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A Computable General Equilibrium Modeling Platform for the Azorean Economy: A simple approach with international trade

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RESUMO/ABSTRACT

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Computable general equilibrium models have become commonplace instruments of economic policy analysis in many developed countries. These models have gained increased acceptance due to their capacity to address many policy questions in a simple way, using now commonly available databases on the structure of production in the form of input-output matrices, while retaining traditional economic assumptions for household, firm and government behaviour, among others such as trade. In this paper we lay –out the model for application to the Azorean economy. The model contemplates households, firms, government, and trade. It is calibrated using a SAM built from a 1998 I-O table with all information updated to 2001. The impact of changes in trade is analysed.

Key words: CGE models; Ultra periphery; EU regional policy

JEL classification: C68

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A Computable General Equilibrium Modeling Platform for the Azorean Economy: A simple approach with international trade

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Abstract: Computable general equilibrium models have become commonplace instruments of economic policy analysis in many developed countries. These models have gained increased acceptance due to their capacity to address many policy questions in a simple way, using now commonly available databases on the structure of production in the form of input-output matrices, while retaining traditional economic assumptions for household, firm and government behaviour, among others such as trade. In this paper we lay –out the model for application to the Azorean economy. The model contemplates households, firms, government, and trade. It is calibrated using a SAM built from a 1998 I-O table with all information updated to 2001. The impact of changes in trade is analysed.

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1. Introduction

Analysing regional policy requires, quite often, that one look at the different levels of government that have a say in what exactly happens in one region. Depending on how government functions are set up, one might have to look at supra-national, national, regional and local government inputs into the policies that affect a certain region.

This is the case when we are analysing policy in the ultraperipheral regions of Europe. Even though French, Portuguese and Spanish regions are administered according to different political regimes, the set-up for policy analysis is the same. Some of the policies with significant impact in these regions are directly managed by the EU, some are managed by member state governments, others are the responsibility of the regional governments and yet some are managed by municipalities.

Construction of models capable of analysing not only ex-ante but also ex-post impacts of these policies is at a very incipient stage in all these regions. In the Azores and Madeira some econometric models have been specified to address very specific issues but with little use for current policy analysis (Fortuna, et al. (2006)). The same can be said for the other regions. Input-output models have been used in the past but not on a systematic basis.

Efforts are underway to surpass this gap with the construction of Computable General Equilibrium (CGE) models. CGE models have gained increased acceptance due to their capacity to deal with a wide variety of issues and to the fact that they do not require long statistical series as do econometric models (Menezes, et al (2006)). Even though constructing social accounting matrices is not as easy task, it is easier, in many cases, than obtaining relevant long series.

The purpose of the current paper is to specify the basic assumptions of a model to represent the economy of the Azores. This specification was made bearing in mind data limitations, at a first stage. The aim is to make the model increasingly more complex and capable of addressing ever more policy issues. The complexity of the model is constrained by data availability. The benefits of increased detail of policy analysis justify the effort put into data preparation.

In what follows we will start by describing the model, in detail, in section two. Section three briefly describes the data used and presents the model's prediction of a variation in trade flows. Section four discusses the major shortfalls of the model and the recommended extensions. In the final section some concluding remarks are presented.

Model description

2.1. General outline of the model

The main objective of this project is to develop a multi-sectoral, multi-regional dynamic modeling platform of the Azores economy integrated within the European and global context. The platform will have the highest capabilities of analysis and forecasting in Azores for problems related to structural sectoral and regional issues, agriculture, labor markets, public finance, trade, EU funds, regional development, environment, and energy. The modeling platform is intended to act as an analytical and quantitative support for policy-making.

The first version of the modelling platform of the Azores economy is represented by a static multi-sectoral computable general equilibrium model (CGE), which incorporates the economic behaviour of four economic agents: firms, households, government and the rest of the world. All economic agents are assumed to adopt an optimizing behaviour under relevant budget constraints and all markets operate under the perfect competition assumption. The goods-producing sectors, consisting of both public and private enterprises, are disaggregated into 16 sectors¹. The model distinguishes 16 types of commodities, such that each sector produces one homogenous commodity. 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.

Latter on, the core model for Azores will be developed into its multi-regional dimensions taking into account the islands or municipalities, depending on the data and needs. Dynamic feature will also be incorporated.

The core model for Azores is currently calibrated on the regional Social Accounting Matrix for 1998. The model has been solved by using the general algebraic modeling system GAMS (Brooke *et al.*, 1998).

The following conventions are adopted for the presentation of the model. Variable names are given in capital letters; small letters denote parameters calibrated from the database (SAM) and elasticity parameters. Subscript *sec* stands for an identifier of one of the 16 production activities and one of the 16 commodities. Subscript *ct* stands for an identifier of the wholesale and retail trade services. Subscript *nct* stands for an identifier of one of the 15 commodities (except wholesale and retail trade services).

2.2. Firms

The CGE model does not take into account the behaviour of individual firms, but of groups of similar ones aggregated into sectors. The model distinguishes 16 perfectly competitive production sectors (summarized in annex I).

The usual assumption for such a model is that producers operate on perfectly competitive markets and maximize profits (or minimize costs) to determine optimal levels of inputs and output. For example, for the firms operating internationally, the world market dictates the output price to a large extent, so, for an optimal outcome they have to produce as efficiently as possible. Some other firms are constrained in the costs level by domestic competitors. Thus, the optimizing producers minimize their production costs at every output level, given their production technology. Furthermore, production prices equal average and marginal costs, a condition that implies profit maximization for constant returns to scale technology.

¹ A presentation of the production sectors considered in the model is given in section 2.11.

Gross output for each sector is determined from a nested production structure. At the outer nest producers are assumed to choose intermediate inputs and a capital-labour (KL) bundle, according to a Leontief production function, which assume an optimal allocation of inputs. At the second nest, producers choose the optimal level of labour and capital, according to a constant elasticity of substitution (CES) function which assumes substitution possibilities between labour and capital. Rigidities in the labour market are further introduced by the inter-sectoral wage differentials. The inter-sectoral wage differentials are derived as the ratio between the sectoral wage rate and the average wage rate at the national level (Dervis, De Melo and Robinson, 1982).

The demand equations for intermediate inputs, labour and capital and the corresponding zero profit conditions for these sectors are provided in annex II, equations (2.12.5)-(2.12.9). The nested structure and the functional forms used by these sectors are further given in figure 1.

