products and Other industry) use a specific factor, so their technologies show decreasing returns to scale.

Consumption

Each country or region has two consumers: a representative private household behaving as a rational consumer, and a public consumer (see below). The level of private consumer's welfare is determined by the budget constraint that includes the rents from endowments of factors and exogenous savings. The household's decision problem consists of choosing an optimal consumption bundle, by maximizing a nested Cobb-Douglas utility function subject to the budget constraint. Preferences are represented by a nested utility function on consumption of goods. Demand functions for goods are derived from the first-order conditions, and are included in the goods and factor markets equations, as well as in the macroeconomic closure for savings.

Public sector

The GTAP Data Base and GTAP9inGAMS include a single representative agent, so it has been necessary to split it into a private representative household and the public sector. For this

purpose, we have made use of the National Accounts, the GTAP 9 Data Base (Narayanan et al., 2015), as well as other sources such as United Nations (2014), European Commission (2015) and International Monetary Fund (2015). The procedure has involved adding to the multi-country model the level of public savings, as well as the public gross capital formation at national/regional level. Both are necessary to define the government deficit to GDP ratio, which is changed in the simulations.

The role of the public sector in the model is twofold, i.e., it is an owner of resources and a purchaser of certain goods. As an owner of resources, its income includes net tax revenues, where net taxes consist of tax rates on primary factors and commodities, domestic tax rates on firms, tariff rates, subsidy rates on output and subsidy rates on exports. The public sector also enters the model as a purchaser of a Leontief bundle of goods and services, the most relevant in quantitative terms being those included in the sector Government services (i.e., public administration, defence, education, health).

Foreign sector

The model represents the world divided in seven regions, so there is trade balance at a global level, although trade imbalances are allowed at a national or regional level. These aggregate trade balances are endogenous, and sectoral exports and imports are also allowed to change endogenously.

We assume that goods are differentiated according to their origin (i.e., domestic or foreign), following Armington's assumption (Armington, 1969), which allows for the possibility of intra-industry trade. Consumers (both private and public) perceive domestic and imported goods as differentiated.

Factor markets

The representative private household owns fixed endowments of natural resources (i.e., agricultural land and other natural resources), capital and labour, which are internationally immobile. The natural resources' and capital rents adjust to clear domestic markets. Natural resources are sector-specific. The fixed endowment of labour should be interpreted as a maximum supply of labour since unemployment is assumed to be endogenous; hence, labour supply would be elastic up to the endowment constraint. Labour employment (i.e., the labour endowment minus unemployment) is elastic up to the fixed amount of labour.

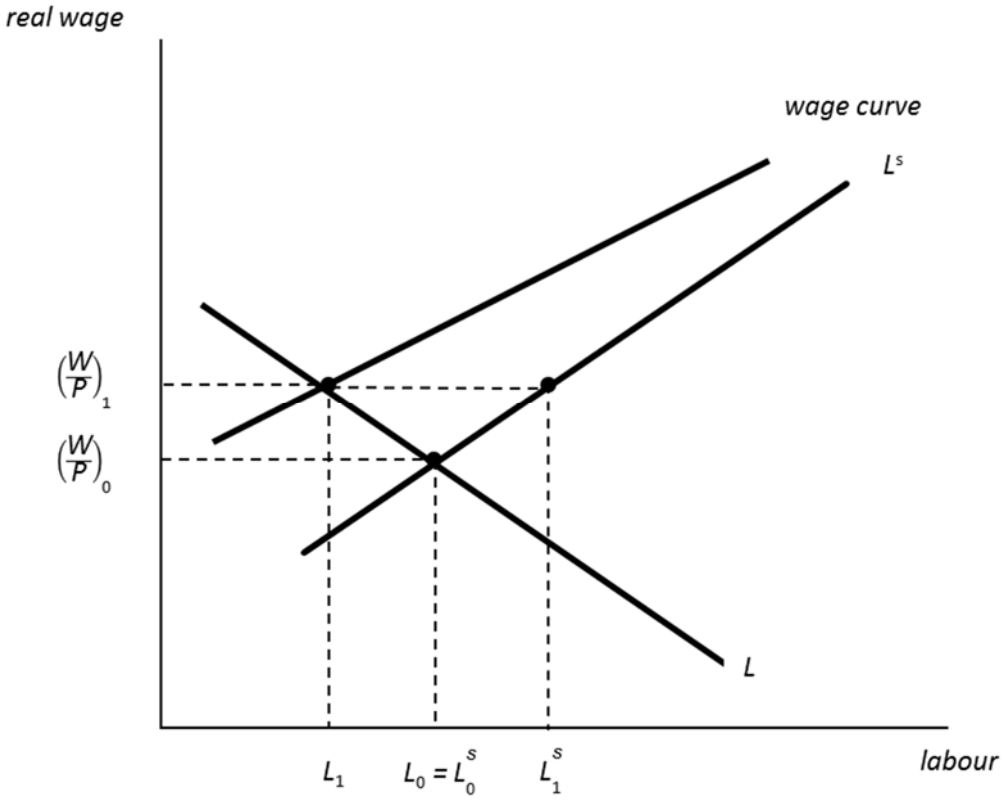
The unemployment rate is determined through a wage equation, which postulates a negative relationship between the real wage rate and the rate of unemployment:

$$\frac{W}{P} = \left(\frac{u}{u0}\right)^{\beta}$$

where W is the nominal wage, P is the consumer price index, u is the unemployment rate, $u0$ is the unemployment rate in the benchmark (see below), and $\beta < 0$. Notice that, as long as $\beta \to 0$, the wage equation approaches a downward-rigid real wage. Such a wage equation (Blanchflower and Oswald, 1990, 1994) has been extensively used in CGE models; see, e.g., Rutherford, Light and Hernández (2002).

Figure 1 illustrates the wage curve in a traditional labour market diagram, where the real wage rate is measured in the vertical axis and the amount of labour in the horizontal axis. Full employment occurs with a real wage rate $(W/P)_0$ at the intersection of the labour demand function L and the formal labour supply function L^s. If we replace the labour supply curve with the real wage curve shown above, the equilibrium wage rate $(W/P)_1$ lies above the market-clearing wage rate, which leads to unemployment equal to $L_1^s - L_1$.

Figure 1. The labour market



Macroeconomic closure

Total investment is split into sectoral gross capital formation using a fixed-coefficients Leontief structure (Dervis, de Melo and Robinson, 1981). Notice that, in our static framework, total gross capital formation affects the economy as an exogenous component of final demand. The model embodies a macroeconomic closure equation stating that investment and savings (private, public, and foreign) are equal.

Finally, the model is solved as explained in Rutherford (1999), with the general equilibrium model defined as a mixed complementarity problem (see Mathiesen, 1985). The software used in the empirical application is GAMS/MPSGE.

3. Calibration and data

The model has been calibrated using the GTAP 9 Data Base (Narayanan et al., 2015) with data for 2011. Most of the data for the public sector have been taken from GTAP (i.e., regional public savings have been estimated as the difference between tax revenue and public expenditure).

The calibration method is based on a benchmark equilibrium corresponding to the National Accounts and a set of exogenous parameters; a detailed explanation of the calibration method can be found in Dawkins, Srinivasan and Whalley (2001). The benchmark values for the elasticities appearing in the different equations of the model, shown in Table 2, are those of the GTAP 9 Data Base (Narayanan et al., 2015). The elasticity β (i.e., the elasticity of the real wage with respect to the unemployment rate) has been fixed as -0.1, a standard value from the wage curve literature (e.g., Blanchflower and Oswald, 1995).

Table 2. Elasticities of substitution

	Factors	Domestic production-imports	Intra-imports
Agricultural products	0.255	2.499	4.866
Chemical industry	1.260	3.300	6.600
Motor vehicles	1.260	2.800	5.600
Other transport equipment	1.260	4.300	8.600
Machinery and equipment	1.260	4.050	8.100
Electronic equipment	1.260	4.400	8.800
Other industry	0.902	3.445	7.810
Construction	1.400	1.900	3.800
Trade	1.680	1.900	3.800
Transport and communications	1.535	1.900	3.800
Financial intermediation	1.260	1.900	3.800
Business services	1.260	1.900	3.800
Recreational services	1.260	1.900	3.800
Government services	1.260	1.900	3.800
Other services	1.260	2.552	4.478

Finally, the data utilised for some regional variables are presented in Table 3. Regional unemployment rates have been estimated using the labour force and the total unemployment for each country or region, with the data coming from World Bank (2015). In turn, the shares of public gross capital formation on total gross capital formation have been estimated with data from European Commission (2015) and United Nations (2014), together with the exchange rates taken from International Monetary Fund (2015) (at 30 December 2011). The figures for the EU, United States (US) and Japan have been taken from European Commission (2015), and those for the rest of the regions from United Nations (2014). Latin America has been proxied using data from Brazil (2009) and Mexico, the Republic of Korea is the proxy for Asia-Pacific, and Rest of the World has been estimated as the average of the other six regions.

