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Three Essays on Regional Economic Modelling

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Preface

This PhD dissertation contains three essays within the area of regional economic modelling and, although each essay can be seen as an independent manuscript, they are linked to each other.

The main purpose of the dissertation is to study regional development policy and regional adjustment mechanisms with the help of applied general equilibrium models.

The first essay describes the building of a Social Accounting Matrix (SAM) for Sardinia which provides the data set necessary for calibrating a general equilibrium model. Scarcity of information at a regional level, means that a well-defined SAM cannot be created using a simple compilation method. For instance, the lack of data on secondary distribution processs inhibits an accurate compilation of the sub matrix of transfers between institutions. This sub matrix is estimated by means of a doubly constrained minimum information (MI) model, originally developed by Plane (1982) and Schneider and Zenios (1989). In order to take account of measurement errors, I have introduced random noise into the MI model using the same method as Robinson et al. (2006) in a Cross Entropy (CE) model. Furthermore, the CE model is used to reconcile all the information employed and to introduce additional precisions in the estimation of some macro aggregates.

The role played by knowledge capital as a factor of regional development is the topic of my second essay, "R&D Investment and External Knowledge Spillovers". I present the model for Sardinia with an analysis of the macroeconomic consequences of policy promoting R&D. The model is a single-county dynamic general equilibrium model where agents have myopic behaviour. Contrary to other regional myopic models found in the literature, this model for Sardinia incorporates labour market imperfections and allows for total adjustment of labour and capital stock through migration and adjustment cost functions.

The third paper is titled "Does the Forward Looking Model Fit the Regional Economic Features?". Intertemporal forward looking models are usually calibrated on national data, however a slavish application of the characteristics of such models may cause some problems in a regional context since regions may differ from the country as a whole. It is argued that intertemporal consumers' optimization based on neoclassical or Fisherian intertemporal resources allocation is inappropriate to the region since endogenizing the path of savings involves a balance of payments constraint, a constraint not faced by regions. Furthermore, I compare forward looking and myopic models. This comparison may be very useful since, in the literature, the intertemporal model has generally been compared to a simple static case lacking any capital adjustment rule. Contrary to previous exercises, we find that the only difference between the two models is in the transitional pathway where consumption and investment might diverge since agents with perfect foresight have rational expectations, whilst those with myopic foresight take decisions according to adaptive expectations without making any intertemporal preferences between periods on future profit and income.

The models contained in these essays are programmed in GAMS 22.8

Abstracts

Essay 1: **Constructing a Social Accounting Matrix for Sardinia.**

Recently, the Social Accounting Matrix (SAM) has been resurrected as a policy analysis tool and, in the last decade, attention has been paid to SAM multipliers, as well as to the use of the SAM as a benchmark for computable general equilibrium models. This paper constructs a SAM for the regional economy of Sardinia that can be used for policy evaluation and impact analysis. A mixture of approaches is used from simple compilation and decomposition methods to procedures for matrix estimations and matrix balancing.

Essay 2: **R&D Investment and External Knowledge Spillovers: an investigation of the impact of R&D subsidy on a recipient region in a computable general equilibrium model.**

In this paper we present a computable general equilibrium model for the region of Sardinia (Italy) with the purpose of evaluating the capacity of R&D policies to affect the long run rate of growth. The model incorporates induced technical change (ITC) obtained through knowledge accumulation, and external knowledge spillovers. It turns out that the cost of R&D policies may change according to the wage setting prevailing in the region. Furthermore, the capacity of such a policy to generate knowledge spillovers from the international and interregional trade is quite modest. Indeed, the capacity of the regional system to internalize the innovations embedded in the imported goods is partially offset by an increase in internal efficiency that lowers the spillover intensity through a reduction in the share of imports.

Essay 3: **An Applied Regional Intertemporal General Equilibrium Model: does the forward looking model fit the usual regional closures?**

We present a stylized regional intertemporal forward-looking model able to take into account regional economic features, an area that is not well developed in the literature. The main difference from standard applications is the role of savings and its implication for the balance of payments. Though maintaining dynamic forward-looking behaviour for agents, the rate of private saving will be exogenously determined, and so no neoclassical financial adjustment is needed. Also, we focus on the similarities and the differences between myopic and forward looking models, highlighting divergences between the main adjustment equations and the resulting simulation outcomes.

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Essay 1

Constructing a Social Accounting Matrix for Sardinia

Constructing a Social Accounting Matrix for Sardinia

Abstract. Recently, the Social Accounting Matrix (SAM) has been resurrected as a policy analysis tool and, in the last decade, attention has been paid to SAM multipliers, as well as to the use of the SAM as a benchmark for computable general equilibrium models. This paper constructs a SAM for the regional economy of Sardinia that can be used for policy evaluation and impact analysis. A mixture of approaches is used from simple compilation and decomposition methods to procedures for matrix estimations and matrix balancing.

JEL: C16, C67, E01.

Keywords: Social Accounting Matrix, Input-Output, Doubly Constrained Minimum Information (MI) Model, Cross Entropy, Regional Account System.

1. Introduction

This paper illustrates the mains steps used to build a Social Accounting Matrix (SAM) for Sardinia for the year 2001. The starting point is the Regional Input Output (RIO) Table for Sardinia built by IRPET[1] covering the year 2001 (see Table A1in Appendix). Data from the following sources were used to fill the sub-matrices of the SAM: System of Regional Economic Account, SRA (ISTAT[2], 2006), Disposal Income Account (ISTAT, 2005), Italian Household Expenditure Survey (ISTAT, 2001) and the Survey on Household Income and Wealth (Bank of Italy, 2002). However, these sources are insufficient to obtain a well detailed SAM; a lack of data on the secondary distribution processes inhibits a proper compilation of the sub matrix of transfers between institutions. The latter is estimated by means of a doubly constrained minimum information (MI) model (Plane, 1982 and Schneider and Zenios, 1989) with the introduction of measurement errors. Furthermore, because of the mixture of sources we have employed, the resulting SAM is inconsistent, i.e., column totals differ from row totals. In addition, some figures of the RIO table are slightly different to those reported in the SRA. We can identify at least two reasons for this: regional account data published by ISTAT in 2004 may be slightly different from that published in 2006 because ISTAT revises the series every two years; secondly, there could be problems caused by an adjustment process used to balance the RIO.

[1] Istituto Regionale per la Programmazione Economica della Toscana.
[2] National Statistics Office (Istituto Nazionale di Statistica).

As a result, it is necessary to incorporate and reconcile the information derived from different sources to produce a consistent and well-defined SAM. To this end, the Cross-Entropy method (Robinson, Cattaneo and El-Said, 2001) is used to readjust the data.

The rest of the paper is organized as follows. Section 2 describes the structure of the SAM. Section 3 presents the main data sources, and section 4 describes the adjustment operations carried out on the RIO table so that it can be incorporated as part of the SAM. The analytical SAM is then developed. In section 5 we focus on the allocation of primary income to institutional sectors and the distributional transfers amongst institutions. Section 6 explains how Households are separated into 14 income groups whilst section 7 is dedicated to the balance of payments. Finally, section 8 is devoted to the balancing method, and, in the last section, concluding remarks are offered.

2. The structure of a regional SAM

The SAM is a system of national/regional accounts (or even sub-regional accounts) in a matrix format. It includes the inter-industry linkages through transactions typically found in the IO accounts and the transactions and transfers of income between different types of economic agents, such as Households, Government, Firms and external institutional sectors (Rest of the World, ROW and the Rest of the Country, ROC). It has the following characteristics:

- it should be a square matrix, in the sense that each account has its own row and a corresponding column;
- for each account, the row total and the column total should be equal.

The architecture of a stylized SAM is shown in Table 1. The first column is the total supply of commodities, given by gross domestic output (cell [1, 1], cell [2, 1] and [4, 1]), plus imports from the external sector[3] (cell [5, 1]). The first row is demand for commodities for intermediate consumption in the production process (cell [1, 1]), for final consumption by the households and government ([1, 3]), investment (cell [1, 4]) and export (cell [1, 5]).

The second column reflects payments or distributions of factor incomes: factor remuneration of capital and labour to domestic institutions (cell [3, 2]) and foreign factor imports (cell [5, 2]). The second row gives the net value added (cell [2, 1]) which reflects the value newly created in the production process by the use of labour and capital and the factor income from the external sector (cell [2, 5]).

[3] As in this schematic representation of the SAM provided in table 1, the taxes and fees are not reported, the domestic output is valued at factor cost whilst the imports are valued free on board. Furthermore the external sector includes both the Rest of the Country and the Rest of the World.

The third column represents payments by institutions for commodity consumption or transfers of income to other institutions. That is, the total institutional expenditure in terms of final consumption (cell [1, 3]), transfers between institutions (cell [3, 3]) and savings (cell [4, 3]). The corresponding row represents receipts of income by institutions in terms of factor payment (cell [3, 2]), transfers from domestic sectors (cell [3, 3]) and from abroad (cell [3, 5]).

The fourth row contains depreciation (cell [4, 1]), domestic savings (cell [4, 3]) and foreign and interregional savings (cell [4, 5]), and the column contains investment demand (cell [1, 4]) and government net debt (cell [3, 4]).

Finally, the external sector account (ROC/ROW) shows the imports of commodities (cell [5, 1]), factor incomes to the external sector (cell [5, 2]) and transfers of firms and government (cell [5, 3]). The column contains the export sales to ROC and ROW (cell [1, 5]), factor income transfers from abroad (cell [2, 5]) and foreign and interregional savings (cell [4, 5]).

The SAM can also be seen as a general equilibrium framework where equality between production column and the row confirms that demand equals supply for all commodities; moreover the institutional row total is equal to the corresponding column total, showing that income is equal to revenue so that all domestic agents have demands that satisfy their budget constraints. Equality between ROC/ROW row and column provide the current-account balance.

Table 1 - *Stylized SAM*

		Production (1)	Factors (2)	Institutions (3)	Accumulation (4)	ROC/ROW (5)
Production	(1)	*Intermediate inputs*		*Consumption*	*Investment*	*Export to ROC/ROW*
Factors	(2)	*Factors Payment*				*Factor Income from ROC/ ROW*
Institutions	(3)		*Income to institutional sectors*	*Transfer*	*Government net Debt*	*Transfer from ROC/ROW*
Accumulation	(4)	*Depreciation*		*Institutional saving*		*Foreign and interregional Saving*
ROC/ROW	(5)	*Imports from ROC/ROW*	*Factor Income to ROC/ROW*	*Transfer*		

3. Data Sources and dimension of the SAM

Several different sources of information are needed to construct the SAM and the level of disaggregation is directly dependent on the data available. The smaller the benchmark economic system, the greater the difficult in finding data to fill up every single cell, resulting in an inevitable reduction in the disaggregation level. Indeed, the regional accounts released by ISTAT do not have the degree of detail needed for building a well disaggregated regional SAM. The SRA, as set by ESA95 (which is the EU version of the 1993 SNA), is limited to:

1. regional industry aggregates on production activities:
    - gross value added;
    - compensation of employees;
    - employment;
    - employees;
    - gross fixed capital formation.
2. gross domestic product per region (GDPR);
3. Regional Income Accounts.

There have been some improvements to Regional Income accounts between ESA70 and ESA95. There is now a detailed compilation of Household Disposal Income, although the accounts are limited to:

i. the Allocation of Primary Income
ii. the Secondary Income Distribution of Income.

Accordingly, the SRA does not contain detailed information about interregional and international trade, or income distribution to institutional sectors. As a result, the use of additional information is necessary. The other main sources can be summarized as follows:

- Regional Input Output Table, RIO
- Households Expenditure Survey
- Households Income Survey
- National or Consolidated Disposal Income account
- Financial Budget of the Autonomous Region of Sardinia.

The RIO table (shown in Table A1 in appendix) is composed of 30 sectors, three domestic institutions (Households, Firms and Government) and two external institutions: Rest of Italy (ROI) and Rest of the World (ROW). The RIO table also includes a column vector of Financial Intermediary Services Indirectly Measured (FISIM) and a row vector of Transfers of the Secondary Production. Using the economic activities classification scheme presently used by ISTAT for the classification of the regional account, the RIO table is aggregated to 23 sectors.

In order to obtain a more disaggregated SAM, including a classification of Households split into 14 income groups, we use the 2001 Italian Households Expenditure Survey (hereafter HES) and the 2001 Survey on Household Income and Wealth (hereafter SHIW). Furthermore, to identify receipts and payments between institutions, the Secondary Income Distribution Account at regional level is required. However, as we have seen above, this account is released by ISTAT only for Households, so a regionalization of some entries of the Consolidated

(National) Disposal Income Account is necessary in order to identify total receipts and payments for each institution.

On the basis of the sources collected, the disaggregated structure of the final SAM (RSAM) is presented in Table 2. Economic activities are classified into 23 sectors, and value added at factor cost is shared between labour income and operating surpluses. The latter is non-labour value added of GDP at factor cost that includes rent, profit and other capital income. Households are split into 14 income groups whilst external relationships are divided into interregional (the Rest of Italy) and international (the Rest of the World).

Table 2 – *Structure of the final SAM*

Economic activities	**Value added**		Income Groups (euros)	
Agricolture, hunting, forestry and logging	Wages and Salaries		**1**	3718.49
Fishing and aquaculture	Employers' Social Contributions		**2**	3718.49 - 6197.48
Mining and Quarrying	Operating Surplus		**3**	6197.48 - 9296.22
Manufacture of food products, beverages and tabacco	Subsidies on production		**4**	9296.22 - 12394.97
Manufacture of textiles and wearing appareal	**Taxes**		**5**	1032.91 - 15493.71
Manufacture of leather and related products	Value added Tax		**6**	15493.71 - 18592.45
Manufacture of paper and paper products ; manufacture of articles of straw and plaiting materials	Other Indirect taxes		**7**	18592.45 - 24789.93
Manufacture of coke, refined petroleum products, chemicals and pharmaceutical	Indirect tax on Import		**8**	24789.93 - 30987.41
Manufacture of other non-metallic mineral products			**9**	30987.41 - 37184.90
Manufacture of fabricated metal products, except machinery and equipment	**Domestic Institutions**		**10**	37184.90 - 43382.38
Manufacture of computer, electronic and optical products , machinery and equipment , transport equip	Government		**11**	43382.38 - 49579.86
Manufacture of wood, rubber, plastic products and other manufacturing	Household (14 income groups)		**12**	49579.86 - 61974.83
Electricity, Gas and water supply			**13**	61974.83 - 74369.79
Construction			**14**	- 74369.79
Wholesale and Retail trade; Repair of Motor vehicles and motorcycles	**Foreign Instituron**			
Accomodation and food sevice activities	Rest of Italy	*Import/Export*		
Transportation and Storage	Rest of the World	*Import/Export*		
Financial and Insurance activities				
Real estate activities, Professional, Scientific and Technical activities	Capital Formation	*Investment/saving*		
Public administration and defence; Compulsory social security				
Education				
Human Health and social work activities				
Other service activities				

4. Adjusting the RIO Table.

The RIO table constitutes the basis of the RSAM. In this table we find the intermediate inputs, the composition of the final demand, and interregional and international trade. The first operations to be carried out involved adjustment of the RIO table so that it can be included as part of the RSAM:

1) Allocation of FISIM among user sectors
2) The treatment of secondary products
3) Consolidation of the Gross Investment (GI) and Inventory change (IC).

4.1. Allocation of FISIM. ESA95 does not require FISIM to be allocated between users because, in practice, there are uncertainties about how to do this. In fact, the RIO Table ascribes the total value of FISIM to the Monetary and Financial Intermediation sector. As this is inconsistent with the SAM approach, the FISIM is allocated along the row entries of the Monetary and Financial Intermediation sector according to the following share, s_j , defined as:

$$s_j = \frac{VA_j^f}{\sum_j VA_j^f}$$

where VA_j^f stand for Value Added and the apex f means that we are dealing with the value added at factor cost. Once FISIM is spread along the Monetary and Financial Intermediation sector, the VA_j^f is reduced by the same amount in order to rebalance the RIO table.

4.2. Secondary production. Let $\hat{\mathbf{v}}$, be the vector of secondary production and **A** the technical coefficients matrix. We can find the matrix of secondary production flows **S**, as follows:

$$\mathbf{S} = \mathbf{A} \cdot \hat{\mathbf{v}}$$

where the hat indicates the diagonal matrix. Now, we are able to determine a new matrix, **G,** by the difference between the inter-industry matrix **M** and **S**:

$$\mathbf{G} = \mathbf{M} - \mathbf{S}$$

and we obtain the new technical coefficient matrix $\mathbf{A}^*$as:

$$\mathbf{A}^* = \mathbf{G} \cdot \widehat{\mathbf{X}}^{-1}$$

where $\widehat{\mathbf{X}}^{-1}$ is the diagonal matrix of total production. Now, we can re-define the final demand **Y** in order to obtain a balanced RIO table:

$$\mathbf{Y}^* = (\mathbf{I} - \mathbf{A}^*)\mathbf{X}$$

where **I** is the identity matrix. With this approach, the vector of secondary production has been allocated to the economic activities while preserving the original total of production.

4.3. Consolidation of Gross fixed capital formation and Inventory change. Gross capital formation, **GFK**, is measured by the total value of the gross fixed capital formation, **GFKF,** and changes in inventories, **IC**. In the RIO table, the capital formation account contains both **GFKF** and **IC** but does not provide the whole measure of **GFK**. So we need to consolidate the **GFKF** and **IC** vectors in order to have a measure of **GKF**. The new vector of consolidated investment is **GKF=GFKF+IC**. As the **IC** vector contains some negative values, a single element of

GKF could be less than zero. In this case, the single elements of **GFK** take the value zero and, to re-balance the RIO, Household consumption is reduced.

5. From the RIO to the RSAM

The aim so far has been to make the data supplied by the RIO table consistent with that in the RSAM. In this section we focus on the construction of the SAM for Sardinia, based on the adjusted RIO and focusing on the sub-matrices that mainly differentiate the SAM from an Input-Output, that is:

- The primary income formation
- The allocation of primary income to institutional sectors
- The transfer among institutions

Essentially, we are introducing the distributional process of income. IO focuses on production and it is therefore inadequate for capturing the complexity of the interrelations between production, on the one hand, and consumption and distribution on the other.

5.1. Primary income formation: value added decomposition. Most of the information we need is already supplied by the RIO table which provides total value added at factor cost, indirect taxes on production, value added tax (VAT) and subsidies on product distributed amongst sectors. As noted above, some aggregates of the RIO table do not match the figures reported in the SRA. In fact, VA at factor cost (both its total amount and its distribution among sectors) is slightly different from that in the SRA, and so the total amount of indirect net taxes[4] also differs. Therefore, the following operations will be based on VA supplied by the SRA and inconsistency with indirect net taxes is solved in section 8 by imposing a control aggregate variable in the CE model.

VA at factor cost is split into its principal components: Labour Income (LI), or compensation of employees, and Gross Operating Surplus (GOS). LI is shared between Wages and Salaries (W&S) and Employers' Social Contributions (ESC). W&S also includes the value of any social contributions and income taxes payable by the employees[5]. The SRA give us the W&S and ESC amongst sectors and the total amount of the GOS (not spread by sectors). As a result we can easily obtain the GOS for each sector as a residual. Unfortunately, at this stage we are not able to distinguish between gross and net VA, due to a lack of data on the consumption of fixed capital at regional level.

[4] We cannot compare the distribution of indirect taxes amongst sectors because the SRA only lists totals.

[5] Unfortunately we do not have enough information to separate ESC into Employers' Actual Social Contribution and Employers' Imputed Social Contribution.

5.2. *The allocation of Primary Income to institutional sectors.* The only information we have from ISTAT is the Household Disposal Income account; from this we get the information for Households concerning W&S (8277.3), ESC (2826.2) and GOS (9375.7) which give a total primary income of 20479.2. SRA provides total GOS (13239.18) which must be allocated between Firms and Government (equal to 3863.48 = 13239.18 - 9375.7). This figure is split according to the shares obtained by GOS in the National Primary Income Distribution Account, available in the National Disposal Income account. That is: 0.04% for Government and 0.96 for Firms.

Table 3 - *Allocation of primary income*

	W&S	ESC	GOS
Households	8277.30	2826.20	9375.7
Firms	-	-	3708.94
Government	-	-	154.53
Total	8277.30	2826.20	13239.18

5.3. *Transfers among Institutions.* The compilation of the sub-matrix of transfers (see Table 4) requires information about receipts and payments of current transfers between institutions. This data may be found in the Secondary Income Distribution (SID) account. However, it is only available for Households so we proceed as follows: first we obtain a macro regional SID account to determine total receipts and total payments for each institution, then, with a non linear optimization model, all the cells $T_{I,J}$ as represented in Table 4 are estimated.

Table 4 - *Transfer matrix*

	Households	Firms	Government	ROW	Total receipts
Households	T_{HH}	$T_{H,F}$	$T_{H,G}$	$T_{H,ROW}$	$T_{H,\blacksquare}$
Firms	$T_{F,H}$	$T_{F,F}$	$T_{F,G}$	$T_{F,ROW}$	$T_{F,\blacksquare}$
Government	$T_{G,H}$	$T_{G,F}$	$T_{G,G}$	$T_{G,ROW}$	$T_{G,\blacksquare}$
ROW	$T_{ROW,H}$	$T_{ROW,F}$	$T_{ROW,G}$	$T_{ROW,ROW}$	$T_{ROW,\blacksquare}$
Total payments	$T_{\blacksquare,H}$	$T_{\blacksquare,F}$	$T_{\blacksquare,G}$	$T_{\blacksquare,ROW}$	$T_{\blacksquare,\blacksquare}$

The regional Households SID account, reported in Table 5, gives total Household receipts $T_{H,\blacksquare}$ and total Households payments $T_{\blacksquare,H}$ that amounts to 5956.3 and 6920.5 (in millions of euros) respectively. In fact, total resources, less BPI (Balance of Primary Income) give total receipts, whilst total uses less Gross Disposal Income gives the total payments. As for total receipts, Households receive a total amount of 5541 given by SB

(5493) and OTC (48 = 381.30-330.30) from Government, and 333 for OCT and 82 for SC (46) and SB (36) from Firms. Total household payment is given by the payments for CT (2710), SC (3784), SB (36) and OCT (391).

Table 5 - *Secondary Income Distribution account for Households (millions of euro)*

	Resource	Uses
Balance of primary income	20479,20	-
Current taxes on income, wealth, etc. (CT)	0,00	2710,00
.Current taxes on income	0,00	0,00
.Other current taxes	0,00	0,00
Social contributions (SC)	46,00	3784,00
.. Actual social contributions	34,00	3535,00
... Actual social contribution (employer)	34,00	2537,00
... Actual social contribution (employee)	0,00	648,00
… Actual social contribution (self-employed and unemployed)	0,00	350,00
.. Imputed social contribution	12,00	249,00
Social benefit (SB)	5529,00	36,00
Other current transfer (OCT)	381,30	390,50
.. From Government	0,00	0,00
.. From other institutions	333,30	344,50
. Net non-life insurance premiums	0,00	190,00
. Non-life insurance claims	231,00	0,00
. Current transfer within general Government	0,00	-
. International current aid	0,00	0,00
.. From EU	0,00	0,00
. Miscellaneous current transfer	150,30	200,50
.. From Government	0,00	0,00
.. From other institutions	0,00	0,00
… 4° resource based on GDP	0,00	0,00
Gross disposal income		19515,00
Total	26435,50	26435,50

Source: ISTAT, 2005

Now we need to get some regional values concerning the BPI, Gross Regional Disposal Income (GRDI), total resources and total uses for the total regional economy as well as for non-Households institutions: Firms, Government and Rest of the Italy/World (ROI/W).

The values of BPI for each institution are found in section 5.3; other information is found by regionalizing some entries of the National SID account. Specifically, the total Sardinian sources is a share of the national one found proportionally to the ratio of regional to national gross domestic product. Then the result is distributed amongst non-Household institutions in proportion to the distribution of shares found in the National SID. GRDI is determined by maintaining the ratio between Gross National Disposal Income (GNDI) and BPI as in the National SID, where the GNDI is less than the primary income (BPI), indicating an appropriation of the primary income operated by the secondary distribution process.

Table 6 - *Sardinian Macro SID Account and Total Receipts and Payments*

	Total Sardinia	Households	Firms	Government	ROI/W
Balance of Primary Income (BPI)	27187,98	20479,20	3708,94	2999,84	0,00
Total sources (TS)	44403,55	26435,50	4373,05	13194,31	400,68
Gross Regional Disposal Income (GRDI)	27071,32	19515,00	2263,73	5292,59	0,00
Total Using (TU)	44286,89	26435,50	4373,05	13194,31	284,02
	$T_{■,■}$	$T_{H,■}$	$T_{F,■}$	$T_{G,■}$	$T_{ROW,■}$
Receipts (TS-BPI)	17215,57	5956,30	664,11	10194,47	400,68
	$T_{■,■}$	$T_{■,H}$	$T_{■,F}$	$T_{■,G}$	$T_{■,ROW}$
Payments (TU-GRDI)	17215,57	6920,50	2109,32	7901,73	284,02

Now it would be quite easy to obtain the total uses. Since the ROI/W can be the only unbalanced institution, its value has been obtained as a residual in order to get total receipts equal to total payments. The resulting Macro SID accounts for Sardinia, along with the receipts and payments are reported in table 6.

With total receipts and payments available for each institution, we are able to estimate the transfer matrix by means of a Doubly Constrained Minimum Information (MI) model (Schneider and Zenios, 1990). Let *T* denote total payment or receipts (which correspond to $T_{■,■}$ in Table 4) and for each *I* = *H*, *F*, *G*, *ROI/W*, let R_I =[$T_{H,■}$, $T_{F,■}$, $T_{G,■}$, $T_{ROW,■}$] and P_I=[$T_{■,H}$, $T_{■,F}$, $T_{■,G}$, $T_{■,ROW}$] be respectively the receipts and payments for institutions *I*. Considering $t_{I,J}$ the model estimated probabilities that any institution receive from *J* and pay to *I* where *I* = *J* and some prior probabilities $\bar{t}_{I,J}$, the model can be formalized as follow:

$$\min \sum_I \sum_J t_{I,J} \left[ln\left(\frac{t_{I,J}}{\bar{t}_{I,J}}\right) - 1 \right]$$

subject to

$$\sum_I t_{I,J} = \frac{P_I}{T}; \quad \sum_J t_{I,J} = \frac{R_J}{T};$$

As we do not have a previous transfer matrix for Sardinia, the prior probabilities $\bar{t}_{I,J}$are derived from the Italian transfer matrix built by

IRPET for the year 1998. Since the vectors R_I and P_I are derived from the regionalization process described above, they may contain some measurement error. Therefore the MI model can be written in the following way:

$$\text{Min} \sum_I \sum_J t_{I,J} \left[ln\left(\frac{t_{I,J}}{\bar{t}_{I,J}}\right) - 1 \right] + \sum_I \sum_h \left[ln\left(\frac{w_{I,h}^P}{\bar{w}_{I,h}^P}\right) - 1 \right] + \sum_J \sum_h \left[ln\left(\frac{w_{J,h}^R}{\bar{w}_{J,h}^R}\right) - 1 \right] \quad (1)$$

where $w_{I,h}^{P,R}$ and $\bar{w}_{J,h}^{P,R}$ are respectively the model estimated weights of the error e and their prior distribution.

The constraint equations are the following:

$$\sum_I t_{I,J} = \frac{(P_I + e_I^P)}{T}; \ \sum_J t_{I,J} = \frac{(R_J + e_J^R)}{T}; \quad (2)$$

$$T = \sum_I P_I + e_I^P = \sum_J R_J + e_J^R \quad (3)$$

$$e_I^P = \sum_h w_{I,h}^P \ v_h^P; \ e_J^R = \sum_h w_{J,h}^R \ v_h^R \quad (4)$$

$$\sum_h w_{I,h}^P = 1 \text{ and } \sum_h w_{J,h}^R = 1; \quad (5)$$

Introduction of the error terms in this MI model follows Robinson, Cattaneo and El Said (2001) which introduced error terms in a CE model in order to balance a macro SAM for Mozambique.

