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RESUMO/ABSTRACT

Analysing the Impacts of Closure of a Military Base Using a Dynamic CGE Model

Military bases are commonplace in many countries and may have a significant impact in the communities where they are integrated. Impacts of military bases have been analysed through different perspectives. Our aim is to analyse their economic impact. The importance of military bases has become a topic of discussion particularly when base closures or base activity reductions are under consideration. In a previous paper the authors looked at the issue using a static CGE model applied to the analysis of the economic impact of a US base located in the island of Terceira in the Azores. In the current paper a dynamic model is used to study the same issue, using more recent data and disaggregating the impact among different household categories.
A base closure scenario is created and the impacts traced through various economic indicators. It is concluded that GDP falls, relative to the base scenario for a number of years recovering after some time, assuming that worsened trade balances are compensated by other transfers. This fall is prompted by a fall in employment, personal income and consumption. The model also predicts that the impact hurts different household income groups with diverse intensity. Lower income households are hurt more in relative terms but generate a smaller absolute impact. With time, the negative impact tapers off for most income groups except for the lowest which keeps on loosing more until the end of the simulation period.

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ANALYSING THE IMPACTS OF CLOSURE OF A MILITARY BASE USING A DYNAMIC CGE MODEL

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Abstract

Military bases are commonplace in many countries and may have a significant impact in the communities where they are integrated. Impacts of military bases have been analysed through different perspectives. Our aim is to analyse their economic impact. The importance of military bases has become a topic of discussion particularly when base closures or base activity reductions are under consideration. In a previous paper the authors looked at the issue using a static CGE model applied to the analysis of the economic impact of a US base located in the island of Terceira in the Azores. In the current paper a dynamic model is used to study the same issue, using more recent data and disaggregating the impact among different household categories.

A base closure scenario is created and the impacts traced through various economic indicators. It is concluded that GDP falls, relative to the base scenario for a number of years recovering after some time, assuming that worsened trade balances are compensated by other transfers. This fall is prompted by a fall in employment, personal income and consumption. The model also predicts that the impact hurts different household income groups with diverse intensity. Lower income households are hurt more in relative terms but generate a smaller absolute impact. With time, the negative impact tapers off for most income groups except for the lowest which keeps on loosing more until the end of the simulation period.

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1. Introduction

Military bases are commonplace in many countries and may have a significant impact in the communities where they are integrated. Impacts of military bases have been analysed through different perspectives. Our aim is to analyse their economic impact. The importance of military bases has become a topic of discussion particularly when base closures or base activity reductions are under consideration. In a previous , Bayar, et al (2007) looked at the issue using a static CGE model applied to the analysis of the economic impact of a US base located in the island of Terceira in the Azores.

The model used was a standard static CGE model calibrated using a SAM constructed with 1998 data, with sixteen sectors. Based on that data it was found that closure of the base would represent a fall of 0,89% of GDP, a fall in equivalent variation of 27,9 million euros and a fall in employment of about 1,2% of an active population of around 100 thousand.

In the current paper a dynamic model is used to study the same issue, using more recent data (2001) and disaggregating the impact among different household categories, different government levels and different trade blocks.

Discussions over the importance and the impact of the base for the local economy are recurrent in an attempt, on the part of the participants, to advance arguments in favour or against its presence. The current paper tries to contribute with a quantification of the economic impact of the base using a dynamic CGE model of the Azorean economy.

A closure scenario is created and the impacts traced through various economic indicators including some household detail.

Hoffmann, et al (1996) analyze the impact of defense cuts on the economy in California using a computable general equilibrium (CGE) model. Their focus is on the migration of factors from California to other states and the impact of this migration on the economy. CGE models are better suited to analyze the economy wide impact of these defense cuts and their study shows that the impacts are highly sensitive to the assumption of inter-state mobility.

Other studies have taken a less elaborate approach looking mostly at lost direct expenditures and jobs on an accounting approach and looking other social and environmental impacts.

In what follows section 2 presents the main variables that characterize the impact of the base on the local economy. Section 3 reviews the main characteristics of a dynamic CGE model of the Azores. Section 4 reviews the results of calibration of the model and the results of the closure scenario developed. Section 5 presents some of the main conclusions that can be drawn from application of the model.

2. The Military Base in Terceira/Azores

The base in Terceira/Azores houses both US and Portuguese military activities. It comprises an airport adequate for landing any known type of aircraft, fuel storage tanks and port facilities. This base has been extensively used in various international conflicts, namely those that have occurred in the last half century and in the Middle East during recent times.

The impact of the American component of the base can be simulated by the model using data on the main variables. In the simulation undertaken here the relevant data collected characterizes expenditures on construction works and repair, employment and private consumption by the US military, servicemen and civilians.

Access of locals to purchases in the base's stores can also be taken into consideration. It is common for some locals to make their purchases in the base stores at prices that are lower than those practiced in the local stores, for a wider variety of products. There are no good estimates for the total value of the purchases made in these stores, which is equivalent to purchasing the goods abroad. Given that there are no good estimates of the values involved, two scenarios will be created to test the impact of these "imports": one where the import effect is zero, the reference scenario and one in which 50% of the income is spent on these "foreign" stores.

The main elements of the data on the activity of the US military are summarized in tables 1 and 2. Table 1 provides an estimate of the value (in US Dollars) of the construction works and repair commissioned by the Lajes Field Base for 2004 and for 2005.

Table 1 Construction works and repair commissioned by the Lajes Field base

US$

Projects	**2004**	**2005**
Repair breakwater	14.400.000	7.000.000
Construct housing, phase 3	13.392.000	0
Add/renovate fitness center	4.086.000	5.689.000
Community Improvements	3.865.644	7.644.000
Airfield improvements	407.592	150.000
Housing improvements	833.241	663.550
Fuel Sustem improvements	556.046	4.010.000
DoDDS improvements	568.117	615.000
	38.110.644	25.771.550

Source: U.S. Air force

An evaluation of the local consumption expenditure by the US base staff in the Azores is given in Table 2.

To estimate the local impact of the Lajes Field Base it is assumed that 30 per cent of the payroll of active duty personnel living on base is spent outside the base. For the active duty personnel living off base this figure is estimated at 50 per cent, and for US civilians living outside the base it is assumed at 55%. For the Portuguese civilians working on base, it is assumed that 100 per cent of their income is spent off base. This means that the total money impact amounts to about USD35 million.

Table 2 Annual payroll and estimates regarding the loss in terms of private consumption

	Annual Payroll		Impact Factor	Local Impact	
	2004	**2005**		**2004**	**2005**
Reference Scenario	**57.509.059**	**61.247.015**		**34.710.940**	**37.311.796**
Active duty on base	19,814.147	19,287.261	0.30	5,944.244	5,786.178
Active duty off base	13,209.431	12,858.174	0.50	6,604.716	6,429.087
US civilians	5,163.335	8,900.109	0.55	2,839.834	4,895.060
Portuguese civilians	19,322.146	20,201.471	1.00	19,322.146	20,201.471

Source: U.S. Air force

The closure of the US component of the Lajes Field base would have direct and indirect impacts on the economy of the Azores through the following channels:

- The reduction in the demand for construction works and repair;
- The employment loss of the Portuguese civilians working on the base, which leads to a loss in the labour income and consumption demand both domestic and foreign, namely the demand of goods from the base's stores;
- The loss in the consumption demand from the US active duty personnel living on base and off base;
- The loss of the rents of local lodging contracted quarters.

The original impact comes through a reduction in the purchases of goods and services in the local market, equivalent to a reduction of exports to the US.

3. The Model

The current version of the modelling platform of the Azores economy was first presented in Bayar, et. al (2007b). For this reason, only the main characteristics of the model will be presented here. All derived equations of the model are presented in the annex to the current paper as are lists of relevant variables and parameters.

It is a dynamic multi-sectoral computable general equilibrium model (CGE), which incorporates the economic behaviour of six economic agents: firms, households, regional government, Mainland government, European Commission and the external sector.

The goods-producing sectors, consisting of both public and private enterprises, are disaggregated into 45 branches of activity. Households are divided into six income groups, to analyze the distributional effects of various policy measures. Special attention is paid to the economic links between the regional government, the Mainland government and the European Commission. With regard to the rest of the world the economy is treated as a small open economy with no influence on (given) world market prices. Trade relations are differentiated according to four main trade partners: Mainland, EU, US and the rest of the world. The behaviour of each agent in the model is described in detail below.

The model has been solved by using the general algebraic modelling system GAMS (Rosenthal, 2006).

3. Firms

Producers are assumed to operate in 45 perfectly competitive markets, corresponding to an equal number of branches as listed in Table 1, and maximize profits (or minimize costs for each level of output) to determine the optimal levels of inputs and output. Furthermore, production prices equal average and marginal costs, a condition implied by profit maximization for constant returns to scale technology.

The level of production for each branch of activity is determined from a nested production structure (see Figure 1). In the first stage, producers are assumed to choose between intermediate inputs and value-added according to a Leontief production

function. In the second stage, the optimal mix between capital and labour is given by another optimization process, where substitution possibilities between capital and labour are represented by a constant elasticity of substitution (CES) function. Firms' costs related to corporate income tax and social security contributions are also taken into account in the optimization process.

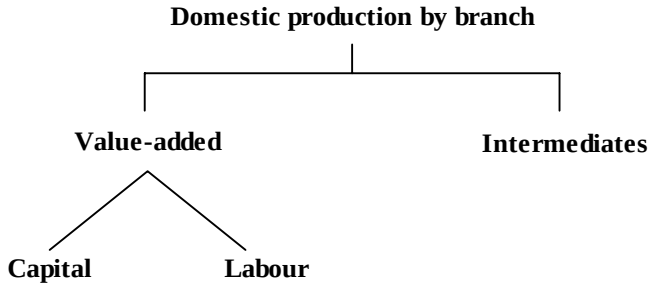

Figure 1. The nested Leontief and CES production technology for the domestic production by branch of activity

Value-added is related to domestic production by branch through a Leontief production function, which assumes an optimal allocation of inputs.

Similarly, total intermediate inputs used by industry depend on domestic demand according to fixed coefficients.

Thus, domestic production are valued at basic prices net of taxes but including direct subsidies on production from the regional government and direct subsidies on production from the European Agricultural Guidance and Guarantee Fund (EAGGF), from the Financial Instrument for Fisheries Guidance (FIFG), from the European Regional Development Fund (ERDF), from the European Social Fund (ESF) and from US, is given by the sum of value-added for each branch valued at basic prices and intermediate commodities used by each sector valued at the price of the commodities, less subsidies on intermediate consumption but including the trade and transport margins and value-added taxes on intermediate consumption.