Table 3. Regional variables

	Unemployment rate (%)	Public gross capital formation (% of total GCF)
European Union	9.581	0.151
United States	9.000	0.209
Japan	4.500	0.155
China	4.296	0.105
Latin America	6.708	0.121
Asia-Pacific	4.418	0.162
Rest of the World	4.924	0.150

4. Simulation results

Three different simulations, representative of the fiscal consolidation strategies followed by the EU governments, have been performed. In all three cases, the objective is getting a fall of one percentage point in the EU's government deficit to GDP ratio:

A) A decrease in public expenditure, holding all tax rates fixed.
B) An increase in ad valorem final consumption tax rates, holding public expenditure fixed.
C) An increase in ad valorem labour tax rates, holding public expenditure fixed.

Notice that the two taxes we have chosen are by far the most relevant in terms of receipts for the EU (Narayanan et al., 2015). Labour taxes include social security contributions.

The results of these simulations on the main macroeconomic variables are shown in Table 4 as percentage changes from benchmark, except for the unemployment rate, where changes are expressed as percentage points. Notice that, in this Walrasian framework, the numeraire used is the US consumer price index. In particular, we present the results of the simulations on the levels of GDP and employment, the unemployment rate, real wage rate, compensation of employees, gross operating surplus, as well as the levels of public expenditure and public revenue. When discussing the results, we will make a particular emphasis on the variables compensation of employees and gross operating surplus, which proxy the shares of labour and capital on total income, i.e., the functional distribution of income. The analysis of distributional issues is usually neglected in empirical assessments of austerity policies.

Starting with the results for the EU's economy, we can see that GDP falls in all scenarios. The negative effects on GDP range from −0.24% for the decrease in government expenditure, to −0.36% for the increase in consumption taxes, and −1.02% for the increase in labour taxes. Employment also falls, and the rate of unemployment rises, in all scenarios, corresponding again the worse results to the rise in labour taxes, followed by the rise in consumption taxes, being milder when cutting government spending. On the other hand, real wages fall in the first and third scenarios, unlike the second scenario, where they experience a small increase.

Some interesting distributive effects appear, too, detrimental to labour in all cases. The compensation of employees clearly falls in all scenarios due to the decrease in both real wages and employment, especially when labour taxes are risen. In turn, the gross operating surplus falls in the two scenarios of tax increases although much less than the compensation of employees; and rises slightly in the scenario of cuts in spending. As a result, income distribution clearly worsens for labour in all scenarios, especially in the case of an increase in labour taxes, followed by the case of a cut in government spending.

Notice, finally, that, in order to reduce the ratio government deficit/GDP in one percentage point, total government expenditure should fall by 4.54% when cutting government spending, at the same time that government revenues would be reduced by 0.14% due to the fall in the level of activity. On the other hand, in the scenarios of tax increases government expenditure would not change, and total government revenue should rise by 0.85% and 0.58% in the cases of increasing consumption taxes and labour taxes, respectively.

Table 4. Simulation results: Effect on macroeconomic variables (% change from benchmark)

A. Decrease in public expenditure

	European Union	United States	Japan	China	Latin America	Asia-Pacific	Rest of the World
GDP	−0.239	0.011	−0.007	−0.012	−0.020	−0.009	−0.018
Employment	−0.227	0.007	0.002	0.002	0.000	0.002	0.002
Unemployment rate (p.p.)	0.205	−0.007	−0.002	−0.002	0.000	−0.002	−0.002
Real wage rate	−0.317	0.006	−0.008	−0.013	−0.022	−0.013	−0.023
Compensation of employees	−0.543	0.013	−0.006	−0.011	−0.022	−0.011	−0.022
Gross operating surplus	0.044	0.006	−0.008	−0.011	−0.021	−0.005	−0.018
Public expenditure	−4.542	0.003	−0.010	−0.015	−0.023	−0.014	−0.027
Public revenue	−0.135	0.012	−0.010	−0.024	−0.021	−0.021	−0.034

B. Increase in ad valorem final consumption tax rates

	European Union	United States	Japan	China	Latin America	Asia-Pacific	Rest of the World
GDP	−0.361	0.003	0.023	0.017	−0.009	0.020	−0.015
Employment	−0.626	0.003	0.002	0.003	0.001	0.005	0.001
Unemployment rate (p.p.)	0.566	−0.003	−0.002	−0.003	−0.001	−0.005	−0.001
Real wage rate	0.076	0.002	0.022	0.018	−0.008	0.020	−0.013
Compensation of employees	−0.550	0.005	0.025	0.021	−0.008	0.024	−0.012
Gross operating surplus	−0.172	0.000	0.022	0.020	−0.008	0.023	−0.015
Public expenditure	0.000	0.001	0.020	0.015	−0.008	0.017	−0.013
Public revenue	0.854	0.002	0.018	0.038	−0.009	0.015	−0.007

C. Increase in ad valorem labour tax rates

	European Union	United States	Japan	China	Latin America	Asia-Pacific	Rest of the World
GDP	−1.022	0.003	0.027	0.022	−0.008	0.024	−0.012
Employment	−0.912	0.003	0.003	0.004	0.001	0.005	0.001
Unemployment rate (p.p.)	0.825	−0.003	−0.003	−0.004	−0.001	−0.005	−0.001
Real wage rate	−0.885	0.003	0.026	0.023	−0.007	0.023	−0.011
Compensation of employees	−1.788	0.006	0.029	0.026	−0.007	0.028	−0.010
Gross operating surplus	−0.264	0.000	0.026	0.024	−0.007	0.028	−0.011
Public expenditure	0.000	0.001	0.024	0.019	−0.008	0.020	−0.011
Public revenue	0.579	0.003	0.022	0.042	−0.008	0.018	−0.007

Regarding the effects on the other world regions, in the first scenario of a decrease in government expenditure GDP falls in all regions (with the only exception of the US), although the effects on employment and unemployment tend to be favourable; in all cases, however, the figures are very small. Notice that Government services is a non-traded sector, and that world regions are linked through trade. In any case, the contraction in the EU demand should be behind the negative output effect in the rest of the world, although the non-EU regions also experience some positive effects through the cheaper EU goods. Indeed, the lower demand in the EU decreases the price of EU's goods, generating a small substitution effect with respect to domestic goods in the rest of regions. On the other hand, in the two scenarios of tax increases GDP only falls in Latin America and Rest of the World, and the results on employment and unemployment are always positive, even though the effects are again quantitatively very small. Although the contraction in EU's demand is still present, now the higher indirect taxes (especially those on labour) make EU's goods relatively more expensive, so the substitution effect works in the opposite sense. Finally, the results for both the distributive variables and public expenditures and revenues, in all three scenarios, are mostly negligible, with very small changes that roughly cancel out.

Next, we present in Table 5 the percentage changes in employment across sectors, following from the above three scenarios; the results for other variables are available from the authors upon request. The last row of every part of the table shows, for the sake of comparison, the overall change in employment, as it appears in the second row of each part of Table 4.