In the formulation of the problem specified above [(1), (2), (3) ,(4), (5)] two noise variables are identified: e_I^P and e_J^R. The former is related to P while the latter is associated to R. So, unlike the previous MI model, receipts and payments contain some possible measurement errors that matter for the estimated probabilities $t_{I,J}$ as can be seen in equation (2). Furthermore such errors are reproduced in the total receipts (or payments) T as in equation (3). The error terms are seen as a weighted average of a constant term v as in equation (4), where the weights w must respect the constraints specified in (5), as is usual in this kind of formulation. The set h defines the dimension of the support set for the error distribution and the number of weights that must be estimated for each error. The prior variance of the error term can be specified as $\sigma^2 = \sum_h \bar{w}_{i,h} \ \bar{v}_h^2$, whilst we define a domain for the support set of ±3 standard errors (see Golan, Judge, and Miller, 1996 and Robinson, Cattaneo and El-Said, 2001).

Thus the transfer matrix is derived by minimizing equation (1) subject to the constraints equation (2), (3), (4) and (5). The resulting matrix is presented in table 7.

Table 7 - *Transfers among Institutions*

	Households	Firms	Government	ROW	Total receipts
Households	164,57	1577,69	4012,70	201,33	5956,29
Firms	175,40	117,49	337,86	33,46	664,21
Government	6463,07	356,60	3323,21	49,23	10192,11
ROW	117,45	58,04	225,22	0,00	400,71
Total payments	6920,49	2109,82	7898,99	284,02	17213,34

6. Splitting Households in 14 income groups.

In this section, Households are split into 14 income groups (see table 2). Not only are the vectors of income and consumption split, but also payments and receipts for every single household group. The disaggregation is achieved by means of information contained in HES and in SHIW. HES is primarily a survey of household expenditure on goods and services. It collects detailed information on expenditures and on the characteristics of a sample of households resident throughout Italy and classifies them into 14 income groups. SHIW mainly gathers data on the incomes and savings of Italian households, plus some other aspects of households' economic and financial behaviour. In both surveys we can identify the Sardinian sample.

6.1. Households income. The total income earned by households, (Y_I^H), and its components given by labour income (Y_L^H), capital income (Y_K^H) and transfers (Y_T^H) from the other institutions (determined in the previous sections 5.2 and 5.3) are split in 14 income groups through a system of weights $W_{h,I}$ obtained from SHIW. Also from SHIW, we find the average labour income, $Y_{h,L}^A$, the average capital income, $Y_{h,K}^A$, and the average transfer income, $Y_{h,T}^A$, for each group. Given N_h the number of households for each group *h* (from HES), the total average income, $Y_{h,I}^{Total}$ is determined as follows:

$$Y_{h,I}^{Total} = Y_{h,I}^A \cdot N_h \quad \text{where } I = L,K,T$$

Now, we can find a system of weights $W_{h,I}$ such that the income for *h* Households and for the *I* category is given by:

$$Y_{h,I}^* = Y_I^H \cdot W_{h,I}$$

where

$$W_{h,I} = \frac{Y_{h,I}^{Total}}{\sum_h Y_{h,I}^{Total}}$$[6].

6.3. Household consumption. In order to split Household consumption into 14 income groups, we first construct a share $h \times s$ matrix **G**, obtained from HES, where h is the 14 income groups, and s the 12 categories of expenditure. Now, using the Household total consumption for expenditure category supplied by SRA, **g,** we can find a $h \times s$ matrix $\mathbf{C} = [c_{h,s}]$ as follows:

$$\mathbf{C} = \mathbf{G} \cdot \hat{\mathbf{g}}$$

The next step is to translate $\mathbf{C}$ into a matrix with 14 household and 23 sectors. To this end, we use the bridge coefficients $i \times s$ matrix, $\mathbf{B} = [b_{i,s}]$, that allow us to convert an expenditure category configuration s (as in **C**) to a sector configuration i. So the matrix **H** of Household consumption $i \times h$ is obtained as follows (see Table 8)**:**

$$\mathbf{H} = \mathbf{B} \times \mathbf{C}'$$

The Sardinian bridge coefficient matrix **B** is derived from a doubly constrained minimum information (MI) model as explained for estimating the transfer matrix. However, at this time, we are not considering errors terms. The prior information is given by the Italian bridge matrix for the year 1992[7], whereas the vector of household consumption for 23 sectors is contained in the RIO table. In Table A2 in the Appendix we report the Sardinia Bridge flow matrix.

6.4. Transfer of Households to other institutions. Previously, we have dealt with the transfers of income received by households as payment from other institutions. Now we turn to payments made by the h households to other institutions. The vector of Households' payments reported in Table 6 (175 to Firms, 6494 to Government and 117 to ROW) must be spread between h groups. The main difficulty is due to the fact that SHIW does not specify any variables relating to the transfer of income from households to other institutions. Thus we have made the assumption that each h Household transfers part of its income proportionally to its total income.

[6] As SHIW does not contain sufficient data to split the transfer of Household from Government, Firms, External Institutions and the same Households, the same weight, $W_{h,t}$ is applied in this case. Moreover the transfers of income between h, are considered to be made within the same group of Households.

[7] The Italian bridge matrix built by ISTAT for the year 1992 links 57 expenditure categories to 110 sector. It is aggregated in order to reduce the number of categories to 12 and sectors to 23.

Table 8 – *Households consumption matrix (millions of euro)*

	Income groups														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
Agricolture, hunting, forestry and logging	3.38	16.40	36.08	66.65	61.47	29.33	62.67	25.90	7.13	3.95	5.59	0.20	0.00	1.56	320.30
Fishing and aquaculture	0.46	3.23	6.35	12.51	10.20	6.88	9.05	4.05	1.92	0.82	0.57	0.02	0.00	0.25	56.31
Mining and Quarrying	0.01	0.04	0.08	0.15	0.13	0.08	0.11	0.05	0.02	0.01	0.01	0.00	0.00	0.00	0.69
Manufacture of food products, beverages and tabacco	15.93	108.55	215.52	422.19	348.49	227.79	313.89	139.28	62.84	27.36	20.60	0.67	0.00	8.54	1911.64
Manufacture of textiles and wearing appareal	6.31	44.80	88.00	173.46	141.45	95.36	125.45	56.18	26.57	11.34	7.84	0.25	0.00	3.45	780.46
Manufacture of leather and related products	2.06	14.59	28.66	56.50	46.08	31.06	40.87	18.30	8.65	3.69	2.55	0.08	0.00	1.12	254.22
Manufacture of paper and paper products ; manufacture of articles of straw and plaiting materials	1.15	4.48	10.54	30.55	36.79	40.93	39.52	22.57	6.96	9.31	2.93	0.09	0.00	2.78	208.60
Manufacture of coke, refined petroleum products, chemicals and pharmaceutical	3.06	27.96	50.11	122.29	128.53	98.46	142.10	84.91	31.09	20.91	8.81	0.29	0.00	6.30	724.83
Manufacture of other non-metallic mineral products	0.21	2.20	4.55	15.33	13.20	8.12	11.95	10.09	3.32	1.23	0.94	0.00	0.00	0.85	72.00
Manufacture of fabricated metal products, except machinery and equipment	0.23	1.38	2.76	6.16	6.26	5.12	7.03	3.47	1.26	1.05	0.47	0.01	0.00	0.28	35.48
Manufacture of computer, electronic and optical products , machinery and equipment , transport equipment	4.50	33.08	72.30	157.41	167.51	110.56	150.47	95.38	30.87	20.66	7.66	0.15	0.00	8.01	858.57
Manufacture of wood, rubber, plastic products and other manufacturing	2.15	11.20	25.29	64.24	74.89	74.89	80.88	44.99	15.59	15.50	5.31	0.14	0.00	4.22	419.29
Electricity, Gas and water supply	4.59	43.65	76.06	130.76	138.51	75.79	113.55	70.63	24.52	11.50	8.97	1.00	0.00	5.02	704.56
Construction	0.17	1.58	2.76	4.73	5.02	2.73	4.11	2.57	0.89	0.42	0.33	0.04	0.00	0.18	25.52
Wholesale and Retail trade; Repair of Motor vehicles and motorcycles	14.79	113.47	288.71	767.96	775.65	649.73	744.14	450.99	193.19	75.45	57.55	0.02	0.00	17.86	4149.50
Accomodation and food sevice activities	2.54	44.88	87.28	366.57	292.70	219.51	374.51	196.03	104.67	46.06	28.52	1.28	0.00	7.94	1772.49
Transportation and Storage	6.48	42.46	106.53	237.26	264.14	217.22	238.76	131.52	54.74	29.71	13.35	0.63	0.00	5.23	1348.03
Financial and Insurance activities	1.39	11.75	19.90	52.11	59.25	55.96	79.86	40.92	16.15	13.73	4.36	0.06	0.00	2.85	358.30
Real estate activities, Professional, Scientific and Technical activities	17.42	165.23	287.93	501.15	534.34	301.67	448.51	276.87	96.54	47.67	34.83	3.75	0.00	19.69	2735.58
Public administration and defence; Compulsory social security	0.21	1.43	2.72	6.01	6.05	4.73	7.16	3.46	1.33	0.99	0.45	0.01	0.00	0.23	34.78
Education	0.49	6.16	12.69	33.74	62.57	34.48	49.38	29.84	7.14	2.65	3.60	0.02	0.00	0.90	243.66
Human Health and social work activities	1.62	13.92	26.85	56.21	62.33	44.46	69.00	36.95	13.79	9.72	3.09	0.05	0.00	2.37	340.37
Other service activities	3.21	30.00	56.36	155.26	151.50	109.45	156.88	104.93	37.19	21.09	10.78	0.23	0.00	8.16	845.03
Total	92.36	742.46	1508.00	3439.22	3387.06	2444.32	3269.83	1849.87	746.36	374.82	229.09	8.99	0.00	107.82	18200.20

7. Sector Financial Balance.

The sectoral financial balance requires that: $(S - I) + (T - G) = E - M - TR$, where the private sector portfolio (saving, S, less investment, I) plus the government deficit/surplus (total resources, T, less expenditure, G) equals the current account imbalance (export, E, less import, M, less net transfer, TR).

Households' and Firms' savings are calculated as balanced items: total income less expenditure. The Government deficit is obtained from the 2001 Financial Budget of the Region of Sardinia (Consiglio Regionale della Sardegna XIII Legislatura, 2001). The capital inflow/outflow to and from the ROI and the ROW is determined by imputing the trade deficit (M-E) as capital inflows: 1719 for ROI and 2788 for ROW.

We know from the SRA that the total net import (both ROI and ROW) for the year 2001 is positive and equal to 4809.3, slightly greater than the one obtained as a residual, namely 4507 = 1719+2788. At this stage we are not able to re-determine the new level of current account balance, but it will be sorted out in the next section where the adjusting and balancing problems are treated.

8. New information and balancing

Operations carried out thus far use a mixture of different sources which, in some cases, are not linked to each other. For instance, HES has been carried out independently of SHIW, furthermore, in the RIO table some macro-variables, such as GDP and total households consumptions, are not consistent with the data reported in SRA. Therefore, the unbalanced SAM reported in the appendix is adjusted using the Cross-Entropy model (Robinson, Cattaneo and El-Said, 2001[8]). Looking at the unbalanced SAM, we can see that the main discrepancies occur in sectoral production and in the sector financial balance.

8.1. The CE model. The unbalanced SAM $t_{i,j}$, provides the prior distribution $\bar{a}_{i,j}$ and data on column sum x_j that we hypothesis to be measured with error. Then, according to Robinson, Cattaneo and El-Said (2001) the CE problem can be formalized as an equations system with variables measured with noises:

$$y_i = x_j + e_j \tag{6}$$

where y_i is the sum in row and e_j is the errors terms. We know also that:

$$\sum_i a_{i,j}\ x_j = y_j \tag{7}$$

and

$$\sum_i a_{i,j} = 1 \text{ with } 0 < a_{i,j} \leq 1 \tag{8}$$

The error term e_j can be also seen as a weighted average of known constants v :

$$\sum_h w_{i,h}\ v_h = e_i \tag{9}$$

where $w_{i,h}$ is an h-dimensional vector of weights treated as probability to be estimated. It means that $w_{i,h}$ has to satisfy the following constraints:

$$\sum_h w_{i,h} = 1 \text{ and } 0 < w_{i,h} \leq 1; \tag{10}$$

the constant v_h is the *support set* for the error and is always selected to produce a symmetrical distribution around zero.

[8] The CE model derives from the information theory developed by Shannon (1948) and from Theil's work (1967) which transposed Shannon's approach into economic problems. For more detail about the CE approach see Robinson, Cattaneo and El-Said (2000). They used a CE approach to estimate a consistent Macro-SAM for Mozambique, starting from inconsistent data estimated with error.

Now we can define a model in which the optimization problem is to find a set of **A**'s and **W**'s that minimize the following cross entropy equation:

$$H(A,W;\bar{A},\bar{W}) = \left[\sum_i \sum_j a_{i,j}\, ln\left(\frac{a_{i,j}}{\bar{a}_{i,j}}\right)\right] + \left[\sum_i \sum_h w_{i,h}\, ln\left(\frac{w_{i,h}}{\bar{w}_{i,h}}\right)\right] \tag{11}$$

subject to equations (6), (7), (8), (9) and (10).

In equation (11), $\bar{a}_{i,j}$ and $\bar{w}_{i,h}$ are the prior probabilities, whereas $a_{i,j}$ and $w_{i,h}$ are treated as probabilities to be estimated (posterior distribution). The object is to minimize the joint entropy distance H in order to get the matrix **A** and **W** close to their priors $\bar{A}$ and $\bar{W}$. It is worth remembering that in this CE model specification, we are assuming an error term in a variable (the error term is attached to the variable x_j) and not in an equation. In other words, the error in this model is due to the hypothesis that the sum in column x_j has been measured with noise rather than assuming a model that includes random noise through an error term in its equations (for an application see Golan and Vogel, 2000).

Considering k aggregate constraints and an n-by-n aggregator matrix G, we can include in the constraints set some information about the new SAM. We can write:

$$\sum_i \sum_j g_{i,j}^{k}\; t_{i,j} = \gamma^{\mathrm{k}} \tag{12}$$

where $t_{i,j}$ is the SAM transaction matrix and γ^{k} is the value of the aggregate constraints, that is, the new information we are adding to the CE. The aggregate macro data introduced in the model via equation (7) does not preserve the same values as those of the initial SAM (unbalanced). Basically we introduce new constraints into the model in order to adjust the figures to be consistent with the regional account data. This means that the explicit application of the CE approach on the Sardinia SAM is not only used as a simple balancing method, but is also an adjustment procedure to incorporate new information in order to produce a well defined scheme of data as close as possible to the official data.

The set of additional restrictions that constrain some sub-matrices of the SAM are reported in the table below. On the production side, the total GDP at factor cost and valued at market price, is constrained to the figures reported in SRA. On the demand side the total Household consumption, government consumption and investment demand are also restricted. The overall trade deficit (interregional and international) is constraint to the net import entry reported in SRA.

In developing the CE model specified above, it is assumed that totals in the rows and columns, and the macro aggregates are inexact due to measurement errors. The error term in equation (4) is a weighted sum of a constant v where the set h defines the dimension of the support set for the error distribution and the number of weights that must be estimated for each error. As in Golan, Judge, and Miller (1996) and Robinson, Cattaneo and El-Said (2001), given the prior variance on the error term $\sigma^2 = \sum_h \bar{w}_{i,h}\ \bar{v}_h^2$ we define a domain for the support set of ±3 standard errors. By considering variance, skewness, and kurtosis the moments of the error distribution, in order to get a symmetric distribution around zero, both the vector of the prior weight and the vector of the support set should contains 5 elements (see, Golan, Judge, and Miller, 1996 and Robinson, Cattaneo and El-Said, 2001).

Table 9 - Macro Variable constraints (millions of euros)

Value added at factor cost	24342.68
Net Indirect Taxes	3204.91
Gross regional product (market price)	27547.59
Household Consumption	18200.2
Government consumption	7662.10
Investment Demand	6403.50
Overall trade deficit	4809.28

Once the prior distribution is determined, the CE is solved by minimizing equation (11) subject to equations (6), (7), (8), (9) and (10). The optimization problem yields the following posterior distributions:

$$a_{i,j} = \frac{\bar{a}_{i,j}\exp(\lambda_i y_j)}{\sum_i a_{i,j}\exp(\lambda_i y_j)}$$

and

$$w_{i,h} = \frac{\bar{w}_{i,h}\exp\,(\lambda_i v_h)}{\sum_{i,h} w_{i,h}\exp\,(\lambda_i v_h)}$$

where λ_i is the Lagrange multiplier and the denominator in both equations is a normalization factor (see Golan, Judge, and Miller, 1996 and Robinson, Cattaneo and El-Said, 2001).

9. Concluding remarks

An increasing number of countries have found the SAM framework useful for designing socio-economic policy. However there is still some resistance to the use of this useful integrated data framework at regional level.

This paper has detailed a process for constructing the SAM for Sardinia. We have combined different sources, including country specific features, describing how the different data might be integrated and adjusted. We faced a number of snags in the compilation of some specific sub-matrices since the actual system of regional accounts is still inadequate, especially the regional income accounts. We have endeavoured to produce a satisfactory solution for this which, however, is still not enough. Obviously, there is opportunity for improvement and further developments are needed.

Table A1- *The Input-Output Table of Sardinia (2001) - millions of euros -*

ESA95 NACE rev.1 code (Millions of euros)	Agricolture and forestry	Fishing and fishing activities	Mining and Quarrying	Mining and Quarrying n.e.c.	Manufacture of food products, beverages and tabacco	Manufacture of textiles and wearing appareal	Manufacture of leather and related products	Manufacture of wood and wood products	Manufacture of paper and paper products	Manufacture of coke and refined petroleum products	Manufacture of chemicals and pharmaceutical	Manufacture of rubber and plastic products	Manufacture of other non-metallic mineral products	Manufacture of fabricated metal products, except machinery and equipment	Manufacture of machinery and equipment	Manufacture of eletrical equipment	Manufacture of transport equipment	Other manufacturing	Electricity, Gas and water supply
Agricolture and forestry	186.8	0.0	0.0	0.0	459.2	8.4	0.2	4.9	1.3	0.1	5.1	1.2	1.3	0.3	0.1	0.1	0.1	0.3	0.2
Fishing and fishing activities	0.0	0.2	0.0	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Mining and Quarrying	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	1010.1	0.4	0.0	3.1	1.5	0.0	0.0	0.0	0.0	196.3
Mining and Quarrying n.e.c.	0.1	0.0	0.0	22.6	1.0	0.0	0.0	0.1	0.9	2.9	13.0	0.0	44.5	12.7	0.0	0.6	0.0	1.3	0.1
Manufacture of food products, beverages and tabacco	129.7	1.4	0.0	0.0	353.1	0.1	2.7	0.1	0.2	0.0	27.7	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Manufacture of textiles and wearing appareal	0.7	1.7	0.0	0.0	2.7	146.6	0.4	0.2	1.6	0.1	1.7	2.7	0.8	1.2	0.3	0.5	0.4	1.9	0.1
Manufacture of leather and related products	0.3	0.0	0.0	0.0	0.5	1.7	3.7	0.1	0.1	0.0	0.5	0.3	0.0	0.2	0.1	0.2	0.0	0.9	0.0
Manufacture of wood and wood products	0.3	0.2	0.0	0.6	4.6	0.8	0.1	180.2	0.5	0.0	2.6	0.8	5.5	3.9	0.9	1.4	0.8	25.2	0.0
Manufacture of paper and paper products	0.5	0.2	0.0	0.9	28.3	1.8	0.3	3.1	102.5	0.6	34.6	3.4	12.8	8.4	4.3	5.2	0.5	1.5	2.3
Manufacture of coke and refined petroleum products	19.6	2.1	0.0	7.1	3.7	1.4	0.1	2.2	0.5	225.7	39.0	0.7	9.2	25.0	1.1	0.9	0.2	0.4	83.6
Manufacture of chemicals and pharmaceutical	51.6	0.4	0.0	8.6	7.8	22.8	0.8	10.7	14.3	19.1	430.9	50.3	22.5	29.8	5.3	11.7	1.4	7.7	36.9
Manufacture of rubber and plastic products	1.9	0.4	0.0	1.5	23.6	2.4	1.3	4.2	2.3	0.4	26.0	17.5	6.3	6.6	14.4	17.8	3.5	2.6	2.1
Manufacture of other non-metallic mineral products	2.8	0.1	0.0	20.4	29.6	0.1	0.0	4.7	0.4	2.1	36.6	1.0	105.9	24.8	1.9	7.7	0.8	1.7	2.7
Manufacture of fabricated metal products, except machinery and equipment	2.0	1.2	0.0	1.2	14.6	1.4	0.7	12.3	2.0	7.4	13.2	5.4	16.1	269.4	108.5	60.9	13.4	22.3	9.1
Manufacture of machinery and equipment	1.4	0.0	0.0	5.3	8.1	1.6	0.1	2.4	2.0	6.1	7.6	1.1	6.1	11.0	61.6	6.8	4.2	1.0	9.7
Manufacture of eletrical equipment	0.3	0.9	0.0	1.7	2.9	0.8	0.0	1.0	0.9	3.8	6.2	1.2	3.4	8.4	26.5	108.5	5.3	1.2	15.2
Manufacture of transport equipment	1.3	1.3	0.0	2.2	1.7	0.1	0.0	0.2	0.1	0.2	0.3	0.2	0.7	0.7	1.7	0.3	14.8	0.0	0.1
Other manufacturing	0.0	0.0	0.0	0.1	0.6	2.6	0.0	2.1	1.5	0.4	1.1	0.5	3.5	33.6	0.9	1.1	0.2	9.9	0.2
Electricity, Gas and water supply	32.4	2.6	0.0	19.3	39.4	21.5	0.4	16.1	11.7	38.7	71.9	11.6	59.5	70.4	8.3	8.2	1.1	5.1	266.2
Construction	0.5	0.0	0.0	0.6	2.4	0.8	0.0	2.3	1.0	3.4	4.2	0.7	4.7	7.5	1.2	2.2	0.5	0.2	121.0
Wholesale and Retail trade; Repair of Motor vehicles and motorcycles	65.4	1.7	0.0	13.6	185.7	22.5	2.4	19.7	22.3	53.0	77.3	7.2	39.4	69.4	19.4	24.3	4.6	8.9	23.0
Accomodation and food sevice activities	0.2	0.0	0.0	0.5	2.1	0.6	0.0	1.0	0.6	5.3	11.1	0.5	3.7	5.1	2.5	4.0	0.6	0.6	5.4
Transporation and storage	21.1	1.2	0.0	10.6	82.7	11.1	0.7	15.9	12.4	48.8	82.8	9.1	35.7	69.5	27.9	23.7	3.7	7.0	17.6
Financial and Insurance activities	34.3	1.1	0.0	2.4	19.6	6.5	0.3	12.6	3.9	14.4	14.3	1.8	8.0	23.3	9.4	8.5	0.7	11.4	5.2
Scientific research and development	3.1	0.3	0.0	17.3	63.7	20.7	1.2	20.1	21.4	16.1	87.0	7.7	36.6	62.8	32.7	41.8	6.3	8.4	26.9
Public administration and defence; Compulsory social security	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Education	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Human healt services	1.4	0.0	0.0	0.1	0.4	0.1	0.0	0.1	0.1	0.1	0.3	0.1	0.1	0.3	0.1	0.1	0.0	0.0	0.0
Other service activities	4.3	0.0	0.0	0.7	18.3	4.2	0.2	1.5	2.8	2.1	16.1	0.9	2.6	5.8	2.6	2.5	0.5	0.6	9.0
Real estate activity	0.2	0.1	0.0	7.8	6.9	4.6	0.1	2.6	6.0	3.2	13.0	1.9	7.1	8.1	5.1	5.9	0.6	2.0	6.4
Total intermediates	562.2	17.1	0.0	145.1	1364.5	285.3	15.7	320.4	213.3	1464.1	1024.7	127.9	439.1	759.7	336.8	344.9	64.2	122.2	839.3
Value added at factor cost	1052.4	62.7	0.8	128.6	441.4	135.2	5.0	178.9	109.8	163.8	426.7	61.1	260.2	261.5	155.6	179.0	26.8	63.8	794.8
Indirect taxes on production	0.0	6.5	0.0	3.4	290.7	0.8	0.0	1.2	0.9	643.5	3.9	0.3	1.7	0.0	1.4	1.6	1.7	0.5	109.2
Production subsidies	-96.8	-6.3	0.0	-2.9	-40.8	-0.7	0.0	-1.0	-1.0	0.0	-2.4	-0.3	-1.4	-4.2	-1.6	-1.2	-1.5	-0.3	-20.9
Value added tax	12.7	2.5	0.4	0.1	128.4	53.1	22.2	4.5	29.8	81.0	53.2	9.8	5.3	13.2	24.8	20.2	22.9	40.1	83.5
Secondary production	-106.1	0.0	0.0	-0.1	62.2	-0.1	0.0	-0.1	-0.4	-4.3	-0.1	0.4	-0.4	-4.1	-0.8	-2.3	-0.1	0.0	13.0
Interregional import	198.6	5.6	200.0	5.8	1159.9	575.8	145.6	105.9	483.7	287.8	494.9	156.7	327.7	545.5	383.1	548.8	500.9	242.0	32.7
International import	151.9	13.7	1024.3	31.1	384.6	171.4	76.7	56.9	68.7	163.8	488.6	92.7	50.5	316.2	329.7	600.5	813.4	71.2	17.5
Indirect taxes on international imports	3.4	0.1	0.4	0.0	13.7	7.9	3.0	0.2	0.3	16.1	5.7	1.3	0.8	1.1	3.3	20.3	42.8	2.8	0.4
Total	1778.3	101.9	1225.9	311.1	3804.6	1228.7	268.2	666.9	905.1	2815.8	2495.2	449.9	1083.5	1888.9	1232.3	1711.8	1471.1	542.3	1869.5