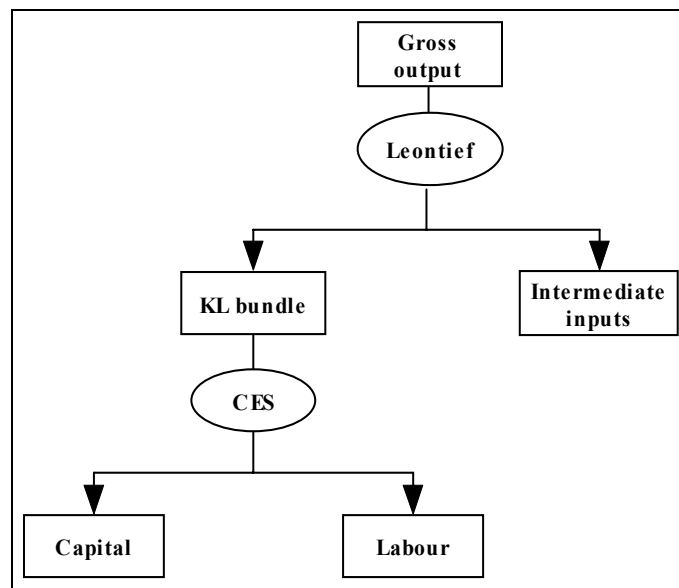


Figure 1. The nested Leontief and CES production technology for the production sectors

Treated at an aggregate level, firms receive income from sales of goods; they purchase intermediate inputs, make wage payments and save (see equation(2.12.10), annex II).

2.3. Households

The households receive income from labour and a fixed share of the capital income and transfers from the government as unemployment benefits (see equation (2.12.2), annex II) and pay taxes on income to government and save a fixed fraction of net (money) income (see equation (2.12.3), annex II). Further, households' budget devoted to consumption of commodities is given by the total income minus the taxes and savings (see equation(2.12.4), annex II). A schematic representation of households' decisions is given in figure 2.

The optimal allocation between the consumption commodities (C_{sec}) is given by maximizing a Stone-Geary utility function:

$$U(C_{sec}) = \prod_{sec} (C_{sec} - \mu H_{sec})^{\alpha H_{sec}} \quad (1)$$

subject to the budget constraint:

$$CBUD = (1 - t_{sc_{sec}}) \cdot (1 + t_{sc_{sec}}) \cdot P_{sec} \cdot C_{sec} \quad (2)$$

where: $\sum_{sec} \alpha H_{sec} = 1$.

C_{sec} represents the consumption of commodity sec by the households, P_{sec} is the consumer price net of taxes for the commodity sec , μ_{sec} is the minimum (subsistence) level of consumption of commodity sec by the households, and αH_{sec} is the income elasticity of the demand for commodity sec .

Sixteenth categories of consumer goods are distinguished. As already explained, each production sector is assumed to produce one homogenous commodity. Thus, the classification of the commodities follows the classification of the production sectors.

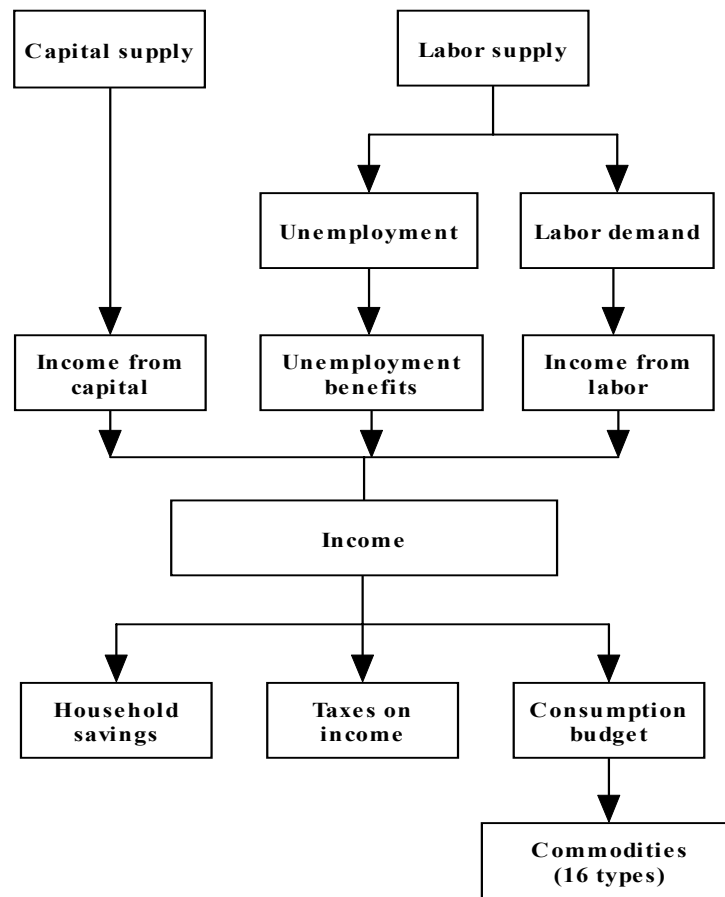


Figure 2. Decision structure of the households

Consumption is valued at consumer prices $(1 - t_{sc_{sec}}) \cdot (1 + t_{sc_{sec}}) \cdot P_{sec}$, which incorporate taxes on consumption ($t_{sc_{sec}}$) and subsidies on consumption ($t_{sc_{sec}}$).

After some rearrangements, the optimization process generates the demand equations for consumption commodities (see equations(2.12.1), annex II)².

To evaluate the overall change in consumer welfare we use the equivalent variation in income (EV), which is based on the concept of a money metric indirect utility function (Varian, 1992):

² The Linear Expenditure System (LES) was developed by Stone (1954) and represents a set of consumer demand equations linear in total expenditure.

$$EV = (V-VZ) \cdot \prod_{sec} \left[\frac{PZ_{sec} \cdot (1+tc_{sec}) \cdot (1-tsc_{sec})}{\alpha H_{sec}} \right]^{\alpha H_{sec}} \quad (3)$$

The indirect utility function of the LES function in the counter-factual (policy scenario) equilibrium (V) is defined as:

$$V = \left[CBUD - \sum_{sec} P_{sec} \cdot (1+tc_{sec}) \cdot (1-tsc_{sec}) \cdot \mu H_{sec} \right] \cdot \prod_{sec} \left[\alpha H_{sec} / (P_{sec} \cdot (1+tc_{sec}) \cdot (1-tsc_{sec})) \right]^{\alpha H_{sec}} \quad (4)$$

and the indirect utility function of the LES function in the benchmark equilibrium (VZ) is given by:

$$VZ = \left[CBUDZ - \sum_{sec} PZ_{sec} \cdot (1+tc_{sec}) \cdot (1-tsc_{sec}) \cdot \mu H_{sec} \right] \cdot \prod_{sec} \left[\alpha H_{sec} / (PZ_{sec} \cdot (1+tc_{sec}) \cdot (1-tsc_{sec})) \right]^{\alpha H_{sec}} \quad (5)$$

where $CBUDZ$ reflects the household's budget available for consumption in the benchmark equilibrium, PZ_{sec} is the price of commodity sec in the benchmark and tc_{sec} and tsc_{sec} are the consumption tax rate and the subsidy rate in the benchmark equilibrium, respectively.

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 (Harrison and Kriström, 1997).