Table 5. Simulation results: effects on sectoral employment (% change from benchmark)

A. Decrease in public expenditure

	European Union	United States	Japan	China	Latin America	Asia-Pacific	Rest of the World
Agricultural products	0.491	−0.009	−0.005	−0.003	0.022	−0.002	0.017
Chemical industry	0.579	−0.105	−0.052	−0.025	−0.025	−0.061	−0.071
Motor vehicles	1.288	−0.008	−0.037	−0.048	0.007	−0.027	0.022
Other transport equipment	1.554	0.070	0.003	−0.020	0.041	0.084	0.039
Machinery and equipment	2.181	0.005	0.007	0.016	−0.006	0.026	0.078
Electronic equipment	2.230	0.071	0.063	0.255	0.070	0.221	0.099
Other industry	0.846	−0.018	−0.011	−0.005	0.006	−0.013	0.017
Construction	4.370	0.096	0.028	−0.033	−0.012	−0.023	−0.035
Trade	0.296	0.016	0.000	−0.006	0.001	0.005	0.004
Transport and communications	0.376	−0.008	0.007	0.001	−0.004	0.012	−0.001
Financial intermediation	0.422	0.003	−0.003	0.010	−0.001	−0.002	−0.002
Business services	1.097	0.010	0.001	−0.003	0.002	0.002	0.007
Recreational services	0.012	0.004	0.002	0.000	−0.006	−0.014	−0.013
Government services	−3.376	−0.003	0.000	0.001	−0.002	−0.013	−0.004
Other services	0.241	0.006	0.004	0.007	0.004	0.012	0.010
Total	**−0.227**	**0.007**	**0.002**	**0.002**	**0.000**	**0.002**	**0.002**

Table 5 (continued)

B. Increase in ad valorem final consumption tax rates

	European Union	United States	Japan	China	Latin America	Asia-Pacific	Rest of the World
Agricultural products	−0.176	−0.025	−0.024	−0.023	−0.018	−0.024	−0.011
Chemical industry	−0.289	−0.048	−0.051	−0.025	−0.007	−0.063	−0.032
Motor vehicles	0.375	0.008	−0.025	−0.005	0.030	−0.003	0.057
Other transport equipment	0.789	0.229	0.089	0.053	0.177	0.224	0.209
Machinery and equipment	1.365	0.112	0.078	0.075	0.093	0.126	0.248
Electronic equipment	1.214	0.114	0.063	0.221	0.104	0.198	0.179
Other industry	−0.223	−0.015	−0.024	−0.027	−0.003	−0.041	−0.010
Construction	3.805	0.004	0.025	0.007	0.005	0.039	0.011
Trade	−0.410	0.005	0.000	−0.001	0.001	0.010	0.000
Transport and communications	−0.466	−0.017	−0.006	−0.005	−0.011	−0.030	−0.018
Financial intermediation	−0.439	−0.009	−0.005	0.004	−0.003	−0.014	−0.011
Business services	0.382	0.004	−0.001	0.004	0.004	−0.004	0.015
Recreational services	−0.916	−0.007	0.001	−0.004	−0.013	−0.026	−0.028
Government services	−2.773	−0.004	0.000	0.000	−0.003	−0.004	−0.011
Other services	−1.137	−0.008	0.002	−0.001	−0.009	−0.005	−0.026
Total	**−0.626**	**0.003**	**0.002**	**0.003**	**0.001**	**0.005**	**0.001**

C. Increase in ad valorem labour tax rates

	European Union	United States	Japan	China	Latin America	Asia-Pacific	Rest of the World
Agricultural products	−0.240	−0.031	−0.027	−0.025	−0.031	−0.027	−0.017
Chemical industry	−0.344	−0.054	−0.059	−0.030	−0.011	−0.072	−0.048
Motor vehicles	0.398	0.014	−0.020	−0.005	0.038	0.004	0.068
Other transport equipment	0.799	0.261	0.102	0.059	0.199	0.254	0.230
Machinery and equipment	1.488	0.134	0.094	0.086	0.107	0.150	0.278
Electronic equipment	1.354	0.135	0.075	0.252	0.117	0.231	0.196
Other industry	−0.114	−0.009	−0.023	−0.024	0.007	−0.036	0.001
Construction	4.132	0.004	0.028	0.008	0.006	0.043	0.013
Trade	−0.945	0.004	−0.004	−0.015	0.000	0.004	−0.003
Transport and communications	−0.704	−0.024	−0.007	−0.007	−0.016	−0.038	−0.027
Financial intermediation	−0.636	−0.012	−0.006	0.004	−0.003	−0.018	−0.013
Business services	0.244	0.001	−0.002	0.001	0.002	−0.015	0.008
Recreational services	−1.092	−0.008	0.001	−0.005	−0.015	−0.033	−0.034
Government services	−3.541	−0.006	0.000	0.002	−0.003	−0.005	−0.010
Other services	−1.264	−0.007	0.002	0.001	−0.007	−0.001	−0.020
Total	**−0.912**	**0.003**	**0.003**	**0.004**	**0.001**	**0.005**	**0.001**

Focusing on the results for the EU, in the first scenario of a decrease in government expenditure employment falls markedly in the Government services sector. However, employment rises in the rest of sectors due to the fall in the wage rate; additionally, since the model assumes full capital employment, the capital expelled out from the Government services sector must be employed in other sectors. The overall effect on employment is negative, though. On the other hand, when raising consumption taxes in the second scenario, the prices of all final goods increase. For that reason, those sectors more involved in the production of intermediate inputs are less affected in terms of lower employment; some examples are the positive changes in employment found in Construction, Machinery and equipment, or Electronic equipment. In turn, in the third scenario of an increase in labour taxes, those sectors more burdened with labour taxes attract more capital for substitution purposes. Due to the technological requirements of the model, the sectors losing capital are those that are also losing workers, as is the case of Government services, Other services, or Recreational services. Finally, the effects on sectoral employment in the other world regions are asymmetric across sectors and mostly negligible.

To conclude, we present a sensitivity analysis of the previous results. The new results are shown in Table 6 for six macroeconomic variables in the case of the EU, namely, GDP, employment, compensation of employees, gross operating surplus, and total public expenditure and revenue; as well as for GDP in the case of the other six regions. Specifically, we perform a change in the different elasticities appearing in the model, which are alternatively halved and doubled. The full sensitivity analysis for all variables is available from the authors upon request.

All results are robust in sign, except in two cases for the gross operating surplus in the EU, in the scenario of reducing government spending (recall that the change in this variable was close to zero in the benchmark equilibrium). Since Government services is the least capital intensive sector, when the elasticity of substitution between labour and capital increases, labour becomes cheaper in the latter simulation, so if capital can be more easily substituted for labour, then capital worsens. On the other hand, the elasticities of substitution related to trade (i.e., σ_i^d and σ_i^m) are those more influencing the results, which should be expected since the transmission channel of any shock from the EU to the rest of the world is through international trade. Finally, variations in the degree of flexibility of the real wage to the unemployment rate, β, lead to changes in some variables for the EU. So, for instance, in the first two scenarios the decrease in labour demand under more rigid wages (i.e., a higher β) reduces the fall in the compensation of employees with respect to the gross operating surplus, given that the sector Government services is labour intensive. This is not the case of the third scenario, where the increase in labour taxes compensates that effect.

Table 6. Sensitivity analysis: Effect on macroeconomic variables (% change from benchmark)

A. Decrease in public expenditure

	European Union						United States	Japan	China	Latin America	Asia-Pacific	Rest of the World
	GDP	Employment	Compensation of employees	Gross operating surplus	Public expenditure	Public revenue	GDP					
Simulation	−0.239	−0.227	−0.543	0.044	−4.542	−0.135	0.011	−0.008	−0.012	−0.020	−0.009	−0.018
σ_i^{VA}=[0.26-1.68]												
σ'^{VA}_i=0.5*σ_i^{VA}	−0.273	−0.328	−0.724	0.146	−4.565	−0.235	0.010	−0.008	−0.012	−0.019	−0.010	−0.018
σ'^{VA}_i=2*σ_i^{VA}	−0.213	−0.147	−0.400	−0.038	−4.523	−0.056	0.011	−0.006	−0.012	−0.019	−0.008	−0.018
σ_i^{d}=[1.90-4.40]												
σ'^{d}_i=0.5*σ_i^{d}	−0.258	−0.230	−0.563	0.027	−4.557	−0.152	0.012	−0.013	−0.013	−0.025	−0.013	−0.018
σ'^{d}_i=2*σ_i^{d}	−0.212	−0.222	−0.514	0.069	−4.520	−0.111	0.009	−0.001	−0.009	−0.014	−0.003	−0.017
σ_i^{m}=[3.80-8.80]												
σ'^{m}_i=0.5*σ_i^{m}	−0.383	−0.253	−0.701	−0.087	−4.659	−0.270	0.019	0.000	−0.021	−0.030	−0.005	−0.038
σ'^{m}_i=2*σ_i^{m}	−0.160	−0.211	−0.454	0.116	−4.477	−0.059	0.005	−0.008	−0.007	−0.012	−0.008	−0.008
β=−0.1												
β'=0.5*β	−0.292	−0.344	−0.604	0.001	−4.517	−0.195	0.013	−0.004	−0.009	−0.019	−0.006	−0.018
β'=2*β	−0.198	−0.134	−0.496	0.078	−4.561	−0.088	0.009	−0.010	−0.014	−0.021	−0.011	−0.018

Table 6 (continued)