ESA95 NACE rev.1 code (Millions of euros)	Construction	Wholesale and Retail trade; Repair of Motor vehicles and motorcycles	Accomodation and food sevice activities	Transporation and storage	Financial and Insurance activities	Scientific research and development	Public administration and defence; Compulsory social security	Education	Human healt services	Other service activities	Real estate activity	Total Intermediate	Households consumption	Government consumption	Gross fixed capital formation	Financial Intermediary Services Indirectly Measured	Changes in inventories and valuables	Interregional Export	International Export	Total
Agricolture and forestry	0.6	0.5	43.9	1.4	0.0	0.2	0.9	2.8	6.2	2.0	0.2	728.3	293.9	0.5	4.4	0.0	-6.5	752.5	5.1	1778.2
Fishing and fishing activities	0.0	0.0	2.0	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.0	4.0	52.2	0.0	0.5	0.0	0.0	44.3	1.1	102.1
Mining and Quarrying	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	1211.6	0.0	0.0	0.0	0.0	13.7	0.0	0.0	1225.3
Mining and Quarrying n.e.c.	25.2	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	125.6	0.4	0.0	0.0	0.0	0.0	167.1	17.7	310.8
Manufacture of food products, beverages and tabacco	0.0	0.0	361.7	4.9	0.0	0.4	3.0	8.0	18.4	3.7	0.0	915.2	1803.3	4.5	0.0	0.0	-8.7	945.0	145.2	3804.5
Manufacture of textiles and wearing appareal	2.7	4.0	3.4	3.4	0.2	3.8	1.9	0.7	6.7	3.8	0.2	194.4	778.3	0.0	6.9	0.0	-19.8	250.6	18.1	1228.5
Manufacture of leather and related products	0.3	2.8	0.0	0.2	0.2	0.1	1.7	0.1	0.3	0.4	0.0	14.7	252.3	0.0	3.1	0.0	-3.3	0.0	1.4	268.2
Manufacture of wood and wood products	68.8	4.4	3.6	1.7	0.0	0.4	3.2	0.9	0.2	2.7	1.5	315.8	44.4	0.0	5.8	0.0	-1.8	272.7	29.6	666.5
Manufacture of paper and paper products	14.4	97.1	13.4	39.0	23.4	57.1	42.6	7.1	8.7	16.1	4.5	534.6	202.5	0.0	3.1	0.0	-1.7	160.0	6.4	904.9
Manufacture of coke and refined petroleum products	21.8	129.9	11.6	193.7	6.5	34.2	20.1	3.3	20.3	9.0	9.0	881.9	431.2	0.0	0.0	0.0	-22.4	294.7	1230.3	2815.7
Manufacture of chemicals and pharmaceutical	33.4	21.0	9.8	5.6	2.1	14.6	14.0	4.5	390.6	21.4	2.1	1251.7	288.6	0.0	0.0	0.0	-17.8	672.8	300.4	2495.7
Manufacture of rubber and plastic products	42.4	25.0	2.5	46.0	6.1	16.2	2.8	1.6	5.9	6.1	1.9	291.3	57.9	0.0	3.5	0.0	-3.4	81.0	19.7	450.0
Manufacture of other non-metallic mineral products	503.9	1.9	7.4	1.7	0.0	0.7	1.5	1.8	1.3	5.6	2.4	771.5	70.4	0.0	15.4	0.0	0.1	210.4	15.8	1083.6
Manufacture of fabricated metal products, except machinery and equipment	279.5	31.0	1.7	7.7	1.2	2.9	12.8	3.8	5.0	3.5	9.2	919.4	32.8	0.0	182.0	0.0	0.5	543.8	210.6	1889.1
Manufacture of machinery and equipment	30.7	22.8	3.7	16.4	1.2	7.0	21.0	2.6	3.8	7.4	3.4	256.1	125.1	0.0	684.0	0.0	-23.8	138.0	52.8	1232.2
Manufacture of eletrical equipment	101.2	59.2	3.5	46.1	2.6	37.5	8.2	5.1	38.2	7.4	1.6	498.8	213.1	0.0	702.6	0.0	-5.1	285.4	16.6	1711.4
Manufacture of transport equipment	0.0	76.1	0.0	93.3	0.0	3.8	69.7	0.3	0.1	5.6	1.7	276.5	512.5	0.0	640.9	0.0	-3.6	36.1	8.8	1471.2
Other manufacturing	1.8	14.6	0.8	1.5	2.6	3.3	4.1	2.6	3.9	1.2	0.3	95.0	306.1	0.0	122.1	0.0	-25.5	40.9	3.6	542.2
Electricity, Gas and water supply	24.7	133.7	61.6	48.1	12.9	27.8	57.1	23.5	42.5	24.8	19.8	1160.9	664.5	5.1	0.0	0.0	0.0	39.5	0.0	1870.0
Construction	414.8	19.1	6.6	36.2	6.2	26.7	53.2	9.2	29.2	6.4	116.8	877.6	25.2	0.0	2845.4	0.0	0.0	21.1	0.4	3769.7
Wholesale and Retail trade; Repair of Motor vehicles and motorcycles	66.6	174.5	94.3	92.8	11.9	23.9	38.1	12.6	75.1	17.7	11.2	1278.5	4061.9	0.0	382.7	0.0	0.0	44.0	180.2	5947.3
Accomodation and food sevice activities	18.6	25.7	2.9	44.1	8.5	58.6	12.8	1.5	17.4	7.2	2.1	243.2	1676.5	2.3	0.0	0.0	0.0	2.6	0.0	1924.6
Transporation and storage	107.4	209.5	38.4	473.2	91.2	153.9	98.0	15.7	51.7	43.3	13.2	1777.0	1244.2	24.9	111.4	0.0	0.0	210.7	413.9	3782.1
Financial and Insurance activities	48.6	170.0	5.2	78.0	377.2	86.0	44.4	3.1	14.8	21.1	56.4	1082.5	354.8	0.0	0.0	969.6	0.0	74.1	15.6	2496.6
Scientific research and development	176.0	706.9	71.9	194.9	347.0	585.0	203.8	30.4	199.0	166.7	158.2	3313.9	122.0	152.6	334.9	0.0	0.0	109.1	8.1	4040.6
Public administration and defence; Compulsory social security	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.8	2822.9	0.0	0.0	0.0	287.8	0.0	3140.5
Education	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	220.2	1905.4	0.0	0.0	0.0	3.9	0.0	2129.5
Human healt services	1.5	3.2	0.5	0.5	1.4	0.8	3.7	0.0	509.8	2.0	0.1	526.8	313.3	2220.4	0.0	0.0	0.0	4.8	0.0	3065.3
Other service activities	11.3	59.6	13.5	17.3	17.8	148.4	110.9	22.5	91.1	231.6	27.8	826.5	783.8	250.7	20.7	0.0	-0.1	12.2	0.7	1894.5
Real estate activity	23.7	302.0	30.5	78.0	62.2	172.0	21.4	16.6	52.7	58.4	19.3	918.4	2578.6	0.0	103.3	0.0	0.0	2.1	53.8	3656.2
Total intermediates	2019.9	2294.9	794.5	1525.8	982.4	1465.3	850.9	180.3	1593.1	675.1	463.0	21291.7	17539.8	7389.3	6172.7	969.6	-129.2	5707.2	2755.9	61697.0
Value added at factor cost	1483.3	3327.4	1002.2	1752.8	1030.8	2047.4	2153.4	1944.2	1465.7	904.4	2961.4	24581.1								
Indirect taxes on production	42.1	0.0	1.6	0.0	72.3	121.4	0.0	2.6	0.0	212.1	0.3	1519.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3039.4
Production subsidies	0.0	-70.3	0.0	-121.4	0.0	0.0	0.0	0.0	-2.4	0.0	0.0	-377.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-754.8
Value added tax	192.5	397.3	123.8	135.7	39.7	94.8	0.0	0.3	4.6	81.5	25.1	1703.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3406.0
Secondary production	-1.1	-99.4	0.0	-3.5	-5.0	46.0	-7.2	-1.9	-0.6	-0.6	116.7	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Interregional import	21.2	74.1	2.5	205.8	343.8	210.4	143.2	4.0	5.1	12.3	2.9	7426.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14852.6
International import	12.0	23.5	0.0	287.0	32.5	54.8	0.0	0.0	0.0	9.8	87.8	5430.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10861.6
Indirect taxes on international imports	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	123.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	247.8
Total	3769.9	5947.5	1924.6	3782.2	2496.7	4040.2	3140.3	2129.5	3065.5	1894.6	3657.2	61699.2	17539.8	7389.3	6172.7	969.6	-129.2	5707.2	2755.9	

Table A2. - *Sardinia Bridge Matrix for the year 2001- millions of euros -*

	Generi alimentari e bevande non alcoliche	Bevande Alcoliche tabacco e narcotici	Vestiario e calzature	Abitazione energia e combustibili	Mobili ed elettrodomestici	Salute	Trasporti	Comunicazioni	Ricreazione e cultura	Istruzione	Ristoranti e Alberghi	Altri beni e servizi	Totals
Agricolture, hunting, forestry and logging	27.23	293.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	320.30
Fishing and aquaculture	56.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	56.31
Mining and Quarrying	0.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.69
Manufacture of food products, beverages and tabacco	1738.61	173.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1911.64
Manufacture of textiles and wearing appareal	780.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	780.46
Manufacture of leather and related products	254.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	254.22
Manufacture of paper and paper products ; manufacture of articles of straw and plaiting materials	0.00	0.00	0.00	0.96	0.00	0.00	0.00	0.00	207.64	0.00	0.00	0.00	208.60
Manufacture of coke, refined petroleum products, chemicals and pharmaceutical	0.00	0.00	0.00	151.64	145.19	23.06	0.00	0.00	16.73	0.00	0.00	388.20	724.83
Manufacture of other non-metallic mineral products	0.00	0.00	0.00	0.00	66.96	0.00	0.00	0.00	0.00	0.00	0.00	5.04	72.00
Manufacture of fabricated metal products, except machinery and equipment	7.50	7.49	0.00	0.00	0.00	0.00	0.00	0.00	7.58	0.00	0.00	12.91	35.48
Manufacture of computer, electronic and optical products , machinery and equipment , transport equipment	0.00	0.00	0.00	0.00	162.84	338.75	0.00	0.00	342.59	0.00	0.00	14.39	858.57
Manufacture of wood, rubber, plastic products and other manufacturing	7.35	7.33	0.00	8.90	0.00	13.50	58.29	0.00	250.55	0.00	0.00	73.38	419.29
Electricity, Gas and water supply	7.28	0.00	0.00	695.11	0.00	0.00	2.16	0.00	0.00	0.00	0.00	0.00	704.56
Construction	0.00	0.00	0.00	25.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	25.52
Wholesale and Retail trade; Repair of Motor vehicles and motorcycles	7.45	7.43	1446.29	0.00	924.92	0.00	1738.80	5.09	12.85	0.00	0.00	6.67	4149.50
Accomodation and food sevice activities	45.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1727.30	0.00	1772.49
Transportation and Storage	7.34	7.33	0.00	0.00	0.00	0.00	658.64	479.71	195.01	0.00	0.00	0.00	1348.03
Financial and Insurance activities	7.35	7.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	343.62	358.30
Real estate activities, Professional, Scientific and Technical activities	0.00	0.00	0.00	2591.01	0.00	0.00	20.00	0.00	15.65	0.00	0.00	108.92	2735.58
Public administration and defence; Compulsory social security	7.34	7.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.12	34.78
Education	7.31	7.30	0.00	0.00	0.00	0.00	34.81	0.00	39.94	154.30	0.00	0.00	243.66
Human Health and social work activities	7.48	7.47	0.00	0.00	0.00	103.72	0.00	0.00	18.48	0.00	0.00	203.22	340.37
Other service activities	0.00	0.00	22.11	117.96	370.09	10.27	0.00	0.00	19.97	0.00	0.00	304.63	845.03
Totals	2969.10	525.10	1468.40	3591.10	1670.00	489.30	2512.70	484.80	1127.00	154.30	1727.30	1481.10	18200.20

Table A3 – *Unbalanced SAM - millions of euros -*

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	H_1	H_2	H_3	H_4	H_5	H_6	H_7	H_8	H_9	H_10	H_11	H_12	H_13	H_14	31	32	33	34	35	36	Total
1.0 Agricolture, hunting, forestry and logging	174.5	0.0	0.0	475.0	8.4	0.2	1.3	5.2	1.3	0.3	0.3	6.4	0.2	0.6	0.5	43.9	1.4	0.0	0.4	0.9	2.8	6.2	2.0							3.4	16.4	36.1	66.7	61.5	29.3	62.7	25.9	7.1	3.9	5.6	0.2	0.0	1.6		0.5	0.0		750.0	5.1	1807.8
2.0 Fishing and aquaculture	0.0	0.2	0.0	1.3	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.1	0.0	0.0	0.0	2.0	0.1	0.0	0.0	0.0	0.0	0.1	0.0							0.5	3.2	6.3	12.5	10.2	6.9	9.1	4.1	1.9	0.8	0.6	0.0	0.0	0.2		0.0	0.5		44.2	1.1	106.1
3.0 Mining and Quarrying	0.1	0.0	22.6	1.0	0.1	0.0	0.9	1023.7	47.6	14.1	0.6	1.4	198.0	25.2	0.4	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.0							0.0	0.0	0.1	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	15.4		167.4	17.7	1537.3
4.0 Manufacture of food products, beverages and tabacco	121.2	1.4	0.0	365.3	0.1	2.7	0.2	27.7	0.0	0.0	0.0	0.2	0.0	0.0	0.0	361.7	4.9	0.0	0.4	3.0	8.0	18.4	3.7							15.9	108.5	215.5	422.2	348.5	227.8	313.9	139.3	62.8	27.4	20.6	0.7	0.0	8.5		4.5	0.0		943.8	145.0	3923.8
5.0 Manufacture of textiles and wearing appareal	0.7	1.7	0.0	2.8	146.6	0.4	1.6	1.8	0.8	1.2	1.2	4.8	0.1	2.7	3.9	3.4	3.4	0.2	4.1	1.9	0.7	6.7	3.8							6.3	44.8	88.0	173.5	141.5	95.4	125.5	56.2	26.6	11.3	7.8	0.3	0.0	3.5		0.0	0.0		250.7	18.1	1243.6
6.0 Manufacture of leather and related products	0.3	0.0	0.0	0.5	1.7	3.7	0.1	0.5	0.0	0.2	0.3	1.3	0.0	0.3	2.8	0.0	0.2	0.2	0.1	1.7	0.1	0.3	0.4							2.1	14.6	28.7	56.5	46.1	31.1	40.9	18.3	8.7	3.7	2.6	0.1	0.0	1.1		0.0	0.0		0.0	1.4	270.3
7.0 Manufacture of paper and paper products ; manufacture of articles of straw and plaiting materials	0.5	0.2	0.9	29.3	1.8	0.3	102.4	35.2	12.8	8.4	10.0	8.0	2.3	14.4	95.4	13.4	39.0	23.3	62.5	42.5	7.1	8.7	16.1							1.2	4.5	10.5	30.5	36.8	40.9	39.5	22.6	7.0	9.3	2.9	0.1	0.0	2.8		0.0	1.4		160.2	6.4	910.9
8.0 Manufacture of coke, refined petroleum products, chemicals and pharmaceutical	66.5	2.5	15.7	11.9	24.2	0.9	14.8	714.0	31.7	54.6	20.5	72.1	121.5	55.2	148.2	21.4	199.1	8.6	60.9	34.0	7.8	410.8	30.4							3.1	28.0	50.1	122.3	128.5	98.5	142.1	84.9	31.1	20.9	8.8	0.3	0.0	6.3		0.0	0.0		969.5	1533.4	5355.0
9.0 Manufacture of other non-metallic mineral products	2.6	0.1	20.4	30.6	0.1	0.0	0.4	38.7	105.8	24.7	10.4	7.4	2.7	503.7	1.9	7.4	1.7	0.0	3.2	1.5	1.8	1.3	5.6							0.2	2.2	4.5	15.3	13.2	8.1	11.9	10.1	3.3	1.2	0.9	0.0	0.0	0.9		0.0	15.5		210.0	15.8	1085.2
10.0 Manufacture of fabricated metal products, except machinery and equipment	1.9	1.2	1.2	15.1	1.4	0.7	2.0	20.6	16.1	268.3	182.3	40.0	9.2	279.4	30.5	1.7	7.7	1.2	12.5	12.8	3.8	5.0	3.5							0.2	1.4	2.8	6.2	6.3	5.1	7.0	3.5	1.3	1.0	0.5	0.0	0.0	0.3		0.0	182.7		544.5	210.9	1891.5
11.0 Manufacture of computer, electronic and optical products , machinery and equipment , transport equipment	2.8	2.2	9.2	13.1	2.5	0.1	3.0	24.2	10.2	20.0	229.0	8.3	25.2	131.9	155.3	7.2	155.6	3.8	55.9	98.7	8.0	42.1	20.4							4.5	33.1	72.3	157.4	167.5	110.6	150.5	95.4	30.9	20.7	7.7	0.2	0.0	8.0		0.0	1996.8		459.9	78.2	4422.2
12.0 Manufacture of wood, rubber, plastic products and other manufacturing	2.1	0.6	2.2	29.8	5.8	1.4	4.3	30.5	15.3	43.9	40.9	243.0	2.3	113.0	43.2	6.9	49.1	8.7	24.0	10.1	5.1	10.0	10.0							2.1	11.2	25.3	64.2	74.9	74.9	80.9	45.0	15.6	15.5	5.3	0.1	0.0	4.2		0.0	100.8		394.7	52.9	1669.8
13.0 Electricity, Gas and water supply	30.3	2.6	19.3	40.8	21.5	0.4	11.7	110.5	59.5	70.1	17.5	32.8	268.3	24.7	131.3	61.6	48.0	12.9	48.6	57.0	23.5	42.5	24.8							4.6	43.6	76.1	130.8	138.5	75.8	113.6	70.6	24.5	11.5	9.0	1.0	0.0	5.0		5.1	0.0		39.5	0.0	1909.3
14.0 Construction	0.5	0.0	0.6	2.5	0.8	0.0	1.0	7.6	4.7	7.5	3.9	3.2	122.0	414.7	18.8	6.6	36.2	6.2	147.8	53.1	9.2	29.2	6.4							0.2	1.6	2.8	4.7	5.0	2.7	4.1	2.6	0.9	0.4	0.3	0.0	0.0	0.2		0.0	2841.0		21.1	0.4	3770.3
15.0 Wholesale and Retail trade; Repair of Motor vehicles and motorcycles	61.1	1.7	13.6	192.1	22.5	2.4	22.3	130.2	39.4	69.1	48.2	35.8	23.2	66.6	171.4	94.3	92.7	11.9	35.8	38.0	12.6	75.1	17.7							14.8	113.5	288.7	768.0	775.6	649.7	744.1	451.0	193.2	75.4	57.5	0.0	0.0	17.9		0.0	382.8		44.0	180.2	6034.1
16.0 Accomodation and food sevice activities	0.2	0.0	0.5	2.2	0.6	0.0	0.6	16.4	3.7	5.1	7.1	2.1	5.4	18.6	25.2	2.9	44.1	8.5	61.5	12.8	1.5	17.4	7.2							2.5	44.9	87.3	366.6	292.7	219.5	374.5	196.0	104.7	46.1	28.5	1.3	0.0	7.9		2.3	0.0		2.6	0.0	2020.9
17.0 Transportation and Storage	19.7	1.2	10.6	85.5	11.1	0.7	12.4	131.5	35.7	69.2	55.1	32.0	17.7	107.4	205.8	38.4	472.7	91.0	169.6	97.8	15.7	51.7	43.3							6.5	42.5	106.5	237.3	264.1	217.2	238.8	131.5	54.7	29.7	13.3	0.6	0.0	5.2		24.9	111.5		210.8	414.2	3885.2
18.0 Financial and Insurance activities	70.8	3.6	7.5	38.3	11.8	0.5	8.2	51.9	18.3	33.5	32.8	37.8	36.8	107.1	295.9	44.7	147.0	416.8	348.1	129.0	79.7	72.6	56.8							1.4	11.8	19.9	52.1	59.2	56.0	79.9	40.9	16.2	13.7	4.4	0.1	0.0	2.9		0.0	0.0		74.6	15.7	2498.0
19.0 Real estate activities, Professional, Scientific and Technical activities	3.1	0.4	25.1	73.0	25.3	1.3	27.4	119.2	43.7	70.6	92.1	42.7	33.6	199.6	991.1	102.4	272.6	408.2	950.5	224.7	47.0	251.7	225.0							17.4	165.2	287.9	501.2	534.3	301.7	448.5	276.9	96.5	47.7	34.8	3.8	0.0	19.7		152.4	438.0		111.1	62.0	7729.1
20.0 Public administration and defence; Compulsory social security	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0							0.2	1.4	2.7	6.0	6.1	4.7	7.2	3.5	1.3	1.0	0.4	0.0	0.0	0.2		2822.7	0.0		287.8	0.0	3145.3
21.0 Education	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0							0.5	6.2	12.7	33.7	62.6	34.5	49.4	29.8	7.1	2.7	3.6	0.0	0.0	0.9		1905.4	0.0		3.9	0.0	2153.0
22.0 Human Health and social work activities	1.3	0.0	0.1	0.4	0.1	0.0	0.1	0.4	0.1	0.3	0.2	0.2	0.0	1.5	3.1	0.5	0.5	1.4	0.9	3.7	0.0	509.7	2.0							1.6	13.9	26.8	56.2	62.3	44.5	69.0	36.9	13.8	9.7	3.1	0.0	0.0	2.4		2220.8	0.0		4.8	0.0	3092.5
23.0 Other service activities	4.0	0.0	0.7	18.9	4.2	0.2	2.8	18.2	2.6	5.8	5.6	3.0	9.1	11.3	58.5	13.5	17.3	17.8	179.1	110.6	22.5	91.1	231.5							3.2	30.0	56.4	155.3	151.5	109.5	156.9	104.9	37.2	21.1	10.8	0.2	0.0	8.2		250.3	20.6		12.2	0.7	1957.0
24.0 Wages and Salaries	224.9	39.3	58.1	125.3	48.0	2.2	34.3	169.6	75.4	150.7	156.2	88.6	171.3	509.4	754.8	449.0	756.9	309.7	643.0	1061.6	1057.4	901.1	490.5																											8277.3
25.0 Employers' Social Contributions	49.0	8.6	26.3	49.0	12.9	0.5	14.6	62.5	30.2	60.8	57.7	28.5	68.9	178.2	209.5	72.2	221.1	137.9	156.2	494.4	493.4	303.2	90.6																											2826.2
26.0 Operating Surplus	707.1	16.9	48.4	302.3	50.8	6.1	48.8	168.0	96.7	124.6	138.0	139.8	567.1	759.2	2283.8	645.4	955.4	336.1	3752.8	985.3	255.7	578.9	271.9																											13239.2
27.0 Indirect tax on production	0.0	6.5	3.4	290.7	0.8	0.0	0.9	647.4	1.7	0.0	4.7	2.0	109.2	42.1	0.0	1.6	0.0	72.3	121.7	0.0	2.6	0.0	212.1																											1519.7
28.0 Subsidies on production	-96.8	-6.3	-2.9	-40.8	-0.7	0.0	-1.0	-2.4	-1.4	-4.2	-4.3	-1.6	-20.9	0.0	-70.3	0.0	-121.4	0.0	0.0	0.0	0.0	-2.4	0.0																											-377.4
29.0 Iva	12.7	2.5	0.5	128.4	53.1	22.2	29.8	134.2	5.3	13.2	67.9	54.4	83.5	192.5	397.3	123.8	135.7	39.7	119.9	0.0	0.3	4.6	81.5																											1703.0
30A H1																								12.7	36.2	4.3				0.0														0.5	1.1				0.1	54.9
30B H2																								325.8	365.9	111.3					3.8													36.2	92.1				4.6	939.8
30C H3																								554.6	605.4	189.4						23.8												228.3	580.7				29.1	2211.2
30D H4																								888.7	1844.5	303.4							36.8											353.1	898.0				45.1	4369.7
30E H5																								906.2	1202.2	309.4								28.0										268.3	682.4				34.2	3430.9
30F H6																								1283.9	1040.0	438.4									17.5									167.8	426.8				21.4	3395.8
30G H7																								1760.1	1849.9	601.0										30.0								287.2	730.4				36.6	5295.2
30H H8																								1080.6	991.3	368.9											14.1							135.5	344.6				17.3	2952.4
30I H9																								759.7	410.4	259.4												4.3						41.4	105.2				5.3	1585.7
30L H10																								365.9	335.7	124.9													2.8					26.4	67.3				3.4	926.4
30M H11																								228.3	337.3	78.0														1.7				16.3	41.4				2.1	705.2
30N H12																								59.9	47.5	20.5															0.5			4.7	11.9				0.6	145.6
30O H13																								0.0	0.0	0.0																0.0		0.0	0.0				0.0	0.0
30P H14																								50.8	309.3	17.3																	1.3	12.0	30.5				1.5	422.8
31.0 Firms																										3708.9				0.3	5.8	16.6	30.9	24.0	21.8	34.5	18.7	9.4	5.6	4.2	0.9	0.0	2.6	117.5	337.9	0.0	0.0	0.0	33.5	4373.2
32.0 Government																										154.5	1519.7	-377.4	1703.0	11.5	215.2	610.9	1140.1	886.2	802.6	1272.8	690.9	346.4	205.0	154.0	32.6	0.0	95.0	356.6	3323.2		123.9	0.0	49.2	13315.8
33.0 Capital Formation																														-49.5	-31.4	40.8	-298.2	-910.5	95.0	665.0	366.2	472.9	334.5	313.4	102.1	0.0	214.4	2263.3	-2979.0	0.0	0.0	1719.0	2788.3	5106.5
34.0 Indirect tax on imports	3.4	0.1	0.4	13.7	7.9	3.0	0.3	21.8	0.8	1.1	66.4	4.3	0.4	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.0																					0.0	0.0	0.0	0.0	0.0	0.0	123.9
35.0 ROC	198.6	5.6	205.8	1159.9	575.8	145.6	483.7	782.7	327.7	545.5	1432.8	504.6	32.7	21.2	74.1	2.5	205.8	343.8	213.3	143.2	4.0	5.1	12.3																					0.0	0.0	0.0	0.0	0.0	0.0	7426.3
36.0 ROW	151.9	13.7	1055.4	384.6	171.4	76.7	68.7	652.4	50.5	316.2	1743.6	220.8	17.5	12.0	23.5	0.0	287.0	32.5	142.6	0.0	0.0	0.0	9.8							0.2	3.9	11.1	20.7	16.1	14.6	23.1	12.6	6.3	3.7	2.8	0.6	0.0	1.7	58.0	225.2	0.0	0.0	0.0	0.0	5831.5
Total columns	1814.8	106.5	1545.5	3842.6	1210.6	272.2	897.5	5144.4	1036.0	1974.9	4421.0	1624.1	1907.3	3792.4	6055.9	2128.5	4033.7	2292.7	7315.4	3618.1	2070.2	3441.1	1879.2	8277.3	9375.7	6689.7	1519.7	-377.4	1703.0	54.9	939.8	2211.2	4369.7	3430.9	3395.8	5295.2	2952.4	1585.7	926.4	705.2	145.6	0.0	422.8	4373.2	12308.9	6107.0	123.9	7426.3	5831.5	
Total rows	1807.8	106.1	1537.3	3923.8	1243.6	270.3	910.9	5355.0	1085.2	1891.5	4422.2	1669.8	1909.3	3770.3	6034.1	2020.9	3885.2	2498.0	7729.1	3145.3	2153.0	3092.5	1957.0	8277.3	2826.2	13239.2	1519.7	-377.4	1703.0	54.9	939.8	2211.2	4369.7	3430.9	3395.8	5295.2	2952.4	1585.7	926.4	705.2	145.6	0.0	422.8	4373.2	13315.8	3791.7	123.9	7426.3	5831.5	
Differences (column-row)	7.1	0.4	8.2	-81.2	-33.0	1.9	-13.5	-210.6	-49.2	83.3	-1.1	-45.7	-2.1	22.1	21.8	107.6	148.6	-205.4	-413.7	472.8	-82.8	348.6	-77.8	0.0	6549.5	-6549.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-1006.9	2315.3	0.0	0.0	0.0	