Value-added is a CES aggregation of capital and labour.

Table 1: Activity and commodity desegregation in AzorMod

1	Agriculture, hunting and forestry, logging
2	Fishing
3	Mining and quarrying
4	Production of meat and meat products
5	Processing of fish and fish products
6	Manufacture of dairy products
7	Prepared animal feeds
8	Beverages & tobacco products
9	Fruits, vegetables, animal oils, grain mill, starches
10	Textiles and leather
11	Wood and products of wood and cork
12	Pulp, paper products; publishing and printing
13	Coke, refined petroleum products and nuclear fuel
14	Chemicals and chemical products
15	Rubber and plastic products
16	Other non-metallic mineral products
17	Basic metals and fabricated metal products
18	Machinery and equipment n.e.c.
19	Electrical and optical equipment
20	Transport equipment
21	Manufacturing n.e.c.
22	Electricity, gas, steam and hot water supply
23	Collection, purification and distribution of water
24	Construction
25	Sale, maintenance, repair of motor vehicles and motorcycles
26	Wholesale trade and commission trade, except of motor vehicles and motorcycles
27	Retail trade, except of motor vehicles and motorcycles
28	Hotels and restaurants
29	Land transport; transport via pipelines
30	Water transport
31	Air transport
32	Supporting transport activities; activities of travel agencies
33	Post and telecommunications
34	Financial intermediation, excluding insurance and pension funding
35	Insurance and pension funding, except compulsory social security
36	Activities auxiliary to financial intermediation
37	Real estate activities
38	Renting of machinery and equipment without operator
39	Computer and related activities; research and development
40	Other business activities
41	Public administration and defence; compulsory social security
42	Education
43	Health and social work
44	Other community, social and personal service activities
45	Activities of households as employers of domestic staff

Capital is industry specific, introducing rigidities in the capital market. The inter-sectoral wage differential is a parameter derived as the ratio between the wage by branch and the national average wage (Dervis, De Melo and Robinson, 1982). Holding the inter-sectoral wage differentials constant in counterfactual policy simulations introduces rigidities in the labour market.

Each branch of activity in AzorMod produces several types of goods and services. The optimal allocation of domestic production between the different types of commodities is given by a Leontief function.

4. Households

Households are split into six income groups, the first group being the poorest one. The representative household in each income group receives a part of the capital income (net operating surplus), a part of the labour income, unemployment benefits from the Mainland government and other net transfers from the regional and Mainland governments. The representative household in each income group pays income taxes and saves a share of the net income.

Household propensity to save reacts to changes in the after-tax average return to capital.

The disposable budget for consumption is allocated between different goods and services according to a Stone-Geary utility function.

In the allocation process, the consumer first decides on the minimum (subsistence) level of consumption of commodity. Then, the marginal income is allocated between different types of commodities according to the marginal budget shares. A schematic representation of households' decisions, by income group, is given in Figure 2.

Household welfare gains/losses are valued using the equivalent variation in income, which is based on the concept of a money metric indirect utility function (Varian, 1992).

Equivalent variation measures the income needed to make the household as well off as she is in the new counter-factual equilibrium (policy scenario) evaluated at benchmark prices. Thus, the equivalent variation is positive for welfare gains from the policy scenario and negative for losses.

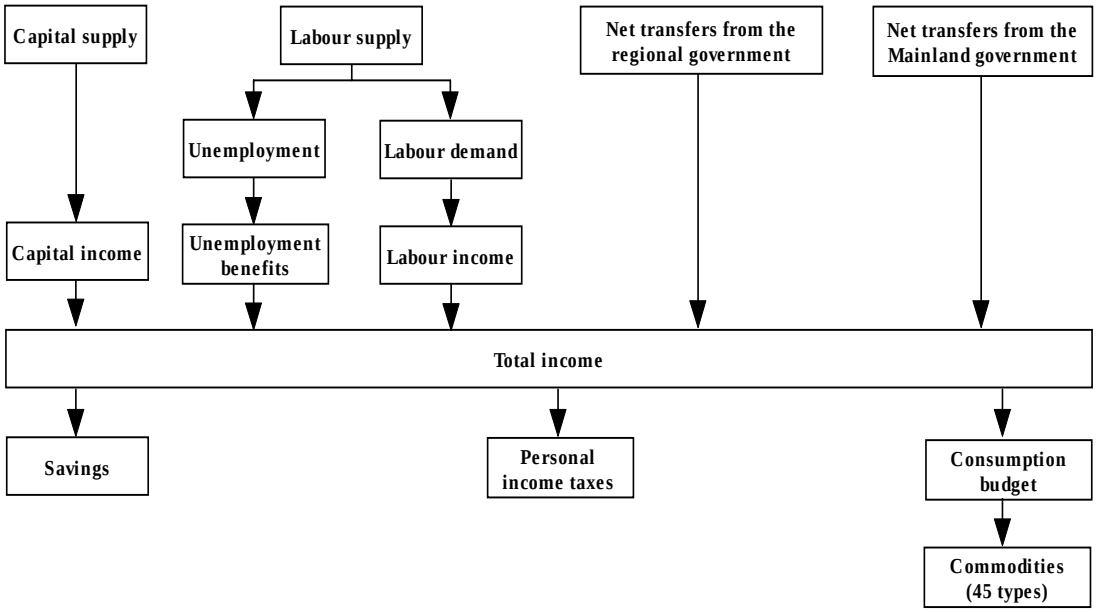

Figure 2. Decision structure of the representative household by income group

5. Regional government

Regional government collects all the taxes, such as: taxes on income and wealth and taxes on products and on production and receives transfers from the Mainland government, EU funds and transfers from the external sector (see Figure 3):

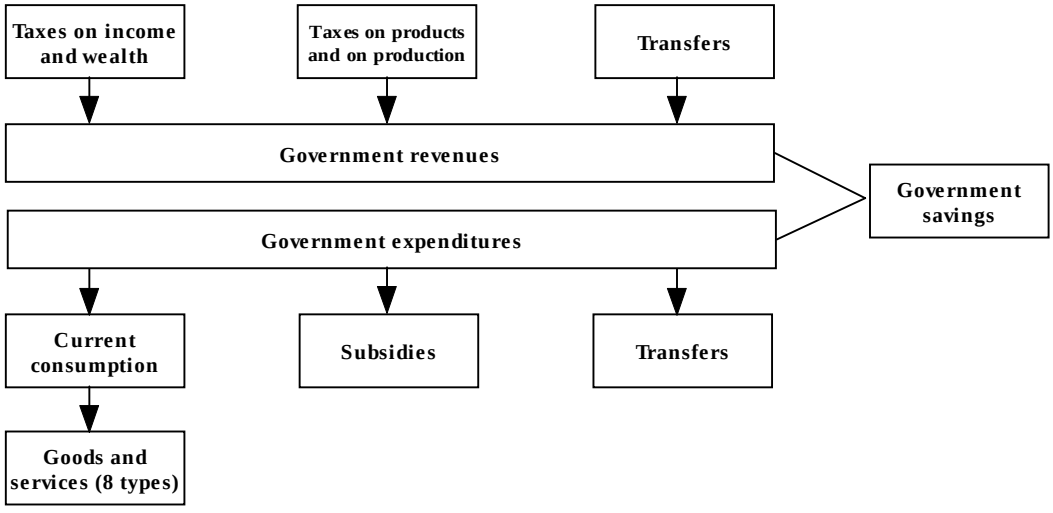

Figure 3. Structure of the regional government budget

In the derivation of each category of tax revenue the tax rate is applied to the corresponding tax base.

Taxes on products are differentiated in the model according to the category of consumption on which they apply: intermediate consumption, private consumption, and gross capital formation.

The total transfers received by the regional government are given by transfers from the Mainland government, transfers from EU as direct subsidies on production and other transfers from EU, transfers from US and transfers from the rest of the world.

Regional government expenditures comprise the public current consumption, total transfers by the government and subsidies on products and on production.

The optimal allocation of the public current consumption between different types of goods and services is given by the maximization of a Cobb-Douglas function, subject to the budget constraint.

The maximization of the utility function yields the demand equations for public current consumption by type of commodity.

Total transfers by the regional government include transfers to the households.

The difference between the regional government revenues and the government expenditures yields the government savings, which are set to zero in all cases to reflect the fact that the regional government is not allowed to incur new debt.

6. Mainland government

Mainland government collects all the social security contributions, provides unemployment benefits and makes transfers to the households and to the regional government.

Social security contributions are derived by applying the social contributions rate to gross wages. Unemployment benefits received by each household income group are determined by the combination of the replacement rate, the national average wage, the total number of unemployed, and the share of unemployed subject to unemployment benefits in each household income group.

7. European Commission

European Commission provides EU funds as direct subsidies to the production sectors and other EU funds to the regional government.

8. Foreign trade

The specification of the foreign trade is based on the small-country assumption, which means that the country is a price taker in both its import and its export markets. Four different trade partners are distinguished in the model: Mainland, EU, US and the rest of the world.

On the import side, imperfect substitution is assumed between domestically produced and imported goods, according to the Armington function (see Figure 4). Thus, domestic consumers use composite goods of imported and domestically produced goods, according to a CES function.