B. Increase in ad valorem final consumption tax rates

	European Union						United States	Japan	China	Latin America	Asia-Pacific	Rest of the World
	GDP	Employment	Compensation of employees	Gross operating surplus	Public expenditure	Public revenue	GDP					
Simulation	−0.361	−0.626	−0.550	−0.172	0.000	0.854	0.003	0.023	0.017	−0.009	0.020	−0.015
σ_i^{VA}=[0.26-1.68]												
σ'^{VA}_i=0.5*σ_i^{VA}	−0.335	−0.545	−0.449	−0.221	0.005	0.852	0.004	0.023	0.018	−0.008	0.021	−0.013
σ'^{VA}_i=2*σ_i^{VA}	−0.391	−0.716	−0.663	−0.120	0.003	0.856	0.002	0.023	0.016	−0.010	0.019	−0.016
σ_i^{d}=[1.90-4.40]												
σ'^{d}_i=0.5*σ_i^{d}	−0.372	−0.639	−0.556	−0.186	0.004	0.882	0.004	0.025	0.018	−0.013	0.019	−0.019
σ'^{d}_i=2*σ_i^{d}	−0.345	−0.607	−0.542	−0.149	0.003	0.813	0.003	0.019	0.015	−0.005	0.019	−0.010
σ_i^{m}=[3.80-8.80]												
σ'^{m}_i=0.5*σ_i^{m}	−0.398	−0.671	−0.575	−0.217	0.004	0.933	0.004	0.041	0.029	−0.014	0.038	−0.027
σ'^{m}_i=2*σ_i^{m}	−0.323	−0.579	−0.525	−0.123	0.003	0.770	0.002	0.012	0.010	−0.005	0.010	−0.007
β=−0.1												
β′=0.5*β	−0.444	−0.776	−0.686	−0.204	0.005	0.432	0.004	0.025	0.020	−0.007	0.022	−0.011
β′=2*β	−0.265	−0.451	−0.391	−0.135	0.003	1.351	0.003	0.022	0.015	−0.012	0.018	−0.019

Table 6 (continued)

C. Increase in ad valorem labour tax rates

	European Union						United States	Japan	China	Latin America	Asia-Pacific	Rest of the World
	GDP	Employment	Compensation of employees	Gross operating surplus	Public expenditure	Public revenue	GDP					
Simulation	−1.022	−0.912	−1.788	−0.264	0.000	0.579	0.003	0.027	0.022	−0.008	0.024	−0.012
σ_i^{VA}=[0.26-1.68]												
σ'^{VA}_i=0.5*σ_i^{VA}	−0.939	−0.775	−1.550	−0.336	0.005	0.613	0.004	0.027	0.023	−0.007	0.025	−0.010
σ'^{VA}_i=2*σ_i^{VA}	−1.122	−1.079	−2.066	−0.188	0.003	0.542	0.002	0.027	0.021	−0.010	0.022	−0.014
σ_i^{d}=[1.90-4.40]												
σ'^{d}_i=0.5*σ_i^{d}	−1.048	−0.930	−1.826	−0.279	0.004	0.593	0.004	0.030	0.024	−0.012	0.023	−0.015
σ'^{d}_i=2*σ_i^{d}	−0.981	−0.883	−1.730	−0.241	0.003	0.559	0.003	0.023	0.019	−0.005	0.023	−0.008
σ_i^{m}=[3.80-8.80]												
σ'^{m}_i=0.5*σ_i^{m}	−1.151	−1.001	−1.971	−0.338	0.004	0.639	0.004	0.047	0.037	−0.014	0.044	−0.021
σ'^{m}_i=2*σ_i^{m}	−0.894	−0.824	−1.608	−0.192	0.003	0.520	0.003	0.015	0.012	−0.005	0.012	−0.006
β=−0.1												
β′=0.5*β	−0.914	−1.033	−1.556	−0.281	0.005	0.146	0.004	0.028	0.024	−0.006	0.025	−0.008
β′=2*β	−1.180	−0.739	−2.127	−0.242	0.003	1.206	0.003	0.026	0.019	−0.012	0.022	−0.016

5. Conclusions

Following the current financial crisis, the EU authorities have endorsed the implementation of fiscal consolidation strategies, known as austerity policies, addressed to cope with the high government deficits that appeared in last years. In this paper, we have simulated the effects of three alternative austerity policies, through a decrease in the level of public spending, an increase in consumption taxes, and an increase in labour taxes; and examined their effects on the main macroeconomic variables of seven regions of the world economy, i.e., the EU, the US, Japan, China, Asia-Pacific, Latin America and Rest of the World. The objective of the three simulations was getting a fall of one percentage point in the EU's government deficit to GDP ratio. The empirical methodology made use of a CGE model, through an extension of the GTAP model.

We found that the GDP of the EU fell in all the simulated scenarios, with the negative effects ranging from −0.24% for the decrease in government expenditure, to −0.36% for the increase in consumption taxes, and −1.02% for the increase in labour taxes. In addition, employment also fell and the rate of unemployment rose, which came in all cases together with a change in income distribution that was detrimental to labour. That is, contrarily to the predictions of the "non-Keynesian" effects of fiscal policy, all these three policy measures would lead to contractionary effects on the EU's levels of activity. These contractionary effects, in turn, would be stronger in the case of raising labour taxes and, to a much lower extent, raising consumption taxes, and weaker in the case of government spending cuts. In addition, the economic contraction would be accompanied with a worsening of income distribution for labour, an aspect usually neglected in empirical assessments of austerity policies.

The decline of the labour share of income is a recurrent feature of the evolution of both advanced and emergent economies since the early 1980s. From a longer term point of view, this fact reflects the decrease in the bargaining power of labour, which is related to the lower mobility of labour compared to capital (Rodrik, 2018). On the one hand, firms can threaten workers with leaving the country or outsourcing certain tasks if they do not accept lower wages. On the other hand, it is increasingly difficult for governments taxing such more and more mobile capital, so they end up reducing corporate tax rates and taxing what is less mobile, mainly labour and consumption. Our results show how, in the short run, the lower levels of wages and employment associated with austerity policies lead also to a fall in the labour share.

Regarding the effects on the other world regions, the contraction in EU's demand was transmitted to most regions with the same sign in the first scenario of a decrease in government expenditure, which was not the case in the other two scenarios of an increase in either consumption or labour taxes; in all cases, however, the effects were quantitatively very small. This result, on the other hand, should not be too surprising. In a recent paper, Latorre, Olekseyuk and Yonezawa (2017) analyse, in terms of the GTAP model, the impact of the withdrawal of the United Kingdom (UK) from the EU (i.e., the so called Brexit). The authors conclude that, while the effects for the EU and, especially, the UK, were significant, the rest of the world remained nearly unaffected. This also can be related to the extent of the home bias in international trade, i.e., the term used to define the preference that domestic consumers have for domestic, rather

than foreign, goods. As stressed by Obstfeld and Rogoff (2000, pp. 341-342), there is "growing evidence that international goods markets appear to be far more segmented than is commonly supposed". They explain this fact (the first of their "six major puzzles in international macroeconomics") in terms of the existence of trade costs, in a broad sense, which include not only transport costs, but also tariffs, non-tariff barriers, exchange rate risk, and the like.

Some caveats to the conclusions of the paper are in order. First, recall that the results from a CGE model apply just to the short run. In any case, it is important to stress how austerity policies are associated with a fall in the level of activity in the short run for the economy where they are implemented (the EU, in our case), which might jeopardise future increases in government revenues. On the other hand, the Walrasian framework underlying the GTAP model includes real aspects and sectoral interrelations, but does not incorporate international financial constraints. It should also be noticed that, although the scenario of a cut in government spending led to the smallest contractionary effect in our simulations, government expenditure in GTAP is just government consumption, since government investment is added up to private investment. However, austerity policies in the EU have frequently consisted of cuts in government investment. Even more, government consumption includes items such as education or health care, which, together with government investment, are potentially growth-enhancing (European Commission, 2012). Finally, the distributive effects found in this paper might also have relevant implications for future macroeconomic prospects, in terms of social cohesion and the recovery of the levels of activity (Paulus, Figari and Sutherland, 2017).