Table A4 – *Balanced SAM - millions of euros -*

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	H_1	H_2	H_3	H_4	H_5	H_6	H_7	H_8	H_9	H_10	H_11	H_12	H_13	H_14	31	32	33	34	35	36	Total
1 Agricolture, hunting, forestry and logging	180.5			485.0	8.5	0.2	1.3	5.3	1.3	0.3	0.3	6.5	0.2	0.6	0.6	44.0	1.4		0.6	0.8	2.6	5.6	2.1							3.4	16.5	36.6	68.4	62.9	29.9	63.7	26.2	7.1	3.9	5.6	0.2	0.0	1.6		0.6			732.0	4.8	1811.1
2 Fishing and aquaculture		0.2		1.4				0.2				0.1				2.0	0.1					0.1								0.5	3.3	6.4	12.8	10.5	7.0	9.2	4.1	1.9	0.8	0.6	0.0	0.0	0.3			0.7		42.9	1.1	106.3
3 Mining and Quarrying	0.1		22.2	1.1	0.1		0.9	1027.8	48.7	13.7	0.6	1.4	202.5	25.1	0.5	0.1			0.2			0.1								0.0	0.0	0.1	0.2	0.2	0.1	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0			17.8		161.1	16.3	1541.5
4 Manufacture of food products, beverages and tabacco	124.6	1.4		368.8	0.1	2.7	0.2	27.7				0.2				360.1	4.7		0.6	2.6	7.3	16.5	3.8							15.9	108.9	216.9	427.2	352.3	229.4	314.1	139.5	62.6	27.3	20.5	0.7	0.0	8.5		4.1			901.9	132.4	3883.4
5 Manufacture of textiles and wearing appareal	0.7	1.7		2.8	148.0	0.4	1.6	1.8	0.8	1.2	1.2	4.9	0.1	2.7	4.1	3.4	3.3	0.2	4.8	1.6	0.7	6.0	3.9							6.3	44.8	88.1	173.7	141.7	95.3	124.1	55.9	26.4	11.3	7.8	0.3	0.0	3.4					235.7	16.4	1227.1
6 Manufacture of leather and related products	0.3			0.6	1.7	3.7	0.1	0.5		0.2	0.3	1.3		0.3	2.9		0.2	0.2	0.2	1.5	0.1	0.3	0.4							2.1	14.6	28.8	56.9	46.4	31.2	40.7	18.3	8.6	3.7	2.5	0.1	0.0	1.1						1.3	271.2
7 Manufacture of paper and paper products ; manufacture of articles of straw and plaiting materials	0.5	0.2	0.9	29.3	1.8	0.3	102.8	34.7	13.1	8.1	9.6	8.1	2.4	14.2	98.6	13.3	37.1	24.1	72.9	36.2	6.4	7.7	16.3							1.2	4.5	10.6	30.6	36.8	40.9	39.0	22.4	6.9	9.3	2.9	0.1	0.0	2.8			1.7		150.2	5.8	904.2
8 Manufacture of coke, refined petroleum products, chemicals and pharmaceutical	68.9	2.5	15.5	12.2	24.6	0.9	14.9	728.2	32.5	53.2	20.3	73.6	125.0	55.6	159.4	21.5	194.6	9.0	74.6	29.6	7.2	371.3	31.1							3.1	28.2	50.9	126.0	132.1	100.5	145.2	86.0	31.1	20.9	8.8	0.3	0.0	6.3					953.2	1431.0	5249.9
9 Manufacture of other non-metallic mineral products	2.7	0.1	19.9	30.6	0.1		0.4	38.1	107.9	23.7	9.9	7.5	2.8	493.5	2.0	7.3	1.7		3.8	1.3	1.6	1.2	5.7							0.2	2.2	4.6	15.3	13.2	8.1	11.8	10.0	3.3	1.2	0.9	0.0	0.0	0.9			17.2		195.8	14.2	1060.7
10 Manufacture of fabricated metal products, except machinery and equipment	2.0	1.2	1.2	15.7	1.4	0.7	2.0	21.4	16.6	262.8	182.2	41.0	9.5	284.6	33.4	1.7	7.7	1.3	15.7	11.3	3.5	4.6	3.6							0.2	1.4	2.8	6.5	6.6	5.3	7.4	3.6	1.3	1.1	0.5	0.0	0.0	0.3			223.1		547.7	200.4	1933.2
11 Manufacture of computer, electronic and optical products , machinery and equipment , transport equipment	2.9	2.2	8.9	12.9	2.5	0.1	3.0	23.3	10.4	19.1	214.7	8.3	25.4	127.2	155.9	7.1	145.3	3.9	62.9	82.7	7.2	36.7	20.5							4.5	33.0	71.6	153.9	164.0	108.6	144.8	93.4	30.4	20.5	7.6	0.2	0.0	8.0			2114.8		415.9	68.4	4422.4
12 Manufacture of wood, rubber, plastic products and other manufacturing	2.1	0.6	2.2	29.8	5.9	1.4	4.3	30.1	15.6	42.2	39.2	245.3	2.4	111.0	44.7	6.9	46.8	9.0	28.0	8.6	4.6	8.9	10.1							2.1	11.2	25.3	64.2	74.9	74.8	79.9	44.7	15.5	15.4	5.3	0.1	0.0	4.2			112.0		369.9	47.6	1647.0
13 Electricity, Gas and water supply	31.1	2.6	18.9	41.0	21.7	0.4	11.8	109.7	60.7	67.6	16.9	33.2	273.3	24.4	136.8	61.2	46.0	13.3	57.3	48.7	21.3	37.8	25.2							4.6	43.7	76.3	131.5	139.2	76.0	112.9	70.5	24.4	11.5	8.9	1.0	0.0	5.0		4.5			37.4		1908.3
14 Construction	0.5		0.6	2.4	0.8		1.0	7.2	4.8	7.1	3.6	3.2	121.8	393.5	18.4	6.4	33.2	6.3	161.0	43.8	8.2	25.1	6.4							0.2	1.6	2.7	4.6	4.9	2.7	3.9	2.5	0.9	0.4	0.3	0.0	0.0	0.2			2883.1		18.5	0.4	3782.1
15 Wholesale and Retail trade; Repair of Motor vehicles and motorcycles	62.6	1.7	13.3	192.6	22.7	2.4	22.4	128.9	40.2	66.6	46.3	36.2	23.6	65.6	178.1	93.5	88.6	12.3	42.1	32.5	11.4	66.7	17.9							14.8	113.6	289.4	770.4	777.9	650.1	737.5	449.1	191.7	75.0	57.2	0.0	0.0	17.8			428.7		41.6	162.8	6046.0
16 Accomodation and food sevice activities	0.2		0.5	2.3	0.6		0.6	16.8	3.8	5.0	7.0	2.2	5.6	18.8	27.3	2.9	43.2	8.9	75.7	11.2	1.4	15.8	7.4							2.5	45.2	88.7	378.7	301.6	224.4	383.7	198.8	104.9	46.1	28.5	1.3	0.0	7.9		2.3			2.6		2074.6
17 Transportation and Storage	20.5	1.2	10.5	88.2	11.3	0.7	12.5	135.0	36.7	67.6	54.7	32.8	18.3	108.6	223.1	38.7	464.4	95.4	209.6	85.5	14.4	46.9	44.5							6.5	42.8	108.4	245.9	273.0	222.5	245.5	133.7	54.9	29.7	13.3	0.6	0.0	5.2		23.7	133.8		209.3	389.5	3959.8
18 Financial and Insurance activities	70.8	3.6	7.2	36.5	11.8	0.5	8.2	48.0	18.4	31.4	29.7	37.4	36.6	100.3	283.2	43.2	132.9	416.4	369.2	105.3	70.2	61.7	56.1							1.4	11.6	19.4	49.2	56.1	53.5	73.8	39.2	15.7	13.5	4.3	0.1	0.0	2.8					63.7	13.2	2395.7
19 Real estate activities, Professional, Scientific and Technical activities	3.1	0.4	24.2	70.6	25.3	1.3	27.3	112.5	44.2	66.8	85.0	42.5	33.6	190.0	972.9	99.7	250.7	411.8	1040.0	186.0	41.7	216.7	224.0							17.4	164.0	282.8	481.6	514.8	292.5	423.3	268.3	94.4	47.0	34.4	3.7	0.0	19.5		111.2	447.6		97.8	53.1	7523.8
20 Public administration and defence; Compulsory social security																														0.2	1.5	2.8	6.5	6.5	5.0	7.7	3.6	1.4	1.0	0.5	0.0	0.0	0.2		3042.3			303.2		3382.5
21 Education																														0.5	6.2	13.0	35.3	65.2	35.6	51.3	30.5	7.2	2.7	3.6	0.0	0.0	0.9		1856.3			4.0		2112.2
22 Human Health and social work activities	1.4		0.1	0.5	0.1		0.1	0.5	0.1	0.3	0.2	0.2		1.6	3.7	0.5	0.5	1.5	1.3	3.4		475.5	2.1							1.6	14.2	27.9	60.6	66.9	46.9	74.2	38.5	14.0	9.8	3.1	0.0	0.0	2.4		2408.2			5.1		3267.2
23 Other service activities	4.1		0.7	18.9	4.2	0.2	2.8	18.0	2.7	5.6	5.4	3.0	9.2	11.1	60.5	13.4	16.5	18.3	208.7	94.2	20.3	80.6	234.2							3.2	30.0	56.4	155.2	151.4	109.2	154.8	104.2	36.9	21.0	10.7	0.2	0.0	8.1		209.0	22.9		11.5	0.7	1918.2
24 Wages and Salaries	234.2	39.2	57.6	129.9	49.0	2.2	34.8	175.5	77.7	147.5	155.8	90.8	177.2	518.1	825.4	453.2	748.1	326.0	803.6	932.6	974.2	821.9	505.0																											8279.5
25 Employers' Social Contributions	75.5	8.8	35.8	113.5	16.9	0.5	17.8	189.8	38.7	88.5	142.6	41.0	105.8	393.4	802.1	111.5	504.2	237.1	912.0	868.5	700.7	540.3	138.2																											6083.3
26 Operating Surplus	638.1	16.8	42.7	233.3	47.3	5.9	46.2	117.3	92.0	105.5	98.8	126.7	507.5	581.4	1578.1	557.5	695.1	295.5	2666.1	671.5	201.1	413.1	242.4																											9979.9
27 Indirect tax on production		6.5	3.3	286.3	0.8		0.9	625.9	1.7		4.5	2.0	110.2	40.8		1.6		73.8	138.1		2.3		213.0																											1511.8
28 Subsidies on production	-96.8	-6.3	-2.9	-40.8	-0.7	0.0	-1.0	-2.4	-1.4	-4.2	-4.3	-1.6	-20.9	0.0	-70.2	0.0	-121.5	0.0	0.0	0.0	0.0	-2.4	0.0																											-377.4
29 Iva	12.9	2.5	0.5	126.2	53.3	22.1	29.8	129.3	5.4	12.6	63.8	54.5	84.1	186.0	399.8	121.5	126.9	40.5	135.3		0.3	4.0	81.8																											1693.1
30A H1																								15.1	26.2	10.8				0.0														0.5	2.0				0.2	54.8
30B H2																								330.5	236.4	228.2					3.8													35.6	103.6				6.7	944.8
30C H3																								547.5	383.4	375.8						23.9												220.8	618.8				40.9	2211.2
30D H4																								944.8	1233.7	658.5							38.8											355.1	1106.1				66.6	4403.4
30E H5																								945.9	793.3	656.7								29.1										267.2	810.9				50.0	3553.1
30F H6																								1245.7	650.4	851.9									17.5									160.8	439.8				29.7	3395.9
30G H7																								1754.4	1180.0	1206.5										30.1								279.1	793.3				51.8	5295.2
30H H8																								1063.0	626.3	729.1											14.1							130.8	364.8				24.2	2952.4
30I H9																								707.0	248.9	479.5												4.3						38.8	100.1				7.2	1585.8
30L H10																								361.1	212.6	247.9													2.8					25.6	71.8				4.8	926.4
30M H11																								241.1	224.5	167.8														1.7				16.4	50.5				3.1	705.2
30N H12																								58.0	29.7	39.7															0.5			4.5	12.4				0.9	145.6
30O H13																								0.0	0.0	0.0																0.0		0.0	0.0					0.0
30P H14																								65.4	237.9	47.5																	1.3	13.4	54.7				2.7	422.8
31 Firms																										3981.9				0.3	5.5	14.6	23.4	18.6	17.8	24.9	15.6	8.5	5.2	4.0	0.9	0.0	2.5	86.8	133.1				32.8	4376.5
32 Government																										298.1	1511.8	-377.4	1693.1	11.5	215.1	609.9	1134.2	881.8	798.2	1249.5	684.3	342.8	203.5	152.9	32.5	0.0	94.6	340.5	3379.7		123.9		67.9	13448.3
33 Capital Formation																														-49.6	-26.4	42.6	-263.8	-787.9	101.1	725.4	384.7	483.0	338.3	315.8	102.2	0.0	215.3	2357.7	-2344.2			1925.9	2883.3	6403.5
34 Indirect tax on imports	3.5	0.1	0.4	14.0	8.0	3.0	0.3	22.2	0.8	1.1	65.2	4.4	0.4					0.2	0.2																															123.9
35 ROC	204.2	5.6	202.0	1170.8	582.8	145.0	487.0	782.1	335.1	527.1	1387.7	511.6	33.4	21.1	77.9	2.5	198.0	356.1	253.6	123.0	3.7	4.6	12.5																											7427.2
36 ROW	159.8	13.7	1055.1	407.0	176.1	76.6	69.9	694.4	52.3	312.7	1781.0	228.4	18.3	12.5	26.6		290.0	34.7	185.6				10.2							0.2	3.7	9.8	15.7	12.5	11.9	16.7	10.5	5.7	3.5	2.7	0.6	0.0	1.7	42.9	88.9					5831.9
Total columns	1811.1	106.3	1541.5	3883.4	1227.1	271.2	904.2	5249.9	1060.7	1933.2	4422.4	1647.0	1908.3	3782.1	6046.0	2074.6	3959.8	2395.7	7523.8	3382.5	2112.2	3267.2	1918.2	8279.5	6083.3	9979.9	1511.8	-377.4	1693.1	54.8	944.8	2211.2	4403.4	3553.1	3395.9	5295.2	2952.4	1585.8	926.4	705.2	145.6	0.0	422.8	4376.5	13448.3	6403.5	123.9	7427.2	5831.9	
Total rows	1811.1	106.3	1541.5	3883.4	1227.1	271.2	904.2	5249.9	1060.7	1933.2	4422.4	1647.0	1908.3	3782.1	6046.0	2074.6	3959.8	2395.7	7523.8	3382.5	2112.2	3267.2	1918.2	8279.5	6083.3	9979.9	1511.8	-377.4	1693.1	54.8	944.8	2211.2	4403.4	3553.1	3395.9	5295.2	2952.4	1585.8	926.4	705.2	145.6	0.0	422.8	4376.5	13448.3	6403.5	123.9	7427.2	5831.9	#N/A
Differences (column-row)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	

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Essay 2

R&D Investment and External Knowledge Spillovers: the impact of regional R&D subsidy in a computable general equilibrium model

R&D Investment and External Knowledge Spillovers: the impact of regional R&D subsidy in a computable general equilibrium model

Abstract. In this paper we present a computable general equilibrium model for the region of Sardinia (Italy) with the purpose of evaluating the capacity of R&D policies to affect the long run rate of growth. The model incorporates induced technical change (ITC) obtained through knowledge accumulation, and external knowledge spillovers. It turns out that the cost of R&D policies may change according to the wage setting prevailing in the region. Furthermore, the capacity of such a policy to generate knowledge spillovers from the international and interregional trade is quite modest. Indeed, the capacity of the regional system to internalize the innovations embedded in the imported goods is partially offset by an increase in internal efficiency that lowers the spillover intensity through a reduction in the share of imports.

JEL: R13; R58.

Keywords: Regional CGE models, Induced Technical Change and R&D policies

1. Introduction

The aim of this paper is to analyze the impact of regional R&D subsidy using a computable general equilibrium (CGE) model. The need for this analysis stems from the strategic policy recently implemented by the Sardinia Executive. Most of the European Structural and Social Funds are used by the Regional Government to increase the domestic stock of R&D.

The model, that we call SGEM (Sardinia General Equilibrium Model) incorporates an intangible factor in the production function representing the regional level of knowledge endowment, divided into excludable and non-excludable knowledge. The former is treated as a primary factor of production that accumulates according to traditional perpetual inventory change; the latter derives from potential knowledge spillover effects that arise from interregional and international trade. External spillover is incorporated into the model following some econometric findings (i.e. Coe and Helpman, 1995) and recent applied economic models (i.e. Diao et al., 1999 and Ghosh, 2007). This enables us to capture the complementarities between foreign trade, and local and global stocks of knowledge.

As regions are more open than nations, we would expect a stronger effect of foreign R&D capital stock on domestic productivity since, as suggested by the estimates of Coe and Helpman (1995), larger productivity benefit accrues to more open economies. Indeed, by importing more high quality and sophisticated inputs (either intermediate or capital goods), local production may improve its efficiency and, in turn, the competitiveness of the local system with respect to other regions. A capacity to exploit the stock of global knowledge depends on the expansion of international trade which is, however, an exogenous variable, as regions have no control over trade policy.

As most of the Structural and Social Funds that Sardinia received from the EU are targeted at growth and competitiveness through increased domestic stock of R&D, the model sets the level of financial aid that will reach the long-run growth rate obtained by simulating an exogenous increase in competitiveness. Proceeding in this way allows us to study the capacity of R&D policy to achieve a sustainable target growth, identifying the likely cost of such a policy instrument, when knowledge (intangible capital) is seen as a component of the value added, and thus, is subject to substitution with physical capital and labour.

In our experiment, we demonstrate the important role played by regional wage setting in determining the cost of R&D policies and, specifically, we confirm that Government policies can affect economic growth positively by encouraging firms to devote more resources to R&D activities. We find that the cost of the R&D policy, defined as a percentage increment of the base year R&D investment, may vary according to regional labour market conditions. Its cost is quite high in Keynesian labour market and very small for flexible wages that respond to a regional excess demand for labour. This is quite an interesting result, since one of the region's aims is to use the financial aid provided by the EU more efficiently. We also find that the interregional and international knowledge spillovers improve growth even though their effects are rather modest.

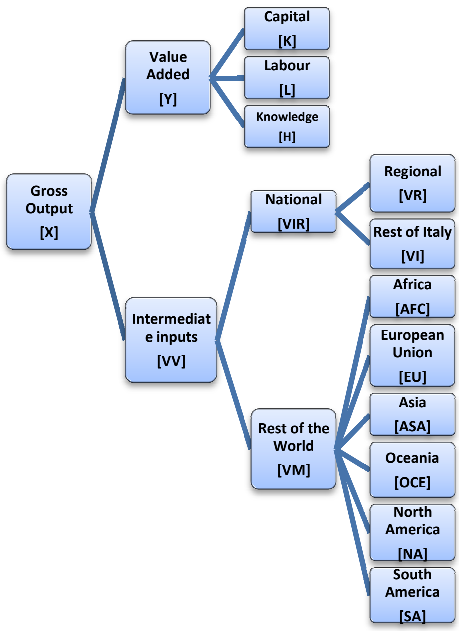
The paper proceeds with an outline of the model in section 2. In section 3, we explain how knowledge is incorporated into the Social Accounting Matrix (SAM) of Sardinia. Simulation results are described in section 4 while section 5 is devoted to sensitivity analysis. Finally, in section 6, remarks and conclusions will be drawn.

2. The model of Sardinia

Specification of production and demand parameters are obtained through the well known calibration method using the Social Accounting Matrix (SAM) of Sardinia for the year 2001 (Ferrari et al., 2009). The set of prices at which the excess demand is zero is the result of an optimization process, where market clearing prices equal marginal costs in each sector. Five economic activities or sectors are considered: Primary sector, Heavy Industry, Light Industry, Energy and Services. No distinction between traded and non-traded sectors is considered. Intermediate (VV) and primary inputs (capital, K, knowledge, $\boldsymbol{H}$ and labour L) constitute the production inputs of the model. Firms, Households and Government are the three domestic institutional sectors. The external institutions are split into the Rest of the Italy (ROI) and Rest of the World (ROW). We adopt assumptions typically used for a small open economy, i.e. the region is too small to affect prices in international and interregional markets. As a consequence, the ROI and ROW prices are taken to be exogenous. In addition, since Sardinia belongs to a common currency area, the model takes the nominal exchange rate to be fixed. Households' and firms' behaviour are the result of an optimization process with myopic expectations; Government is a consolidated sector merging central and local government levels. Its expenditure can be either the result of an optimization process where Government is simply treated as a new consumer, maximizing utility subject to the budget constraints or held constant throughout.

Figure 1

Production Structure of the Model



The model's production structure is illustrated in figure 1. *K*, *H* and *L* are combined in a CES production function in order to produce the value added, Y, allowing for substitution amongst primary factors of production. The demand for *K*, *H* and *L* is obtained from the first order condition of profit maximization. Leontief technology between *VV* and *Y* is imposed. The intermediate goods produced locally and imported are considered as imperfect substitutes. Basically, we mix regional and imported goods under the so called Armington assumption through a CES function. Furthermore, the imports from the ROW are split into Europe (EU), North America (NA), Middle and South America (SA),

Africa (AFC), Oceania (OCE) and Asia (ASA), through a Leontief function.
The regional commodities supply is bought by industries and by domestic and external institutions. That is to say, each industry in the region produces a composite commodity that can be exported or sold in the regional market. An export demand function closes the model where the foreign demand for Sardinian goods depends on the terms of trade effect and on export price elasticity.

Incorporating Knowledge in SGEM

Knowledge creation is the source of ITC in the model. The approach we take is to enlarge the set of substitution possibilities into the value added production function by allowing substitution between tangible (*K* and *L*) and intangible (*H*, knowledge) inputs. The magnitude of shifting between these alternative technologies is related to their relative price changes and the degree of substitutability of the inputs, ρ_i, that define the shape of *Y*:

$$Y_{i,t} = A(\xi_{i,t})\left[\delta_i^k K_{i,t}^{\rho_i} + \delta_i^h H_{i,t}^{\rho_i} + \delta_i^l L_{i,t}^{\rho_i}\right]^{\frac{1}{\rho_i}} \qquad 0 < \delta_i^{k,h,l} < 1$$

In other words, we are considering knowledge as a primary factor of production. This is also in line with one of the main changes of the new System of National Account 2008 (SNA 2008 Rev 1) that considers assets created by R&D as part of the value added.

Price changes encourage substitution between knowledge and tangible inputs. Technical change arises as a consequence of an increase in the quantity of knowledge which, through the accumulation process, creates the condition for an output effect by increasing the quantity of tangible inputs. This contrasts with the traditional approach where induced technical change is determined exogenously by augmenting input technological coefficients. Our approach is quite similar to the one used by Bovenberger and Smulders (1995), Goulder and Shneider (1999) and Sue Wing (2003) for ITC in climate policy analysis. However, in our case we consider knowledge as part of the value added allowing substitution between primary factors of production.

The scale factor A in the production function is related to non-excludable knowledge which is the result of external spillover, $\xi_{i,t}$, enjoyed by all firms in sector *i*. Following Coe and Helpman (1995), Diao et al., (1999) and Ghosh (2007), we have that:

$$A_{i,t} = (1 + \xi_{i,t})\bar{A}$$

where $\bar{A}$ is the initial level of the scale factor in the production function; external spillover is related to import-weighted foreign R&D stock:

$$\xi_{i,t} = \vartheta \sum_{r} \omega_r \, ln \, (FSK_{r,t})$$

$FSK_{r.t}$ is the stock of domestic knowledge/stock of R&D in the rest of the world, and ω_r, is the fraction of import from *r* regions to total import (where *r* = *EU, NA, SA, ASA, AFC, OCE, ROI*). ϑ is the spillover elasticity of regional productivity with respect to foreign R&D stock. Whilst ϑ is a proxy for capacity to exploit the level of technology existing in foreign country, ω_r is a measure of the intensity of spillover or a metric to appraise the technological closeness of the region (Coe and Helpman, 1995).

Investment in physical capital

The model incorporates a capital adjustment rule initially proposed by Bourguignon et al. (1989) and Jung and Thorbecke (2003) and compatible with Uzawa's (1969) formulation. According to this, the investment capital ratio φ is determined by the rate of return to capital (*rk*) and the user cost of capital (*uck*), allowing the capital stock to reach its desire level in a smooth fashion over time. This formulation is also compatible with those used in other regional CGE models, such as AMOS McGregor et al. (1996), where the optimal path of investment, *I*, is derived trough the flexible accelerator mechanism.

Sectoral investment with the quadratic and homogeneous adjustment costs (see Hayashi, 1982 and Devarajan and Go, 1999) is:

$$J_{i,t} = I_{i,t}\left[1 + \frac{b_i}{2} \cdot \frac{I_{i,t}^2}{K_{i,t}}\right]$$

So, total investment by destination $J_{i,t}$, is given by net investment demand by destination $I_{i,t}$ and adjustment cost $\left[1 + \frac{b_i}{2} \cdot \frac{I_{i,t}^2}{K_{i,t}}\right]$ where b is an adjustment parameter.

R&D investment

Technical change occurs through time in response to accumulated knowledge obtained from investment in R&D. Given *R*, the investment in R&D, *H* accumulates as follows:

$$\dot{H}_{i,t} = \psi(R_{i,t}, H_{i,t})$$

where,

$$\frac{\partial\psi}{\partial R} > 0; \; \frac{\partial\psi}{\partial H} < 0$$

Unless specified differently, the knowledge adjustment mechanism follows the flexible accelerator mechanism:

$$R_{i,t} = \lambda \cdot [H^{*}_{i,t} - H_{i,t}] + \delta^{H} \cdot H_{i,t}$$

where $H^{*}_{i,t}$ is the desired level of knowledge capital stock and λ is the speed of adjustment; $H^{*}_{i,t}$ is obtained by solving a cost minimization problem.

Migration

We assume that there is no natural population change but that labour forces adjust through a migration model commonly employed in AMOS (Harrigan et al.1991, McGregor at al. 1996). The model starts with zero net migration flow, and in any period migration is taken to be positively related to the gap between regional (*w/cpi*) and national (w^N/cpi^N) real wage, and negatively related to the gap between national (u^N) and regional unemployment rates (u):

$$nim_t = \varsigma - \nu^{u}[ln(u_t) - ln\,(\bar{u}^{N})] + \nu^{w}\left[ln\left(\frac{w_t}{cpi_t}\right) - ln\left(\frac{w^N}{cpi^N}\right)\right]$$

where *nim* is the rate of net migration and ς is a parameter calibrated in order to get zero net migration. ν^u and ν^w are elasticities that measure the impact of the gap between regional and national unemployment rate and real wage rate.

The model also incorporates two labour market closures defining the form of wage setting according to the following labour market regimes: regional wage bargaining (RB) and national bargaining (NB). In the regional wage bargaining regime the labour market is defined by the wage curve (Blanchflower and Oswald, 1994) according to which, wage and unemployment are negatively related. The wage-setting function is defined as follow:

$$ln\left[\frac{w_t}{cpi_t}\right] = \beta - \mu\, ln\,(u_t)$$

where cpi is the consumer price index, β is a parameter calibrated to the steady state and u is the regional unemployment rate. μ is the elasticity of wages related to the level of unemployment rate and it can also be interpreted as an index of wage flexibility. Thus the regional wage is directly related to the worker's bargaining power and it responds to the excess demand for labour.

NB is a typical Keynesian closure rule. It assumes that the nominal wage is fixed at the base year level. We can imagine that the regional

nominal wage is fixed at the value of the national wage due to a national bargaining regime. For that reason this rule could be called National Bargaining (Harrigan and al. 1991 and McGregor et al. 1996).
Receipts and payment transfers between institutions are an increasing function of the consumer price index.

3. Data and Calibration

Lack of regional information on intangible components prevents a straightforward inclusion of R&D services into a SAM framework so a vector of Sardinia R&D investment expenditure by sectors j, R_j^d was found from the National Account System (ISTAT, 2005). In order to determine a vector of investment by sector of origin, R_i^o, an aggregated version of the Yale Technology Matrix (YTM) built by Evenson et. al. (1989) is used. The YTM is based on patents granted in Canada, where the row represents the industries that are producing knowledge and the columns the industries that are receiving technology. The YTM has been widely used in order to account for knowledge linkage in different countries. For instance, Evenson and Putman (1993) have used the YTM for Italy, Basant (1993) for India and H. van Meijl (1997) has used it for France. By multiplying the YTM, $\psi_{i,j}$ for the diagonal vector of investment in R&D by sector of destination, $\hat{R}_j^d$, we obtain the investment by sector of origin, R_i^o.

$$R_i^o = \sum_j \psi_{i,j} \hat{R}_j^d$$

Intangible capital H_j is determined by using the perpetual inventory change equation that, in a steady state condition with zero growth, leads to the following formulation:

$$H_j = \frac{R_j^d}{\delta^H}$$

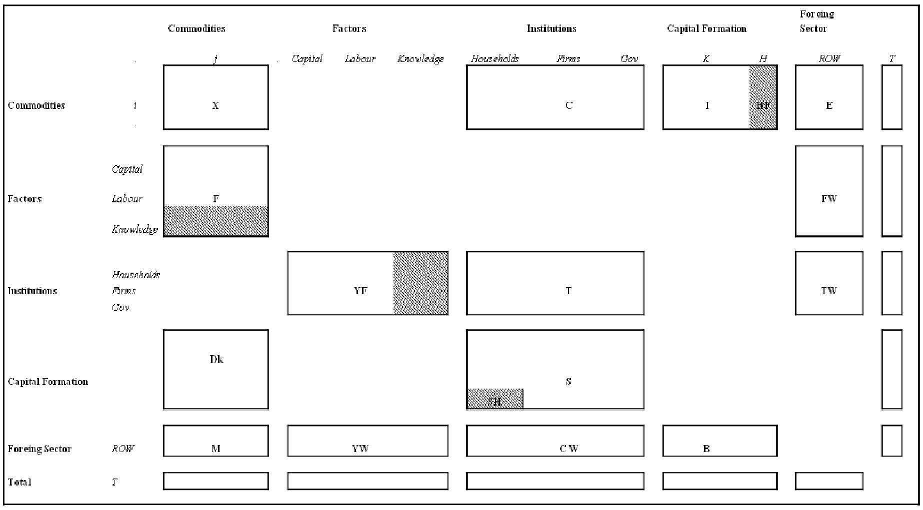
where δ^H is the depreciation rate of knowledge capital. A corresponding amount of saving $\mathrm{S^H}$, generated from knowledge income must be determined. Since in equilibrium savings equal investment we have:

$$S^H = \sum_i R_i^0 = \sum_j R_j^d$$

In table 1, a SAM framework is reported, highlighting the allocation of the new knowledge components. Both $H_j$and R_i^0 are allocated in the shaded parts of the sub matrix **F** and in the knowledge capital formation vector **HF**. The resulting knowledge income and savings are allocated exclusively to households, the shaded parts of the sub-matrices **YF** and **S**.