2.4. Government

Government revenues ($TAXR$) consist of taxes on households' income, consumption taxes, taxes on investment goods and taxes on production plus transfers received by the government from the rest of the world:

$$TAXR = ty \cdot YH + \sum_{sec} (P_{sec} \cdot C_{sec} \cdot (1-tsc_{sec}) \cdot tc_{sec} + XD_{sec} \cdot PD_{sec} \cdot tp_{sec}) + \sum_{sec} P_{sec} \cdot I_{sec} \cdot tcinv_{sec} + ER \cdot TRGW \quad (6)$$

where ty is the tax rate on households income (YH), tp_{sec} is the tax on production of sector sec and $tcinv_{sec}$ is the tax rate on investment good sec . XD_{sec} represents the gross output of sector sec , where its price is given by PD_{sec} , and I_{sec} reflects the demand for the investment commodity sec . The transfers received by the government from the rest of the world ($TRGW$) are transformed in domestic currency by multiplying them with the exchange rate (ER).

Government expenditures ($GEXP$) consists of disposable budget for current consumption ($CGBUD$), unemployment benefits to the households' and subsidies on consumption and production:

$$GEXP = CGBUD + trep \cdot PL \cdot UNEMP + \sum_{sec} (P_{sec} \cdot C_{sec} \cdot tsc_{sec} + XD_{sec} \cdot PD_{sec} \cdot tsp_{sec}) \quad (7)$$

where $UNEMP$ represents the number of unemployed, PL is the average wage rate, $trep$ is the replacement rate out of the average wage rate, tsc_{sec} is the subsidy rate on consumption of commodity sec and tsp_{sec} is the subsidy rate on production of sector sec .

Thus, government savings are given by the difference between government revenues and government expenditures:

$$SG = TAXR - GEXP \quad (8)$$

The optimal consumption of commodities by the government is given by the maximization of a Cobb-Douglas utility function:

$$U(CG_{sec}) = \prod_{sec} CG_{sec}^{\alpha CG_{sec}} \quad (9)$$

subject to the budget constraint:

$$CGBUD = \sum_{sec} CG_{sec} \cdot P_{sec} \quad (10)$$

with: $\sum_{sec} \alpha CG_{sec} = 1$. The optimization process yields the demand equations for each type of commodity (see equation (2.12.13), annex II).

2.5. Foreign trade

The specification of foreign trade is based on the small-country assumption, which means that the country is a price taker in both its imports and exports markets. As a result, both world import prices and world export prices are exogenously fixed. Two main groups of trading partners are distinguished in the model: the Mainland and the rest of the world.

The assumption of limited substitution possibilities between domestically produced and imported goods, which goes back to Armington (1969), is now a standard feature of applied models and will also be adopted here. It indicates that domestic consumers use composite goods (X_{sec}) of imported and domestically produced goods, according to a CES function:

$$X_{sec} = aA_{sec} \cdot (\gamma A1_{sec} \cdot MML_{sec}^{-\rho A_{sec}} + \gamma A2_{sec} \cdot MROW_{sec}^{-\rho A_{sec}} + \gamma A3_{sec} \cdot XDD_{sec}^{-\rho A_{sec}})^{-1/\rho A_{sec}} \quad (11)$$

Minimizing the cost function:

$$Cost_{sec}(MML_{sec}, MROW_{sec}, XDD_{sec}) = PMML_{sec} \cdot MML_{sec} + PMROW_{sec} \cdot MROW_{sec} + PDD_{sec} \cdot XDD_{sec} \quad (12)$$

subject to (11), yields the demand equations for imports from Mainland (MML_{sec}), for imports from the rest of the world ($MROW_{sec}$) and domestically produced goods (XDD_{sec}) (see equations (2.12.16)-(2.12.18), annex II); where aA_{sec} is the efficiency parameter, $\gamma A1_{sec}$, $\gamma A2_{sec}$, $\gamma A3_{sec}$ are the distribution parameters and the elasticity of substitution between imports from different regions and domestically produced goods (σA_{sec}) is given by $1/(1 + \rho A_{sec})$. $PMML_{sec}$ is the domestic price of imports of commodity sec from Mainland including trade margins, $PMROW_{sec}$ is the domestic price of imports of commodity sec from the rest of the world including trade margins,

and PDD_{sec} is the price of domestically produced commodity sec delivered to the domestic market also including trade margins.

The corresponding zero profit condition for the CES function is given by:

$$P_{sec} \cdot X_{sec} = PMML_{sec} \cdot MML_{sec} + PMROW_{sec} \cdot MROW_{sec} + PDD_{sec} \cdot XDD_{sec} \quad (13)$$

where P_{sec} is the composite price of commodity sec net of taxes.

A limited substitution is also assumed to exist between goods produced for the domestic market (XDD_{sec}), exports to Mainland (EML_{sec}) and exports to the rest of the world ($EROW_{sec}$), as captured by a constant elasticity of transformation (CET) function:

$$XD_{sec} = aT_{sec} \cdot (\gamma T1_{sec} \cdot EML_{sec}^{-\rho T_{sec}} + \gamma T2_{sec} \cdot EROW_{sec}^{-\rho T_{sec}} + \gamma T3_{sec} \cdot XDD_{sec}^{-\rho T_{sec}})^{-1/\rho T_{sec}} \quad (14)$$

where aT_{sec} is the efficiency parameter, $\gamma T1_{sec}$, $\gamma T2_{sec}$, $\gamma T3_{sec}$ are the distribution parameters, and the elasticity of substitution (σT_{sec}) between exports to different regions and domestically produced goods delivered to domestic market is given by $1/(1 + \rho T_{sec})$.

By maximizing the revenue function of the producer:

$$Revenue_{sec}(EML_{sec}, EROW_{sec}, XDD_{sec}) = PEML_{sec} \cdot EML_{sec} + PEROW_{sec} \cdot EROW_{sec} + PDS_{sec} \cdot XDD_{sec} \quad (15)$$

subject to (14) we derive the demand equations for exports and domestically produced goods (see equations (2.12.20)-(2.12.22), annex II), where $PEML_{sec}$ is the domestic price of exports of sector sec to the Mainland, $PEROW_{sec}$ is the domestic price of exports of sector sec to the rest of the world, and PDS_{sec} is the price of domestic output of sector sec delivered to domestic market excluding trade margins.

The zero profit condition for the CET function is further given by:

$$PD_{sec} \cdot XD_{sec} = PEML_{sec} \cdot EML_{sec} + PEROW_{sec} \cdot EROW_{sec} + PDS_{sec} \cdot XDD_{sec} \quad (16)$$

where PD_{sec} is the price of output produced by sector sec . Both exports and domestic output delivered to the domestic market are valued at basic prices, $PEML_{sec}$, $PEROW_{sec}$ and PDS_{sec} .

The balance of payments is now determined as all international incoming and outgoing payments have been taken into account:

$$\sum_{sec} (MML_{sec} \cdot PWMMLZ_{sec} + MROW_{sec} \cdot PWMROWZ_{sec}) = \sum_{sec} (EML_{sec} \cdot PEMLZ_{sec} + EROW_{sec} \cdot PWEROWZ_{sec}) + TRGW + SW + LW \cdot PLWZ \quad (17)$$

The surplus/deficit of the balance of payments (SW), expressed in foreign currency, is determined by the difference between imports and exports, valued at world prices, the transfers received by the government from the rest of the world ($TRGW$) and the labor income from non-residential firms ($LW \cdot PLWZ$), where $PWMMLZ_{sec}$ is the foreign price of imports of commodity sec from the Mainland, $PWMROWZ_{sec}$ is the foreign price of imports of commodity sec from the rest of the world, and $PEMLZ_{sec}$, $PWEROWZ_{sec}$ are

the foreign prices of exports of sector sec to the Mainland and to the rest of the world, respectively.