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Appendix I

A.1. Regional aggregation

The correspondence with the GTAP9 Data Base (Narayanan et al., 2015) is:

European Union (EU)

AUT	!	Austria
BEL	!	Belgium
DNK	!	Denmark
FIN	!	Finland
FRA	!	France
DEU	!	Germany
ITA	!	Italy
GBR	!	United Kingdom
GRC	!	Greece
IRL	!	Ireland
LUX	!	Luxembourg
NLD	!	Netherlands
PRT	!	Portugal
ESP	!	Spain
SWE	!	Sweden
CZE	!	Czech Republic
HUN	!	Hungary
MLT	!	Malta
POL	!	Poland
ROU	!	Romania
SVK	!	Slovakia
SVN	!	Slovenia
EST	!	Estonia
LVA	!	Latvia
LTU	!	Lithuania
BGR	!	Bulgaria
CYP	!	Cyprus
HRV	!	Croatia

United States (USA)

Japan (JPN)

China (CHI)

CHN	!	China
HKG	!	Hong Kong

Latin America (LAT)

MEX	!	Mexico
BRA	!	Brazil
ARG	!	Argentina
BOL	!	Bolivia
CHL	!	Chile
COL	!	Colombia
ECU	!	Ecuador
PRY	!	Paraguay

PER	!	Peru
URY	!	Uruguay
VEN	!	Venezuela
XSM	!	Rest of South America
CRI	!	Costa Rica
GTM	!	Guatemala
NIC	!	Nicaragua
PAN	!	Panama
HND	!	Honduras
SLV	!	El Salvador
XCA	!	Rest of Central America
DOM	!	Dominican Republic
JAM	!	Jamaica
PRI	!	Puerto Rico
TTO	!	Trinidad and Tobago
XCB	!	Caribbean

Asia-Pacific (PAC)

KHM	!	Cambodia
LAO	!	Lao People's Democratic Republic
MYS	!	Malaysia
TWN	!	Taiwan
PHL	!	Philippines
SGP	!	Singapore
THA	!	Thailand
VNM	!	Vietnam
XSE	!	Rest of Southeast Asia
KOR	!	Korea
IDN	!	Indonesia
BRN	!	Brunei Darussalam

Rest of the World (ROW)

IND	!	India
BGD	!	Bangladesh
XSA	!	Rest of South Asia
XEA	!	Rest of East Asia
PAK	!	Pakistan
LKA	!	Sri Lanka
NPL	!	Nepal
MNG	!	Mongolia
KGZ	!	Kyrgyzstan
XWF	!	Rest of Western Africa
XCF	!	Rest of Central Africa
XAC	!	Rest of South Central Africa
ETH	!	Ethiopia
KEN	!	Kenya
MDG	!	Madagascar
MWI	!	Malawi
MOZ	!	Mozambique
TZA	!	Tanzania
RWA	!	Rwanda

UGA	!	Uganda
ZMB	!	Zambia
ZWE	!	Zimbabwe
XEC	!	Rest of Eastern Africa
EGY	!	Egypt
MAR	!	Morocco
TUN	!	Tunisia
XNF	!	Rest of North Africa
BEN	!	Benin
BFA	!	Burkina Faso
CMR	!	Cameroon
CIV	!	Cote d'Ivoire
GHA	!	Ghana
GIN	!	Guinea
NGA	!	Nigeria
SEN	!	Senegal
TGO	!	Togo
MUS	!	Mauritius
BWA	!	Botswana
ZAF	!	South Africa
NAM	!	Namibia
XSC	!	Rest of South African Customs Union
AUS	!	Australia
NZL	!	New Zealand
XOC	!	Rest of Oceania
CAN	!	Canada
XNA	!	Rest of North America
ALB	!	Albania
RUS	!	Russia
BLR	!	Belarus
UKR	!	Ukraine
XEE	!	Rest of Eastern Europe
KAZ	!	Kazakhstan
XSU	!	Rest of Former Soviet Union
ARM	!	Armenia
AZE	!	Azerbaijan
GEO	!	Georgia
CHE	!	Switzerland
NOR	!	Norway
XEF	!	Rest of EFTA
XER	!	Rest of Europe
IRN	!	Iran, Islamic Republic of
BHR	!	Bahrain
ISR	!	Israel
JOR	!	Jordan
KWT	!	Kuwait
OMN	!	Oman
QAT	!	Qatar

SAU ! Saudi Arabia
ARE ! United Arab Emirates
TUR ! Turkey
XWS ! Rest of Western Asia

XTW ! Rest of the World

A.2. Sectoral aggregation

The correspondence of sectors included in Table 1 with the GTAP9 Data Base sector listing (Narayanan et al., 2015) is:

Sector	Code	Description
AGR	**PDR**	Paddy rice
AGR	**WHT**	Wheat
AGR	**GRO**	Cereal grains nec
AGR	**V_F**	Vegetables, fruit, nuts
AGR	**OSD**	Oil seeds
AGR	**C_B**	Sugar cane, sugar beet
AGR	**PFB**	Plant-based fibres
AGR	**OCR**	Crops nec
AGR	**CTL**	Bovine cattle, sheep and goats, horses
AGR	**OAP**	Animal products nec
AGR	**RMK**	Raw milk
AGR	**WOL**	Wool, silk-worm cocoons
AGR	**FRS**	Forestry
AGR	**FSH**	Fishing
IND	**COA**	Coal
IND	**OIL**	Oil
IND	**GAS**	Gas
IND	**OMN**	Minerals nec
IND	**CMT**	Bovine meat products
IND	**OMT**	Meat products nec
IND	**VOL**	Vegetable oils and fats
IND	**MIL**	Dairy products
IND	**PCR**	Processed rice
IND	**SGR**	Sugar
IND	**OFD**	Food products nec
IND	**B_T**	Beverages and tobacco products
IND	**TEX**	Textiles
IND	**WAP**	Wearing apparel
IND	**LEA**	Leather products
IND	**LUM**	Wood products
IND	**PPP**	Paper products, publishing

IND	**P_C**	Petroleum, coal products
CRP	**CRP**	Chemical, rubber, plastic products
IND	**NMM**	Mineral products nec
IND	**I_S**	Ferrous metals
IND	**NFM**	Metals nec
IND	**FMP**	Metal products
MVH	**MVH**	Motor vehicles and parts
OTN	**OTN**	Transport equipment nec
ELE	**ELE**	Electronic equipment
OME	**OME**	Machinery and equipment nec
IND	**OMF**	Manufactures nec
SER	**ELY**	Electricity
SER	**GDT**	Gas manufacture, distribution
SER	**WTR**	Water
CNS	**CNS**	Construction
TRD	**TRD**	Trade
TCM	**OTP**	Transport nec
TCM	**WTP**	Water transport
TCM	**ATP**	Air transport
TCM	**CMN**	Communication
OFI	**OFI**	Financial services nec
SER	**ISR**	Insurance
OBS	**OBS**	Business services nec
ROS	**ROS**	Recreational and other services
OSG	**OSG**	Public Administration, Defence, Education, Health
SER	**DWE**	Dwellings

Appendix II

As a general rule, the notation in the model is as follows: endogenous variables are denoted by capital letters, exogenous variables by capital letters with a bar, and parameters by small Latin and Greek letters. There are 15 (*i,j* = 1,...,15) production sectors and each sector produces one good. The world economy is divided into 7 countries and regions (*r,s* = 1,…,7). In each country, the public and the private sectors have been detached. There are 3 production factors (*pf* = labour, capital and specific; *F*=labour, capital; *S*=specific). All endogenous variables, and the exogenous variables and parameters, are listed in Tables A.1 and A.2 below. The description of the model is as follows.

Production

Technology presents constant returns to scale and firms apply a competitive pricing rule. The nested production function of good *i* in country *r* is:

$$Y_{ir} = min\left(II_r^i, VA_r^i\right)$$

where:

$$VA_r^i = \left(\sum_f \theta_{ir}^f \left(Q_{ir}^{pf}\right)^{1-\sigma_i^{VA}}\right)^{\frac{1}{1-\sigma_i^{VA}}}$$

$$II_r^i = min(II_{i1r}, \dots, II_{i15r})$$

$$II_{ijr} = \left(\theta_{ijr}^d \left(II_{ijr}^Y\right)^{1-\sigma_i^d} + \left(1-\theta_{ijr}^d\right)\left(II_{ijr}^m\right)^{1-\sigma_i^d}\right)^{\frac{1}{1-\sigma_i^d}}$$

Since the top nest is a Leontief function, the zero-profit condition for sector *i* in country *r* is:

$$PROFIT_{ir}^Y = P_{ir}^Y\left(1-t_{ir}^O\right) - \theta_f P_{ir}^f - \sum_{j=1}^{15}\theta_j P_{jr}^i = 0$$

where, according to the nested structure, the unit cost of the value added composite produced by sector *i* in country *r* is a CES function:

$$P_{ir}^f = \left(\sum_f \theta_{ir}^f \left(P_{ir}^{pf}\right)^{1-\sigma_i^{VA}}\right)^{\frac{1}{1-\sigma_i^{VA}}}$$

$$P_{ir}^{pf} = \begin{cases} P_r^F\left(1+t_{ir}^F\right) \\ P_r^S\left(1+t_{ir}^S\right) \end{cases}$$

where *F* represents labour and capital, and *S* is the natural resources and agricultural land' specific factor (used in sectors *AGR* and *IND*).