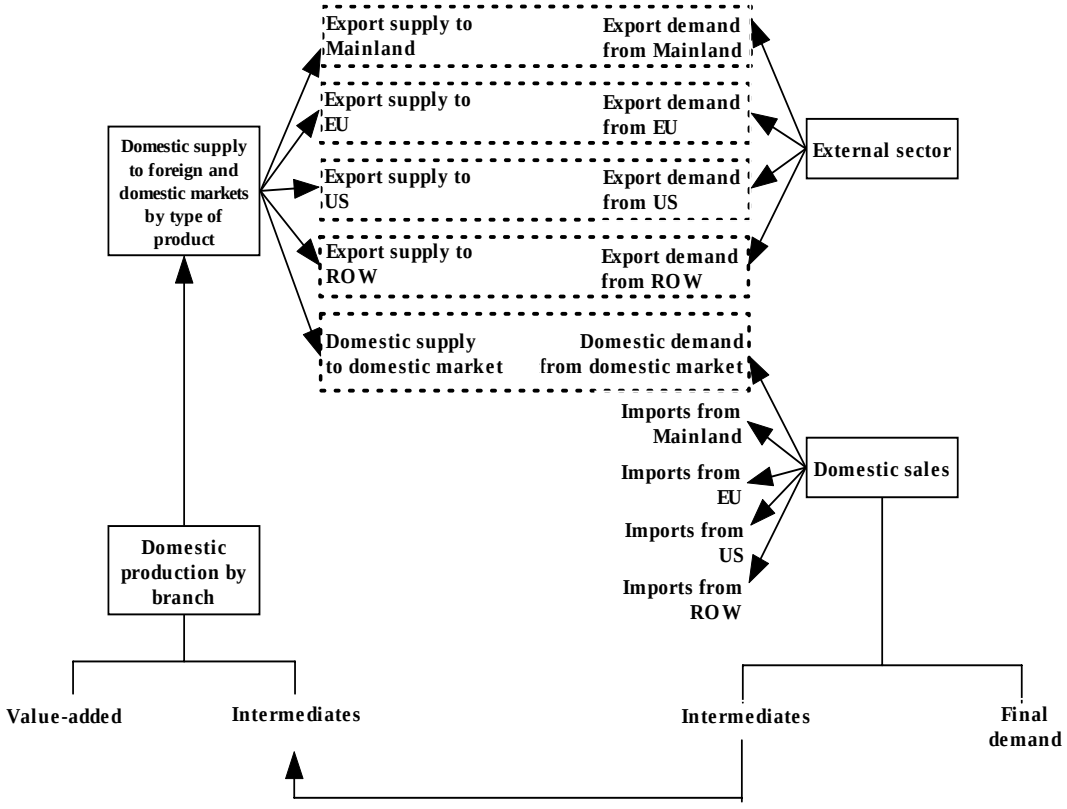

Figure 4. Foreign trade specification

Balance of payments, expressed in foreign currency, takes into account all the trade and capital flows and is differentiated according to each trade partner.

9. Investment demand

Total savings, used to buy investment goods, are given by the sum of savings from the different agents and the trade partners.

Total investments in real terms are given by the difference between savings and inventories.

The optimal allocation of total investments between different types of investment commodities is given by the Leontief function.

The composite price (unit cost) of investments is defined as the weighted average of the price of investment goods.

10. Price equations

A common assumption for CGE models, which has also been adopted here, is that the economy is initially in equilibrium with the quantities normalized in such a way that prices of commodities equal unity. Due to the homogeneity of degree zero in prices, the model only determines the relative prices. Therefore, a particular price is selected to provide the *numeraire* against which all relative prices in the model will be measured. We choose the GDP deflator as the numeraire.

Different prices are defined for all the branches, exports and imports. As already explained, trade and transport margins are paid on all categories of demand in AzorMod except the government consumption (on intermediate consumption, on private consumption and on investment goods).

The domestic price of imports from Mainland is determined by the price of imports from Mainland expressed in foreign currency and the exchange rate.

Similarly, the domestic price of imports from EU is given by the price of imports from EU expressed in foreign currency and the corresponding exchange rate.

The domestic price of imports from US and from ROW, further include the tariff rate on each commodity for imports from US and the tariff rate on imports from ROW.

The consumer price index *(PCINDEX)* used in the model is defined as:

$$PCINDEX = \sum_{c,qu}\{[P_c + \sum_{ctm} tchtm_{ctm,c,qu} \cdot P_{ctm}] \cdot (1+texc_{c,qu}) \cdot (1+tc_{c,qu}+vatc_{c,qu}) \cdot CZ_{c,qu}\} /$$
$$\sum_{c,qu}\{[PZ_c + \sum_{ctm} tchtmz_{ctm,c,qu} \cdot PZ_{ctm}] \cdot (1+texcz_{c,qu}) \cdot (1+tcz_{c,qu}+vatcz_{c,qu}) \cdot CZ_{c,qu}\}$$

where P_c is the price index of commodity *c* net of taxes and PZ_c gives its benchmark level, $tchtm_{ctm,c,qu}$ represents the trade and transport margin rate on private consumption and $tchtmz_{ctm,c,qu}$ is its benchmark level, $texc_{c,qu}$ gives the excise duties rate and $texcz_{c,qu}$ its benchmark level, $vatc_{c,qu}$ provides the value-added tax rate and $vatcz_{c,qu}$ its benchmark level and $tc_{c,qu}$ gives the tax rate corresponding to other taxes on private consumption, while $tcz_{c,qu}$ is its benchmark level. Finally, $CZ_{c,qu}$ accounts for the benchmark level of private consumption of commodity *c* by income group *qu*.

Consumer prices $(PCT_{c,qu})$ are further defined as:

$$PCT_{c,qu} = [P_c + \sum_{ctm} tchtm_{ctm,c,qu} \cdot P_{ctm}] \cdot (1+texc_{c,qu}) \cdot (1+tc_{c,qu}+vatc_{c,qu})$$

11. Labour market

The following identity defines the relation between the labour supply, the labour demand, and unemployment:

$$\sum_s LSK_s = LSR - UNEMP$$

where LSK_s stands for the number of employees in industry *s*, $UNEMP$ represents the number of unemployed and LSR reflects the active population.

The responsiveness of real wage to the labour market conditions is surprised by a wage curve (Sanz-de-Galdeano & Turunen, 2006):

$$log(PL/PCINDEX) = elasU \cdot log(UNRATE) + err$$

where PL is the nominal average wage corresponding to national employment (net of social security contributions), $PCINDEX$ is the consumer price index, $UNRATE$ provides the unemployment rate, err is the error term and $elasU$ is the unemployment elasticity.

The labour supply is provided by the following equation:

$$LSR = LSRI \cdot \{[PL \cdot (1-tyavr) \cdot PCINDEXZ] / [PLZ \cdot (1-tyavrz) \cdot PCINDEX]\}^{elasLS}$$

where $LSRI$ is the benchmark level corresponding to the active population, $tyavr$ is the average personal income tax rate and $tyavrz$ its benchmark level, and PLZ and $PCINDEXZ$ are the benchmark levels corresponding to the nominal national wage and CPI, respectively. $elasLS$ further provides the elasticity of labour supply.

The average personal income tax rate is determined as:

$$tyavr = \sum_{qu}(ty_{qu} \cdot YH_{qu}) / \sum_{qu} YH_{qu}$$

where ty_{qu} stands for the personal income tax rate levied on the household income group *qu* and YH_{qu} gives the total income of the household income group *qu*.

The national employment $(EMPN)$ is defined as:

$$EMPN = LSR - UNEMP$$

The national average wage including social security contributions $(PLAVRT)$ is determined as:

$$PLAVRT \cdot (LSR - UNEMP) = \sum_{s}[PL \cdot (1+tl_s/(1-tl_s)) \cdot (1+premLSK_s) \cdot LSK_s]$$

where PL is the national average wage, $premLSK_s$ gives the wage premium is sector *s* and tl_s provides the social contributions rate in sector *s*.

12. Market clearing equations

The equilibrium in the product, capital and labour markets requires that demand equals supply at prevailing prices (taking into account unemployment for the labour market). Labour market clearing equation has already been presented above. Capital stock is sector specific, such that the equality between capital demand and supply determines the return to capital by branch of activity.

Separate market clearing equations are distinguished in the model for each commodity. For the trade and transport services, the sum of demand for intermediate consumption of each commodity, the private demand for each commodity, the public demand for each commodity the demand for investment goods, the demand for inventories and the demand for trade and transport services which are invoiced separately (trade and transport margins)

should be equal with the total supply of each commodity from imports and domestic production:

The demand for trade and transport services, invoiced separately (Löfgren, Harris and Robinson, 2002), is further derived as the sum of demand for trade and transport services on private consumption, of demand for trade and transport services on investment goods and of demand for trade and transport services on intermediate consumption.

The demand for inventories for each commodity is defined as a fixed share of domestic sales.

13. Incorporation of dynamics

AzorMod has a recursive dynamic structure composed of a sequence of several temporary equilibria. The first equilibrium in the sequence is given by the benchmark year. In each time period, the model is solved for an equilibrium given the exogenous conditions assumed for that particular period. The equilibria are connected to each other through capital accumulation. Thus, the endogenous determination of investment behaviour is essential for the dynamic part of the model. Investment and capital accumulation in year *t* depend on expected rates of return for year *t+1*, which are determined by actual returns on capital in year *t*.

The normal rate of return to capital in each branch is specified as an inverse logistic function (see Figure 5) of the proportionate growth in sector's *s* capital stock (Dixon and Rimmer, 2002).

The minimum possible growth rate is set at the negative of the rate of depreciation in each branch. This condition implies that investments in each branch of activity have positive values, such that once installed, capital cannot be shifted from one sector to another except for the gradual process of depreciation. The maximum possible growth rate of capital stock in industry is constrained in order to avoid unrealistically large simulated growth rates (Dixon and Rimmer, 2002). In the current version the limit is taken equal to 6 per cent for all the branches. For example, if the historically normal growth rate in an industry is 4 per cent, the upper limit in any year *t* would not exceed 10 per cent.