2.6. Investment demand

Total national savings are given by:

$$S = SH + SF + SG - SW \cdot ER + \sum_{sec} DEP_{sec} \cdot PI \quad (18)$$

where SH are the households' savings, SF firms savings, SG government savings and DEP_{sec} is the depreciation of the capital stock. Depreciation is modelled as a fixed share of capital stock (see equation (2.12.26), annex II).

The demand for investment commodities by type of commodity (I_{sec}) is modelled in a simple way, by maximizing a Cobb-Douglas utility function:

$$U(I_{sec}) = \prod_{sec} I_{sec}^{\alpha_{sec}} \quad (19)$$

subject to the budget constraint:

$$S - \sum_{sec} SV_{sec} \cdot P_{sec} = \sum_{sec} I_{sec} \cdot P_{sec} \cdot (1 + tcinv_{sec}) \quad (20)$$

with $\sum_{sec} \alpha_{sec} = 1$, where SV_{sec} are the changes in stocks of commodity sec and $tcinv_{sec}$ is the tax rate on investment commodity sec . Changes in stocks are modelled in this case as a fixed share out of supply of commodities (see equation (2.12.27), annex II). Further, the maximization process yields the demand equations for investment commodities by type of commodity (see equation (2.12.28), annex II). The price of the composite investment commodity is further given by:

$$PI = \prod_{sec} [(P_{sec} \cdot (1 + tcinv_{sec})) / \alpha_{sec}]^{\alpha_{sec}} \quad (21)$$

2.7. 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 relative prices. Therefore, a particular price is selected to provide the numeraire price level against which all relative prices in the model will be measured. In this case, the GDP deflator ($GDPDEF$) is chosen as the numeraire.

Different prices are distinguished for all producing sectors, exports and imports. The domestic price of exports to Mainland ($PEML_{sec}$) reflects the price received by the domestic producers for selling their output to the Mainland, where $PWEMLZ_{sec}$ is the foreign price of exports to Mainland and ER is the exchange rate. The cost of trade inputs further reduces the domestic price received by the producers:

$$PEML_{sec} = PWEMLZ_{sec} \cdot ER - \sum_{ct} tcoeml_{ct,sec} \cdot P_{ct} \quad (22)$$

where $tcoeml_{ct,sec}$ is the quantity of commodity ct as trade input per unit of commodity sec exported and P_{ct} represents the price of commodity ct . Commodity ct is in fact the

wholesale and retail sale commodity. In a similar way is defined the domestic price of exports to the rest of the world (see equation (2.12.38), annex II).

The domestic price of imports from Mainland ($PMML_{sec}$) is determined by the foreign price of imports from Mainland ($PWMLZ_{sec}$), the exchange rate, and the cost of trade inputs for imports:

$$PMML_{sec} = ER \cdot PWMLZ_{sec} + \sum_{ct} tcomm_{ct,sec} \cdot P_{ct} \quad (23)$$

where $tcomm_{ct,sec}$ is the quantity of commodity ct as trade input per imported unit of commodity sec .

The model distinguishes the price of domestic output supplied to domestic market paid by the consumers (PDD_i) and the price received by the producers (PDS_i). The difference between the two prices is represented by the cost of trade inputs for domestic output delivered to domestic market:

$$PDD_{sec} = PDS_{sec} + \sum_{ct} tcod_{ct,sec} \cdot P_{ct} \quad (24)$$

where $tcod_{ct,sec}$ is the quantity of commodity ct as trade input per unit of commodity sec delivered to the domestic market.

The consumer price index ($INDEX$) used in the model is of the Laspeyres type and is defined as:

$$INDEX = \frac{\sum_{sec} [P_{sec} \cdot CZ_{sec} \cdot (1+t_{sec}) \cdot (1-tsc_{sec})]}{\sum_{sec} [PZ_{sec} \cdot CZ_{sec} \cdot (1+t_{sec0}) \cdot (1-tsc0_{sec})]} \quad (25)$$

Furthermore, GDP deflator is defined as the ratio of GDP at current market prices to GDP at constant prices (see equation (2.12.42), annex II).

2.8. Labour market

Labour services are used by firms in the production process (see equation (2.12.7), annex II). The model also allows for endogenous unemployment. Thus, the average wage rate paid by the firms is a function of consumer prices and the unemployment rate, as follows:

$$\frac{(PL/INDEX)}{(PLZ/INDEXZ)} - 1 = \beta \cdot \left(\frac{UNEMP/LSR}{UNEMPZ/LSRZ} - 1 \right) \quad (26)$$

where LSR is the domestic labor supply, PL is the average wage rate in the current year and β is a parameter. PLZ , $INDEXZ$, $UNEMPZ$ and $LSRZ$ represent the average wage rate, the consumer price index, the unemployment level and the domestic labor supply in the base year, respectively.

A labor supply curve, which assumes a positive correlation between the domestic labor supply and the real average wage rate:

$$LSR = LSRZ \cdot \left(\frac{PL \cdot INDEXZ}{PLZ \cdot INDEX} \right)^{elasLS} \quad (27)$$

is used to endogenize labor supply in the model, where $elasLS$ is the real wage elasticity of labor supply.

Labour market is closed by changes in unemployment:

$$\sum_{sec} LSK_{sec} = LSR - UNEMP \quad (28)$$

where LSK_{sec} is the labor demand by sector sec . Further, total labor supply (LS) is given by:

$$LS = LSR + LW \quad (29)$$

where LW is the labor supply to non-residential firms.

2.9. Market clearing equations

Equilibrium in the product, capital and labour markets requires that demand equals supply at the prevailing prices (taking into account unemployment for the labour market). The clearing equation for the labour market has already been presented above (see equation (28)).

Similarly, the sum of demand for intermediate inputs nct (excluding the wholesale and retail trade commodity) of sector sec ($io_{nct,sec} \cdot XD_{sec}$), of demand for government and households consumption, of demand for investment goods and inventories must equal the supply of the composite good nct from domestic deliveries and imports (X_{nct}):

$$\sum_{sec} io_{nct,sec} \cdot XD_{sec} + C_{nct} + I_{nct} + SV_{nct} + CG_{nct} = X_{nct} \quad (30)$$

For the wholesale and retail trade commodity the market clearing equation is given by:

$$\sum_{sec} io_{ct,sec} \cdot XD_{sec} + C_{ct} + I_{ct} + SV_{ct} + CG_{ct} + MARG_{ct} = X_{ct} \quad (31)$$

where $MARG_{ct}$ is the demand for trade services (Löfgren, Harris and Robinson, 2002). Total demand for trade services is further given by the sum of demand for trade services generated by the domestic output delivered to the domestic market, of the demand for trade services generated by the imports, and of the demand for trade services generated by the exports:

$$MARG_{ct} = \sum_{sec} (t_{cod}_{ct,sec} \cdot XDD_{sec} + t_{comml}_{ct,sec} \cdot MML_{sec} + t_{comrow}_{ct,sec} \cdot MROW_{sec} + t_{coeml}_{ct,sec} \cdot EML_{sec} + t_{coerow}_{ct,sec} \cdot EROW_{sec}) \quad (32)$$

Further, capital stock is fixed by sector; therefore the equation for the clearing of the capital market has been dropped.