We make the assumption that the intangible components are already embodied in the SAM. In particular H_j is conceptually embodied in the value added vector and R_i^0 is already included in the investment vector. Furthermore household income and saving derived from the intangible component are already incorporated into household wealth. So the new components that were previously determined must be subtracted from the corresponding values of the SAM. Unfortunately this simple operation leads to some negative figures so we use a Cross Entropy (CE) model, imposing some macro variable controls as constraints plus some single constraints, to allocate the new components to the corresponding sub-matrices. Essentially, we base our estimations on the well known works of Golan, Judge and Robinson (1994) and Robinson, Cattaneo and El-Said (2001). The CE model and the set of additional restrictions that constrain some sub-matrices of the SAM can be seen in Appendix B.

Table 1 - SAM structure -Knowledge within the SAM-



Import data for *EU, NA, SA, AFC, OCE* and *ASA* are supplied by ISTAT (2005) whilst the level of R&D capital stock by regions is derived from the data provided by OECD (2004). In table 2, some selected benchmark values are reported. The values of external spillover elasticities are those related to Italy and found in Coe and Helpman (1995). As we did not have any values for SA, OCE and AFC we have arbitrarily ascribe to them the value 0.001.

The model calibration process assumes the economy to be initially in long-run equilibrium. The parameters are generally obtained by the SAM using the well known calibration method. The value of the adjustment cost parameter β in the investment equation is 1.5. The SAM does not supply information concerning the physical investment by destination *J*, so from the System of Regional Account (ISTAY, 2005), through the capital matrix $KM_{i,j}$ the equality condition with total investment by origin in the SAM hold (see Appendix C, for the construction of $KM_{i,j}$).

As in a deterministic approach some parameters remains unspecified, they need to be found from outside the model. For this reason the elasticity of substitutions σ (in trade and production), as well as other behavioural parameters, are based on econometric estimation or best guess. The unemployment elasticity μ is equal to 0.03. This is the value econometrically estimated for the South of Italy in Devicenti et al. (2007). ν^u and ν^w are the coefficients in the migration function estimated by Layard et al. (1991) for the UK economy. Objections can be raised concerning these parameters estimated using UK data but, unfortunately, the lack of data at regional level (especially in Sardinia) precludes a more suitable approach. The elasticity of substitution is set at 0.3 in production and equal to 2 for trade.

Table 2 - Selected benchmark values

Countries	Share of R&D stock %	Import share %	Spillover elasticity
North America	0.39	0.03	0.0254
Asia	0.29	0.04	0.0027
Europe	0.27	0.25	0.0166
South America	0.03	0.01	0.0010
Oceania	0.01	0.00	0.0010
Africa	0.01	0.08	0.0010
Italy	0.01	0.58	0.0018

4. Model solution, simulation strategy and policy analysis

The model's equations are solved simultaneously for a given finite time horizon. The model can also be run for two static time periods: short run and long run. For the short run the supply side is fixed, so capital and labour supplies are kept at their base year value. For the long run we relax all supply side constraints, allowing for capital and labour adjustment. In this time frame, capital stock is at its optimum level, so rental rates and user cost of capital are equal. The labour supply is fully adjusted so that the system exhibits zero net migration. For each time period, SGEM is run to find a set of prices that clears all markets: the supply of each produced good equals its demand and the vector of the equilibrium prices is the result of myopic expectations since agents are not forward-looking. (See the Appendix for a full list of the model's equations.)

Firstly, we simulate a permanent 5% increase in exports. The long run level of growth in gross regional product (GRP) that results will constitute our target growth. Secondly, we determine the growth rate of R&D investment associated with that level of growth. Thirdly, the percentage variation of R&D investment obtained is used to analyse in detail the impact of the financial aid. Finally, cross-border spillovers are integrated in the model.

All simulations are performed for both labour market regimes: national bargaining (NB) and regional bargaining (RB). It should be stressed from the outset that the figures we obtain are not forecasts for the Sardinia economy. The exercise should help us to track the effects of an exogenous stimulus using impact analysis within a general equilibrium framework, and a numerical support represented by the SAM. This lets us deal with a specific regional production structure.

5% increase in export: setting the target growth

Our model is quite similar to the behavioural adjustment presented in AMOS (McGregor et al., 1996). The increase in competitiveness would lead to Leontief results in the long run, where the new steady state equilibrium is equal for all labour market regimes: RB and NB.

In table 3, the percentage changes from base year values are shown for a set of key economic variables for the national and regional bargaining closures. In the short run (period 1 in the table) the main differences can be seen in the behavior of the real wage. For the NB case, the real wage is below its initial equilibrium (-1.04%); indeed, as workers cannot enter into wage bargaining within the region, increase in aggregate demand raises prices thus lowering the purchasing power of workers. In RB the demand stimulus increases labour demand which, in turn, reduces the unemployment rate by -0.85% so increasing the bargaining power of workers and so the real wage (0.03%).

In the long run (LR) prices of goods and wages return to their base year value, however, quantities are above the benchmark equilibrium. Regional output, employment and consumption increase by 1.441%, 1.439% and 1.167% respectively. The new steady state equilibrium is obtained through adjustment in the factors of production. Capital stock (tangible and intangible) increases with investment, which in turn is affected by the real return to capital (tangible and intangible). As aggregate demand rises, commodity prices increase and so do firms' profit expectations, therefore capital rental rate increases more than user cost of capital. This generates an increase in investment that will be moderated by the replacement cost of capital incorporated into the model. As for the labour supply, it increases over time in response to a rise in real wages and a drop in the unemployment rate until the labour market, in the long run, clears, and where all the increase in employment is covered by the increase in working population. The growth in labour supply should put downward pressure on wages until the labour market achieves its long run equilibrium and the real wage is restored to its original level and the price of goods adjusted totally.

Turning to the capacity of such a demand shock to reduce the trade deficit, we see that, in both labour market closures, in the short run the trade deficit gets worse (1.16% for RB and 3.17% for NB). However, year by year there are some improvements of the current account reducing the trade deficit in the long run by 2.18%. Indeed, the exogenous increase in exports raises competitiveness but the augmented aggregate demand generates an increase in production that needs to be met by increasing the demand for imported goods. Essentially, the negative terms of trade produce a substitution effect, lowering exports and raising imports in the initial periods, whilst in the medium and long run, exports begin to increase more than imports because of price adjustments. Prices approach a new steady state in which they return to their initial position, neutralizing, as result, the terms of trade impact.

Table 3 - The impact of 5% increase in export for a set of key variables. (Percentage changes from base year values).

Regional Bargaining	1	10	20	30	40	50	LR
GRP at factor cost	0.06	0.45	0.75	0.95	1.10	1.20	1.44
Consumer price index (CPI)	1.07	0.75	0.52	0.36	0.25	0.18	0.00
Unemployment rate	-0.85	-0.44	-0.30	-0.20	-0.14	-0.10	0.00
Total employment	0.09	0.48	0.77	0.97	1.10	1.20	1.44
Nominal wage	1.10	0.76	0.52	0.37	0.26	0.18	0.00
Real wage	0.03	0.01	0.01	0.01	0.00	0.00	0.00
Capital good price (tangible)	1.04	0.72	0.50	0.35	0.25	0.17	0.00
Capital good price (intangible)	1.09	0.77	0.54	0.38	0.27	0.19	0.00
Current account	1.16	0.15	-0.57	-1.05	-1.38	-1.61	-2.18
Labour supply	0.00	0.43	0.74	0.94	1.09	1.19	1.44
Households Cons	0.16	0.45	0.66	0.81	0.91	0.99	1.17
Tangible investment	0.60	0.83	1.02	1.16	1.26	1.33	1.50
Intangible investment	0.59	1.05	1.38	1.62	1.78	1.90	2.19
National Bargaining							
GRP at factor cost	0.51	1.23	1.39	1.43	1.44	1.44	1.44
Consumer price index (CPI)	1.06	0.16	0.04	0.01	0.00	0.00	0.00
Unemployment rate	-7.78	-0.45	-0.11	-0.03	-0.01	0.00	0.00
Total employment	0.86	1.28	1.40	1.43	1.44	1.44	1.44
Nominal wage	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Real wage	-1.04	-0.16	-0.04	-0.01	0.00	0.00	0.00
Capital good price (tangible)	0.97	0.14	0.03	0.01	0.00	0.00	0.00
Capital good price (intangible)	1.17	0.25	0.06	0.02	0.01	0.00	0.00
Current account	3.17	-1.25	-1.95	-2.12	-2.16	-2.17	-2.18
Labour supply	0.00	1.23	1.38	1.42	1.43	1.44	1.44
Households Cons	0.51	1.01	1.12	1.16	1.16	1.17	1.17
Tangible investment	2.96	1.63	1.52	1.50	1.50	1.50	1.50
Intangible investment	2.84	2.16	2.17	2.19	2.19	2.19	2.19

Knowledge subsidy

The first object of this section is to identify the rate of growth in R&D investment required to achieve a pre-determined long term target growth in GRP of 1.44%. To this end, we run a single period model, for both labour markets specifications using long term closures and fixing the level of GRP growth at 1.44%.This growth rate was previously obtained by simulating a 5% increase in export.

The level of R&D investment will change according to the level of knowledge stock required to achieve the required level of GRP. The results are: 2.22% for RB and 4.49% for NB. Therefore, when knowledge is treated as a component of value added, we should pay attention to substitution between production factors and, especially, to wage setting in the region. When wages are fixed, R&D investment needs to increase to about 4.49%, but the same level of growth can be achieved with a lower increase in R&D investment when wages are bargained locally.

The change in R&D investment can now be treated as a subsidy to firms that is clearly financed from outside the region, namely we consider Sardinia as the recipient region of financial aid. These simulations are performed by permanently increasing R&D investment by destination by 2.22% in the regional bargaining case and 4.49% in the national bargaining. As in the short run we impose capacity constraints, the effect is a clear demand side shock. Indeed, the exogenous increase in R&D investment by destination (when knowledge stock is fixed), leads only to a rise in investment by origin which is a component of the aggregate demand. So supply side effect begins in the second period where capacity constraints are relaxed.

Even though the transitional pathway towards the new steady state is different, (see Figure 2, below) for each labour market we achieve the same level of growth in GRP. The short and long run results of these simulations are illustrated in table 4: column one and two for NB and column three and four for RB.

We start by considering the national bargaining case. As already noted, the short run equilibrium reflects a demand side impact because of capacity constraints imposed in the first period. In this period, output and employment rise in all sectors and, due to capacity constraints, the percentage increase in employment is greater than the increase in value added. The increase in commodity prices crowd out exports leading to a fall in regional competitiveness, thus current account deficit increases by 0.2481%. As nominal wages are invariant, the increase in prices reduces the purchasing power of workers, then the CPI rises and real wages fall (-0.0205%).

The capital goods price for tangible and intangible inputs are above their benchmark equilibrium again because of capacity constraints. Labour supply is fixed, though labour demand rises because aggregated demand expands, reducing the unemployment rate (-0.1399%).

In the long run, there are evidence of supply side effects. With respect to a demand side shock, we do not get Leontief results. In fact, these are no longer consistent with supply side shock. Now, price adjustment results from an increase in investment which in turn generates direct change, not only in aggregate demand, but also in production. R&D investment increases exogenously by 4.48%, so increases in knowledge stock drive the long run knowledge rental rate below its benchmark equilibrium value. Essentially, the slope of the isocost line has changed, making it efficient to substitute the now relatively cheaper knowledge capital for the relatively more expensive tangible inputs. Labour and physical capital rises proportionately less than knowledge stock.

The relative price change has increased system-wide efficiency, so encouraging exports. Foreign demand for regional goods rises as regional prices decrease, resulting in an improvement in the current account which is below the base year value (-2.5321%).

As for the labour market, contrary to the previous simulation, the increase in labour demand is not able to cover the whole of the increase in working population, yielding an increase in unemployment rate of 0.7643%.

The third and the fourth columns report results from the same simulation with regional bargaining. Again, the short run supply side effect is neglected. The major differences with respect to the national bargaining case are related to the behaviour of wages and the associated substitution effects in the production function. In the short run the nominal wage increases by 0.0101%. Such a result leads to an increase in employment of just 0.0004% which is substantially less than the corresponding figure obtained in NB. Furthermore, output and employment rise in all sectors other than Services.

Induced technical change begins from the second period where the increase in R&D investment causes an expansion of knowledge stock which, in turn, leads to an increase in other production factors. This output effect results in a rise in employment of 1.3897% in the long run, which is substantially greater than that obtained with national bargaining (1.1027%). As the level of GRP growth is the same, this means that in a Keynesian framework, tangible capital stock has increased more than the corresponding figures for the regional bargaining case. The output effects that arise from R&D capital accumulation encourage more employment when wages are flexible, and respond to the regional bargaining power of workers.

Figure 2

Gross Regional Product (Percentage change from base year value)

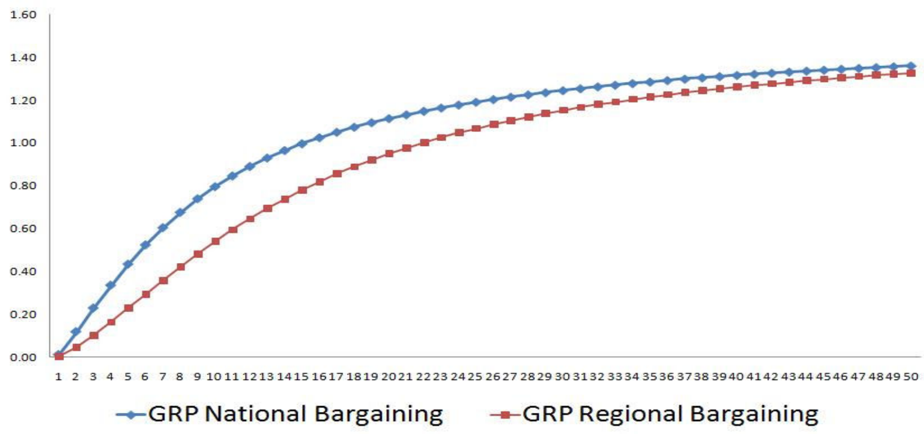


Table 4 - The impact of R&D subsidy on key variables -percentage change with respect to the initial steady state

	No Spillovers				Spillovers			
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
	National Bargaining		*Regional Bargaining*		*National Bargaining*		*Regional Bargaining*	
	SR	LR	SR	LR	SR	LR	SR	LR
Grp Factor Cost	0.009	1.441	0.000	1.441	0.012	1.546	0.002	1.456
Consumer price index	0.020	-1.010	0.010	-1.094	0.018	-1.102	0.009	-1.107
Unemployment rate	-0.140	0.764	-0.003	0.000	-0.142	0.834	-0.010	0.000
Total employment	0.016	1.103	0.000	1.390	0.016	1.116	0.001	1.400
Nominal gross wage	0.000	0.000	0.010	-1.094	0.000	0.000	0.009	-1.107
Real gross wage	-0.020	1.020	0.000	0.000	-0.018	1.114	0.000	0.000
Current account	0.248	-2.532	0.102	-2.624	0.246	-2.813	0.102	-2.658
Labour supply	0.000	1.189	0.000	1.390	0.000	1.210	0.000	1.400
Households Cons	0.008	1.102	0.001	1.036	0.011	1.175	0.002	1.047
Spillover	-	-	-	-	0.003	0.084	0.001	0.005
Knowledge stock								
Primary	0.000	4.487	0.000	2.224	0.000	4.487	0.000	2.224
Heavy Industry	0.000	4.487	0.000	2.224	0.000	4.487	0.000	2.224
Light Industry	0.000	4.487	0.000	2.224	0.000	4.487	0.000	2.224
Energy	0.000	4.487	0.000	2.224	0.000	4.487	0.000	2.224
Services	0.000	4.487	0.000	2.224	0.000	4.487	0.000	2.224
Capital stock								
Primary	0.000	2.645	0.000	2.328	0.000	2.742	0.000	2.346
Heavy Industry	0.000	3.225	0.000	2.381	0.000	3.316	0.000	2.396
Light Industry	0.000	2.182	0.000	1.922	0.000	2.244	0.000	1.936
Energy	0.000	1.783	0.000	1.473	0.000	1.827	0.000	1.482
Services	0.000	1.038	0.000	1.177	0.000	1.070	0.000	1.187
Value added								
Primary	0.015	2.654	0.002	2.316	0.019	2.807	0.004	2.338
Heavy Industry	0.011	3.386	0.002	2.342	0.015	3.526	0.004	2.359
Light Industry	0.016	2.346	0.002	1.969	0.019	2.466	0.004	1.986
Energy	0.019	1.977	0.007	1.563	0.022	2.089	0.008	1.577
Services	0.008	1.061	0.000	1.238	0.011	1.159	0.001	1.252
Employment								
Primary	0.022	2.362	0.003	2.329	0.023	2.430	0.004	2.347
Heavy Industry	0.021	2.941	0.003	2.382	0.022	3.003	0.004	2.397
Light Industry	0.025	1.901	0.003	1.923	0.026	1.933	0.004	1.937
Energy	0.044	1.503	0.016	1.474	0.044	1.518	0.016	1.483
Services	0.013	0.761	-0.001	1.178	0.013	0.764	0.000	1.188
Total Export								
Primary	-0.037	1.582	-0.022	1.780	-0.035	1.713	-0.020	1.800
Heavy Industry	-0.088	4.085	-0.039	2.668	-0.085	4.264	-0.038	2.687
Light Industry	-0.075	3.542	-0.032	3.030	-0.070	3.771	-0.030	3.059
Energy	-0.118	2.225	-0.057	1.998	-0.115	2.402	-0.055	2.019
Services	-0.034	1.985	-0.018	2.602	-0.028	2.220	-0.015	2.636
Physical investment								
Primary	0.182	1.924	0.064	1.631	0.188	1.974	0.070	1.642
Heavy Industry	0.076	1.902	0.012	1.681	0.083	1.959	0.017	1.693
Light Industry	0.054	1.156	0.003	1.246	0.059	1.191	0.008	1.256
Energy	0.110	1.525	0.030	1.443	0.115	1.569	0.035	1.454
Services	0.059	1.286	0.004	1.331	0.064	1.325	0.009	1.342
Rate of return to knowledge.								
Primary	0.073	-6.618	0.020	-0.756	0.077	-6.411	0.024	-0.711
Heavy Industry	0.070	-4.845	0.020	-0.583	0.074	-4.656	0.023	-0.549
Light Industry	0.085	-8.013	0.020	-2.060	0.088	-7.917	0.023	-2.030
Energy	0.146	-9.205	0.062	-3.493	0.146	-9.160	0.063	-3.475
Services	0.043	-11.401	0.008	-4.427	0.043	-11.392	0.009	-4.409
Value added price								
Primary	0.023	-0.944	0.013	-1.055	0.021	-1.021	0.012	-1.066
Heavy Industry	0.034	-1.426	0.015	-0.966	0.033	-1.483	0.014	-0.972
Light Industry	0.032	-1.442	0.014	-1.241	0.030	-1.531	0.013	-1.253
Energy	0.083	-1.539	0.040	-1.384	0.081	-1.659	0.039	-1.398
Services	0.017	-0.988	0.009	-1.289	0.014	-1.103	0.008	-1.305

Real wages in the long run return to their initial position because the unemployment rate returns to its initial level. The purchasing power of workers moves to zero change through an endogenous process by which in-migration reduces the fall in the unemployment rate, thereby limiting the rise in the real wage as regional employment expands. The fall in CPI reduces nominal wages, making labour cheaper than in the national bargaining case.

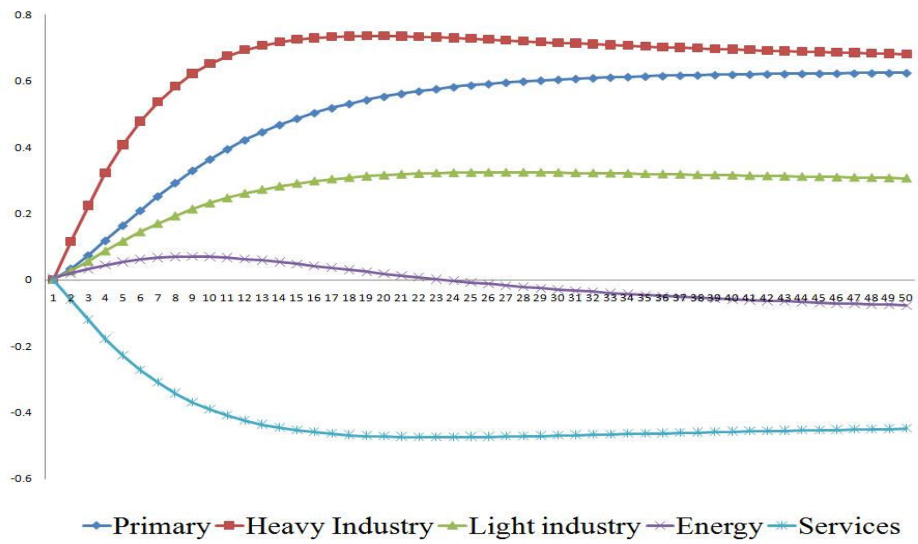
In order to evaluate whether the policy has produced some sectoral structural change, the percentage change with respect to the initial steady state of the share of sectoral output on total output is reported in Figure 3. An increase in output share for an economic sector implies that it will grow faster than the rest of the economy as a result of the subsidy. We see that for the NB scenario, the sectoral share of Heavy industry experiences the largest change in the long run. Although substantially less than Heavy industry, the other sectors benefiting are Primary, Light industry and Energy. On the other hand, Service sector shows a significant drop in its share of total output.

Within the regional bargaining simulation, Heavy industry still remains the sector that, more than any other, benefits from a rise in R&D investment. Contrary to the national bargaining scenario, Energy moves from positive change in the short run to negative change in the medium and long run.

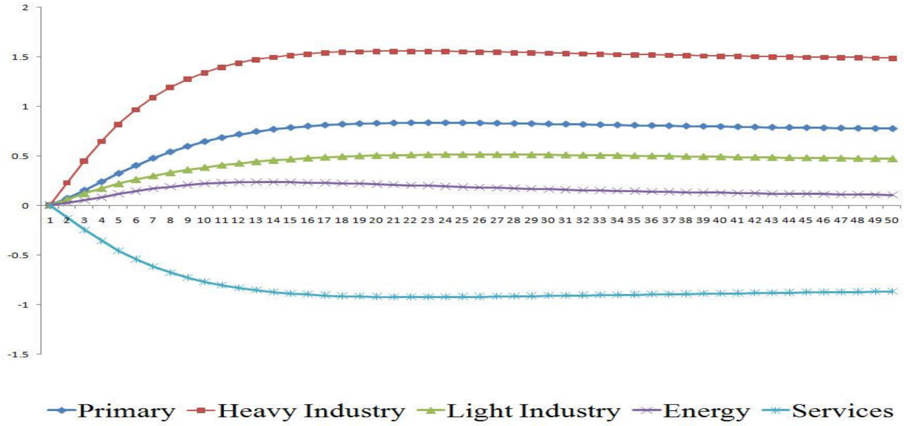
Figure 3

Sectoral structural change - percentage change with respect to the initial steady state- Regional Bargaining and National Bargaining

a)Regional Bargaining: share of sectoral output on total output



b)National Bargaining: share of sectoral output on total output

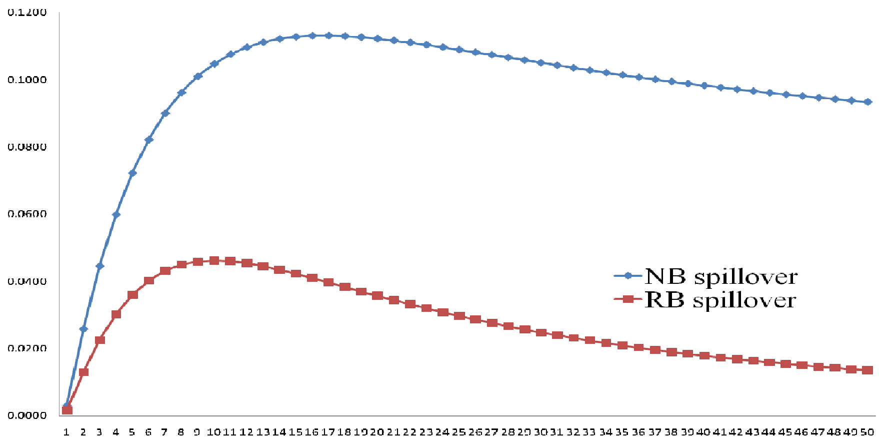


External knowledge spillover effect

In this section, we analyze the capacity of R&D promoting policy to achieve a superior growth if interregional and international knowledge spillovers are incorporated into the model. The simulation is similar to that in the preceding subsection. The only difference is that we allow for a shift in production through a change in total factor productivity. The productivity level in the model depends on domestic and foreign R&D capital stock. When the ratio of domestic to foreign R&D rises, the productivity level also increases according to the value of the spillover elasticities and the level of international and interregional trade as measured by the fraction of intermediate import share.

In Figure 4 the behaviour of the knowledge spillover is reported for the two closures, whilst the short and long run proportionate change from base year values can be seen in table 4.

Figure 4
External knowledge spillover for NB and RB



As pointed out by Coe and Helpam (1995), the accumulation of knowledge stock would increase the capacity of a country to gain larger spillovers from innovation developed in the rest of the world. However, our results suggest that policies seeking to enhance the long-run rate of regional economic growth by increasing the regional stock of knowledge are not able to generate large cross-border technological spillovers or at least not as large as we would expect. To some extent, similar conclusions have also been found in the model developed by Diao et al. (1999) for the Japanese economy.

The model results show that the difference in the long run rate of GRP growth between the spillover and no-spillover cases is about 0.1056 percentage points when wages are bargained nationally, and 0.0153% for wages bargained locally. This means that, cross-border spillovers are positive and rise over time, as shown in Figure 4, but with different intensities between the two closures. Indeed, for all periods, the spillover effect is greater with national bargaining than with regional bargaining. This does explain why, in national bargaining, the GRP increases more with than regional bargaining.

The intensity of knowledge spillover is not so high as to significantly affect the long-run growth in both closures because its contribution to productivity is marginal.

In the short run, the rise in production has to be met by an increase in imports, and the capacity of the region to acquire external spillovers is also driven by negative terms of trade which depress exports and encourage imports. However, the level of spillover is limited as the increase in production is subject to constrained factors of production. In the medium and long runs the reverse situation prevails. Expansion in production leads to a positive shift in the share of imports but the resulting increase in efficiency generates positive terms of trade (so exports rise relatively more than imports) that partially offset the potential spillover contribution to productivity.

One more cause of the small magnitude of the external spillover effect may lie in the characteristics of the Sardinia economy. It can be seen that in the initial benchmark equilibrium, the share of imports from high technological countries, such as *NA,* is quite low (0.03%, see Table 2 above). *NA* is the country with, not only the highest amount of R&D stock, but also with the greatest spillover elasticity. As the total level of imports from the ROW is split amongst countries with a Leontief function, no substitution effects amongst regional imports occur in this simulation. In Table 5 below we show the evolution of imports share for the six countries considered by the model. For both closures the share of imports from *NA* declines. This is happening because Sardinia mainly imports services from North America, but intermediate input services, although positive in the short run, assume negative variation in the long run.

For the regional bargaining scenario, the share of imports is also negative for *EU* and *ROI*. This explains why the change in the external spillover is lower than the national bargaining figures.