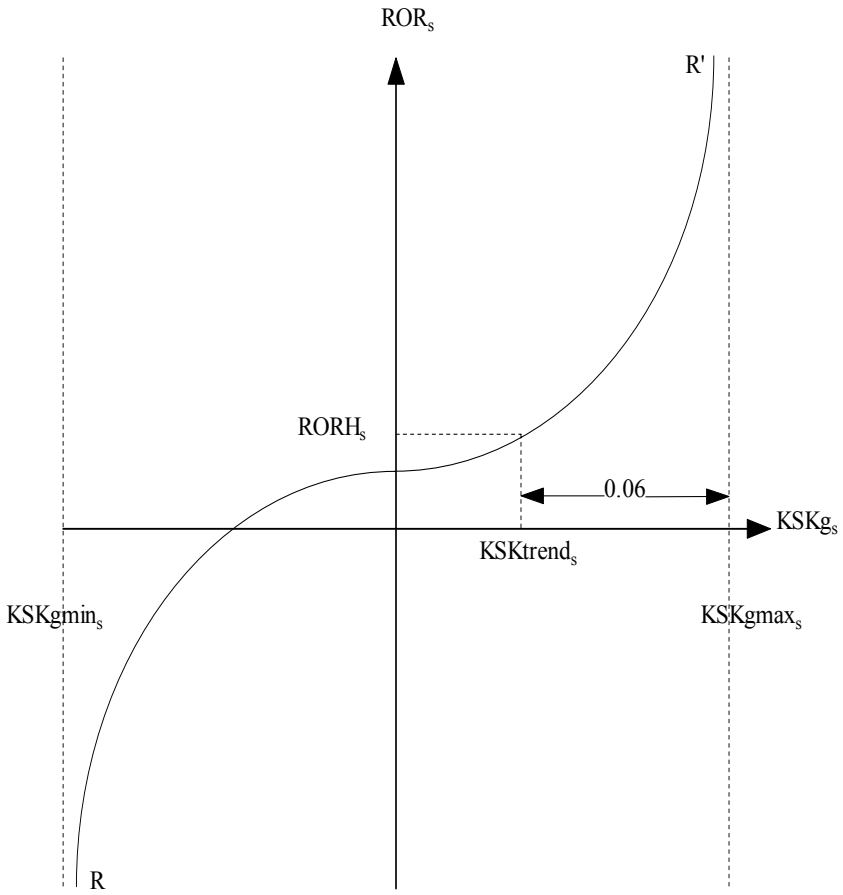

Figure 5. The expected rate of return for industry s

The model is solved dynamically with annual steps. The simulation horizon of the model has been set at 13 years.

14. Closure rules

The closure rules refer to the manner in which demand and supply of commodities, the macroeconomic identities and the factor markets are equilibrated ex-post. Due to the complexity of the model, a combination of closure rules is needed. The particular set of closure rules should also be consistent, to the largest extent possible, with the institutional structure of the economy and with the purpose of the model.

In mathematical terms, the model should consist of an equal number of independent equations and endogenous variables. The closure rules reflect the choice of the model

builder of which variables are exogenous and which variables are endogenous, so as to achieve ex-post equality.

Three macro balances are usually identified in CGE models that can be a potential source of ex-ante disequilibria and must be reconciled ex-post (Adelman and Robinson, 1989):

- The savings-investment balance;
- The government balance;
- The external balance.

The most widely used macro closure rule for CGE models is based on the investment and savings balance. In the model, the investment is assumed to adjust to the available domestic and foreign savings. This reflects an economy in which savings form a binding constraint.

Additional assumptions are needed with regard to regional government behaviour in AzorMod. First, regional government savings are fixed in real terms while regional government total current consumption adjusts to achieve the target set with respect to the government savings. The allocation between the consumption of different goods and services is provided by a Cobb-Douglas function. Secondly, the transfers received by the regional government from the Mainland government, from the EU, from the US and from the ROW are fixed in real terms. On the expenditure side, the regional government transfers to the households are also fixed in real terms.

For the external balance, the exchange rates are kept unchanged in the simulations, while the balances of the current accounts adjust. An alternative closure is also possible where the balances of the current accounts corresponding to US and ROW are set while the real exchange rates adjust.

The setup of the closure rules is important in determining the mechanisms governing the model. Therefore, the closure rules should be established also taking into account the policy scenario in question.

According to Walras' law if *(n-1)* markets are cleared the *n*th one is cleared as well. Therefore, in order to avoid over-determination of the model, the current account balance with respect to ROW is dropped. However, the system of equations guarantees, through Walras' law, that the total imports from ROW less the total exports to ROW and the transfers from ROW equals the current account balance.

4. Calibration of the Model and Simulation of Tax Changes

The model was calibrated using a SAM matrix constructed for the year 2001 for the Azorean economy.

The scenario created, seeks to analyse the impact of the US base in the Azores in the economic activity of this region. This is achieved by assuming that the American component of the base activity is reduced to zero. This implies a direct decline of expenditures in the local economy, a direct loss of about 900 jobs and the absence of about 3.000 foreigners that are associated to the base.

The scenario can be set up in different ways. We consider here a decrease in current account balance in trade with the US. Basically we assume that reduction of activity in the base leads to less sales of Azorean products and services.

As expected, this has a negative impact on most indicators including GDP, private consumption and private GDP. Table 1 shows some of the results.

Table 1: Aggregate Impacts of a Decrease in the US Base Activity

Macroeconomic effects in real terms (% change to the BAU)	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
GDP	-0,44	-0,39	-0,33	-0,28	-0,22	-0,17	-0,12	-0,06	-0,01	0,05	0,10	0,16
Private consumption	-1,79	-1,72	-1,66	-1,59	-1,53	-1,46	-1,40	-1,33	-1,27	-1,20	-1,14	-1,07
Government consumption	-0,32	-0,33	-0,34	-0,35	-0,36	-0,36	-0,37	-0,38	-0,39	-0,40	-0,41	-0,42
Gross fixed investment	3,09	3,20	3,32	3,44	3,56	3,68	3,81	3,94	4,08	4,21	4,35	4,48
Foreign balance	0,54	0,61	0,69	0,77	0,85	0,93	1,02	1,10	1,19	1,28	1,37	1,46
Exports	-1,49	-1,48	-1,46	-1,44	-1,42	-1,40	-1,37	-1,35	-1,32	-1,29	-1,25	-1,22
Imports	-0,23	-0,18	-0,13	-0,07	-0,01	0,05	0,11	0,18	0,24	0,31	0,38	0,45
Private GDP	-0,50	-0,42	-0,33	-0,24	-0,15	-0,07	0,02	0,11	0,20	0,29	0,38	0,47

The impact on the labour market is also consistent with the previous results. Employment falls, unemployment rises and the active population falls. These negative impacts taper off over time as the excess labour is gradually reintegrated in the market.

Table 2: Labour Market Impacts of a Decrease in the US Base Activity

Labour market effects	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
National employment	-0,10	-0,08	-0,05	-0,03	0,00	0,02	0,05	0,07	0,10	0,12	0,15	0,17
Number of unemployed	2,33	1,74	1,18	0,61	0,05	-0,51	-1,07	-1,63	-2,20	-2,77	-3,34	-3,92
Active population	-0,05	-0,04	-0,02	-0,01	0,00	0,01	0,02	0,03	0,05	0,06	0,07	0,08
Unemployment rate (%)	2,27	2,25	2,24	2,23	2,21	2,20	2,19	2,18	2,16	2,15	2,14	2,12
Unemployment rate (% points difference with BAU)	0,05	0,04	0,03	0,01	0,00	-0,01	-0,02	-0,04	-0,05	-0,06	-0,08	-0,09

To assess the redistributive impact of the policy we can look at what it implied for the different household categories considered. Overall, real income, real consumption and equivalent variation decreased due to a decrease in employment and expenditure. The negative impacts taper on these indicators taper off but remain negative for the full period. Tables 3, 4 and 5 show the results.

Table 3: Household Income Impacts of Decrease in the US Base Activity

Effect on HH Real Income %	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
HH1	-5,03	-4,90	-4,77	-4,65	-4,53	-4,41	-4,29	-4,17	-4,06	-3,95	-3,84	-3,74
HH2	-3,50	-3,40	-3,30	-3,21	-3,11	-3,02	-2,93	-2,84	-2,75	-2,66	-2,57	-2,49
HH3	-2,47	-2,40	-2,33	-2,27	-2,20	-2,13	-2,07	-2,00	-1,94	-1,87	-1,81	-1,74
HH4	-1,94	-1,88	-1,82	-1,76	-1,71	-1,65	-1,59	-1,53	-1,47	-1,41	-1,35	-1,29
HH5	-1,67	-1,63	-1,58	-1,53	-1,48	-1,43	-1,39	-1,34	-1,29	-1,24	-1,19	-1,14
HH6	-1,43	-1,39	-1,36	-1,32	-1,29	-1,25	-1,21	-1,18	-1,14	-1,10	-1,07	-1,03

Table 4: Household Real Consumption Impacts of Decrease in the US Base Activity

Effect on HH Consumption%	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
HH1	-5,02	-4,89	-4,77	-4,64	-4,52	-4,40	-4,28	-4,17	-4,05	-3,94	-3,83	-3,72
HH2	-3,48	-3,38	-3,28	-3,19	-3,09	-3,00	-2,91	-2,81	-2,72	-2,63	-2,54	-2,46
HH3	-2,44	-2,37	-2,30	-2,23	-2,16	-2,09	-2,02	-1,95	-1,88	-1,82	-1,75	-1,68
HH4	-1,87	-1,80	-1,74	-1,68	-1,61	-1,55	-1,49	-1,42	-1,36	-1,30	-1,23	-1,17
HH5	-1,55	-1,50	-1,44	-1,39	-1,33	-1,28	-1,22	-1,17	-1,11	-1,05	-1,00	-0,94
HH6	-1,06	-1,00	-0,94	-0,89	-0,83	-0,77	-0,71	-0,65	-0,59	-0,53	-0,47	-0,41

Table 5: Household Equivalent Variation Impacts of Decrease in the USBase Activity

Effect on HH Equivalent Variation Mil€	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
HH1	-3,36	-3,37	-3,38	-3,38	-3,39	-3,39	-3,40	-3,41	-3,41	-3,41	-3,42	-3,42
HH2	-3,74	-3,74	-3,74	-3,73	-3,72	-3,72	-3,71	-3,69	-3,68	-3,67	-3,65	-3,63
HH3	-4,32	-4,31	-4,30	-4,28	-4,26	-4,24	-4,22	-4,19	-4,16	-4,12	-4,08	-4,04
HH4	-4,86	-4,82	-4,77	-4,73	-4,67	-4,61	-4,54	-4,47	-4,39	-4,30	-4,21	-4,10
HH5	-5,67	-5,61	-5,55	-5,48	-5,40	-5,31	-5,22	-5,11	-5,00	-4,87	-4,74	-4,59
HH6	-5,11	-4,93	-4,73	-4,51	-4,28	-4,02	-3,75	-3,45	-3,13	-2,79	-2,43	-2,04
Total	-27,07	-26,78	-26,46	-26,11	-25,72	-25,30	-24,83	-24,32	-23,77	-23,17	-22,53	-21,83

In relative terms, lower income groups tend to bear a greater burden of the reduction in economic activity. This can be assessed through the relative fall on income and on consumption,

In absolute terms, the effect on equivalent variation provides a greater negative impact for higher income groups. It is also interesting to note that the lowest income group becomes worse off with time while the negative impact on the other groups tends to decline.

These numbers can be compared with those obtained from a static model run by Bayar, et al. (2007a)), reproduced in table 6. The numbers seem to be consistent with those obtained from the dynamic model run with more recent data.