2.10. Closure rules

The closure rule refers 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.

To balance the number of endogenous variables and the number of independent equations in the model, additional assumptions are needed. Therefore, the transfers received by the government from the rest of the world and the labour income from non-residential firms is exogenously fixed in real terms. Further, in order to achieve the clearing of the labour market, inter-sectoral mobility of labour is assumed. However, the

presence of unemployment introduces rigidities in the labour market. The unemployment is endogenously determined through a wage curve. Labour supply is endogenously determined through a labor supply curve. On the capital market the sectoral capital stock is exogenously fixed, introducing rigidities.

The most widely accepted macro closure rule for CGE models implies the assumption that 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. The interest rate is assumed to effectively balance the supply and demand for investments, even if the specific mechanism is not incorporated in the model. This macro closure rule is neoclassical in spirit. However, the fact that the model allows for unemployment introduces a Keynesian element. As already mentioned, in models of this size it is not uncommon that a few closure rules are combined to get as close as possible to a realistic representation of the economy.

The government behaviour is modelled through an optimization process, which yields the optimal allocation of governments' consumption by type of commodity. The budget deficits/surpluses of the government is fixed as a share of GDP. For the external sector, the surplus/deficit of the balance of payments is fixed and the endogenous exchange rate brings the balance of payments into equilibrium.

Gross domestic product is given at both constant prices and at current market prices (see equations (2.12.43)-(2.12.44), annex II). 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, balance of payments equation (equation (17)) has been dropped. However, the system of equations guarantees, through Walras' law, that its balance is equal to the difference between the exports and imports and the transfers from the rest of the world.

3. Data and Results

In order to calibrate the model data was collected to complete a SAM matrix. As referred before a 1998 input- output matrix for the Azores (Alves (2004)) was used. The sector detail was determined by the size of the input-output table, restricted to sixteen sectors. As a consequence, it is assumed that there are sixteen sectors all following the same optimizing behaviour. One single level of government was assumed. It was also assumed that there was a single household. Trade is done with two regions, the mainland and the rest of the world.

The structure of the economy was assumed not to change between 1998 and 2001. As such, all data, aside from the input-output table, was compiled for 2001.

On the basis of these assumptions the model was calibrated and a scenario was created to analyse the impact of a 10 % decrease in exports to the rest of the world.

Macroeconomic variables	
GDP (% change)	-0,22
Unemployment rate (%)	2,97
Change in unemployment rate (% points)	0,05

Welfare gains/losses (thousands EURO)	-8.589
Welfare gains/losses (% of households income)	-0,65

4. Model Extensions

The model presented above represents a first attempt at a comprehensive multi-sector modelling of the Azorean economy.

As it is specified, however, it does not contemplate a number of interesting policy issues. The following is a list of some of them:

- a. not all sectors are competitive, transportation, energy supply and telecommunications being some of the most representative examples;
- b. all government expenditure is done through a single level of government while in fact there are at least three relevant levels, the EU, the central and the regional;
- c. trade occurs only with two regions, the mainland and the rest of the world, erasing some interesting regional ties such as the EU and the USA;
- d. the sectors are too aggregated making it impossible to address sector specific issues such as dairy support policies or air transport support policies, for example;
- e. there is a single household, which makes it impossible to analyse the redistributive impact of policies.

Depending on the objectives of analysis, other issues can also be added to the list. These are however those we consider more relevant and easily addressed. As such, work is underway to:

- i. extend the detail of the SAM matrix to 45 sectors based on an input-output matrix constructed for 2001;
- ii. extend the number of government agents to 4 – Foreign, EU, national, regional and municipal;
- iii. make some of the sectors non-competitive;
- iv. expand trade treatment to consider additional regions – mainland, EU, USA and rest of the world;
- v. expand the number of households to three – low income, middle income and high income.

Other policy issues need also to be addressed such as trade restrictions and differentiated tax treatments.

5. Conclusion

In the above section we specified a simple CGE model with general characteristics of models of this nature. The purpose of the exercise was to arrive at a characterization of

the economy of the Azores, with a final objective of arriving at an instrument useful for economic and social policy analysis.

The model is standard in most respects but it was possible to use it in various exercises of the impact of policy measures and of external shocks. In one of the exercises conducted increased government expenditures were assumed. In another an external decrease in export demand was analysed. In both cases general impacts and detailed sector impact can be extracted from the output of the model.

The model, as specified, however, falls short of answering a series of interesting policy issues and is built on a data set that needs considerable improvement. The major shortfalls are associated to the lack of sector detail, desirable for analysing EU policies, for example, the concentration of government policy in one single level, lack of desegregation of trade partners, etc. These drawbacks set an agenda for new improvements in the model.

The current exercise, however, has constituted a positive contribution towards better characterizing the economy of the Azores and the impact of policies that, so far were only evaluated on the basis of empirical feelings and qualitative measures.

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Annex I

Classification of the production sectors in the SAM and in the core model for Azores

Table 17. Classification of the production sectors in the SAM and in the core model for Azores

Code Azores core model	Classification of the production sectors in the SAM and in AzoresMod	NACE Division
sec1	Products of agriculture, hunting and forestry	A
sec2	Fish	B
sec3	Products from mining and quarrying	C
sec4	Manufactured products	D
sec5	Electrical energy, gas, steam and hot water	E
sec6	Construction work	F
sec7	Wholesale and retail trade services; repair services of motor vehicles, motorcycles and personal and household goods	G
sec8	Hotel and restaurant services	H
sec9	Transport, storage and communication services	I
sec10	Financial intermediation services	J
sec11	Real estate, renting and business services	K
sec12	Public administration and defence services, compulsory social security services	L
sec13	Education services	M
sec14	Health and social services	N
sec15	Other community, social and personal services	O
sec16	Private household with employed persons	P

Annex II

Equations of the simulation model

2.11. Model equations

2.12.1. Households

$$P_{sec} \cdot C_{sec} \cdot (1 + tc_{sec}) \cdot (1 - tsc_{sec}) = P_{sec} \cdot \mu H_{sec} \cdot (1 + tc_{sec}) \cdot (1 - tc_{sec}) + \alpha H_{sec} \cdot (CBUD - \sum_{sec c} \mu H_{sec c} \cdot P_{sec c} \cdot (1 + tc_{sec c}) \cdot (1 - tsc_{sec c}))$$