The intermediate input price in $PROFIT_{ir}^Y$ is an aggregate of national and imported intermediate input prices:

$$P_{jr}^i = \left(\theta_{ijr}^d\left(1+t_{ijr}^{fd}\right)^{1-\sigma_i^d}\left(P_{jr}^Y\right)^{1-\sigma_i^d} + \left(1-\theta_{ijr}^d\right)\left(1+t_{ijr}^{fm}\right)^{1-\sigma_i^d}\left(P_{jr}^m\right)^{1-\sigma_i^d}\right)^{\frac{1}{1-\sigma_i^d}}$$

These zero-profit conditions are used to derive the demand functions, by applying Shephard's lemma on cost functions.

Next, we introduce the corresponding market clearing equations, with demands in the left-hand side and supplies in the right-hand side. The factor demands Q_{ir}^{pf} for capital, labour and the specific factor are represented in the left-hand side and they are, respectively:

$$\sum_{i=1}^{15}\left(Y_{ir}\left(\frac{\partial PROFIT_{ir}^{Y}}{\partial P_r^{labour}}\right)\right) = \overline{EVOM_r^{labour}}(1-U_r)$$

$$\sum_{i=AGRI,IND}\left(Y_{ir}\left(\frac{\partial PROFIT_{ir}^{Y}}{\partial P_r^{S}}\right)\right) = \overline{EVOM_r^{S}}$$

The market equilibrium conditions for domestic and imported intermediate inputs are:

$$Y_{ir}\left(\frac{\partial PROFIT_{ir}^{Y}}{\partial P_{jr}^{Y}}\right) = II_{ijr}^{Y}$$

$$Y_{ir}\left(\frac{\partial PROFIT_{ir}^{Y}}{\partial P_{jr}^{m}}\right) = II_{ijr}^{m}$$

Finally, the goods market equilibrium conditions are:

$$C_{ir}^{C} + G_{ir}^{G} + I_{ir}^{I} + \sum_{j=1}^{15} II_{ijr}^{Y} + \sum_{s=1}^{7} EXP_{irs} - IMP_{ir} = Y_{ir}$$

where:

$$C_{ir}^{C} = C_{ir}^{Cd} + C_{ir}^{Cm}$$

$$G_{ir}^{G} = G_{ir}^{Gd} + G_{ir}^{Gm}$$

$$I_{ir}^{I} = I_{ir}^{Id} + I_{ir}^{Im}$$

$$IMP_{ir} = C_{ir}^{Cm} + G_{ir}^{Gm} + I_{ir}^{Im} + \sum_{j=1}^{15} II_{ijr}^{m}$$

Consumption

The final demand functions are derived from the maximization of the representative consumer's nested welfare function (or the equivalent dual problem, the minimization of the expenditure function $PC_r C_r^{priv}$). The welfare functions are:

$$C_r^{priv} = \prod_{i=1}^{15}\left(C_{ir}^{C}\right)^{\theta_{ir}^{C}}$$

where:

$$C_{ir}^{C} = \left(\theta_{ir}^{C}\left(C_{ir}^{Cd}\right)^{1-\sigma_i^d} + \left(1-\theta_{ir}^{C}\right)\left(C_{ir}^{Cm}\right)^{1-\sigma_i^d}\right)^{\frac{1}{1-\sigma_i^d}}$$

subject to the budget constraints:

$$INCOME_r^{priv} = P_r^{labour}\left(\overline{EVOM_r^{labour}}\right)(1-U_r) + P_r^{capital}\left(\overline{EVOM_r^{capital}}\right) + P_r^{s}\left(\overline{EVOM_r^{S}}\right)$$

$$INCOME_r^{priv} = PRIVSAV_r + PC_r C_r^{priv}$$

where:

$$PRIVSAV_r = PI_r\overline{C_r^{privsav}}$$

$$PC_r C_r^{priv} = \sum_{i=1}^{15} P_{ir}^C \, C_{ir}^C$$

$$P_{ir}^C = \left(\theta_{ir}^C \left(1 + t_{ir}^{Cd}\right)^{1-\sigma_i^d} \left(P_{ir}^Y\right)^{1-\sigma_i^d} + \left(1 - \theta_{ir}^C\right)\left(1 + t_{ir}^{Cm}\right)^{1-\sigma_i^d} \left(P_{ir}^m\right)^{1-\sigma_i^d} \right)^{\frac{1}{1-\sigma_i^d}}$$

The solution to the dual optimization problem with the expenditure functions yields the demand functions for final private demand of domestic and imported goods, so the market equilibrium for these goods are:

$$C_r^{priv} \left(\frac{\partial PC_r C_r^{priv}}{\partial P_{ir}^Y} \right) = C_{ir}^{Cd}$$

$$C_r^{priv} \left(\frac{\partial PC_r C_r^{priv}}{\partial P_{ir}^m} \right) = C_{ir}^{Cm}$$

Public sector

Public consumption is represented through a Leontief nested function:

$$G_r^{pub} = min\left(G_{1r}^G, \ldots, G_{15r}^G\right)$$

where:

$$G_{ir}^G = \left(\theta_{ir}^{Gd} \left(G_{ir}^{Gd}\right)^{1-\sigma_i^d} + \left(1 - \theta_{ir}^{Gd}\right)\left(G_{ir}^{Gm}\right)^{1-\sigma_i^d} \right)^{\frac{1}{1-\sigma_i^d}}$$

subject to the budget constraints:

$$INCOME_r^{pub} - PG_r G_r^{pub} = PUBSAV_r$$

$$INCOME_r^{pub} = REV_r^O + REV_r^{fd} + REV_r^{fm} + REV_r^f + REV_r^{Cd} + REV_r^{Cm} + REV_r^{Gd} + REV_r^{Gm} + REV_r^{Id} + REV_r^{Im} + REV_r^{ms} - REV_r^{xs}$$

where the different revenues, denoted by *REV*, come from several taxes:

$$REV_r^O = \sum_{i=1}^{15} t_{ir}^O \, P_{ir}^Y Y_{ir}$$

$$REV_r^{fd} = \sum_{i=1}^{15} \sum_{j=1}^{15} t_{ijr}^{fd} \, P_{ir}^Y II_{ijr}^Y$$

$$REV_r^{fm} = \sum_{i=1}^{15} \sum_{j=1}^{15} t_{ijr}^{fm} \, P_{ijr}^m II_{ijr}^m$$

$$REV_r^f = \sum_{i=1}^{15} \left(t_{ir}^S P_r^S \left(\overline{EVOM_r^S}\right) + t_{ir}^{capital} P_r^{capital} \left(\overline{EVOM_r^{capital}}\right) + t_{ir}^{labour} P_r^{labour} \left(\overline{EVOM_r^{labour}}\right)(1 - U_r) \right)$$

$$REV_r^{Cd} = \sum_{i=1}^{15} t_{ir}^{Cd} \, P_{ir}^Y C_{ir}^{Cd}$$

$$REV_r^{Cm} = \sum_{i=1}^{15} t_{ir}^{Cm} \, P_{ir}^m C_{ir}^{Cm}$$

$$REV_r^{Gd} = \sum_{i=1}^{15} t_{ir}^{Gd}\, P_{ir}^{Y} G_{ir}^{Gd}$$

$$REV_r^{Gm} = \sum_{i=1}^{15} t_{ir}^{Gm}\, P_{ir}^{m} G_{ir}^{Gm}$$

$$REV_r^{Id} = \sum_{i=1}^{15} t_{ir}^{Id}\, P_{ir}^{Y} I_{ir}^{Id}$$

$$REV_r^{Im} = \sum_{i=1}^{15} t_{ir}^{Im}\, P_{ir}^{m} I_{ir}^{Im}$$

$$REV_r^{ms} = \sum_{i=1}^{15} \sum_{\substack{s=1 \\ s \neq r}}^{7} t_{isr}^{ms} \left(P_{is}^{Y}(1 - t_{isr}^{xs}) EXP_{isr} + \sum_{j=1}^{15} P_{jisr}^{t} TRN_{jisr} \right)$$

$$REV_r^{xs} = \sum_{i=1}^{15} \sum_{\substack{s=1 \\ s \neq r}}^{7} t_{irs}^{xs} P_{ir}^{Y} EXP_{irs}$$

and:

$$PG_r G_r^{pub} = \sum_{i=1}^{15} P_{ir}^{G}\, G_{ir}^{G}$$

$$P_{ir}^{G} = \left(\theta_{ir}^{Gd} \left(1 + t_{ir}^{Gd}\right)^{1-\sigma_i^d} \left(P_{ir}^{Y}\right)^{1-\sigma_i^d} + \left(1 - \theta_{ir}^{Gd}\right) \left(1 + t_{ir}^{Gm}\right)^{1-\sigma_i^d} \left(P_{ir}^{m}\right)^{1-\sigma_i^d} \right)^{\frac{1}{1-\sigma_i^d}}$$

$$PUBSAV_r = PI_r C_r^{pubsav}$$

The solution to the dual optimization problem with the expenditure functions yields the demand functions for final public demand of domestic and imported goods used in the next equation conditions:

$$G_r^{pub} \left(\frac{\partial PG_r G_r^{pub}}{\partial P_{ir}^{Y}} \right) = G_{ir}^{Gd}$$

$$G_r^{pub} \left(\frac{\partial PG_r G_r^{pub}}{\partial P_{ir}^{m}} \right) = G_{ir}^{Gm}$$