Table 6: Impacts of a Decrease in the US Base Activity – Static Model 1998

Macroeconomic variables	
GDP (% change)	-0.89
Unemployment rate (%)	4.09
Change in unemployment rate (% points)	1.16
Welfare gains/losses (thousands EURO)	-27,919
Welfare gains/losses (% of households income)	-2.13

5. Conclusions

The current paper set out to measure the impact of a US military facility in the Azores, using a multi sector, multi household, dynamic CGE model, calibrated using a SAM matrix constructed with 2001 data.

The main concern was to analyse the impact of the measure on a few major economic indicators, particularly GDP, as well as on the labour market and on private wellbeing.

As expected, the reduction in the facility's activity led to a reduction in GDP in the short run, a result that is, however, inverted in the longer run.

The impact on private consumption and wellbeing is negative for the full period. Lower income households tend to bear a relatively greater burden of the fall.

The results are partly driven by the model closure methodology that was used, namely the compensation of deteriorated trade balances by increased savings from outside sources. This in turn causes investment to increase, driving up GDP. As such, the negative impacts that were estimated should be considered an underestimate of the real effects.

Future versions of the model will consider different closure rules to avoid the mentioned effects.

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ANNEXES

15. Model equations

15.1.1. Firms

$$SF = shYKF \cdot \sum_{s} PK_s \cdot KSK_s \tag{A.1}$$

$$KL_s = aKL_s \cdot XD_s \tag{A.2}$$

$$KSK_s = KL_s \cdot \{PKL_s/[PK_s \cdot (1+tk_s)+d_s \cdot PI]\}^{\sigma F_s} \cdot \gamma FK_s^{\sigma F_s} \cdot aF_s^{(\sigma F_s - 1)} \tag{A.3}$$

$$LSK_s = KL_s \cdot \{PKL_s/[PL \cdot (1+premLSK_s) \cdot (1+tl_s/(1-tl_s))]\}^{\sigma F_s} \cdot \gamma FL_s^{\sigma F_s} \cdot aF_s^{(\sigma F_s - 1)} \tag{A.4}$$

$$PKL_s \cdot KL_s = PK_s \cdot (1+tk_s) \cdot KSK_s + PL \cdot (1+premLSK_s) \cdot (1+tl_s/(1-tl_s)) \cdot LSK_s + DEP_s \cdot PI \tag{A.5}$$

$$\begin{aligned} &PD_s \cdot (1-tp_s+tsp_s+tspeuea_s \cdot MUtspeu+tspeufi_s \cdot MUtspeu+tspeuer_s \cdot \\ &MUtspeu+tspeues_s \cdot MUtspeu+tspusa_s) \cdot XD_s = PKL_s \cdot KL_s + \\ &\sum_{c} \{io_{c,s} \cdot XD_s \cdot [(1-tsic_{c,s}) \cdot P_c + \sum_{ctm} tcictm_{ctm,c,s} \cdot P_{ctm}] \cdot (1+vatic_{c,s})\} \end{aligned} \tag{A.6}$$

15.1.2. Households

$$\begin{aligned} &[P_c + \sum_{ctm} tchtm_{ctm,c,qu} \cdot P_{ctm}] \cdot (1+texc_{c,qu}) \cdot (1+tc_{c,qu}+vatc_{c,qu}) \cdot C_{c,qu} = [P_c + \sum_{ctm} tchtm_{ctm,c,qu} \cdot P_{ctm}] \cdot \\ &(1+texc_{c,qu}) \cdot (1+tc_{c,qu}+vatc_{c,qu}) \cdot \mu H_{c,qu} + \alpha H_{c,qu} \cdot \{CBUD_{qu} - \sum_{cc} [P_{cc} + \sum_{ctm} tchtm_{ctm,cc,qu} \cdot P_{ctm}] \cdot \\ &(1+texc_{cc,qu}) \cdot (1+tc_{cc,qu}+vatc_{cc,qu}) \cdot \mu H_{cc,qu}\} \end{aligned} \tag{A.7}$$

$$\begin{aligned} &YH_{qu} = shYKH_{qu} \cdot \sum_{s} PK_s \cdot KSK_s + shYLH_{qu} \cdot \sum_{s} PL \cdot (1+premLSK_s) \cdot LSK_s + TRHML_{qu} \cdot \\ &ERML + shUNEMPB_{qu} \cdot trep \cdot PL \cdot UNEMP + TRHG_{qu} \cdot PCINDEX \end{aligned} \tag{A.8}$$

$$CBUD_{qu} = (1-ty_{qu}) \cdot YH_{qu} - SH_{qu} \tag{A.9}$$

$$SH_{qu} = MPS_{qu} \cdot (1-ty_{qu}) \cdot YH_{qu} \tag{A.10}$$

$$MPS_{qu} = MPSZ_{qu} \cdot \{[(1-ty_{qu}) \cdot PKavr]/[(1-tyz_{qu}) \cdot PKavrZ]\}^{elasS_{qu}} \tag{A.11}$$

15.1.3. Regional government

$$GREV = TRPROP + TRPROD + TRANSR \tag{A.12}$$

$$TRPROP = \sum_{qu} ty_{qu} \cdot YH_{qu} + \sum_{s} tk_s \cdot KSK_s \cdot PK_s \tag{A.13}$$

$$\begin{aligned} &TRPROD = \sum_{s} tp_s \cdot XD_s \cdot PD_s + \sum_{c,qu} \{[P_c + \sum_{ctm} tchtm_{ctm,c,qu} \cdot P_{ctm}] \cdot [texc_{c,qu} + (1+ \\ &texc_{c,qu}) \cdot (tc_{c,qu}+vatc_{c,qu})] \cdot C_{c,qu}\} + \sum_{c} [P_c + \sum_{ctm} tcitm_{ctm,c} \cdot P_{ctm}] \cdot vati_c \cdot I_c + \\ &\sum_{c,s} [(1-tsic_{c,s}) \cdot P_c + \sum_{ctm} tcictm_{ctm,c,s} \cdot P_{ctm}] \cdot vatic_{c,s} \cdot io_{c,s} \cdot XD_s + \sum_{c} (tmus_c \cdot PWMUS_c \cdot \\ &MUS_c \cdot ERUS) + \sum_{c} (tmrw_c \cdot PWMROW_c \cdot MROW_c \cdot ERROW) \end{aligned} \tag{A.14}$$

$$TRANSR = TRGML \cdot ERML + TRGEU \cdot EREU + TRGEC \cdot EREU + TRGUS \cdot ERUS + TRGW \cdot ERROW \quad \text{(A.15)}$$

$$GEXP = CGBUD + TRANS + SUBSID \quad \text{(A.16)}$$

$$P_c \cdot CG_c = \alpha CG_c \cdot CGBUD \quad \text{(A.17)}$$

$$TRANS = \sum_{qu} TRHG_{qu} \cdot PCINDEX \quad \text{(A.18)}$$

$$SUBSID = \sum_{c,s} tsic_{c,s} \cdot P_c \cdot io_{c,s} \cdot XD_s + \sum_s [(tsp_s + tspeuea_s \cdot MUtspeu + tspeufi_s \cdot MUtspeu + tspeuer_s \cdot MUtspeu + tspeues_s \cdot MUtspeu + tspusa_s) \cdot XD_s \cdot PD_s] \quad \text{(A.19)}$$

$$TRGEC \cdot EREU = MUtspeu \cdot \sum_s [(tspeuea_s + tspeufi_s + tspeuer_s + tspeues_s) \cdot XD_s \cdot PD_s] \quad \text{(A.20)}$$

$$SG \cdot GDPDEF = GREV - GEXP \quad \text{(A.21)}$$

$$rTRPROPGDP = TRPROP/GDPC \cdot 100 \quad \text{(A.22)}$$

$$rTRPRODGDP = TRPROD/GDPC \cdot 100 \quad \text{(A.23)}$$

$$rTRANSRGDP = TRANSR/GDPC \cdot 100 \quad \text{(A.24)}$$

$$rCGBUDGDP = CGBUD/GDPC \cdot 100 \quad \text{(A.25)}$$

$$rTRANSGDP = TRANS/GDPC \cdot 100 \quad \text{(A.26)}$$

$$rSUBSIDGDP = SUBSID/GDPC \cdot 100 \quad \text{(A.27)}$$

$$rSGGDP = SG \cdot GDPDEF/GDPC \cdot 100 \quad \text{(A.28)}$$

15.1.4. Mainland government

$$SGML = \sum_s [tl_s/(1-tl_s) \cdot LSK_s \cdot PL \cdot (1+premLSK_s)/ERML] - \sum_{qu} TRHML_{qu} - \sum_{qu} (shUNEMPB_{qu} \cdot trep \cdot PL \cdot UNEMP/ERML) - TRGML \quad \text{(A.29)}$$

15.1.5. European Commission

$$SGEC = -TRGEC - TRGEU \quad \text{(A.30)}$$

15.1.6. Domestic supply to domestic and foreign markets

$$XDDE_c = \sum_s ioC_{s,c} \cdot XD_s \quad \text{(A.31)}$$

$$PD_s = \sum_c ioC_{s,c} \cdot PDDE_c \quad \text{(A.32)}$$

15.1.7. Foreign sector

$$EML_c = XDDE_c \cdot (PDDE_c/PEML_c)^{\sigma T_c} \cdot \gamma T1_c^{\sigma T_c} \cdot aT_c^{(\sigma T_c - 1)} \quad \text{(A.33)}$$

$$EEU_c = XDDE_c \cdot (PDDE_c/PEEU_c)^{\sigma T_c} \cdot \gamma T2_c^{\sigma T_c} \cdot aT_c^{(\sigma T_c - 1)} \quad \text{(A.34)}$$

$$EUS_c = XDDE_c \cdot (PDDE_c/PEUS_c)^{\sigma T_c} \cdot \gamma T3_c^{\sigma T_c} \cdot aT_c^{(\sigma T_c - 1)} \quad \text{(A.35)}$$

$$EROW_c = XDDE_c \cdot (PDDE_c/PEROW_c)^{\sigma T_c} \cdot \gamma T4_c^{\sigma T_c} \cdot aT_c^{(\sigma T_c - 1)} \quad \text{(A.36)}$$

$$XDD_c = XDDE_c \cdot (PDDE_c/PDD_c)^{\sigma T_c} \cdot \gamma T5_c^{\sigma T_c} \cdot aT_c^{(\sigma T_c - 1)} \quad \text{(A.37)}$$