(2.12.33)

$$YH = aich \cdot \sum_{sec} KSK_{sec} \cdot RK_{sec} + \sum_{sec} LSK_{sec} \cdot wdif_{sec} \cdot PL + trep \cdot PL \cdot UNEMP + PLWZ \cdot ER \cdot LW$$

(2.12.34)

$$SH = mps \cdot (YH - ty \cdot YH)$$

(2.12.35)

$$CBUD = YH - ty \cdot YH - SH$$

(2.12.36)

2.12.2. Firms

$$aKL_{sec} \cdot XD_{sec} = KL_{sec}$$

(2.12.37)

$$(1 - tp_{sec} + tsp_{sec}) \cdot PD_{sec} \cdot XD_{sec} = KL_{sec} \cdot PKL_{sec} + \sum_{sec c} io_{sec c, sec} \cdot XD_{sec} \cdot P_{sec c}$$

(2.12.38)

$$LSK_{sec} = KL_{sec} \cdot [PKL_{sec} / (PL \cdot wdif_{sec})]^{\sigma P_{sec}} \cdot \gamma P 2_{sec}^{\sigma P_{sec}} \cdot aP_{sec}^{(\sigma P_{sec} - 1)}$$

(2.12.39)

$$KSK_{sec} = KL_{sec} \cdot (PKL_{sec} / (RK_{sec} + d_{sec} \cdot PI))^{\sigma P_{sec}} \cdot \gamma P 1_{sec}^{\sigma P_{sec}} \cdot aP_{sec}^{(\sigma P_{sec} - 1)}$$

(2.12.40)

$$PKL_{sec} \cdot KL_{sec} = RK_{sec} \cdot KSK_{sec} + DEP_{sec} \cdot PI + PL \cdot LSK_{sec} \cdot wdif_{sec}$$

(2.12.41)

$$SF = aicf \cdot \sum_{sec} KSK_{sec} \cdot RK_{sec}$$

(2.12.42)

2.12.3. Government

$$TAXR = ty \cdot YH + \sum_{sec} [P_{sec} \cdot C_{sec} \cdot (1 - tsc_{sec}) \cdot tc_{sec} + XD_{sec} \cdot PD_{sec} \cdot tp_{sec} + P_{sec} \cdot I_{sec} \cdot tcinv_{sec}] + ER \cdot TRGW$$

(2.12.43)

$$GEXP = CGBUD + trep \cdot PL \cdot UNEMP + \sum_{sec} [P_{sec} \cdot C_{sec} \cdot tsc_{sec} + XD_{sec} \cdot PD_{sec} \cdot tsp_{sec}]$$

(2.12.44)

$$P_{sec} \cdot CG_{sec} = \alpha G_{sec} \cdot CGBUD$$

(2.12.45)

$$SG = TAXR - GEXP$$

(2.12.46)

$$RATIO = SG / GDPC$$

(2.12.47)

2.12.4. Foreign trade

$$MML_{sec} = (X_{sec} / aA_{sec}) \cdot (\gamma A1_{sec} / PMML_{sec})^{\sigma A_{sec}} \cdot [\gamma A1_{sec}^{\sigma A_{sec}} \cdot PMML_{sec}^{(1 - \sigma A_{sec})} + \gamma A2_{sec}^{\sigma A_{sec}} \cdot PMROW_{sec}^{(1 - \sigma A_{sec})} + \gamma A3_{sec}^{\sigma A_{sec}} \cdot PDD_{sec}^{(1 - \sigma A_{sec})}] \sigma A_{sec} / (1 - \sigma A_{sec})$$

(2.12.48)

$$MROW_{sec} = (X_{sec} / aA_{sec}) \cdot (\gamma A2_{sec} / PMROW_{sec})^{\sigma A_{sec}} \cdot [\gamma A1_{sec}^{\sigma A_{sec}} \cdot PMML_{sec}^{(1 - \sigma A_{sec})} + \gamma A2_{sec}^{\sigma A_{sec}} \cdot PMROW_{sec}^{(1 - \sigma A_{sec})} + \gamma A3_{sec}^{\sigma A_{sec}} \cdot PDD_{sec}^{(1 - \sigma A_{sec})}] \sigma A_{sec} / (1 - \sigma A_{sec})$$

(2.12.49)

$$XDD_{sec} = (X_{sec} / aA_{sec}) \cdot (\gamma A3_{sec} / PDD_{sec})^{\sigma A_{sec}} \cdot [\gamma A1_{sec}^{\sigma A_{sec}} \cdot PMML_{sec}^{(1 - \sigma A_{sec})} + \gamma A2_{sec}^{\sigma A_{sec}} \cdot PMROW_{sec}^{(1 - \sigma A_{sec})} + \gamma A3_{sec}^{\sigma A_{sec}} \cdot PDD_{sec}^{(1 - \sigma A_{sec})}] \sigma A_{sec} / (1 - \sigma A_{sec})$$

(2.12.50)

$$P_{sec} \cdot X_{sec} = PMML_{sec} \cdot MML_{sec} + PMROW_{sec} \cdot MROW_{sec} + PDD_{sec} \cdot XDD_{sec}$$

(2.12.51)

$$EML_{sec} = (XD_{sec} / aT_{sec}) \cdot (\gamma T1_{sec} / PEML_{sec})^{\sigma T_{sec}} \cdot [\gamma T1_{sec}^{\sigma T_{sec}} \cdot PEML_{sec}^{(1 - \sigma T_{sec})} + \gamma T2_{sec}^{\sigma T_{sec}} \cdot PEROW_{sec}^{(1 - \sigma T_{sec})} + \gamma T3_{sec}^{\sigma T_{sec}} \cdot PDS_{sec}^{(1 - \sigma T_{sec})}] \sigma T_{sec} / (1 - \sigma T_{sec})$$

(2.12.52)

$$EROW_{sec} = (XD_{sec}/aT_{sec}) \cdot (\gamma T2_{sec}/PEROW_{sec})^{\sigma T_{sec}} \cdot [\gamma T1_{sec}^{\sigma T_{sec}} \cdot PEML_{sec}^{(1-\sigma T_{sec})} + \gamma T2_{sec}^{\sigma T_{sec}} \cdot PEROW_{sec}^{(1-\sigma T_{sec})} + \gamma T3_{sec}^{\sigma T_{sec}} \cdot PDS_{sec}^{(1-\sigma T_{sec})}] \sigma T_{sec}/(1-\sigma T_{sec})$$

(2.12.53)

$$XDD_{sec} = (XD_{sec}/aT_{sec}) \cdot (\gamma T3_{sec}/PDS_{sec})^{\sigma T_{sec}} \cdot [\gamma T1_{sec}^{\sigma T_{sec}} \cdot PEML_{sec}^{(1-\sigma T_{sec})} + \gamma T2_{sec}^{\sigma T_{sec}} \cdot PEROW_{sec}^{(1-\sigma T_{sec})} + \gamma T3_{sec}^{\sigma T_{sec}} \cdot PDS_{sec}^{(1-\sigma T_{sec})}] \sigma T_{sec}/(1-\sigma T_{sec})$$