Table 5 - Imports share for the six countries considered by the model (percentage change from base year value)

National Bargaining	1	10	20	30	40	50	LR
EU	0.009	0.411	0.426	0.391	0.363	0.345	0.310
AFC	0.006	0.620	0.748	0.738	0.717	0.701	0.670
NA	0.008	0.016	-0.080	-0.137	-0.171	-0.192	-0.230
SA	0.010	0.149	0.177	0.157	0.132	0.113	0.075
ASA	0.004	0.559	0.708	0.705	0.686	0.670	0.639
OCE	0.003	0.574	0.739	0.739	0.721	0.705	0.675
ITA	0.009	0.166	0.160	0.140	0.123	0.111	0.088
Regional Bargaining	**1**	**10**	**20**	**30**	**40**	**50**	**LR**
EU	0.005	0.167	0.106	0.056	0.027	0.008	-0.024
AFC	0.003	0.314	0.396	0.400	0.393	0.387	0.374
NA	0.005	-0.057	-0.219	-0.302	-0.345	-0.370	-0.414
SA	0.004	0.090	0.100	0.085	0.069	0.058	0.037
ASA	0.002	0.303	0.431	0.455	0.457	0.456	0.450
OCE	0.001	0.316	0.467	0.502	0.508	0.508	0.507
ITA	0.004	0.069	0.025	-0.007	-0.026	-0.038	-0.059

5. Sensitivity analysis

In the preceding simulations we used best guess estimate for the elasticity parameter, ρ. Where $\rho = (\sigma - 1)/\sigma$ and σ was set equal to 0.3. Table 5 shows results from further analysis. We measure the sensitivity of R&D investments by changing the value of σ since variation in the factor substitutions can be seen as key determinants of the cost of R&D policy. By running the model with long run time periods we attempt to determine the level of R&D investment needed to reach a pre-determined level of growth (as in the previous analysis this is set to 1.44) for different values of σ. We only show results for the regional bargaining labour market closure.

By inspecting Table 6, we see that the percentage increase in R&D investment is lower when we allow for external knowledge spillover effect. For the default case ($\sigma = 0.3$), in order to reach a proportionate increase in GRP of 1.4407 in the long run, R&D investment must rise by 4.487% (as in the previous simulation) and 4.4179% when external knowledge spillover are taken into account. When we recalibrate the model, for increasing values of elasticity of substitution, the percentage increment (from base year value) of R&D investments rises; with an increasing substitution effect, firms find it convenient to substitute knowledge for physical capital and labour, since expansion in R&D investment lowers the Knowledge rental rate.

Table 6 - Results from sensitivity analysis

ρ	No Spillover	Spillover
0.3	2.22	2.20
0.6	2.72	2.57
0.9	3.18	2.88
1.5	4.05	3.46
2.0	4.77	3.94
3.0	6.21	4.87
4.0	7.68	5.81
5.0	9.18	6.76

6. Concluding remarks

In this work our intention is to understand the important role played by knowledge capital as a factor in regional development. To fully exploit the foreign R&D capital stock requires a regional production structure with a strong manufacturing sector with high intensity of intangible capital. However, in the past ten years, Sardinia has experienced an intensive deindustrialization process, especially in the Heavy industry sector. Therefore it might be beneficial to change the production structure by making manufacturing the leading sector in order to accommodate R&D policies.

We have also seen that the region may benefit from its openness (in the interregional and international trade market) if it is able to exploit the knowledge embodied in imported goods. This depends on the capacity of the regional system to internalize the technological level embodied in imported goods. We show that the endogenous productivity effect that occurs in response to external spillovers is quite modest. Furthermore, the type of wage setting really matters in this model. The output effect due to induced technical change is greater when wage setting is bargained locally.

The model we have presented is just a first attempt to evaluate the macroeconomic consequences of R&D financial aid. Indeed, such analysis would require a more sophisticated analysis of the degree of economic integration and the introduction into the model of New Economic Geography elements.

Appendix A

The mathematical presentation of the model

Prices

$$PM_{i,t} = \varepsilon_t \cdot PWM_i \cdot (1 + MTAX_i) \qquad \textbf{(A.1)}$$

$$PE_{i,t} = \varepsilon_t \cdot PWE_i \cdot (1 - TE_i) \qquad \textbf{(A.2)}$$

$$PX_{i,t} = \frac{PR_{i,t} \cdot R_{i,t} + PE_{i,t} \cdot E_{i,t}}{R_{i,t} + E_{i,t}} \qquad \textbf{(A.3)}$$

$$PQ_{i,t} = \frac{PR_{i,t} \cdot R_{i,t} + PM_{i,t} \cdot M_{i,t}}{R_{i,t} + M_{i,t}} \qquad \textbf{(A.4)}$$

$$PIR_{j,t} = \frac{\sum_i VR_{i,j,t} \cdot PR_{j,t} + \sum_i VI_{i,j,t} \cdot \overline{PI}_j}{\sum_i VIR_{i,j,t}} \qquad \textbf{(A.5)}$$

$$PY_{j,t} \cdot a_j^Y = \left(PX_{j,t} \cdot \left(1 - btax_j - sub_j - dep_j\right) - \sum_i a_{i,j}^V PQ_{j,t} \right) \qquad \textbf{(A.6)}$$

$$UCK_t = PINV_t \cdot (ir + \delta) \qquad \textbf{(A.7)}$$

$$PC_t^{1-\sigma^c} = \sum_j \sum_h \delta_{j,h}^f \cdot PQ_{j,t}^{1-\sigma^c} \qquad \textbf{(A.8)}$$

$$w_t^b = \frac{w_t}{(1 + sscee + sscer) \cdot (1 + ire)} \qquad \textbf{(A.9)}$$

$$wage\ setting \begin{cases} RB \rightarrow \ ln\left[\dfrac{w_t^b}{PC_t}\right] = \beta - \mu \cdot ln(u_t) \\ \qquad NB \rightarrow \ w_t = w_{t=0} \end{cases} \qquad \textbf{(A.10)}$$

$$rk_{j,t} = PY_{j,t} \cdot \delta_j^k \cdot A\left(\xi_{j,t}\right)^{\varrho_j} \cdot \left(\frac{Y_{j,t}}{K_{j,t}}\right)^{1-\varrho_j} \qquad \textbf{(A.11)}$$

$$rh_{j,t} = PY_{j,t} \cdot \delta_j^h \cdot A\left(\xi_{j,t}\right)^{\varrho_j} \cdot \left(\frac{Y_{j,t}}{H_{j,t}}\right)^{1-\varrho_j} \qquad \textbf{(A.12)}$$

$$PINV_t = \frac{\sum_j PQ_{j,t} \cdot \sum_i KM_{i,j}}{\sum_i \sum_j KM_{i,j}} \qquad \textbf{(A.13)}$$

$$PINVH_t = \frac{\sum_j PQ_{j,t} \cdot \sum_i YTM_{i,j}}{\sum_i \sum_j YTM_{i,j}} \qquad \textbf{(A.14)}$$

Production technology

$$X_{i,t} = min\left(\frac{Y_{i,t}}{a_i^Y}; \frac{V_{i,j,t}}{a_{i,j}^V}\right) \quad \textbf{(A.15)}$$

$$Y_{i,t} = a_i^Y \cdot X_{i,t} \quad \textbf{(A.16)}$$

$$V_{i,t} = a_{i,j}^V \cdot X_{i,t} \quad \textbf{(A.17)}$$

$$Y_{i,t} = A(\xi_{i,t}) \cdot \left[\delta_i^k K_{i,t}^{\rho_i} + \delta_i^h H_{i,t}^{\rho_i} + \delta_i^l L_{i,t}^{\rho_i}\right]^{\frac{1}{\rho_i}} \quad \textbf{(A.18)}$$

$$A_{i,t} = (1 + \xi_{i,t}) \cdot \bar{A} \quad \textbf{(A.19)}$$

$$\xi_t = \sum_r \vartheta_r \cdot \omega_r \cdot ln\left(\frac{\sum_j HS_{j,t}}{FSK_r}\right) \quad \textbf{(A.20)}$$

$$\omega_{r,t} = \frac{\sum_j \sum_r TVMREG_{j,r,t}}{\sum_j TVMREG_{j,r,t}} \quad \textbf{(A.21)}$$

$$L_{j,t} = \left(A(\xi_{j,t})^{\rho_i} \cdot \delta_j^l \cdot \frac{PY_{j,t}}{w_t}\right)^{\frac{1}{1-\rho_j}} \cdot Y_{j,t} \quad \textbf{(A.22)}$$

Trade

$$VV_{i,j,t} = \gamma_{i,j}^{vv} \cdot \left[\delta_{i,j}^{vm} VM_{i,t}^{\rho_i^A} + \delta_{i,j}^{vir} VIR_{i,t}^{\rho_i^A}\right]^{\frac{1}{\rho_i^A}} \quad \textbf{(A.23)}$$

$$\frac{VM_{i,j,t}}{VIR_{i,j,t}} = \left[\left(\frac{\delta_{i,j}^{vm}}{\delta_{i,j}^{vir}}\right) \cdot \left(\frac{PIR_{i,t}}{PM_{i,t}}\right)\right]^{\frac{1}{1-\rho_i^A}} \quad \textbf{(A.24)}$$

$$VIR_{i,j,t} = \gamma_{i,j}^{vir} \cdot \left[\delta_{i,j}^{vi} VI_{i,t}^{\rho_i^A} + \delta_{i,j}^{vr} VR_{i,t}^{\rho_i^A}\right]^{\frac{1}{\rho_i^A}} \quad \textbf{(A.25)}$$

$$\frac{VR_{i,j,t}}{VI_{i,j,t}} = \left[\left(\frac{\delta_{i,j}^{vr}}{\delta_{i,j}^{vi}}\right) \cdot \left(\frac{PI_{i,t}}{PR_{i,t}}\right)\right]^{\frac{1}{1-\rho_i^A}} \quad \textbf{(A.26)}$$

$$TV_{j,t} = \sum_i VV_{i,j,t} \quad \textbf{(A.27)}$$

$$TVR_{j,t} = \sum_i VR_{i,j,t} \quad \textbf{(A.28)}$$

$$TVI_{j,t} = \sum_i VI_{i,j,t} \quad \textbf{(A.29)}$$

$$TVM_{j,t} = \sum_{i} VM_{i,j,t} \quad \textbf{(A.30)}$$

$$TVMREG_{j,r,t} = \begin{cases} \delta_{j,r}^{reg\,\sigma_r^{reg}} \cdot TVM_{j,t} & r \in \langle AFC, EU, ASA, OCE, NA, SA \rangle \\ TVI_{j,t} & r \in ROI \end{cases} \quad \textbf{(A.31)}$$

$$E_{i,t} = \bar{E}_i \cdot \left(\frac{PE_{i,t}}{PR_{i,t}}\right)^{\sigma_i^x} \quad \textbf{(A.32)}$$

$$M_{i,t} = \sum_{j} VI_{i,j,t} + \sum_{j} VM_{i,j,t} + \sum_{h} QHM_{i,h,t} + QGM_{i,t} + QVI_{i,t} + QVM_{i,t} \quad \textbf{(A.33)}$$

$$CA_t = \sum_{i} M_{i,t} \cdot PM_{i,t} - \sum_{i} E_{i,t} \cdot PE_{i,t} + \varepsilon_t \cdot \left(\sum_{dngins} \overline{REM}_{dngins} + \overline{FE}\right) \quad \textbf{(A.34)}$$

$$R_{i,t} = \sum_{j} VR_{i,j,t} + \sum_{h} QHR_{i,h,t} + QVR_{i,t} + QGR_{i,t} + QHK_{i,t} \quad \textbf{(A.35)}$$

$$X_{i,t} = R_{i,t} + E_{i,t} \quad \textbf{(A.36)}$$

Domestic Institutions

$$\begin{aligned} YNG_{dngins,t} = {} & d_{dngins}^{L} \cdot w_t \cdot \sum_{i} L_i + d_{dngins}^{K} \cdot rk_{i,t} \cdot \sum_{i} K_i + d_{dngins}^{h} \cdot rh_{i,t} \cdot \sum_{i} H_i \\ & + \sum_{dnginsp} TRSF_{dngins,dnginsp,t} + PC_t \cdot TRG_{dngins} + \varepsilon_t \cdot REM_{dngins} \end{aligned} \quad \textbf{(A.37)}$$

$$TRSF_{dngins,dnginsp,t} = PC_t \cdot \overline{TRSF}_{dngins,dnginsp} \quad \textbf{(A.38)}$$

$$SAV_{dngins,t} = mps_{dngins} \cdot YNG_{dngins,t} \quad \textbf{(A.39)}$$

$$\begin{aligned} HC_t = {} & \sum_{dngins \in \langle HH \rangle} YNG_{dngins,t} - \sum_{dngins \in \langle HH \rangle} SAV_{dngins,t} - HTAX_t \\ & - \sum_{dngins} \sum_{h} TRSF_{dngins,h,t} \end{aligned} \quad \textbf{(A.40)}$$

$$QH_{i,h,t} = \delta_{i,h}^{f\ \rho_i^c} \cdot \left(\frac{PC_{i,t}}{PQ_{i,t}}\right)^{\rho_i^c} \cdot HC_t \quad \textbf{(A.41)}$$

$$QH_{i,h,t} = \gamma_{i,h}^{f} \cdot \left[\delta_{i,h}^{hr} \cdot QHR_{i,h,t}^{\rho_i^A} + \delta_{i,h}^{hm} \cdot QHM_{i,h,t}^{\rho_i^A}\right]^{\frac{1}{\rho_i^A}} \quad \textbf{(A.42)}$$

$$\frac{QHR_{i,h,t}}{QHM_{i,h,t}} = \left[\left(\frac{\delta_{i,h}^{hr}}{\delta_{i,h}^{hm}}\right) \cdot \left(\frac{PM_{i,t}}{PR_{i,t}}\right)\right]^{\frac{1}{1-\rho_i^A}} \quad \textbf{(A.43)}$$

$$GOVBAL_t = \sum_i QG_{i,t} \cdot PQ_{i,t} + \overline{GSAV} + PC_t \cdot \sum_{dngins} TRG_{dngins,t} - (d_g^k \cdot \sum_i rk_{i,t} \cdot K_{i,t} + d_g^h \cdot \sum_i rh_{i,t} \cdot H_{i,t} + \sum_i IMT_{i,t} + HTAX_t + \overline{FE} \cdot \varepsilon_t \quad \textbf{(A.44)}$$

$$QG_{i,t} = \overline{QG}_i \quad \textbf{(A.45)}$$

$$QG_{i,t} = \gamma_i^g \cdot \left[\delta_i^{gr} \cdot QGR_{i,t}^{\rho_i^A} + \delta_i^{gm} \cdot QGM_{i,t}^{\rho_i^A}\right]^{\frac{1}{\rho_i^A}} \quad \textbf{(A.46)}$$

$$\frac{QGR_{i,t}}{QGM_{i,t}} = \left[\left(\frac{\delta_i^{gr}}{\delta_i^{gm}}\right) \cdot \left(\frac{PM_{i,t}}{PR_{i,t}}\right)\right]^{\frac{1}{1-\rho_i^A}} \quad \textbf{(A.47)}$$

$$QV_{i,t} = \sum_j KM_{i,j} \cdot J_{j,t} \quad \textbf{(A.48)}$$

$$QV_{i,t} = \gamma_i^v \cdot \left[\delta_i^{qvm} \cdot QVM_{i,t}^{\rho_i^A} + \delta_i^{qvir} \cdot QVIR_{i,t}^{\rho_i^A}\right]^{\frac{1}{\rho_i^A}} \quad \textbf{(A.49)}$$

$$\frac{QVM_{i,t}}{QVIR_{i,t}} = \left[\left(\frac{\delta_i^{qvm}}{\delta_i^{qvir}}\right) \cdot \left(\frac{PIR_{i,t}}{PM_{i,t}}\right)\right]^{\frac{1}{1-\rho_i^A}} \quad \textbf{(A.50)}$$

$$QVIR_{i,t} = \gamma_i^{vir} \cdot \left[\delta_i^{qvi} \cdot QVI_{i,t}^{\rho_i^A} + \delta_i^{qvr} \cdot QVR_{i,t}^{\rho_i^A}\right]^{\frac{1}{\rho_i^A}} \quad \textbf{(A.51)}$$

$$QVIR_{i,t} = \gamma_i^{vir} \cdot \left[\delta_i^{qvi} \cdot QVI_{i,t}^{\rho_i^A} + \delta_i^{qvr} \cdot QVR_{i,t}^{\rho_i^A}\right]^{\frac{1}{\rho_i^A}} \quad \textbf{(A.52)}$$

$$\frac{QVR_{i,t}}{QVI_{i,t}} = \left[\left(\frac{\delta_i^{qvr}}{\delta_i^{qvi}}\right) \cdot \left(\frac{PI_{i,t}}{PR_{i,t}}\right)\right]^{\frac{1}{1-\rho_i^A}} \quad \textbf{(A.53)}$$

$$QHK_{i,t} = \sum_j YTM_{i,j} \cdot R_{j,t} \quad \textbf{(A.54)}$$

Investments

$$\frac{I_{i,t}}{KS_{i,t}} = \delta^K \cdot \left(\frac{rk_{i,t}}{uck_{i,t}}\right)^{\alpha_i} \quad \textbf{(A.55)}$$

$$J_{i,t} = I_{i,t}\left[1 + \frac{\beta_i}{2} \cdot \frac{I_{i,t}^2}{K_{i,t}}\right] \quad \textbf{(A.56)}$$

$$R_{i,t} = \lambda \cdot \left[HS_{i,t}^* - HS_{i,t}\right] + \delta^H \cdot HS_{i,t}$$
$$Or$$
$$R_{i,t} = R_{i,t=0} \cdot (1 + zsub) \quad \textbf{(A.57)}$$

Factors accumulation **(A.58)**

$$KS_{i,t} = (1 - \delta^K) \cdot KS_{t-1} + I_{i,t-1}$$

Short Run

$$KS_{i,t} = KS_{i,t=0} \quad \textbf{(A.59)}$$

Long Run

$$I_{i,t=LR} = \delta^K \cdot KS_{t=LR}$$

$$HS_{i,t} = (1 - \delta^H) \cdot HS_{t-1} + R_{i,t-1}$$

Short Run

$$HS_{i,t} = HS_{i,t=0} \quad \textbf{(A.60)}$$

Long Run

$$R_{i,t=LR} = \delta^H \cdot HS_{t=LR}$$

$$LS_t = (1 + nim_t) \cdot LS_{t-1} \quad \textbf{(A.61)}$$

Short Run

$$LS_t = LS_{t=0}$$

$$nim_t = \varsigma - \nu^u[ln(u_t) - ln\,(\bar{u}^N)] + \nu^w \left[ln\left(\frac{w_t}{cpi_t}\right) - ln\left(\frac{w^N}{cpi^N}\right)\right] \quad \textbf{(A.62)}$$

$$K_{i,t} = KS_{i,t} \quad \textbf{(A.63)}$$

$$H_{i,t} = HS_{i,t} \quad \textbf{(A.64)}$$

$$LS_t \cdot (1 - u_t) = \sum_j L_{j,t} \quad \textbf{(A.65)}$$

Taxes and subsidies **(A.66)**

$$IBT_{i,t} = btax_i \cdot X_{i,t} \cdot PX_{i,t} \quad \textbf{(A.67)}$$

$$IMT_{j,t} = \sum_i MTAX_j \cdot VM_{i,j,t} \cdot PM_{i,t} \quad \textbf{(A.68)}$$

$$SUBSY_{i,t} = SUB_i \cdot X_{i,t} \cdot PX_{i,t} \quad \textbf{(A.69)}$$

$$HTAX_t = \sum_h dtr_h \cdot (ssce + sscer) \cdot \sum_j L_{j,t} \cdot w_t \quad \textbf{(A.70)}$$

Glossary

i,j	the set of goods or industries
ins	the set of institutions
dins $(\subset ins)$	the set of domestic institutions
dngins $(\subset dins)$	the set of non government institutions
h $(\subset dngins)$	the set of households
r	the set of regions

Prices

$PX_{i,t}$	output price
$PY_{i,t}$	value added price
$PR_{i,t}$	regional price
$PQ_{i,t}$	commodity price
$PIR_{i,t}$	national commodity price (regional + ROI)
$PI_{i,t}$	ROI price
$rk_{i,t}$	rate of return to tangible capital
$rh_{i,t}$	rate of return to intangible capital (knowledge)
w_t	unified nominal wage
w_t^b	after tax wage
$PINV_t$	capital good price
$PINVH_t$	capital knowledge price
uck_t	user cost of physical capital
uch_t	user cost of tangible capital
PC_t	aggregate consumption price
ε_t	exchange rate

Endogenous Variables

$X_{i,t}$	total output
$R_{i,t}$	Regional supply
$M_{i,t}$	total import
$E_{i,t}$	total export (interregional + international)
$Y_{i,t}$	value added
$A_{i,t}$	scale factor in CES function
$L_{i,t}$	labour demand
$K_{i,t}$	demand of physical capital
$H_{i,t}$	demand of Knowledge
$KS_{i,t}$	physical capital stock
$HS_{i,t}$	knowledge stock
$LS_{i,t}$	labour supply
$VV_{i,jt}$	intermediate inputs
$VR_{i,jt}$	regional intermediate inputs
$VM_{i,jt}$	ROW intermediate inputs
$VIR_{i,jt}$	national intermediate inputs (regional+ROI)
$VI_{i,jt}$	ROI intermediate inputs
$TVMREG_{j,rt}$	intermediate import from region *r*
$QGR_{i,t}$	regional government expenditure

$QGM_{i,t}$	government expenditure from ROI+ROW
HC_t	aggregated household consumption
$QH_{i,h,t}$	total households consumption in sector *i* for *h*
$QHR_{i,h,t}$	regional consumption in sector *i* for group *h*
$QHM_{i,h,t}$	import consumption in sector *i* for group *h*
$QV_{i,t}$	total investment by sector of origin *i*
$QVR_{i,t}$	regional investment by sector of origin *i*
$QVM_{i,t}$	ROW investment
$QVIR_{i,t}$	national investment (REG+ROI)
$QVI_{i,t}$	ROI investment
$QHK_{i,t}$	R&D investment by sector of origin *i*
$I_{j,t}$	investment by sector of destination *j*
$J_{j,t}$	investment by destination *j* with adjustment cost
$R_{j,t}$	R&D investment by sector of destination *j*
$H^*_{j,t}$	optimal level of knowledge stock
u_t	regional unemployment rate
nim_t	net in migration
ξ_t	external knowledge spillover
ω_t	import share in the knowledge spillover function
$SAV_{dngins,t}$	domestic non government saving
$YNG_{dngins,t}$	domestic non government income
$TRSF_{dngins,dnginsp,t}$	transfer among *dngins*
$HTAX_t$	total household tax
CA_t	current account balance
$SUBSY_t$	production subsidies
$GOVBAL_t$	government balance

Exogenous variable

$\overline{FSK}_{r,t}$	R&D stock of region *r*
$\overline{REM}_t$	remittance for *dngins*
$\overline{FE}_t$	remittance for the Government
$QG_{i,t}$	government expenditure
$GSAV_t$	government saving

Elasticities:

ρ_j	between knowledge and tangible inputs in sector *j*
σ_i^x	of export with respect to terms of trade
ρ_i^A	in Armington functions
μ	of real wage with respect to unemployment rate
α_j	of acc. rate with respect to the real shadow price
ϑ	of non-excludable *H* with respect to foreign R&D
σ_r^{reg}	elasticity of substitutions of imported import from country *r*

Parameters

$a_{i,j}^V$	input output coefficients for i used in j
a_j^Y	share of value added on production
$\delta_j^{k.h,l}$	shares in value added function in sector j
$\delta_{i,j}^{vir,vm,vr,vi}$	shares parameters in Armington function for intermediate goods
$\delta_{i,j}^{qvir,qvm,qvr,qvi}$	shares parameters in Armington function for investment

$\delta_{i,h}^{hr,hm}$	shares parameters in Armington function for investment in R&D
$\delta_{i}^{gr,gm}$	shares parameters in Armington function for Government consumption
$\gamma_{i,j}^{vv,vir}$	shift parameter in Armington functions for intermediate goods
γ_{i}^{f}	shift parameter in Armington function for households consumption
γ_{i}^{g}	shift parameter in Armington function for government consumption
$\delta^{K,H}$	rate of depreciation for *KS* and *HS*
λ	Speed of adjustment in R&D investment function
β_i	adjustment cost in tangible investment function
$btax_i$	business tax
sub_i	rate of production subsidy
$MTAX_i$	rate of import tax
$YTM_{i,j}$	Yale Technology Matrix
$KM_{i,j}$	physical capital matrix
mps_{dngins}	rate of saving in institutions *dngins*
$ssce$	rate of social security paid by employees
$sscer$	rate of social security paid by employer
ire	rate of income tax

Appendix B

CE model. The ill-specified SAM+R&D provide the prior distribution coefficient $\bar{c}_{i,j}$ and data on column sum x_j.We minimize the entropy distance *E* between the prior $\bar{c}_{i,j}$ and the new estimated coefficient matrix $c_{i,j}$:

$$Min\ E = \left[\sum_i \sum_j c_{i,j} ln \frac{c_{i,j}}{\bar{c}_{i,j}}\right] \quad \textbf{(B.1)}$$

Subject to:

$$\sum_j c_{i,j} x_j = y_i \quad \textbf{(B.2)}$$

$$\sum_i c_{i,j} = 1 \qquad and \quad 0 < c_{i,j} \leq 1 \quad \textbf{(B.3)}$$

Where y_i is the resulting sum in row. Considering k aggregates constraints and an n-by-n aggregator matrix **G**, we can write:

$$\sum_i \sum_j g_{i,j}^{k}\, t_{i,j} = \gamma^k \quad \textbf{(B.4)}$$

where $t_{i,j}$ is the SAM transaction matrix and γ^k is the value of the aggregate constraints. With equation (B.4) we introduce in the set of constraints, some aggregated macro-control variables to deal with intangible components when these are allocated to the sub-matrices of the RSAM seen in Table 1: **F**, **YF**, **S** and **I**. The macro-control variables allow us to consider the intangible components as already part of the SAM maintaining at the same time the original aggregated figures.

Appendix C
The method to obtain the physical capital matrix $KM_{i,j}$

The physical capital matrix $KM_{i,j}$ has been derived by means of a doubly constraint minimum information (MI) model (Schneider and Zenios, 1990). Let T denote the total amount of investment and for each j, let I_j be the investment by sectors of destination and QV_i the investment by sectors of origin i. Considering $t_{i,j}$ the model estimated probabilities and some prior probabilities $\bar{t}_{i,j}$, the model can be formalized as follow:

$$\mathrm{Min} \sum_i \sum_j t_{i,j} \left[\ln\left(\frac{t_{i,j}}{\bar{t}_{i,j}}\right) - 1 \right]$$

subject to

$$\sum_i t_{i,j} = \frac{I_j}{T}; \quad \sum_J t_{i,j} = \frac{QV_i}{T};$$

where

$$\sum_i \sum_j t_{i,j} = \sum_i QV_i = \sum_j I_j = T$$

In this problem as we do not have previous capital matrix concerning Sardinia the prior probabilities $\bar{t}_{i,j}$are derived from the Italian matrix estimated by Costa and Marangoni (1995) for the year 1985. The investment by destination are supplied by the regional account system (ISTAT, 2004) whilst the investment by origin are provided by the RSAM.

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Essay 3
An Applied Regional Intertemporal General Equilibrium Model: does the forward-looking model fit the usual regional closures?

An Applied Regional Intertemporal General Equilibrium Model: does the forward-looking model fit the usual regional closures?

Abstract. We present a stylized regional intertemporal forward-looking model able to take into account regional economic features, an area where the literature is not well developed. The main difference, from the standard applications, is the role of saving and its implication for the balance of payments. Though maintaining dynamic forward-looking behaviour for agents, the rate of private saving will be exogenously determined and so no neoclassical financial adjustment is needed. Also, we focus on the similarities and the differences between myopic and forward-looking models, highlighting the divergences among the main adjustment equations and the resulting simulation outcomes.

JEL classification: C68; D91; R10

Keywords: Myopic and Forward-looking Behaviour; Computable General Equilibrium Models; Regional Adjustment

1. Introduction

CGE models based on myopic expectations have been criticised by the supporters of forward-looking models because of the intertemporal inconsistency involved in assuming backward-looking expectations. The models solve complex optimization problems within periods in order to determine the best allocation of resources, however, between periods they remain myopic, with consumption, saving and investment decisions abstracting from future periods (Devarajan and Go, 1999). Some doubts also arise when the policy to be evaluated has intrinsic long run effects (e.g. trade liberalization policy). As noted by Go (1994), Devarajan and Go (1999), and Dissou (2002), myopic models fail to capture dynamic policy gains and, consequently, produce both inaccurate and incorrect results. For example, Devarajan and Go (1999) demonstrate that the welfare gains of eliminating trade tariffs are greater in forward-looking models than in static models[9].