$$PDDE_c \cdot XDDE_c = PDD_c \cdot XDD_c + PEML_c \cdot EML_c + PEEU_c \cdot EEU_c + PEUS_c \cdot EUS_c + PEROW_c \cdot EROW_c \quad \text{(A.38)}$$

$$E_c = (PEML_c \cdot EML_c + PEEU_c \cdot EEU_c + PEUS_c \cdot EUS_c + PEROW_c \cdot EROW_c)/INDEXE_c \quad \text{(A.39)}$$

$$EDML_c = EDIML_c \cdot (PWEML_c \cdot ERML/PEML_c)^{elasE_c} \quad \text{(A.40)}$$

$$EDEU_c = EDIEU_c \cdot (PWEEU_c \cdot EREU/PEEU_c)^{elasE_c} \quad \text{(A.41)}$$

$$EDUS_c = EDIUS_c \cdot (PWEUS_c \cdot ERUS/PEUS_c)^{elasE_c} \quad \text{(A.42)}$$

$$EDROW_c = EDIROW_c \cdot (PWEROW_c \cdot ERROW/PEROW_c)^{elasE_c} \quad \text{(A.43)}$$

$$MML_c = X_c \cdot (P_c/PMML_c)^{\sigma A_c} \cdot \gamma A1_c^{\sigma A_c} \cdot aA_c^{(\sigma A_c - 1)} \quad \text{(A.44)}$$

$$MEU_c = X_c \cdot (P_c/PMEU_c)^{\sigma A_c} \cdot \gamma A2_c^{\sigma A_c} \cdot aA_c^{(\sigma A_c - 1)} \quad \text{(A.45)}$$

$$MUS_c = X_c \cdot (P_c/PMUS_c)^{\sigma A_c} \cdot \gamma A3_c^{\sigma A_c} \cdot aA_c^{(\sigma A_c - 1)} \quad \text{(A.46)}$$

$$MROW_c = X_c \cdot (P_c/PMROW_c)^{\sigma A_c} \cdot \gamma A4_c^{\sigma A_c} \cdot aA_c^{(\sigma A_c - 1)} \quad \text{(A.47)}$$

$$XDD_c = X_c \cdot (P_c/PDD_c)^{\sigma A_c} \cdot \gamma A5_c^{\sigma A_c} \cdot aA_c^{(\sigma A_c - 1)} \quad \text{(A.48)}$$

$$P_c \cdot X_c = PMML_c \cdot MML_c + PMEU_c \cdot MEU_c + PMUS_c \cdot MUS_c + PMROW_c \cdot MROW_c + PDD_c \cdot XDD_c \quad \text{(A.49)}$$

$$M_c = (PWMML_c \cdot ERML \cdot MML_c + PWMEU_c \cdot EREU \cdot MEU_c + PWMUS_c \cdot ERUS \cdot MUS_c + PWMROW_c \cdot ERROW \cdot MROW_c)/INDEXM_c \quad \text{(A.50)}$$

$$SML = \sum_c (MML_c \cdot PWMML_c - EML_c \cdot PEML_c/ERML) + SGML \quad \text{(A.51)}$$

$$SEU = \sum_c (MEU_c \cdot PWMEU_c - EEU_c \cdot PEEU_c/EREU) + SGEC \quad \text{(A.52)}$$

$$SUS = \sum_c (MUS_c \cdot PWMUS_c - EUS_c \cdot PEUS_c/ERUS) - TRGUS \quad \text{(A.53)}$$

$$SROW = \sum_c (MROW_c \cdot PWMROW_c - EROW_c \cdot PEROW_c/ERROW) - TRGW \quad \text{(A.54)}$$

15.1.8. Investment

$$S = \sum_{qu} SH_{qu} + SF + SG \cdot GDPDEF + SML \cdot ERML + SEU \cdot EREU + SUS \cdot ERUS + SROW \cdot ERROW + \sum_s DEP_s \cdot PI \quad \text{(A.55)}$$

$$I_c = ioI_c \cdot ITT \quad \text{(A.56)}$$

$$PI = \sum_c \{(1 + vati_c) \cdot [P_c + \sum_{ctm} tcitm_{ctm,c} \cdot P_{ctm}] \cdot ioI_c\} \quad \text{(A.57)}$$

$$PI \cdot ITT = S - \sum_{c} SV_c \cdot P_c \tag{A.58}$$

$$SV_c = svr_c \cdot X_c \tag{A.59}$$

$$DEP_s = d_s \cdot KSK_s \tag{A.60}$$

15.1.9. Labor market

$$log(PL/PCINDEX) = elasU \cdot log(UNRATE) + err \tag{A.61}$$

$$LSR = LSRI \cdot \{ [PL \cdot (1 - tyavr) \cdot PCINDEXZ] / [PLZ \cdot (1 - tyavrz) \cdot PCINDEX] \}^{elasLS} \tag{A.62}$$

$$tyavr = \sum_{qu} (ty_{qu} \cdot YH_{qu}) / \sum_{qu} YH_{qu} \tag{A.63}$$

$$EMPN = LSR - UNEMP \tag{A.64}$$

$$UNRATE = UNEMP/LSR \tag{A.65}$$

15.1.10. Trade and transport margins

$$MARGTM_{ctm} = \sum_{c,qu} tchtm_{ctm,c,qu} \cdot C_{c,qu} + \sum_{c} tcitm_{ctm,c} \cdot I_c + \sum_{s,c} tcictm_{ctm,c,s} \cdot io_{c,s} \cdot XD_s \tag{A.66}$$

15.1.11. Market clearing

$$\sum_{s} LSK_s = LSR - UNEMP \tag{A.67}$$

$$\sum_{s} io_{ctm,s} \cdot XD_s + \sum_{qu} C_{ctm,qu} + CG_{ctm} + I_{ctm} + SV_{ctm} + MARGTM_{ctm} = X_{ctm} \tag{A.68}$$

$$\sum_{s} io_{nctm,s} \cdot XD_s + \sum_{qu} C_{nctm,qu} + CG_{nctm} + I_{nctm} + SV_{nctm} = X_{nctm} \tag{A.69}$$

$$EML_c = EDML_c \tag{A.70}$$

$$EEU_c = EDEU_c \tag{A.71}$$

$$EUS_c = EDUS_c \tag{A.72}$$

$$EROW_c = EDROW_c \tag{A.73}$$

15.1.12. Price definitions

$$PCINDEX = \sum_{c,qu} \{ [P_c + \sum_{ctm} tchtm_{ctm,c,qu} \cdot P_{ctm}] \cdot (1 + texc_{c,qu}) \cdot (1 + tc_{c,qu} + vatc_{c,qu}) \cdot CZ_{c,qu} \} /$$
$$\sum_{c,qu} \{ [PZ_c + \sum_{ctm} tchtmz_{ctm,c,qu} \cdot PZ_{ctm}] \cdot (1 + texcz_{c,qu}) \cdot (1 + tcz_{c,qu} + vatcz_{c,qu}) \cdot CZ_{c,qu} \} \tag{A.74}$$

$$INDEXE_c = (PEML_c \cdot EMLZ_c + PEEU_c \cdot EEUZ_c + PEUS_c \cdot EUSZ_c + PEROW_c \cdot EROWZ_c) /$$
$$(PEMLZ_c \cdot EMLZ_c + PEEUZ_c \cdot EEUZ_c + PEUSZ_c \cdot EUSZ_c + PEROWZ_c \cdot EROWZ_c) \tag{A.75}$$

$$INDEXM_c = (PWMML_c \cdot ERML \cdot MMLZ_c + PWMEU_c \cdot EREU \cdot MEUZ_c + PWMUS_c \cdot ERUS \cdot$$
$$MUSZ_c + PWMROW_c \cdot ERROW \cdot MROWZ_c) / (PWMMLZ_c \cdot ERMLZ \cdot MMLZ_c + PWMEUZ_c \cdot$$
$$EREUZ \cdot MEUZ_c + PWMUSZ_c \cdot ERUSZ \cdot MUSZ_c + PWMROWZ_c \cdot ERROWZ \cdot MROWZ_c) \tag{A.76}$$

$$PMML_c = PWMML_c \cdot ERML \tag{A.77}$$

$$PMEU_c = PWMEU_c \cdot EREU \tag{A.78}$$

$$PMUS_c = PWMUS_c \cdot ERUS \cdot (1+tmus_c) \tag{A.79}$$

$$PMROW_c = PWMROW_c \cdot ERROW \cdot (1+tmrw_c) \tag{A.80}$$

$$RINT = \sum_s [(PK_s/PD_s) \cdot KSK_s] / \sum_s KSK_s \tag{A.81}$$

$$PKavr = \sum_s [(PK_s/PCINDEX) \cdot KSK_s] / \sum_s KSK_s \tag{A.82}$$

$$PCT_{c,qu} = [P_c + \sum_{ctm} tchtm_{ctm,c,qu} \cdot P_{ctm}] \cdot (1+texc_{c,qu}) \cdot (1+tc_{c,qu}+vatc_{c,qu}) \tag{A.83}$$

$$PLAVRT \cdot (LSR - UNEMP) = \sum_s [PL \cdot (1+tl_s/(1-tl_s)) \cdot (1+premLSK_s) \cdot LSK_s] \tag{A.84}$$