(2.12.54)

$$PD_{sec} \cdot XD_{sec} = PEML_{sec} \cdot EML_{sec} + PEROW_{sec} \cdot EROW_{sec} + PDS_{sec} \cdot XDD_{sec}$$

(2.12.55)

2.12.5. Investments

$$PI = \prod_{sec} [(P_{sec} \cdot (1+tcinv_{sec})) / \alpha I_{sec}]^{\alpha I_{sec}}$$

(2.12.56)

$$S = SH + SF + SG - SW \cdot ER + \sum_{sec} DEP_{sec} \cdot PI$$

(2.12.57)

$$DEP_{sec} = d_{sec} \cdot KSK_{sec}$$

(2.12.58)

$$SV_{sec} = svr_{sec} \cdot X_{sec}$$

(2.12.59)

$$(1+tcinv_{sec}) \cdot P_{sec} \cdot I_{sec} = \alpha I_{sec} \cdot (S - \sum_{secc} SV_{secc} \cdot P_{secc})$$

(2.12.60)

2.12.6. Labor market

$$\sum_{sec} LSK_{sec} = LSR - UNEMP$$

(2.12.61)

$$LS = LSR + LW$$

(2.12.62)

$$LSR = LSRZ \cdot ((PL \cdot INDEXZ) / (PLZ \cdot INDEX))^{elasLS}$$

(2.12.63)

$$(PL / INDEX) / (PLZ / INDEXZ) - 1 = \text{beta} \cdot ((UNEMP / LSR) / (UNEMPZ / LSRZ) - 1)$$

(2.12.64)

2.12.7. Market clearing

$$MARG_{ct} = \sum_{sec} (t\text{cod}_{ct,sec} \cdot XDD_{sec} + t\text{comml}_{ct,sec} \cdot MML_{sec} + t\text{comrow}_{ct,sec} \cdot MROW_{sec} + t\text{coeml}_{ct,sec} \cdot EML_{sec} + t\text{coerow}_{ct,sec} \cdot EROW_{sec})$$

(2.12.65)

$$\sum_{sec} i\text{o}_{nct,sec} \cdot XD_{sec} + C_{nct} + I_{nct} + SV_{nct} + CG_{nct} = X_{nct} \quad (2.12.66)$$

$$\sum_{sec} i\text{o}_{ct,sec} \cdot XD_{sec} + C_{ct} + I_{ct} + SV_{ct} + CG_{ct} + MARG_{ct} = X_{ct}$$

(2.12.67)

2.12.8. Price equations

$$INDEX = \left[\sum_{sec} P_{sec} \cdot CZ_{sec} \cdot (1 + t\text{c}_{sec}) \cdot (1 - t\text{sc}_{sec}) \right] / \left[\sum_{sec} PZ_{sec} \cdot CZ_{sec} \cdot (1 + t\text{c}0_{sec}) \cdot (1 - t\text{sc}0_{sec}) \right]$$

(2.12.68)

$$PEML_{sec} = PWEMMLZ_{sec} \cdot ER - \sum_{ct} t\text{coeml}_{ct,sec} \cdot P_{ct}$$

(2.12.69)

$$PEROW_{sec} = PWEROWZ_{sec} \cdot ER - \sum_{ct} t\text{coerow}_{ct,sec} \cdot P_{ct}$$

(2.12.70)

$$PMML_{sec} = ER \cdot PWMMLZ_{sec} + \sum_{ct} t\text{comml}_{ct,sec} \cdot P_{ct}$$

(2.12.71)

$$PMROW_{sec} = ER \cdot PWMROWZ_{sec} + \sum_{ct} t\text{comrow}_{ct,sec} \cdot P_{ct}$$

(2.12.72)

$$PDD_{sec} = PDS_{sec} + \sum_{ct} t\text{cod}_{ct,sec} \cdot P_{ct}$$

(2.12.73)

$$GDPDEF = GDPC/GDP$$

(2.12.74)

2.12.9. Other macroeconomic variables

$$GDP = \sum_{sec} [C_{sec} \cdot PZ_{sec} \cdot (1+tc0_{sec}) \cdot (1-tsc0_{sec}) + CG_{sec} \cdot PZ_{sec} + I_{sec} \cdot PZ_{sec} \cdot (1+tcinv0_{sec}) + SV_{sec} \cdot PZ_{sec} + EML_{sec} \cdot PWEMLZ_{sec} \cdot ERZ + EROW_{sec} \cdot PWEROWZ_{sec} \cdot ERZ - MML_{sec} \cdot PWMLZ_{sec} \cdot ERZ - MROW_{sec} \cdot PWMROWZ_{sec} \cdot ERZ]$$

(2.12.75)

$$GDPC = \sum_{sec} [C_{sec} \cdot P_{sec} \cdot (1+tc_{sec}) \cdot (1-tsc_{sec}) + CG_{sec} \cdot P_{sec} + I_{sec} \cdot P_{sec} \cdot (1+tcinv_{sec}) + SV_{sec} \cdot P_{sec} + EML_{sec} \cdot PWEMLZ_{sec} \cdot ER + EROW_{sec} \cdot PWEROWZ_{sec} \cdot ER - MML_{sec} \cdot PWMLZ_{sec} \cdot ER - MROW_{sec} \cdot PWMROWZ_{sec} \cdot ER]$$

(2.12.76)

$$UNRATE = UNEMP/LS \cdot 100$$

(2.12.77)

$$V = \left[CBUD - \sum_{sec} P_{sec} \cdot (1+tc_{sec}) \cdot (1-tsc_{sec}) \cdot \mu H_{sec} \right] \cdot \prod_{sec} [\alpha H_{sec} / (P_{sec} \cdot (1+tc_{sec}) \cdot (1-tsc_{sec}))]^{\alpha H_{sec}}$$

(2.12.78)

$$VZ = \left[CBUDZ - \sum_{sec} PZ_{sec} \cdot (1+tc0_{sec}) \cdot (1-tsc0_{sec}) \cdot \mu H_{sec} \right] \cdot \prod_{sec} [\alpha H_{sec} / (PZ_{sec} \cdot (1+tc0_{sec}) \cdot (1-tsc0_{sec}))]^{\alpha H_{sec}}$$

(2.12.79)

$$EV = (V - VZ) \cdot \prod_{sec} \left[\frac{PZ_{sec} \cdot (1+tc0_{sec}) \cdot (1-tsc0_{sec})}{\alpha H_{sec}} \right]^{\alpha H_{sec}}$$

(2.12.80)