The theoretical structure of many intertemporal forward-looking CGE models is that described in Abel and Blanchard (1983). Such a model can be solved as a decentralized economy where consumption decisions are

[9] Also see Dellink (2005) on environmental policy

made by intertemporal optimizing households, and savings and investment decisions are separated. The sectoral financial balance equilibrium is maintained, either through adjusting foreign borrowing, the interest rates, or by means of fiscal policy that, in turn, affects the financial wealth of households. Firms' forward-looking behaviour influences their investment decisions which depend on the tax-adjusted Tobin's q. Furthermore, in their stylized form, such models usually make households fully liable for the financial needs of the system. Hence, household savings would cover, not only the needs of domestic investment, but also eventually, trade and Government deficits. Accordingly, households have to save as much as is required to clear the financial sector which, in turn, implies the imposition of a balance of payments constraint.

In fact, forward-looking models are frequently calibrated on national data and their specification is nowadays becoming standardized. However, a slavish application of specifications that imply a zero balance of payments, and where the savings rate is obtained endogenously through sectoral financial balance equilibrium, may be inappropriate in a regional context since regions may differ from the country as a whole.

It is widely recognised that regions are more open than nations and that these economies do not have full macroeconomic power. Both monetary and fiscal policy are centralized, therefore target policies and some macroeconomic adjustment mechanisms whose incorporation is uncontroversial in a national model, cannot be applied to the case of a region[10]. Furthermore, regions, unlike nations, do not face a balance of payments constraint. We can identify at least two reasons for this. Firstly, balance of payments is not required as a policy target since regions usually belong, both to a common currency area, and to a nationally integrated financial system. As a result, fiscal and monetary policies cannot be used to produce balance of payments adjustments through control variables such as exchange rates, reserve assets and interest rates. Secondly, the subvention that regions receive from higher level authorities such as centralized Government and the EU, may cause some distortionary effects so that a rigorous theory of the composition of the balance of payments is not really a regional issue. As pointed out by McGregor et al. (1995), such subventions are key determinants of the trade deficit in the region.

The point is that forward-looking models impose a balance of payments equilibrium in order to maintain financial sector sustainability, but regions are not obliged to undergo any form of financial adjustment. For instance, if a region faces an unsustainable position in which a net foreign debt is accompanied by a persistent trade deficit, it is not required to adopt rigorous adjustment in order to produce a trade surplus to cover

[10]Even though some nations are likely to behave as regions (European countries for example).

interest payments because there are no superior authorities to impose it. A superior institution such as central Government, may reduce the subvention to reduce its level of debt and, in turn, the region's debt (that is unobservable). However, this is a process that happens outside of the region. It means that if any adjustment exists this is imposed exogenously, from outside the region, not as an endogenous mechanism. This also means that the Ricardian implication of the fiscal deficit usually embedded in consumers' optimal decisions might be unrealistic; regional Government cannot finance its expenditure by levying taxes or issuing bonds since regional policy is an exogenous variable that depends on the subvention received from outside the region.

Of course, given widespread movement towards greater devolution within the EU, more regions will be equipped with instruments to deal with the reduction in subvention, thereby introducing specific sustainable targets that might bring about a partial endogenous financial adjustment operating within the region. So, only when regions start to behave like countries belonging to a common currency area, e.g. the European countries, does the balance of payments begin to be a matter for the regional level, and any adjustment in internal and foreign assets ceases to be exogenously determined. This does not mean that the traditional approach to the balance of payments should be applied. Also for these regions, interregional and international payments constraints should not necessarily be imposed.

We think that the treatment of internal and external debt should differ from the usual application in intertemporal models. Thus, in a stylized regional model, Government and external debt with their correspondent flows, internal and external deficits, should not be involved in the process that determines financial adjustment. This also means that the role of savings should differ from standard applications. In a region, the household savings decisions are independent of the regional financial system. In fact, it is more likely to be affected by national adjustment which is, of course, exogenous in a single small open regional economy model.

The intertemporal model developed in this paper maintains forward-looking behaviour for both households and firms, and investment and saving decisions are kept separate. However, unlike standard applications, in our formulation savings follow the Solow-Swan assumption so that the rate of savings is exogenous. This does not prevent the absolute level of savings from varying through time.

Comparisons between myopic and forward-looking models are required and under particular circumstances we find the same long run steady state equilibrium. Furthermore, these comparisons may be very useful since it would seem that in the literature the intertemporal forward-looking model has generally been compared to the simple static case that lacks any capital adjustment rule. Independently of the dynamic structure, forward-looking and myopic regional models should incorporate a separate investment function and the investment decision must be determined independently of the savings decision. Instead, in several papers an intertemporal model has been compared with a simple myopic one in which investment is either roughly assumed fixed to the base year or is passive. The myopic model used in this example, which follows the usual AMOS closures (McGregor et al. 1995, 1996), allows investment to respond to the current rate of return to capital. In addition the analysis will be enriched by assuming labour supply adjustment through migration, and by investigating the role of different labour market closures.

The paper continues in Section 2 with the outline of the model. In Section 3 we deal with the calibration method, whilst Sections 4 and 5 are devoted to a discussion of the main outcomes of the simulations. Finally, Section 6 is a conclusion.

2. Model Description

A single-region dynamic CGE model is presented in this section. The full mathematical presentation of the model is in Appendix (A.1 - A.77).

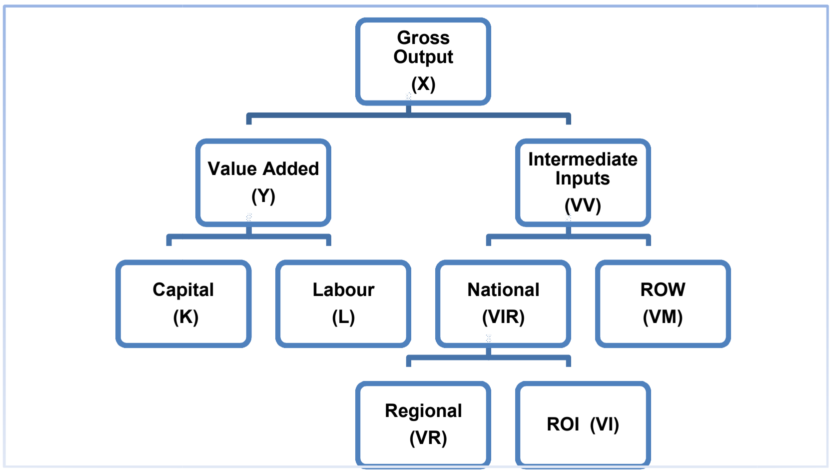
Production and demand parameter specifications have been implemented through the well known calibration method using the Social Accounting Matrix (SAM) for Sardinia for the year 2001 (Ferrari et al., 2009). The set of prices at which excess demand is zero is the result of an optimization process where market clearing prices equal marginal costs in each sector.

Three economic activities or sectors are considered: Primary, Manufacturing and Services. No distinction is made between traded and non-traded sectors. Sardinia is a very small open economy and almost all sectors compete in the interregional and international markets. Even health care services, traditionally a sheltered sector, are now inter-regionally traded. Intermediate and primary inputs constitute the production inputs. The model also includes three domestic institutional sectors: Firms, Households and Government. External institutions are split into the Rest of Italy (ROI) and Rest of the World (ROW). We adopt assumptions typically used for a small open economy. The region is too small to affect prices in international and interregional markets and, as a consequence, the ROI and ROW prices are taken to be exogenous. The behaviour of Households and Firms is based on intertemporal optimization with perfect foresight. Government is a consolidated sector merging central and local Government levels whose expenditure can be either the result of an optimization process, where Government is simply treated as a new consumer maximizing utility subject to the budget constraints, or it is held constant in real terms.

Production. The model's production structure is illustrated in Figure 1. Intermediate inputs (*VV*), labour (*L*) and capital (*K*) constitute the production inputs of the model. L and K are combined in a CES production function in order to produce value added, Y, allowing for substitution among primary factors of production (A.17). The demand for L and K is obtained from the first order condition of profit maximization. This means that the demand for both K and L is positively related to the volume of value added, Y, and is a decreasing function of their prices (rk and w, respectively). Leontief technology between VV and Y is imposed (A.14), so the combination of value added and intermediate inputs can be shown with an L-shaped isoquant. Intermediate goods produced locally or imported are considered as imperfect substitutes. Basically, we mix regional and imported goods under the so called Armington assumption through a CES function. The demand function for regionally produced and imported intermediate inputs (from ROI and ROW) derives from the solution of a cost minimization problem (A.19-A.22). Regional commodities supply is bought by industries and by domestic and external institutions (A.24). That is to say, each industry in the region produces a composite commodity that can be exported or sold in the regional market. An export demand function closes the model where the foreign demand for Sardinian goods depends on the terms of trade effect and on the export price elasticity (A.23).

Figure 1

The production structure of the model



Investment. This follows Hayashy (1982) with the rate of investment as a function of marginal q (or average q)[11], the ratio of the value of firms (VF) to the replacement cost of capital $Pk{\cdot}K$. There are adjustment costs that are quadratic in investment and linear homogeneous in investment and capital stock, so for a positive shock, the economy does not adjust

[11] As we are assuming that the firm is price taker, the marginal q is equal to the average q. For more detail see Hayashy (1982).

instantaneously to the desired level of capital stock. Accordingly, firms respond to the shock by making continuous small investments over time. The dynamic path of investment is the result of an intertemporal programme that seeks to maximize VF subject to the capital accumulation equation, $\dot{K}$ (A.50). The value of firm, *VF,* is given by the present value of the net income or cash flow, *CF,* that is to say, the capital income $\Pi_{i,t}$ less investment expenditure $J_{i,t}$. The investment expenditure equation (A.45) is defined as a function of the adjustment cost $\theta(x_t)$ (A.48) as in Devarajan and Go (1998), Go (1994) and Hayashi (1982). The solution to this intertemporal problem[12] produces the time path of investment (A.46) along with the law of motion of the costate variable λ (A.47).

Consumption. Individuals optimise their lifetime utility function of consumption, *C* (A.26) subject to a lifetime wealth and time constraint. Once the optimal path of consumption is obtained from the solution of the intertemporal problem (A27), aggregate consumption is allocated within each period and between different groups through a CES function (A.34). Household demand for regional and imported goods (A.35 and A.36) is the result of the intra-temporal cost minimization problem. According to the dynamic budget constraint, the discounted present value of consumption must not exceed total household wealth, *W*. The model distinguishes between financial wealth (*FW*) and non financial wealth (*NFW*). So total Wealth, *W*, is given by:

$$W_t = NFW_t + FW_t$$

The NFW accumulate as follow:

$$NFW_t(1 + r_t) = NFW_{t+1} + YL_t$$

where *YL* is the net labour income plus transfers of income from internal and external institutions. *FW*, unlike in the standard applications, is accumulated through saving, *S* as follows:

[12] The optimality conditions (or the canonic system which gives the system of differential equations in the optimal control problem) are given by the first order condition of the Hamiltonian in current value:

A. $\frac{\partial H}{\partial I} = 0 \Rightarrow J'(I_t) = \lambda_t$
B. $\dot{\lambda} = -\frac{\partial H}{\partial K} \Rightarrow \dot{\lambda} = (r_t + \delta)\lambda_t - R_t^k$
C. $\lim_{t\to\infty} \mu_t \lambda_t K_t = 0$ (trasversality condition)

The canonic system [A, B and C] can be solved to yield the costate variable in terms of discounted future revenue of capital which in turn leads to equation (5). More detail about the dynamic solution can be found in Go (1994) and Devarajan and Go (1999).

$$FW_t(1 + r_t) = FW_{t+1} + \Pi_t - S_t \qquad (1)$$

and

$$S_t = mps \cdot YH_t$$

where Π_t is capital income, YH_t is total household current income whilst *mps* is a parameter calibrated from the SAM. This way of proceeding, although allowing us to deal with an exogenous rate of household saving, is wholly consistent with forward-looking consumption behaviour. In fact, consumption still depends on lifetime income. That is to say, consumers base consumption decisions on expected future income, and although saving is not affected by investment and from the current account situation, it still allows the consumers to smooth consumption across periods. In the traditional approach, financial wealth is obtained by assuming asset equilibrium so that financial wealth accumulates according to the following:

$$FW_t(1 + r_t) = FW_{t+1} + \Pi_t - \left(\sum_i J_{i,t} + FD_t - TB_t\right) \qquad (2)$$

Where *FD* is the fiscal deficit and *TB* is the trade balance. Then $\sum_i J_{i,t} + FD_t - TB_t$ gives us endogenous saving. This means that household financial wealth is equal to total assets, internal and external. That is to say:

$$FW_t = \sum_i VF_{i,t} + GD_t + D_t \qquad (3)$$

In others words the wealth derived from asset holdings consists of the value of firms (*VF*), public assets (*GD*) and foreign assets (*D*). The value of firms represents the wealth generated from assets that consist of domestic firms' shares. Foreign assets reflect holdings of foreign firms' shares. The value of public assets is derived from Government bonds issued to finance the fiscal deficit.

In our formulation, as described in equation (1), the balance of payments still clear and we do not need to impose any balance of payments adjustment because the total absorption equation is sufficient to guarantee equilibrium in the payments account since we are not considering money as a commodity. In contrast, implicit in equations (2) and (3) is the imposition of a balance of payments adjustment because savings are determined endogenously according to the financial needs of the regional system. This method is incoherent if a regional context is considered. As we have said in the introduction, it is plausible that the regional savings rate depends very much on the national system and, unlike countries, there is no saving-investment association. Furthermore, regions are unlikely to face a balance of payments problem because the multiregional capital market is highly integrated and capital moves freely across regions.

In other intertemporal models household savings have also been determined as a fixed share of income, as for instance in Go, (1994). He exploits Abel's and Blanchard's (1983) equivalence to delete the household budget constraint, solving the model as a centralized economy but imposing financial sector equilibrium and making foreign borrowing endogenous. We can also run the model as a master plan, not considering the motion equation of the state variable W (see Section 4).

Domestic private Assets. From Hayashi's (1982) work we know that if the firm is a price taker, then marginal q is equal to average q. Therefore we can specify the shadow price of capital λ as the ratio of the value of the firm VF to its capital stock K (A.59).

Foreign and public assets. The common hypothesis is that both internal and external debt accumulates over time in accordance with the level of deficit and interest payments. Moreover, terminal conditions for assets are imposed in order to avoid Ponzi games. As many CGEs are calibrated on a steady state equilibrium, the need to maintain a sustainable position may generate a dataset that does not reflect the real situation of the region. For instance, the calibration of the foreign asset/debt is derived by imposing regional sustainability with respect to foreign creditors or debtors. In doing this, if the regional SAM registers a trade deficit, we need to impose (and suppose) that, in the past, the region has run in surplus for many years in order to accumulate assets; the presence of a trade surplus should imply foreign debt. But several regions are in a permanent Ponzi game condition. If we do not take this situation into account, the quantitative nature of the results may change. So, if foreign debt accumulates according to the following: $\dot{D} = rD_t + TB_t$ and the trade balance TB is positive (so a trade deficit), a sustainable long-run position should require interest-bearing foreign assets held by the private sector. Alternatively, a negative TB (trade surplus) in the long run would be able to cover interest payments on any outstanding foreign debt. In a regional context we may suppose, instead, that capital inflows necessary to cover the trade deficit are partially constituted by subvention on which no interest is paid and that, therefore, will not reduce internal assets because these are resources coming free of charge. In Sardinia's case, trade deficits exist on both the interregional and the international side. Sardinia is a region that receives extensive subvention from the EU and the Italian Government: any payments from the Social or Structural funds of the EU are matched by the National Government. In these circumstances it would seem that the causality relationship, according to which the current account balance determines financial and capital account, is inverted; capital inflow that is free of charge drives the trade deficit, where such capital inflows are free of charge and not determined by the desire of an investor to acquire Sardinia assets. In this case the change in debt that may affect the sectoral financial balance should be net of this capital inflow. In modelling this situation we may assume that a proportion of debt, τ, is the amount of subvention that the region receives from the National Government or EU, and not because there is the desire to invest in the region:

$$\dot{D} = (r - \tau)D_t + TB_t$$

So the debt accumulates only if $TB > -(r - \tau)D_t$ and the net foreign debt is equal to the gross debt less the accumulated subvention on the assets in the gross debt.

As regards Government debt or assets, because Sardinia experiences an internal deficit, according to the usual calibration that imposes sustainability of fiscal deficits, we would need to suppose the presence of Government assets which reduce the total assets available for private agents. However for the same reasons, as explained above, we consider an "unsustainable" position as one in which the debt is going to accumulate net of the resources that the region receives from outside of the region (A.62).

Labour market regimes and labour supply. The model incorporates three labour market closures defining the form of wage setting: regional wage bargaining (RB), national bargaining (NB) and fixed real wage, (FRW). The wage-setting functions are defined below, where *w* is the nominal wage, *cpi* is the consumer price index, β is a parameter calibrated to the steady state and u is the regional unemployment rate. ε is the elasticity of wages related to the level of unemployment rate and it can also be interpreted as an index of wage flexibility.

$$\text{Wage setting} \begin{cases} ln\left[\dfrac{w_t}{cpi_t}\right] = \beta - \varepsilon \ln(u_t) & \text{(Regional Bargaining)} \\ \dfrac{w_t}{cpi_t} = \dfrac{w_{t=0}}{cpi_{t=0}} & \text{(Fixed Real Wage)} \\ w_t = w_{t=0} & \text{(National Bargaining)} \end{cases}$$

In the regional wage bargaining regime, the labour market is defined by the wage curve (Blanchflower and Oswald, 1994) according to which wages and unemployment are negatively related.[13] Thus regional wages are directly related to workers' bargaining power and respond to excess demand for labour. NB is a Keynesian closure for traditional regional

[13] See application of this closure in McGregor et al. 1995 and 1996.

economies. It assumes that the nominal wage is fixed at the base year level. We can imagine that the regional nominal wage is fixed at the value of the national wage due to a national bargaining regime. For that reason this closure rule could be called National Bargaining (Harrigan et al. 1991). FRW is used to obtain an alternative counterfactual analysis. We hypothesise that the purchasing power of wages remains stable over time.

As regards demographic developments and labour supply, we assume that there is no natural population change but the labour force adjusts through a migration model commonly employed in AMOS (Harrigan et al.1996, McGregor at al. 1996). The model starts with zero net migration flow and, in any period, migration is taken to be positively related to the gap between regional and national (w^N/cpi^N) real wages, and negatively related to the gap between national, (u^N) and regional unemployment rates:

$$nim_t = \varsigma - \nu^u[\ln(u_t) - \ln(\bar{u}^N)] + \nu^w \left[ln\left(\frac{w_t}{cpi_t}\right) - ln\left(\frac{\bar{w}^N}{\overline{cpi}^N}\right)\right] \quad (4)$$

where *nim* is the rate of net migration and ς is a parameter calibrated in order to get zero net migration. ν^u and ν^w are elasticities that measure the impact of the gap between regional and national unemployment and real wage rates.

3. Calibration

The model calibration process assumes the economy to be initially in a steady state equilibrium. The parameters of the models are obtained from the SAM by means of the usual calibration method. Since, in a deterministic approach, some of the parameters remain unspecified, we need to find them from outside the model, so the elasticities of substitution and other behavioural parameters are based on econometric estimation or best guesses. For all sectors, trade elasticities are set equal to 2 whilst production elasticities are equal to 0.3. The wage curve elasticity is set to -0.033, following to a recent econometric estimation reported in Devicienti et al. (2008), whilst in the migration function, we use the elasticities commonly used in AMOS and econometrically estimated by Layard et al. (1991).

The values of adjustment cost parameters[14] α and β in equations (A.46-9) are assigned values 0 and 1.5, respectively. The World interest rate is set to 0.04, the rate of depreciation to 0.07 and the inter-temporal elasticity of substitution is equal to 1.5. Given the value of total

[14] In many applications the parameter α is set to zero. The value of β is set to 0.9 in Dissou (2002) in a model of Senegal and in Go (1994) and Devarajan and Go (1999) in their model of Philippine is set at 2.

investment, J, as supplied by the System of National Accounts (ISTAT, 2005) through the capital matrix[15], $KM_{i,j}$, the equality condition with total investment by origin in the SAM holds true. The price of capital goods, Pk, is set equal to unity since the benchmark prices on the consumption side are set equal to one. W corresponds to the discounted flow of current income, NFW to the discounted flow of net labour income, and FW is obtained by maintaining asset equilibrium. By imposing equality[16] between the rate of return to capital rk and the user cost of capital[17], uck, from the constraint equations (A.28), A(.40), (A.45-49), (A59) and (A.62-67), we obtain consistent values for the variables I, K, λ, W, NFW and FW.

The model is solved by applying the usual procedure in solving an infinite time horizon model, by imposing steady state conditions at a specific point in time. In the first periods we impose factor constraints in order to see short-run impact; however the transitional pathway is the result of the discrete time solution of the model.

The myopic model developed here,[18] and which is compared with the intertemporal model, is not obtained recursively, rather the equations of the model are solved simultaneously for a given finite time horizon. Since the model does not incorporate jumping variables the results are, of course, those of the recursive one. In addition, the model incorporates an adjustment cost function through which investment is determined independently of savings. The adjustment rule introduced in the myopic model follows that employed in AMOS (McGregor et al., 1996) which is consistent with the neoclassical formulation developed in Jorgenson (1963) and Eisner-Stroz (1963); the optimal path of investment is derived through the accelerator mechanism v:

$$I = v\,[K^{*} - K]$$

where K^{*} is the desired level of capital. This is wholly compatible with the Uzawa formulation of adjustment cost where the investment capital ratio (φ) is determined by the rate of return to capital (rk) and the user cost of capital (uck), allowing the capital stock to reach its desire level in a smooth fashion over time:

$$\varphi = \varphi(rk, uck)$$

$$\frac{\partial \varphi}{\partial rk} > 0; \ \frac{\partial \varphi}{\partial uck} < 0$$

[15] For detail about the construction of the Sardinian capital matrix, see Garau and Lecca (2008).

[16] The equality between rk and uck is necessary since we are proposing the same calibration method for the myopic and the intertemporal model.

[17] Given that the interest rate and the depreciation rate are fixed, the user cost of capital depends on the variation of the capital good price, Pk.

[18] For a full list of equations of the myopic model see Garau and Lecca, 2008.

Although Uzawa's formulation and the *q* theory proposed by Tobin are formally different, they are in essence "equivalent," as noted in Hayashi[19] (1982).

The myopic model can also be run for two static conceptual time closures: the Short-Run (SR) and the Long-Run (LR). In the SR, capital and labour supplies are fixed at their base year value; in the LR, factor constraints are relaxed allowing for complete capital and labour adjustment. Capital stock is at its optimum level, with rental rate equal to user cost of capital. With regard to the labour supply, the population is fully adjusted so that the system exhibits zero net migration. This kind of adjustment is quite similar to the ones presented in AMOS, a CGE for Scotland (McGregor et al., 1996).

4. Simulation strategy

We present several simulations in order to compare different forward-looking model specifications (which are declared by an FL prefix). Comparisons between forward-looking and myopic models (MYP prefix) are also carried out. In all simulations the disturbance takes the form of a 10% increase in interregional exports. We prefer a simple demand shock since the paper is not policy oriented, but its aim is to highlight the main differences in the adjustment mechanism that may arise by changing the dynamic structure of the model and some household closure rules.

We present the proportionate changes from base year values for a set of key economic variables in Tables 1 and 2 for the intertemporal and myopic model, respectively. In the tables, only the short run and long run results are reported, along with outcomes related to different labour market regimes: Regional Bargaining (RB), National Bargaining (NB) and Fixed Real Wage (FRW). The main difference between FL1 and MYP1 and FL2 and MYP2 is in the financial adjustment process and its implication for the balance of payments.

In FL1 we try to design a hypothetical stylized regional intertemporal model in which, not only is the balance of payments trivial, but household saving decisions do not involve any financial adjustment process. We are aware that this may change the nature of the intertemporal model. However, as we have explained above, in a regional economic framework it does not seems appropriate to incorporate

[19] This equivalence allows Hayashy to integrate the two theories deriving a rate of investment function of *q*.

household saving decisions in the manner usually applied in intertemporal models, as in eq. (2). The outcomes obtained can also be replicated by running the model as a centralized solution by exploiting Abel's and Blanchard's equivalence (Abel and Blanchard, 1983). Such a solution has also been used in Go (1994) to remove the household budget constraint. As a result, this reduces the dimensions of the problem. Go thus closes the model by imposing equality between total savings and investment through adjustment in the level of foreign borrowing. However, this is not our method. We may exploit Abel's and Blanchard's (1983) equivalence to delete the motion equation of the state variable W and resolve the problem as a centralized economy as in Go (1994), but without imposing financial sector equilibrium. This is consistent with a regional macroeconomic framework in which the constant savings rate (Solow-Swan assumption) does not involve an adjustment of the private sector financial balance, as seen above. That is, regional private assets, Government and foreign borrowing do not take part in determining the consumer's intertemporal decisions (compared with e.g. Devarajan and Go, 1999, Go, 1994 and Dissou, 2002). Such a specification does not prevent the consumer from behaving with perfect foresight. Indeed, consumers still take decisions on the basis of future wealth, preserving the condition of instability between current consumption and wealth during the transitional pathway. Of course, in the long run, the trasversality condition is satisfied and stability restored.

MYP1 represents the traditional myopic regional model. This model, as noted above, is quite similar to the type of adjustment present in AMOS (McGregor et al. 1996). Household savings are a fixed proportion of income and consumption is obtained from a simple budget constraint equation.

In FL2 households are responsible for all of the financial needs of the regional system, so their financial wealth is related to outstanding foreign debt, the value of firms and Government debt, as specified in eq. (3). We are assuming that the Government is financing the debt by issuing bonds that are borne exclusively by households. Since saving and investment are separately determined, the equilibrium condition is obtained through foreign savings, which enters into the household consumption decision and allows us to avoid fiscal policy, given that there is no borrowing constraint. In this case, the balance of payments is no longer trivial. However, the imposition of sectoral financial equilibrium is equivalent to the imposition of a balance of payments constraint which requires saving to adjust in order to satisfy the intertemporal payment constraint.

In order to make a comparison with a myopic formulation, in MYP2 not only the balance of payment holds, moreover we attempt to emulate the same financial adjustment that would occur in FL2. In doing so the household budget constraint equation and the financial balance equilibrium are included in the myopic model. Of course in this case, household consumption becomes endogenous and the value of firm is calculated using the capital rental rate obtained within each period.

For all models, three labour market closures (Regional Bargaining, National Bargaining and Fixed Real Wage) are analysed. Furthermore, all models are run in order to generate an endogenous updating of the working population through migration (see eq. 4). Indeed, imperfect labour markets and labour supply adjustment obtained through the introduction of quantity signals (given by the unemployment rate), and migration, are key factors in regional economic models. Such elements make regional models different to their national counterparts where the wage is often flexible and the labour supply is exogenous.

5. Simulation results

From Tables 1 and 2 we immediately note that, in the long run, for all closures and in all cases we obtain Leontief-type results (see McGregor et al., 1996), characterized by changes in quantity and zero change in prices. This reflects the complete adjustment of factors of production. Indeed, both capital and labour endogenously adjust over time. Capital stock increases with investment which in turn, is affected by its real shadow price. As aggregate demand rises, prices increase and so do firms' profit expectations. This leads to an increase in investment that is moderated by the replacement cost of capital reflected in the real shadow price. In-migration increases in response to a rise in real wages and falling unemployment until, in the long run, the labour market is cleared, and all the increase in employment is covered by the increase in working population. In turn, the growth in labour supply puts downward pressure on wages until the labour market is in long run equilibrium, the real wage is restored to its original level, and goods' prices adjust totally.

From the tables we can also see that there are no differences in the long run impact between myopic and forward-looking models (LR: FL1≡MYP1 and FL2≡MYP2). This equivalence arises because, in our myopic model, consumption is passive and results from the budget constraint. Its value should equal that obtained in forward-looking models given that, in the long run, the transversality condition are satisfied, consequently eliminating divergences between current income and current consumption. On the investment side of the forward-looking model, the accumulation rate adjusts totally as Tobin's q equalizes. Such a situation corresponds, in the myopic formulation, to zero gap between desired and actual level of capital (if we adopt a Jorgenson-type adjustment) or that the change in the rate of return to capital equals that of the user cost of capital (if Uzawa-type adjustment are applied).