15.1.13. Gross domestic product at current and constant market prices

$$\begin{aligned} GDPC = & \sum_{c,qu} \{C_{c,qu} \cdot [P_c + \sum_{ctm} tchtm_{ctm,c,qu} \cdot P_{ctm}] \cdot (1+texc_{c,qu}) \cdot (1+tc_{c,qu}+vatc_{c,qu})\} + \\ & \sum_c CG_c \cdot P_c + \sum_c \{I_c \cdot (1+vati_c) \cdot [P_c + \sum_{ctm} tcitm_{ctm,c} \cdot P_{ctm}]\} + \sum_c SV_c \cdot P_c + \sum_c EML_c \cdot PEML_c \\ & + \sum_c EEU_c \cdot PEEU_c + \sum_c EUS_c \cdot PEUS_c + \sum_c EROW_c \cdot PEROW_c - \\ & \sum_c MML_c \cdot PWMML_c \cdot ERML - \sum_c MEU_c \cdot PWMEU_c \cdot EREU - \\ & \sum_c MUS_c \cdot PWMUS_c \cdot ERUS - \sum_c MROW_c \cdot PWMROW_c \cdot ERROW \end{aligned} \tag{A.85}$$

$$\begin{aligned} GDP = & \sum_{c,qu} \{C_{c,qu} \cdot [PZ_c + \sum_{ctm} tchtmz_{ctm,c,qu} \cdot PZ_{ctm}] \cdot (1+texcz_{c,qu}) \cdot (1+tcz_{c,qu}+vatcz_{c,qu})\} + \\ & \sum_c CG_c \cdot PZ_c + \sum_c \{I_c \cdot (1+vatiz_c) \cdot [PZ_c + \sum_{ctm} tcitmz_{ctm,c} \cdot PZ_{ctm}]\} + \sum_c SV_c \cdot PZ_c + \\ & \sum_c EML_c \cdot PEMLZ_c + \sum_c EEU_c \cdot PEEUZ_c + \sum_c EUS_c \cdot PEUSZ_c + \sum_c EROW_c \cdot PEROWZ_c - \\ & \sum_c MML_c \cdot PWMMLZ_c \cdot ERMLZ - \sum_c MEU_c \cdot PWMEUZ_c \cdot EREUZ - \\ & \sum_c MUS_c \cdot PWMUSZ_c \cdot ERUSZ - \sum_c MROW_c \cdot PWMROWZ_c \cdot ERROWZ \end{aligned} \tag{A.86}$$

$$\begin{aligned} GDPP = & \sum_{c,qu} \{C_{c,qu} \cdot [PZ_c + \sum_{ctm} tchtmz_{ctm,c,qu} \cdot PZ_{ctm}] \cdot (1+texcz_{c,qu}) \cdot (1+tcz_{c,qu}+vatcz_{c,qu})\} + \\ & \sum_c \{I_c \cdot (1+vatiz_c) \cdot [PZ_c + \sum_{ctm} tcitmz_{ctm,c} \cdot PZ_{ctm}]\} + \sum_c SV_c \cdot PZ_c + \sum_c EML_c \cdot PEMLZ_c + \\ & \sum_c EEU_c \cdot PEEUZ_c + \sum_c EUS_c \cdot PEUSZ_c + \sum_c EROW_c \cdot PEROWZ_c - \\ & \sum_c MML_c \cdot PWMMLZ_c \cdot ERMLZ - \sum_c MEU_c \cdot PWMEUZ_c \cdot EREUZ - \\ & \sum_c MUS_c \cdot PWMUSZ_c \cdot ERUSZ - \sum_c MROW_c \cdot PWMROWZ_c \cdot ERROWZ \end{aligned}$$

$$GDPDEF = GDPC/GDP \tag{A.87}$$

15.1.14. Components of GDP at constant prices

$$CT = \sum_{c,qu}\{C_{c,qu}\cdot[PZ_c+\sum_{ctm} tchtmz_{ctm,c,qu}\cdot PZ_{ctm}]\cdot(1+texcz_{c,qu})\cdot(1+tcz_{c,qu}+vatcz_{c,qu})\} \quad \text{(A.88)}$$

$$CGT = \sum_{c} CG_c \cdot PZ_c \quad \text{(A.89)}$$

$$IT = \sum_{c}\{I_c\cdot(1+vatiz_c)\cdot[PZ_c+\sum_{ctm} tcitmz_{ctm,c}\cdot PZ_{ctm}]\}+\sum_{c} SV_c\cdot PZ_c \quad \text{(A.90)}$$

$$ET = \sum_{c}(EML_c\cdot PEMLZ_c + EEU_c\cdot PEEUZ_c + EUS_c\cdot PEUSZ_c + EROW_c\cdot PEROWZ_c) \quad \text{(A.91)}$$

$$MT = \sum_{c}(MML_c\cdot PWMMLZ_c\cdot ERMLZ + MEU_c\cdot PWMEUZ_c\cdot EREUZ + MUS_c\cdot PWMUSZ_c\cdot ERUSZ + MROW_c\cdot PWMROWZ_c\cdot ERROWZ) \quad \text{(A.92)}$$

15.1.15. Equivalent variation in income

$$VU_{qu} = \{CBUD_{qu} - \sum_{c}[P_c+\sum_{ctm} tchtm_{ctm,c,qu}\cdot P_{ctm}]\cdot(1+texc_{c,qu})\cdot(1+tc_{c,qu}+vatc_{c,qu})\cdot \mu H_{c,qu}\}\cdot\prod_{c}\{\alpha H_{c,qu}/\{[P_c+\sum_{ctm} tchtm_{ctm,c,qu}\cdot P_{ctm}]\cdot(1+texc_{c,qu})\cdot(1+tc_{c,qu}+vatc_{c,qu})\}\}^{\alpha H_{c,qu}} \quad \text{(A.93)}$$

$$VUI_{qu} = \{CBUDZ_{qu} - \sum_{c}[PZ_c+\sum_{ctm} tchtmz_{ctm,c,qu}\cdot PZ_{ctm}]\cdot(1+texcz_{c,qu})\cdot(1+tcz_{c,qu}+vatcz_{c,qu})\cdot \mu H_{c,qu}\}\cdot\prod_{c}\{\alpha H_{c,qu}/\{[PZ_c+\sum_{ctm} tchtmz_{ctm,c,qu}\cdot PZ_{ctm}]\cdot(1+texcz_{c,qu})\cdot(1+tcz_{c,qu}+vatcz_{c,qu})\}\}^{\alpha H_{c,qu}} \quad \text{(A.94)}$$

$$EV_{qu} = \prod_{c}\{\{[PZ_c+\sum_{ctm} tchtmz_{ctm,c,qu}\cdot PZ_{ctm}]\cdot(1+texcz_{c,qu})\cdot(1+tcz_{c,qu}+vatcz_{c,qu})\}/\alpha H_{c,qu}\}^{\alpha H_{c,qu}}\cdot(VU_{qu}-VUI_{qu}) \quad \text{(A.95)}$$

15.1.16. Capital accumulation

$$ROR_{s,t} = -1+(PK_{s,t}/PI_t+1)/(1+RINT_t) \quad \text{(A.96)}$$

$$\alpha ROR_{s,t} = e^{\{[(ROR_{s,t}-RORH_s)\cdot(KSKgmax_s-KSKgmin_s)]/[(KSKgmax_s-KSKtrend_s)\cdot(KSKtrend_s-KSKgmin_s)]\}} \quad \text{(A.97)}$$

$$INVS_{s,t} = KSK_{s,t}\cdot[\alpha ROR_{s,t}\cdot KSKgmax_s\cdot(KSKtrend_s-KSKgmin_s)+KSKgmin_s\cdot(KSKgmax_s-KSKtrend_s)]/[\alpha ROR_{s,t}\cdot(KSKtrend_s-KSKgmin_s)+(KSKgmax_s-KSKtrend_s)]+d_s\cdot KSK_{s,t} \quad \text{(A.98)}$$

$$INV_{s,t} = INVS_{s,t}/\sum_{ss} INVS_{ss,t}\cdot(S_t-\sum_{c} SV_{c,t}\cdot P_{c,t})/PI_t \quad \text{(A.99)}$$

$$KSK_{s,t+1} = (1-d_s)\cdot KSK_{s,t}+INV_{s,t} \quad \text{(A.100)}$$

16.

17.

18.

19. List of Endogenous variables

$CBUD_{qu}$	households budget disposable for consumption by income group
$C_{c,qu}$	consumer demand for commodity *c* by income group *qu*
CGBUD	regional government current expenditures
CG_c	public current consumption of commodity *c* by the regional government
CGT	total public consumption by the regional government at constant prices
CT	total private consumption at constant prices
DEP_s	depreciation related to public and private capital stock
$EDEU_c$	export demand of commodity *c* from EU
$EDML_c$	export demand of commodity *c* from Mainland
$EDROW_c$	export demand of commodity *c* from the rest of the world
$EDUS_c$	export demand of commodity *c* from US
EEU_c	export supply of commodity *c* by the domestic producers to EU
EML_c	export supply of commodity *c* by the domestic producers to Mainland
EMPN	national employment
$EROW_c$	export supply of commodity *c* by the domestic producers to the rest of the world
ET	total exports at constant prices
EUS_c	export supply of commodity *c* by the domestic producers to US
EV_{qu}	equivalent variation in income, by household income group
GDP	gross domestic product at constant prices
GDPC	gross domestic product at current market prices
GDPP	private gross domestic product at constant prices
GEXP	total regional government expenditures
GREV	total regional government revenues
I_c	demand for investment good *c*
$INDEXE_c$	price index corresponding to exports by type of commodity *c*
$INDEXM_c$	price index corresponding to imports by type of commodity *c*
INV_s	investments carried out in branch *s* (actual level)
$INVS_s$	investments carried out in branch *s* (first estimate)
IT	total gross capital formation at constant prices (including inventories)
ITT	total investments in real terms
KL_s	value-added by branch
LSK_s	number of employees in branch *s*
LSR	active population
$MARGTM_{ctm}$	trade and transport margins

MEU_c	imports of commodity *c* from EU
MML_c	imports of commodity *c* from Mainland
MPS_{qu}	households propensity to save, by income group
$MROW_c$	imports of commodity *c* from the rest of the world
MT	total imports at constant prices
MUS_c	imports of commodity *c* from US
P_c	price level of domestic sales (composite commodities coming from imports and domestic production)
PCINDEX	consumer price index
$PCT_{c,qu}$	consumer prices (including taxes)
PDD_c	price index of domestic production delivered to home market by type of good *c*
$PDDE_c$	price index of domestic production delivered to home and foreign markets by type of good *c*
PD_s	price index of domestic production by branch of activity
$PEEU_c$	domestic price of exports to EU received by the domestic producers
$PEML_c$	domestic price of exports to Mainland received by the domestic producers
$PEROW_c$	domestic price of exports to the rest of the world received by the domestic producers
$PEUS_c$	domestic price of exports to US received by the domestic producers
PI	price index corresponding to composite investment good
PKavr	real average return to capital received by the household
PKL_s	price index corresponding to value-added by branch of activity
PK_s	return to capital by branch of activity
PL	national average wage (excluding social security contributions)
PLAVRT	national average wage (including social security contributions)
$PMEU_c$	domestic price of imports from EU
$PMML_c$	domestic price of imports from Mainland
$PMROW_c$	domestic price of imports from the rest of the world (including tariffs)
$PMUS_c$	domestic price of imports from US (including tariffs)
RINT	average return to capital corresponding to firms
$ROR_{s,t}$	normal rate of return to capital
rSGGDP	regional government savings to the GDP ratio
rSUBSIDGDP	total subsidies by the regional government to the GDP ratio
rTRANSGDP	total transfers by the regional government to the GDP ratio
rTRANSRGDP	total transfers received by the regional government to the GDP ratio
rTRPRODGDP	regional government revenues from taxes on products and on production to the GDP ratio
rTRPROPGDP	regional government revenues from taxes on income and wealth to the GDP ratio
S	total savings
SEU	balance of the current account with respect to EU
SF	firms savings
SGEC	net transfers by the European Commission to Azores
SGML	net transfers by the Mainland government to Azores