Investment and savings

The aggregate gross capital formation enters the model as an exogenous component of final demand. It can be interpreted in this static framework as a component of final demand representing future consumption:

$$\overline{I_r} = min\left(I_{1r}^{I}, \ldots, I_{15r}^{I}\right)$$

where:

$$I_{ir}^{I} = \left(\theta_{ir}^{Id} \left(I_{ir}^{Id}\right)^{1-\sigma_i^d} + \left(1 - \theta_{ir}^{Id}\right) \left(I_{ir}^{Im}\right)^{1-\sigma_i^d} \right)^{\frac{1}{1-\sigma_i^d}}$$

subject to:

$$PRIVSAV_r + PUBSAV_r + PC_{num} VB_r = PI_r \overline{I_r}$$

$$PI_r\overline{I_r} = \sum_{i=1}^{15} PI_{ir}\, I_{ir}^{I}$$

$$PI_{ir}^{I} = \left(\theta_{ir}^{Id}\left(1+t_{ir}^{Id}\right)^{1-\sigma_i^d}\left(P_{ir}^{Y}\right)^{1-\sigma_i^d} + \left(1-\theta_{ir}^{Id}\right)\left(1+t_{ir}^{Im}\right)^{1-\sigma_i^d}\left(P_{ir}^{m}\right)^{1-\sigma_i^d}\right)^{\frac{1}{1-\sigma_i^d}}$$

$$\sum_{r=1}^{7} PC_{num} VB_r = 0$$

The solution to the dual optimization problem yields the demand for gross domestic formation of domestic (I_{ir}^{Id}) and imported goods (I_{ir}^{Im}):

$$\overline{I_r}\left(\frac{\partial PI_r\overline{I_r}}{\partial P_{ir}^{Y}}\right) = I_{ir}^{Id}$$

$$\overline{I_r}\left(\frac{\partial PI_r\overline{I_r}}{\partial P_{ir}^{m}}\right) = I_{ir}^{Im}$$

Foreign sector

The choice among imports from several sources involves the maximization of the Armington aggregate subject to the foreign sector constraints (or the dual problem, i.e., minimization of the cost of the Armington aggregate). The Armington aggregate is:

$$IMP_{ir} = \left(\sum_{s} \theta_{isr}^{m}(EXPA_{isr})^{1-\sigma_i^m}\right)^{\frac{1}{1-\sigma_i^m}}$$

where:

$$EXPA_{isr} = min\left(EXP_{isr}, TRM_{jisr}\right) \qquad j = TRN$$

$$\sum_{i=1}^{15}\sum_{\substack{r=1\\ r\neq s}}^{7}\sum_{\substack{s=1\\ s\neq r}}^{7} TRM_{jisr} = \sum_{r=1}^{7} \theta_j^T Y_{jr}$$

The constraints related to the foreign sector in this open economy are:

$$\sum_{i=1}^{15}\sum_{\substack{s=1\\ s\neq r}}^{7} Pt_{isr}^{m}\, EXPA_{isr} + PC_{num} VB_r \;\; = \sum_{i=1}^{15} P_{ir}^{m}\, IMP_{ir}$$
$$r$$

where:

$$Pt_{isr}^{m} = \theta_{isr}^{m} P_{isr} + \sum_{j} \theta_j^T P_{jisr}^{t}$$

$$P_{isr} = P_{is}^{Y}(1-t_{isr}^{xs})(1+t_{isr}^{ms})$$

$$P_{jisr}^{t} = P_j^T(1+t_{isr}^{ms})$$

$$P_j^T = \prod_{r=1}^{7}\left(P_{jr}^{Y}\right)^{\theta_r^T}$$

$$P_{ir}^{m} = \left(\sum_{s} \theta_{isr}^{m}(P_{isr})^{1-\sigma_i^m}\right)^{\frac{1}{1-\sigma_i^m}}$$

Labour market constraint

The equilibrium in the labour market is given by the previously shown market clearing condition:

$$\sum_{i=1}^{15}\left(Y_{ir}\left(\frac{\partial PROFIT_{ir}^{Y}}{\partial P_{r}^{labour}}\right)\right)=\overline{EVOM_{r}^{labour}}(1-U_{r})$$

and the restriction related to unemployment:

$$\frac{P_{r}^{labour}}{PC_{r}}=\left(\frac{U_{r}}{\overline{U_{r}}}\right)^{\beta}$$

where β <0.

Simulations

In the main text, we perform three simulations in order to get a decrease of one percentage point in the government deficit to GDP ratio. These simulations involve some changes in the previous equations, which are as follows. Recall that, in each simulation, "country *r*" refers to the EU.

(1) Scenario of reduction in the size of the real public expenditure in country *r*, holding all tax rates constant. The parameter $\overline{ADJUST_{r}}$ is 1 at the benchmark and takes a positive but lower value in the simulation, so that the benchmark real public expenditure $\overline{G_{r}^{pub*}}$ falls. This reduction leads to an increase in public savings $PUBSAV_{r}$ since tax rates do not change, even though the public income $INCOME_{r}^{pub}$ can change endogenously:

$$INCOME_{r}^{pub}-PG_{r}\overline{G_{r}^{simul}}=PUBSAV_{r}$$

where:

$$\overline{G_{r}^{simul}}=\overline{ADJUST_{r}}\,\overline{G_{r}^{pub*}}$$

(2) Scenario of increase in consumption taxes in country *r*, holding public expenditure constant. The parameter $\overline{ADJUST_{r}}$ is 1 at the benchmark and takes a value above 1 in the simulation, so that the benchmark ad valorem consumption taxes rise. This increase leads to an increase in public savings $PUBSAV_{r}$ since public expenditure does not change, even though the public income $INCOME_{r}^{pub}$ can change endogenously:

$$P_{ir}^{C}=\left(\theta_{ir}^{C}\left(1+\overline{ADJUST_{r}}\,t_{ir}^{Cd}\right)^{1-\sigma_{i}^{d}}\left(P_{ir}^{Y}\right)^{1-\sigma_{i}^{d}}+\left(1-\theta_{ir}^{C}\right)\left(1+\overline{ADJUST_{r}}\,t_{ir}^{Cm}\right)^{1-\sigma_{i}^{d}}\left(P_{ir}^{m}\right)^{1-\sigma_{i}^{d}}\right)^{\frac{1}{1-\sigma_{i}^{d}}}$$

$$REV_{r}^{Cd}=\sum_{i=1}^{15}\overline{ADJUST_{r}}\;t_{ir}^{Cd}\;P_{ir}^{Y}C_{ir}^{Cd}$$

$$REV_{r}^{Cm}=\sum_{i=1}^{15}\overline{ADJUST_{r}}\;t_{ir}^{Cm}\;P_{ir}^{m}C_{ir}^{Cm}$$

$$INCOME_{r}^{pub}-\overline{PG_{r}}\,\overline{G_{r}^{pub*}}=PUBSAV_{r}$$

(3) Scenario of increase in labour taxes in country *r*, holding public expenditure constant. The parameter $\overline{ADJUST_{r}}$ is 1 at the benchmark and takes a value above 1 in the

simulation, so that the benchmark ad valorem labour taxes rise. This increase leads to an increase in public savings $PUBSAV_r$ since public expenditure does not change, even though the public income $INCOME_r^{pub}$ can change endogenously:

$$P_{ir}^{f} = \left(\sum_{f} \theta_{ir}^{f} \left(P_{ir}^{pf} \right)^{1-\sigma_i^{VA}} \right)^{\frac{1}{1-\sigma_i^{VA}}}$$

$$P_{ir}^{pf} = \begin{cases} P_r^{labour}\left(1 + \overline{ADJUST_r} t_{ir}^{labour}\right) \\ P_r^{capital}\left(1 + t_{ir}^{capital}\right) \\ P_r^{S}\left(1 + t_{ir}^{S}\right) \end{cases}$$

$$REV_r^{f} = \sum_{i=1}^{15} \left(t_{ir}^{S} P_r^{S} \left(\overline{EVOM_r^{S}} \right) + t_{ir}^{capital} P_r^{capital} \left(\overline{EVOM_r^{capital}} \right) + \overline{ADJUST_r} t_{ir}^{labour} P_r^{labour} \left(\overline{EVOM_r^{labour}} \right)(1 - U_r) \right)$$

$$INCOME_r^{pub} - \overline{PG_r}\,\overline{G_r^{pub*}} = PUBSAV_r$$

Table A1
Endogenous variables

Symbol	Definition
C_{ir}^{C}	Final private consumption of good *i* in country *r*
C_{ir}^{Cd}	Final private consumption of good *i* in country *r*, origin domestic production
C_{ir}^{Cm}	Final private consumption of good *i* in country *r*, origin imports
C_r^{priv}	Aggregate final private consumption in country *r*
C_r^{pubsav}	Aggregate public savings in country *r*
EXP_{irs}	Exports of good *i* from country *r* to country *s*
$EXPA_{irs}$	Exports of good *i* from country *r* to country *s*, including transportation margins
G_{ir}^{G}	Final public consumption of good *i* in country *r*
G_{ir}^{Gd}	Final public consumption of good *i* in country *r*, origin domestic production
G_{ir}^{Gm}	Final public consumption of good *i* in country *r*, origin imports
G_r^{pub}	Aggregate final public consumption in country *r*
I_{ir}^{I}	Investment (gross capital formation) in goods produced by sector *i* in country *r*
I_{ir}^{Id}	Investment (gross capital formation) in goods produced by sector *i* in country *r*, origin domestic production
I_{ir}^{Im}	Investment (gross capital formation) in goods produced by sector *i* in country *r*, origin imports
II_{ijr}	Intermediate inputs from sector *j* used by good *i* in country *r*
II_r^{i}	Aggregate intermediate inputs used by good *i* in country *r*
II_{ijr}^{Y}	Intermediate inputs from sector *j* used by good *i* in country *r*, origin domestic production
II_{ijr}^{m}	Intermediate inputs from sector *j* used by good *i* in country *r*, origin imports
IMP_{ir}	Imports of good i in country *r*
$INCOME_r^{priv}$	Private income in country *r*
$INCOME_r^{pub}$	Public income in country *r*
P_{isr}	Price (unit cost) of good *i* exported from country *s* to country *r*, excluding transportation margins
P_{ir}^{C}	Price (unit cost) for private consumption of good *i* in country *r*
$P_r^{capital}$	Price (unit cost) for capital in country *r*

P_{jr}^{i}	Price (unit cost) for aggregate intermediate input *j* used by good *i* in country *r*
P_{ir}^{f}	Price (unit cost) for aggregate factors used in good *i* produced at country *r*
P_{r}^{F}	Price (unit cost) for factor *F* (= labour, capital) in country *r*
P_{ir}^{G}	Price (unit cost) for public consumption of good *i* in country *r*
P_{ir}^{I}	Price (unit cost) for investment in sector *i* in country *r*
P_{r}^{labour}	Price (unit cost) for labour in country *r*
P_{ir}^{m}	Price (unit cost) for good *i* imported and used in country *r*
P_{ir}^{pf}	Price (unit cost) for factor *pf* (= labour, capital, specific) used in good *i* in country *r*
P_{r}^{S}	Price (unit cost) for specific factor *S* in country *r*
P_{j}^{T}	World price (unit cost) for transportation margins (*j*=*TRN*)
P_{jisr}^{t}	Price (unit cost) for international transportation (*j*=*TRN*) margins in good *i* traded from country *s* to country *r*, including tariffs
P_{ir}^{Y}	Price (unit cost) for good Y_{ir}
PC_{num}	Price (unit cost) for aggregate final private consumption in numeraire country
PC_{r}	Price (unit cost) for aggregate final private consumption in country *r*
PG_{r}	Price (unit cost) for aggregate final public consumption in country *r*
PI_{r}	Price (unit cost) for aggregate savings in country *r*
Pt_{isr}^{m}	Price (unit cost) of exports from country *s* to country *r*, including transportation margins
$PRIVSAV_{r}$	Private savings in country *r*
$PROFIT_{ir}^{Y}$	Unit profits for Y_{ir}
$PUBSAV_{r}$	Public savings in country *r*
Q_{ir}^{pf}	Quantity demanded of factor for good *i* in country *r*
REV_{r}^{Cd}	Revenue in country *r* from taxes on final private consumption of domestic goods
REV_{r}^{Cm}	Revenue in country *r* from taxes on final private consumption of imports
REV_{ir}^{f}	Revenue in country *r* from factor taxes
REV_{r}^{fd}	Revenue in country *r* from taxes on domestic intermediate inputs
REV_{r}^{fm}	Revenue in country *r* from taxes on imported intermediate inputs
REV_{r}^{Gd}	Revenue in country *r* from taxes on final public consumption of domestic goods
REV_{r}^{Gm}	Revenue in country *r* from taxes on final public consumption of imported goods
REV_{r}^{Id}	Revenue in country *r* from taxes on investment of domestic goods
REV_{r}^{Im}	Revenue in country *r* from taxes on investment of imported goods
REV_{r}^{ms}	Revenue in country *r* from tariffs
REV_{r}^{O}	Revenue in country *r* from output tax
REV_{r}^{xs}	Export subsidies in country *r*
TRM_{jisr}	Transportation (*j*=*TRN*) margin for good *i* exported from country *s* to country *r*
U_{r}	Unemployment rate in country *r*
VA_{r}^{i}	Aggregate value added used by good *i* in country *r*
VB_{r}	Foreign savings in country *r*
Y_{ir}	Quantity of good *i* produced in country *r*

Table A2

Exogenous variables and parameters

Symbol	Definition
$\overline{ADJUST_r}$	Parameter for adjustments in simulations, for country *r* (benchmark=1)
$\overline{C_r^{privsav}}$	Aggregate private savings in country *r*
$\overline{EVOM_r^{capital}}$	Capital endowment in country *r*
$\overline{EVOM_r^{labour}}$	Labour endowment in country *r*
$\overline{EVOM_r^{S}}$	Specific factor *S* endowment in country *r*
$\overline{G_r^{pub*}}$	Benchmark public expenditure in country *r*
$\overline{I_r}$	Aggregate gross capital formation in country *r*
$\overline{U_r}$	Benchmark unemployment rate
$t_{ir}^{capital}$	Taxes on capital for good *i* in country *r*
t_{ir}^{Cd}	Taxes on private consumption for good *i* in country *r*, origin domestic production
t_{ir}^{Cm}	Taxes on private consumption for good *i* in country *r*, origin imports
t_{ir}^{F}	Taxes on factor *F* (=labour, capital) for good *i* in country *r*
t_{ijr}^{fd}	Taxes on domestic intermediate input *j* for good *i* in country *r*
t_{ijr}^{fm}	Taxes on imported intermediate input *j* for good *i* in country *r*
t_{ir}^{Gd}	Taxes on public consumption for good *i* in country *r*, origin domestic production
t_{ir}^{Gm}	Taxes on public consumption for good *i* in country *r*, origin imports
t_{ir}^{Id}	Taxes on investment for good *i* in country *r*, origin domestic production
t_{ir}^{Im}	Taxes on investment for good *i* in country *r*, origin imports
t_{ir}^{labour}	Taxes on labour for good *i* in country *r*
t_{isr}^{ms}	Tariff for good *i* exported from country *s* to country *r*
t_{ir}^{O}	Output taxes for good *i* in country *r*
t_{ir}^{S}	Taxes on specific factor *S* for good *i* in country *r*
t_{isr}^{xs}	Export subsidy for good *i* exported from country *s* to country *r*
β	Parameter of flexibility of the real wage to the unemployment rate
θ	Share parameters
σ_i^d	Armington elasticity of substitution domestic-imported components in good *i*
σ_i^m	Armington elasticity of substitution among imported components in good *i*
σ_i^{VA}	Elasticity of substitution among factors in good *i*