2.12.10. Endogenous variables

<i>CBUD</i>	household's disposable budget for consumption
<i>CGBUD</i>	disposable budget for public consumption
<i>CG_{sec}</i>	government demand for commodity <i>sec</i>
<i>C_{sec}</i>	consumer demand for commodity <i>sec</i>
<i>DEP_{sec}</i>	depreciation in sector <i>sec</i>
<i>EML_{sec}</i>	export supply of sector <i>sec</i> to Mainland
<i>ER</i>	exchange rate
<i>EROW_{sec}</i>	export supply of sector <i>sec</i> to ROW (rest of the world)
<i>EV</i>	equivalent variation in income
<i>GDP</i>	gross domestic product at constant prices
<i>GDPC</i>	gross domestic product at current prices
<i>GDPDEF</i>	GDP deflator
<i>GEXP</i>	total government expenditures
<i>INDEX</i>	consumer price index

I_{sec}	investment demand for commodity <i>sec</i>
LS	total labour supply
LSK_{sec}	labour demand by sector <i>sec</i>
LSR	labour supply to domestic market
$MARG_{ct}$	trade margins
MML_{sec}	import demand of commodity <i>sec</i> from Mainland
$MROW_{sec}$	import demand of commodity <i>sec</i> from ROW
PDD_{sec}	price level of domestic commodity <i>sec</i> delivered to the domestic market (including trade margins)
PD_{sec}	price level of domestic production of sector <i>sec</i>
PDS_{sec}	price level of domestic commodity <i>sec</i> delivered to the domestic market (excluding trade margins)
$PEML_{sec}$	price of exports to Mainland in domestic currency
$PEROW_{sec}$	price of exports to ROW in domestic currency
PI	price of the composite investment good
PL	average wage rate
$PMML_{sec}$	price of imports from Mainland in domestic currency
$PMROW_{sec}$	price of imports from ROW in domestic currency
P_{sec}	price level of domestic composite commodity <i>sec</i> (net of taxes)
PKL_{sec}	return to capital-labour bundle
RK_{sec}	return to capital in sector <i>sec</i>
S	total saving
SF	firms' savings
SG	government savings
SH	household's savings
SV_{sec}	changes in stocks of commodity <i>sec</i>
$TAXR$	government revenue
$UNEMP$	number of unemployed
$UNRATE$	unemployment rate
V	household's indirect utility function
KL_{sec}	capital-labour bundle
XDD_{sec}	domestic production delivered to domestic markets
XD_{sec}	sectoral production
X_{sec}	domestic sales of commodity <i>sec</i>
YF	firms' income
YH	households' income

2.12.11. Exogenous variables

ERZ	exchange rate in the benchmark
$INDEXZ$	consumer price index in the benchmark
KSK_{sec}	capital stock in sector <i>sec</i>
$LSRZ$	labour supply to domestic market in the benchmark
LW	labour supply to non-residential firms
$PLWZ$	return to labour employed by the non-residential firms
PLZ	average wage rate in the benchmark
$PWEMLZ_{sec}$	price of exports to Mainland in foreign currency
$PWEROWZ_{sec}$	price of exports to ROW in foreign currency
$PWMMLZ_{sec}$	price of imports from Mainland in foreign currency
$PWMROWZ_{sec}$	price of imports from ROW in foreign currency
$RATIO$	government savings to GDP ratio
SW	foreign savings
$TRGW$	transfers received by the government from the rest of the world
$UNEMPZ$	number of unemployed in the benchmark
VZ	households' indirect utility function in the benchmark

2.12.12. Parameters

aA_{sec}	efficiency parameter in the Armington function
$aicf$	share of capital income received by the firms
$aich$	share of capital income received by the households
aP_{sec}	efficiency parameter in the CES production function (capital-labor)
aT_{sec}	efficiency parameter in the CET production function
aKL_{sec}	Leontief parameter corresponding to the capital-labour bundle
β	wage curve parameter
d_{sec}	depreciation rate
$elasLS$	real wage elasticity of domestic labor supply
$io_{sec,secc}$	technical coefficients
mps	marginal propensity to save
svr_{sec}	share of inventories of commodity sec in domestic sales
$tc0_{sec}$	initial average tax rate on households' consumption of commodity sec (to be used in the definition of CPI)
$tcinv_{sec}$	average tax rate on investment commodity sec
$tcinv0_{sec}$	initial average tax rate on investment commodity sec (to be used in the definition of GDP at constant prices)
$tcod_{ct,sec}$	quantity of commodity ct as trade input per unit of commodity sec produced and sold domestically
$tcoeml_{ct,sec}$	quantity of commodity ct as trade input per exported unit of commodity sec to Mainland
$tcoerow_{ct,sec}$	quantity of commodity ct as trade input per exported unit of commodity sec to ROW
$tcomml_{ct,sec}$	quantity of commodity ct as trade input per imported unit of commodity sec from Mainland
$tcomrow_{ct,sec}$	quantity of commodity ct as trade input per imported unit of commodity sec from ROW
tc_{sec}	average tax rate on households' consumption of commodity sec
tp_{sec}	average tax rate on production of sector sec
$trep$	replacement rate
$tsc0_{sec}$	initial average subsidy rate on households' consumption of commodity sec (to be used in the definition of CPI)
tsc_{sec}	average subsidy rate on households' consumption of commodity sec
tsp_{sec}	average subsidy rate on production of sector sec
ty	tax rate on households' income
$wdif_{sec}$	wage rate differential of sector sec with respect to the national average wage rate
αG_{sec}	income elasticity of government demand for commodity sec
αH_{sec}	income elasticity of households' demand for commodity sec
αI_{sec}	income elasticity of demand for investment commodity sec
$\gamma A1_{sec}$	distribution parameter for imports of commodity sec from Mainland in the Armington function
$\gamma A2_{sec}$	distribution parameter for imports of commodity sec from ROW in the Armington function
$\gamma A3_{sec}$	distribution parameter for domestic demand from the domestic market of commodity sec in the Armington function

$\gamma P1_{sec}$	distribution parameter for capital in the CES production function of sector <i>sec</i>
$\gamma P2_{sec}$	distribution parameter for labor in the CES production function of sector <i>sec</i>
$\gamma T1_{sec}$	distribution parameter for exports of sector <i>sec</i> to Mainland in the CET production function
$\gamma T2_{sec}$	distribution parameter for exports of sector <i>sec</i> to ROW in the CET production function
$\gamma T3_{sec}$	distribution parameter for domestic deliveries to domestic market of sector <i>sec</i> in the CET production function
μH_{sec}	subsistence households' consumption of commodity <i>sec</i>
σA_{sec}	elasticity of substitution between imports from ROW, imports from Mainland and domestic demand from domestic market for commodity <i>sec</i> in the Armington function
σP_{sec}	elasticity of substitution between capital and labor in sector <i>sec</i>
σT_{sec}	elasticity of transformation in the CET production function

2.12.13. Indexes

<i>ct</i>	a subscript for wholesale and retail trade sector (1 sector) and also a subscript for wholesale and retail trade commodity (1 commodity)
<i>sec</i>	a subscript for one of the production sectors (16 sectors) and also a subscript for one of the commodities (16 types of commodities)
<i>secc</i>	the same as <i>sec</i> (used for exposition purposes)
<i>nct</i>	a subscript for one of the production sectors except wholesale and retail trade sector (15 sectors) and also a subscript for one of the commodities except wholesale and retail trade services (15 commodities)