SH_{qu}	households savings by income group
SML	balance of the current account with respect to Mainland
SROW	balance of the current account with respect to ROW
SUBSID	total subsidies by the regional government
SUS	balance of the current account with respect to US
SV_c	inventories
TRANS	total transfers by the regional government
TRANSR	total transfers received by the regional government
TRPROD	regional government revenues from taxes on products and on production
TRPROP	regional government revenues from taxes on income and wealth
tyavr	average personal income tax rate
UNEMP	number of unemployed
UNRATE	unemployment rate
VU_{qu}	level of indirect utility corresponding to the households, by income group
X_c	domestic sales of composite commodities coming from imports and domestic production
XDD_c	domestic production delivered to home market
$XDDE_c$	domestic production delivered to home and foreign markets (by type of commodity)
XD_s	domestic production by branch of activity
YH_{qu}	households income, by income group
$\alpha ROR_{s,t}$	parameter in the supply of capital function

20. List of Exogenous variables

$CZ_{c,qu}$	consumer demand for commodity *c* (benchmark value)
$EDIEU_c$	export demand of commodity *c* from EU (benchmark value)
$EDIML_c$	export demand of commodity *c* from the Mainland (benchmark value)
$EDIROW_c$	export demand of commodity *c* from the rest of the world (benchmark value)
$EDIUS_c$	export demand of commodity *c* from US (benchmark value)
EREU	exchange rate with respect to EU
EREUZ	exchange rate with respect to EU (benchmark value)
ERML	exchange rate with respect to Mainland
ERMLZ	exchange rate with respect to Mainland (benchmark value)
ERROW	exchange rate with respect to the rest of the world
ERROWZ	exchange rate with respect to the rest of the world (benchmark value)
ERUS	exchange rate with respect to US
ERUSZ	exchange rate with respect to US (benchmark value)
GDPDEF	GDP deflator
KSK_s	capital demand by branch (capital stock)
LSRI	active population (benchmark value)
$MPSZ_{qu}$	households propensity to save, by income group (benchmark value)
PCINDEXZ	consumer price index (benchmark value)
$PEEUZ_c$	domestic price of exports to EU received by the domestic producers (benchmark value)
$PEMLZ_c$	domestic price of exports to Mainland received by the domestic producers (benchmark value)
$PEROWZ_c$	domestic price of exports to the rest of the world received by the domestic producers (benchmark value)
$PEUSZ_c$	domestic price of exports to US received by the domestic producers (benchmark value)
PKavrZ	real average return to capital received by the household (benchmark value)
PLZ	national average wage (excluding social security contributions) – benchmark value
$PWEEU_c$	price of exports to EU in foreign currency
$PWEML_c$	price of exports to Mainland in foreign currency
$PWEROW_c$	price of exports to ROW in foreign currency
$PWEUS_c$	price of exports to US in foreign currency
$PWMEU_c$	price of imports from EU in foreign currency
$PWMEUZ_c$	price of imports from EU in foreign currency (benchmark value)
$PWMML_c$	price of imports from Mainland in foreign currency
$PWMMLZ_c$	price of imports from Mainland in foreign currency (benchmark value)
$PWMROW_c$	price of imports from ROW in foreign currency

$PWMROWZ_c$	price of imports from ROW in foreign currency (benchmark value)
$PWMUS_c$	price of imports from US in foreign currency
$PWMUSZ_c$	price of imports from US in foreign currency (benchmark value)
PZ_c	price level of domestic sales (composite commodities coming from imports and domestic production) – benchmark value
$RORH_s$	historically normal rate of return to capital
SG	regional government savings
TRGEC	transfers received by the regional government from EU as direct subsidies on production
TRGEU	other transfers received by the regional government from EU
TRGML	transfers received by the regional government from the Mainland government
TRGUS	transfers received by the regional government from US
TRGW	transfers received by the regional government from the rest of the world
$TRHG_{qu}$	transfers received by the households from the regional government, by income group
$TRHML_{qu}$	transfers received by the households from the Mainland government, by income group
VUI_{qu}	level of indirect utility corresponding to the household, by income group (benchmark level)

21. List of Parameters

aA_c	efficiency parameter in the Armington function for imports
aF_s	efficiency parameter in the CES production function of the firm
aKL_s	Leontief parameter - share of value added in domestic production
aT_c	efficiency parameter in the CET function for exports
d_s	depreciation rate by branch of activity
$elasE_c$	price elasticity of export demand
elasLS	elasticity of labour supply
$elasS_{qu}$	elasticity of private savings with respect to after-tax rate of return, by income group
elasU	unemployment elasticity
err	error term in the wage curve equation
$io_{c,s}$	technical coefficients corresponding to intermediate consumption
$ioC_{s,c}$	shares of domestic production delivered to home and foreign markets by branch of activity and commodity
ioI_c	Leontief parameter for the investment demand by type of investment good
$KSKgmax_s$	maximum possible growth rate of capital stock in branch *s*
$KSKgmin_s$	minimum possible growth rate of capital stock in branch *s* (equal to the negative of the rate of depreciation in branch *s*)
$KSKtrend_s$	industry's historically normal growth rate
$premLSK_s$	wage premium over the average wage in domestic employment by branch
$shUNEMPB_{qu}$	share of unemployment benefits received by the households, by income group
shYKF	share of the net operating surplus retained by the firms
$shYKH_{qu}$	share of the net operating surplus received by the households, by income group
$shYLH_{qu}$	share of labour income received by the households, by income group
svr_c	share of inventories in domestic sales
$tc_{c,qu}$	tax rate corresponding to other taxes on private consumption of commodity *c*
$tchtm_{ctm,c,qu}$	quantity of commodity *ctm* as trade and transport services per unit of private consumption
$tchtmz_{ctm,c,qu}$	quantity of commodity *ctm* as trade and transport services per unit of private consumption (benchmark value)
$tcictm_{ctm,c,s}$	quantity of commodity *ctm* as trade and transport services per unit of intermediate consumption
$tcitm_{ctm,c}$	quantity of commodity *ctm* as trade and transport services per unit of investment goods
$tcitmz_{ctm,c}$	quantity of commodity *ctm* as trade and transport services per unit of investment goods (benchmark value)
$tcz_{c,qu}$	tax rate corresponding to other taxes on private consumption of commodity *c* (benchmark value)
$texc_{c,qu}$	excise duties rate on private consumption of commodity *c*

$texcz_{c,qu}$	excise duties rate on private consumption of commodity *c* (benchmark value)
tk_s	corporate tax rate in branch *s*
tl_s	social security contributions rate in branch *s*
$tmrw_c$	tariff rate applied on imports of commodity *c* from ROW
$tmus_c$	tariff rate applied on imports of commodity *c* from US
tp_s	tax rate on production in branch *s*
trep	replacement rate out of national average wage (net of social security contributions)
$tsic_{c,s}$	subsidy rate on intermediate consumption
$tspeuea_s$	subsidy rate on production from the European Agricultural Guidance and Guarantee Fund (EAGGF)
$tspeuer_s$	subsidy rate on production from the European Regional Development Fund (ERDF)
$tspeues_s$	subsidy rate on production from the European Social Fund (ESF)
$tspeufi_s$	subsidy rate on production from the Financial Instrument for Fisheries Guidance (FIFG)
tsp_s	subsidy rate on production in branch *s*
$tspusa_s$	subsidy rate on production from US
tyavrz	average personal income tax rate (benchmark level)
ty_{qu}	personal income tax rate by income group
tyz_{qu}	personal income tax rate by income group (benchmark level)
$vatc_{c,qu}$	value-added tax rate on private consumption of commodity *c*
$vatcz_{c,qu}$	value-added tax rate on private consumption of commodity *c* (benchmark value)
$vati_c$	value-added tax rate on investment good *c*
$vatic_{c,s}$	value-added tax rate on intermediate consumption of commodity *c*
$vatiz_c$	value-added tax rate on investment goods (benchmark level)
αCG_c	Cobb-Douglas preference parameter in the regional government utility function
$\alpha H_{c,qu}$	marginal budget shares in the Stone-Geary utility function
$\gamma A1_c$	CES distribution parameter for imports from Mainland in the Armington function
$\gamma A2_c$	CES distribution parameter for imports from EU in the Armington function
$\gamma A3_c$	CES distribution parameter for imports from US in the Armington function
$\gamma A4_c$	CES distribution parameter for imports from ROW in the Armington function
$\gamma A5_c$	CES distribution parameter for the domestic demand from the domestic producers in the Armington function
γFK_s	CES distribution parameter for capital in the production function of the firm
γFL_s	CES distribution parameter for labour in the production function of the firm
$\gamma T1_c$	CET distribution parameter for exports to Mainland
$\gamma T2_c$	CET distribution parameter for exports to EU
$\gamma T3_c$	CET distribution parameter for exports to US
$\gamma T4_c$	CET distribution parameter for exports to ROW

$\gamma T5_c$	CET distribution parameter for domestic production delivered to home markets
$\mu H_{c,qu}$	subsistence level out of consumer demand for commodities
σA_c	substitution elasticities for the Armington function
σF_s	CES capital-labour substitution elasticities by branch
σT_c	elasticities of transformation in the CET function

22. List of indices used in the model

c	a subscript for one of the commodities (45 types of commodities)
cc	the same as *c* (used for exposition purposes)
ctm	a subscript for trade and transport services (7 types of trade and transport services)
nctm	a subscript for all the other commodities except trade and transport services (38 types of commodities)
qu	a subscript for one of the households income groups (6 households income groups)
s	a subscript for one of the production activities (45 branches of activity)
ss	the same as *s* (used for exposition purposes)
t	a subscript for year *t*