5.1. Fixed saving rate. We begin by analysing simulation results from the intertemporal model FL1. As we are analysing three labour market closures, the main differences between these models are driven by wage dynamics. However, wage behaviour affects only the short run and the transitional path since, in the long run, labour supply adjustment allows the economy to reach Leontief-type results. In the first period of RB, which corresponds to the short run solution, the demand stimulus increases labour demand which reduces the unemployment rate by 1.34% increasing, as a consequence, the bargaining power of workers and so the real wage (0.05%). For the national bargaining case, the real wage is below its initial equilibrium (-0.91%). As workers cannot bargain wages within the region, the increase in aggregate demand raises prices, thereby lowering the purchasing power of wages. In the FRW, the real wage is fixed, so the increase in the consumer price index increases the nominal wage by the same amount (1.11%).

Given that in NB workers cannot bargain their wages, the level of employment and the reduction in the unemployment rate is greater than for the RB and FRW cases. Furthermore, as the price of goods adjusts according to the wages dynamic by making the supply smoothly responsive, the analysis of the transitional path suggests that the capacity to reach the new steady state faster will depend on the speed of price adjustment. In NB prices adjust faster than in RB and FRW because nominal wages are fixed, implying less resistance to reaching their long run equilibrium, as we can see from Figures 2 and 3.

In the short-run, the increase in interregional exports is not enough to cover the rise in total imports. The total trade deficit increases and for all labour market closures the ROI trade deficit improves while the ROW deficit gets worse. This is happening as the exogenous increase in interregional exports raises competitiveness with respect to the Rest of Italy, but the augmented aggregate demand generates an increase in production that needs to be satisfied by increasing the demand for import goods. This is driven also by the increase in regional prices. The result is a substitution effect which lowers ROW exports and raises ROW imports. In the long-run, as prices adjust totally back to their benchmark values, the terms of trade effect is nullified, generating complete variation in interregional exports (10%) and zero change in international exports. So, as imports are increasing to satisfy production needs, the international current account get worse, generating, however, a total positive effect (current account ROI+ROW, -3.14%) given that part of the interregional current account improves by 17.87%.

In the first period, household consumption increases only in NB (0.10%). For RB and FRW the proportionate change is negative. This is the distinctive impact we would expect in an intertemporal model that incorporates permanent income type behaviour; it implies that when households make decisions on current consumption, they take into consideration their future earnings, thus creating instability between current income and current consumption. Such instability disappears in the long-run where the change in consumption equals the positive variation in total wealth (1.48%).

Change in the real shadow price drives the impact on investment which rises in the short run, settling in the long-run at a level of 2.03% higher than the initial steady state. The reason is that the increase in exports affects domestic goods prices, raising profit expectations for firms in every sector. Indeed, in the first period we see that the change in the shadow price of capital is greater than the change in the capital goods price. Furthermore, change in investment is greater in NB than in FRW and RB (*J*: NB>FRW>RB). The reason can be identified in the variation of the replacement cost of capital which is higher in RB (1.08%) and lower in NB (0.86%). The NB case is less sensitive to factor constraints because workers do not have the power to re-establish their purchasing power (see real wage, -0.91%) under centralized wage bargaining, leading to less upward pressure on the prices of consumption goods.

With regard to sectoral impacts, all three sectors receive permanent benefits. Breaking down the commodity composition of total exports although the primary sector makes up the smallest share of total exports, it seems to be the sector that has the largest proportionate gains in terms of real output and investment, both in the short run and in the long run. Since the policy analyzed here is a simple demand side shock, the initial steady state coefficients matter for the long run outcome. As a matter of fact, exports represent 28% of primary sector output compared to 12% in Manufacturing and 2% in Services.

By comparing the results with the myopic case we see that, as expected, they exhibit the same long run equilibrium. Indeed, we recall that in both models, investment is responsive to the rate of return to capital and its increase is tempered by adjustment costs that are incorporated into both models. The second reason is due to the fixed rate of savings incorporated in both intertemporal and myopic cases. The transitional pathway towards the long run may differ since, in the myopic model, agents' expectations are based on the past, whilst in the forward-looking model both consumption and the shadow price of capital depend on future conditions.

If we look at the GRP charts in Figure 4, for RB and FRW it seems that FL1 achieves the steady state equilibrium faster than MYP1. In fact the FL1 GRP curve from the Medium term to the long run is above that of MYP1. However, in the short run we have a different situation (see also Table 2 and 3); for NB, the GRP MYP curve is always above the FL GRP curve. Of course, the results are strongly conditioned by the parameters of the models. In the myopic model the accelerator (the adjustment parameter applied to the gap between actual and desired level of capital stock) in the investment function, set to 0.5, drives the speed of adjustment; in the forward-looking model the speed of adjustment is particularly affected by the intertemporal elasticity of substitution, here equal to 1.5, that generates consumer preferences between periods (see the next subsection 5.3 on this point).

In order to understand these differences it is helpful to chart the path of those variables subject to forward-looking behaviour, namely consumption and investment (Fig. 5). For all labour market closures, the proportionate changes in consumption for the first periods are greater in MYP1 than FL1. For instance, in the Regional Bargaining case, only after the 30th period does consumption in the intertemporal model exceed that in the myopic model. As regards the pattern of investment, we see that for all closures but NB, the percentage change in FL1 is greater than MYP1 for every period. Investments appear rather interesting in the NB case. In FL1 investment jumps immediately to about 3.09 times the benchmark level and gradually comes to rest at 2.03% in the long run, producing a percentage curve convex to the origin. Indeed in the SR, given capital constraints, the shadow price of capital increases relatively much more with respect to the prices of capital goods because the latter experiences less upward pressure from wages which are fixed. Usually, the intertemporal model is compared to the myopic model in which investment is passive and roughly determined by available savings expressed as a fixed share of income. Here instead, the behaviour of investment is quite similar in both the myopic and the forward-looking models.

5.2. Endogenous saving rate. The difference between FL1 and FL2, on the one hand, and MYP1 and MYP2 on the other, rests on savings behaviour. Indeed, the rate of saving in FL2 and MYP2 is endogenous, affected by the variations in the value of the firm, Government and outstanding foreign debt. However, we do not find much difference with respect to the previous case (FL1) as far as the direction of the effect is concerned. This is true even for price adjustment which seems quite similar to FL1, as does the impact of different labour market closures. The price of domestic goods drives up the increase in full consumption price and the capital goods price. Price adjustments seem more affected by the wage dynamic, as in the previous case, than by the balance of payments equilibrium constraint.

The main difference with respect to FL1 and MYP1 is the intertemporal constraint present in FL2 which leads to payments equilibrium through sectoral financial flows, in all periods that, in turn, impose a balance of payments adjustment constraint according to which savings depends on domestic and foreign financial assets. According to our experiment this has the effect to invert the behaviour of saving in the short run and to raise the long-run impact of an increase in competitiveness.

In the short run for all labour market regimes (see Table 1, FL2) the rate of saving fall due to the rise in trade deficit and Government deficit. In fact although investment is increasing this is not able to counterbalance the negative behaviour of the internal and external balance. So, the intertemporal constraint makes households decisions part of the regional financial mechanism even though for a region is difficult to see this kind of mechanism in operation. The composition of the

In the long-run, we have a bigger impact in terms of real variables in FL2 than in FL1. The Gross Regional Product is above its benchmark equilibrium by 2.06% in FL2 and 1.91% in FL1. Such differences are driven by consumption which is greater in FL2 (1.85%) than FL1 (1.48%). So the long-run difference between the two models is due substantially by consumption which in turn is affected by total wealth.

Wealth increased more in FL2 than in FL1. Wealth, in fact, is composed of NFW and FW. NFW is determined in the same way in both models but FW is the result of different specifications. In FL2, the increase in assets also raises total wealth, and consumption is positively affected. Consequently, household financial wealth increases as the value of the firm is above its benchmark equilibrium (1.97%), and the decrease in Government debt (-1.54%) is not able to offset the fall in foreign debt (-2.77%). The change in total assets is positive (see Fig. 6a). This will affect consumption since, in the long run, the instability between current wealth and consumption disappear.

Surprisingly, the same type of adjustment is also obtained in MYP2, the myopic counterpart of FL2. First, in the short run, the rate of saving fall for the same reason explain above and furthermore the long-run impact coincide with FL2. Results for MYP2 can be seen in Table 2 while the behaviour of savings and wealth for the forward-looking and myopic models can be seen in Figure 6a and 6b. In both models, savings fall in the initial periods and then rise. Financial Wealth rise immediately in the first period and then decrease (maintaining positive change) because foreign debt rises. As soon as foreign debt get negative change the financial wealth curve rise gently tempered by negative change of Government assets hold by households.

This path analysis confirm that no difference in adjustment and impact exist in both model MYP and FL. Previous literature has emphasis the incapacity of myopic model to produce consistent results based on rational behaviour. In our experiments instead we prove that both models may reproduce similar behaviour for the main macroeconomic variables since we have made the effort to render both models close to each other.

5.3. Sensitivity analysis. As we have seen above, the only difference between myopic and forward-looking models is in the transitional pathway towards a new steady state. In particular, due to the characteristics of both models, two parameters are able to govern and alter the speed of adjustment: the myopic model is highly sensitive to the parameter, v, in the investment equation, whilst the inverse of the constant elasticity of marginal utility $1/\sigma$ is the parameter that more than any other alters the rate at which the new steady state equilibrium is reached.

As in the preceding simulations, even here we increase interregional exports by 10% using the MYP1 and the FL1 models by changing the parameters v and σ. As seen from Figure 7, increasing v the curve of the proportionate change in the accumulation rate tends to approach the stable point (zero change) rapidly. Given that capital stock accumulates over time due to past net investment, a positive shock produces a growth of GRP generating a large gap between desired and actual K. This causes current net investment to rise. This rise in investment will increase with the parameter v, thereby increasing the speed of adjustment of the accumulation rate.

In Figure 8 we report the percentage change of consumption obtained by changing the value of σ. Given an intertemporally additive utility function, the Euler equation for expected utility maximization under rational expectations implies that, by increasing the value of the marginal utility of consumption and keeping fixed the *sacrifice* of not consuming (the interest rate), the cost of reallocating consumption between the present and the future will decrease. So changing σ, we modify the cost of reallocating consumption between periods that, according to the figures, imply that, for a positive shock, consumption will reach faster the new steady state when σ is high or its inverse is low ($1/\sigma$). When σ is equal to 0.5 and 0.4, consumption in the very first periods assume negative change due to the fact that households prefer to save in these periods and allocate more consumption to future periods.

6. Final comments

Since regional CGE models are often based on a recursive dynamic structure and the lack of forward-looking expectation has been stressed as an important drawback of such models (Partridge and Rickman, 1998; 2008) the focus of this paper is to produce a simple stylized forward-looking model applicable in a regional context, given that a mechanical and slavish application of the usual mechanism and closures applied in intertemporal CGE model would misrepresent the adjustment mechanisms that might occur in a region. Of course, we do not have the presumption to say that we have given an answer, but at least we have posed a problem.

Our main conclusion is that intertemporal consumer optimization, based on neoclassical or Fisherian analysis of intertemporal resource allocation, seems to be inappropriate from a regional point of view. Consumer intertemporal maximization process yields, not only the time path of consumption, but also the time path of savings which became a function of total financial assets. Thus, not only the instability between current income and current consumption related to the permanent income hypothesis approach are under discussion, but more emphasis is put on the dynamic path of savings where households are liable for all the financial needs of the region. In turn, this implies an imposed balance of payments adjustment mechanism. Furthermore, we argue the plausibility, from a regional point of view, of the imposition of an intertemporal budget constraint where internal and external debts are made repayable from the private sector. No internal and external debt sustainability problems occur in a region. Deficit in the current account cannot be seen as hypothetical surplus in later periods making external debt repayable because there is no requirement to do so, and foreign debt, especially for declining regions, is the result of capital subvention supplied by supra-regional institutions, such as a national Government or the European Union. Regional public deficit is not a problem at all. It would, therefore, be a mistake to allow consumers to take the public deficit into account in their intertemporal optimization problem, as no taxes will be imposed to cover it and no change in consumption plans is required. As we have said above, regional policy is an exogenous variable for regions so no Ricardian equivalence of fiscal deficit would be considered.

We have also argued that some of the objections, such as the presumed lack of capital adjustment in the myopic model and differences in long run steady state results, cannot be correct. In some articles, forward-looking models are compared with myopic specifications that preclude any adjustment in investment and consumption. The usual assumptions are passive investment (or investment held constant to the base year in real terms) and consumption simply obtained as a fixed share of current income. In this paper, both models are quite close to each other and the intertemporal and the myopic model generate the same results in the long-run. The only difference is in the transitional pathway where consumption and investment might diverge: perfect foresight agents have rational expectations whilst myopic foresight agents take decisions according to adaptive expectations and so make no intertemporal preferences between periods on future profits and incomes. Furthermore, from the sensitivity analysis we show that the transitional path may be affected by the two adjustment parameters present in the myopic (v) and forward-looking models (σ). In the myopic model we have just a cost adjustment equation in investment while in the forward looking model we have two cost adjustment equations, one in investment and the other in consumption. The latter can be interpreted in fact as a flexible accelerator mechanism (like for investment) where the parameter that govern the intertemporal preferences, $1/\sigma$ can also be seen as an adjustment parameter. This is the main structural difference between the myopic and forward looking models presented in this paper.

Tables and Figures

Table 1 - Forward-Looking models. The short-run and long-run impact of 10% increase in interregional export under three different labour market closures and three types of financial sector adjustment. Percentage change with respect to the initial staedy state.

	FL1				FL2			
	Short-Run			Long-Run	Short-Run			Long-Run
	RB	NB	FRW	RB=NB=FRW	RB	NB	FRW	RB=NB=FRW
GRP Factor Cost	0.039	0.247	0.049	1.859	0.044	0.273	0.055	2.060
Consumer Price Index	1.114	0.918	1.107	0.000	1.231	1.014	1.223	0.000
Unemployment Rate	-1.337	-8.431	-1.671	0.000	-1.496	-9.335	-1.871	0.000
Total Employment	0.149	0.937	0.186	1.956	0.166	1.037	0.208	2.155
Nominal Wage	1.159	0.000	1.107	0.000	1.282	0.000	1.223	0.000
Real Wage	0.045	-0.910	0.000	0.000	0.050	-1.004	0.000	0.000
Replacemnet cost of capital	1.073	0.861	1.065	0.000	1.193	0.959	1.184	0.000
Government Deficit	-0.004	-0.414	-0.025	-1.452	0.044	-0.409	0.021	-1.575
Labour Supply	0.000	0.000	0.000	1.956	0.000	0.000	0.000	2.155
Households Cons	-0.184	0.105	-0.174	1.480	0.006	0.326	0.017	1.849
Households Saving	1.302	1.389	1.309	1.407	-2.033	-2.215	-2.160	0.806
Financial Wealth	3.496	5.195	3.714	3.985	5.299	4.870	5.301	8.342
Non Financial Wealth	1.164	1.220	1.174	1.333	1.283	1.344	1.294	1.469
Total Wealth	1.292	1.439	1.314	1.480	1.505	1.539	1.516	1.849
Gov. Expenditure	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Current Account ROI+ROW	0.140	0.937	0.215	-3.143	0.893	1.772	0.975	-2.629
Current Account ROI	-10.746	-9.771	-10.639	-17.873	-9.567	-8.494	-9.451	-17.120
Current Account ROW	7.302	7.982	7.356	6.550	7.776	8.526	7.835	6.905
Investment	1.077	3.087	1.212	2.026	1.157	3.373	1.305	2.224
Value added								
Primary	0.963	1.797	1.002	4.980	0.916	1.837	0.959	5.130
Manufacturing	0.327	1.034	0.363	3.184	0.317	1.098	0.357	3.371
Services	0.002	0.454	0.023	1.473	0.021	0.520	0.045	1.678
Interregional exports								
Primary	6.279	6.934	6.306	10.000	6.147	6.869	6.177	10.000
Manufacturing	6.112	6.340	6.110	10.000	5.881	6.134	5.879	10.000
Services	7.520	8.140	7.544	10.000	7.186	7.870	7.214	10.000
International exports								
Primary	-3.382	-2.788	-3.358	0.000	-3.503	-2.846	-3.475	0.000
Manufacturing	-3.534	-3.327	-3.536	0.000	-3.745	-3.515	-3.746	0.000
Services	-2.255	-1.691	-2.233	0.000	-2.558	-1.937	-2.533	0.000
Investment demand								
Primary	2.772	5.792	2.997	3.184	2.711	6.034	2.958	3.371
Manufacturing	1.117	3.147	1.253	2.052	1.193	3.432	1.344	2.250
Services	0.841	2.729	0.965	1.872	0.938	3.022	1.076	2.072
Shadow price of capital								
Primary	2.331	2.790	2.372	0.000	2.400	2.906	2.446	0.000
Manufacturing	1.611	1.981	1.647	0.000	1.720	2.126	1.759	0.000
Services	1.111	1.199	1.122	0.000	1.258	1.355	1.270	0.000
Value added price								
Primary	2.071	1.698	2.055	0.000	2.149	1.736	2.131	0.000
Manufacturing	1.652	1.561	1.654	0.000	1.760	1.659	1.762	0.000
Services	1.163	0.868	1.151	0.000	1.322	0.996	1.309	0.000

Table 2 - Myopic models. The short-run and long-run impact of 10% increase in interregional export under three different labour market closures and three types of financial sector adjustment. Percentage change with respect to the initial steady.

	MYP 1				MYP2			
	Short-Run			Long-Run	Short-Run			Long-Run
	RB	NB	FRW	RB=NB=FRW	RB	NB	FRW	RB=NB=FRW
GRP Factor Cost	0.049	0.308	0.061	1.859	0.044	0.267	0.055	2.060
Consumer Price Index	1.338	1.137	1.328	0.000	1.226	0.987	1.216	0.000
Unemployment Rate	-1.666	-10.522	-2.084	0.000	-1.514	-9.117	-1.891	0.000
Total Employment	0.185	1.169	0.232	1.956	0.168	1.013	0.210	2.155
Nominal Gross Wage	1.394	0.000	1.328	0.000	1.278	Eps	1.216	0.000
Real Gross Wage	0.056	-1.124	0.000	0.000	0.051	-0.977	0.000	0.000
Capital Good Price	1.307	1.088	1.296	0.000	1.193	0.937	1.182	0.000
Government Deficit	0.115	-0.366	0.092	-1.452	0.068	-0.377	0.046	-1.575
Labour Supply	0.000	0.000	0.000	1.956	0.000	0.000	0.000	2.155
Households Cons	0.272	0.731	0.293	1.480	0.087	0.379	0.105	1.849
Households Saving	1.587	1.749	1.595	1.407	-1.107	-0.257	-1.078	0.806
Financial Wealth	3.838	5.562	4.015	3.985	3.433	3.141	3.424	8.342
Non Financial Wealth	1.225	1.246	1.227	1.333	1.191	1.266	1.199	1.469
Total Wealth	1.369	1.485	1.381	1.480	1.315	1.370	1.322	1.849
Gov. Expenditure	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Eps
Current Account ROI+ROW	1.370	2.546	1.425	-3.143	0.661	1.268	0.701	-2.629
Current Account ROI	-8.842	-7.349	-8.772	-17.873	-9.951	-9.301	-9.903	-17.120
Current Account ROW	8.089	9.057	8.135	6.550	7.643	8.223	7.678	6.905
Investment	0.816	3.180	0.928	2.026	0.756	2.775	0.857	2.224
Value added								
Primary	0.867	1.881	0.915	4.980	0.912	1.819	0.956	5.130
Manufacturing	0.281	1.144	0.322	3.184	0.292	1.047	0.329	3.371
Services	0.047	0.616	0.074	1.473	0.029	0.512	0.053	1.678
Interregional Exports								
Primary	6.031	6.797	6.068	10.000	6.158	6.897	6.193	10.000
Manufacturing	5.751	5.984	5.762	10.000	5.968	6.297	5.982	10.000
Services	6.847	7.479	6.877	10.000	7.164	7.901	7.196	10.000
International Export								
Primary	-3.608	-2.911	-3.575	0.000	-3.493	-2.821	-3.461	0.000
Manufacturing	-3.863	-3.651	-3.853	0.000	-3.665	-3.366	-3.653	0.000
Services	-2.866	-2.292	-2.839	0.000	-2.578	-1.908	-2.549	0.000
Investment demand								
Primary	1.553	4.798	1.707	3.184	1.605	4.454	1.745	3.371
Manufacturing	0.835	3.216	0.948	2.052	0.778	2.813	0.879	2.250
Services	0.703	2.964	0.810	1.872	0.629	2.550	0.725	2.072
Rate of return to capital								
Primary	5.203	8.307	5.349	0.000	5.284	8.028	5.418	0.000
Manufacturing	2.777	5.659	2.912	0.000	2.710	5.171	2.832	0.000
Services	1.645	3.275	1.722	0.000	1.430	2.717	1.496	0.000
Value added price								
Primary	2.216	1.778	2.195	0.000	2.142	1.720	2.122	0.000
Manufacturing	1.819	1.729	1.814	0.000	1.718	1.581	1.712	0.000
Services	1.485	1.182	1.471	0.000	1.333	0.981	1.318	0.000

Figure 2
Gross Regional Product, Model FL1

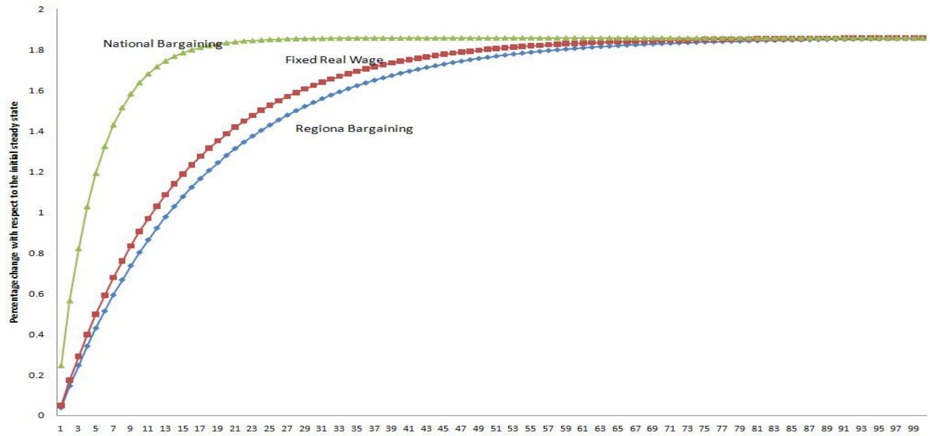


Figure 3
Consumer Price Index, Model FL1

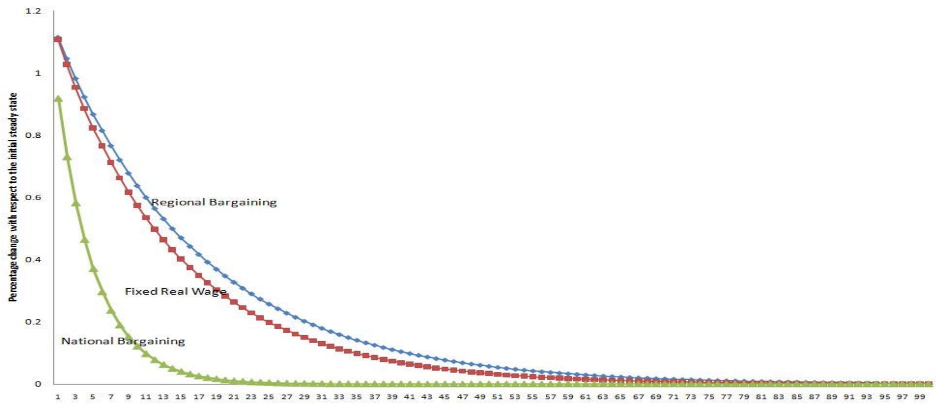


Figure 4
Gross Regional Product: a comparison between FL1 and MYP1

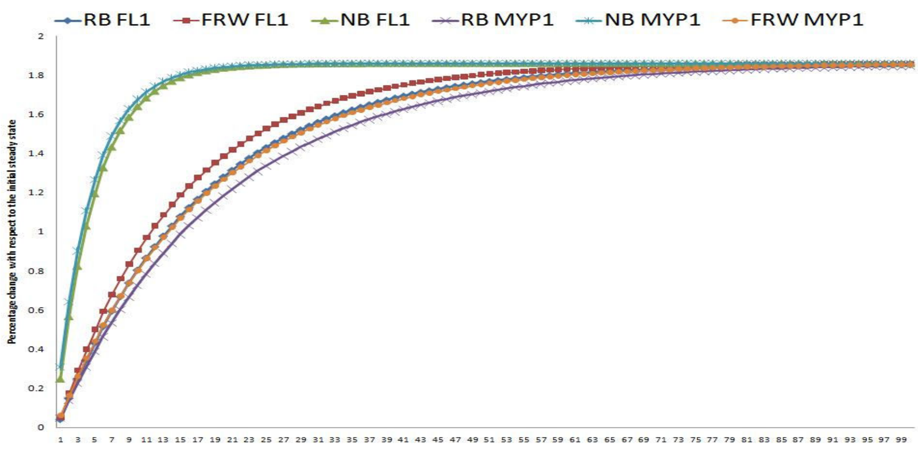
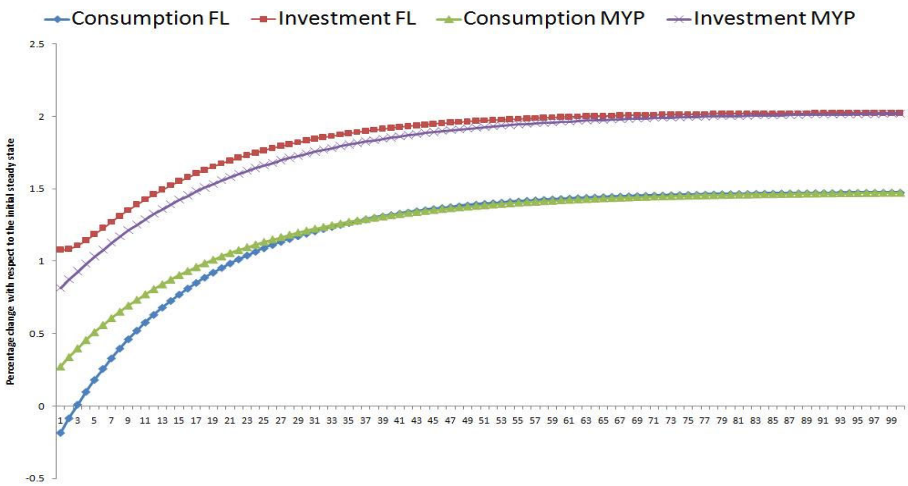
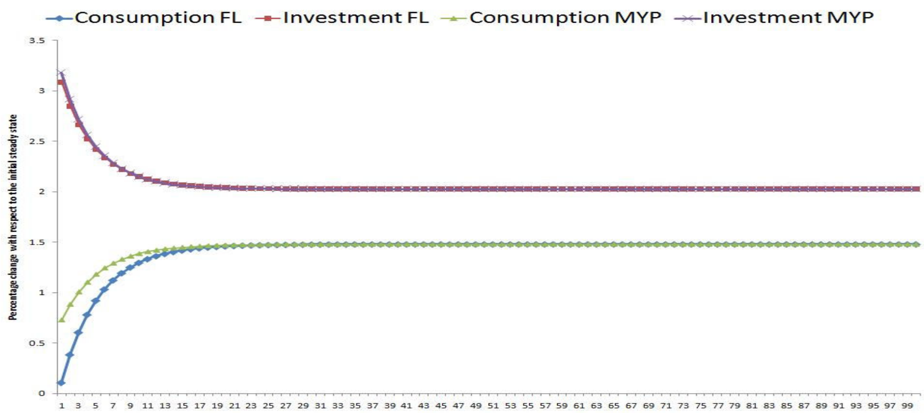


Figure 5
Consumption and Investment

a) Consumption and Investment Regional bargaining model FL1 and MYP1



b) Consumption and Investment National bargaining model FL1 and MYP1



c) Consumption and Investment Fixed real wage model FL1 and MYP

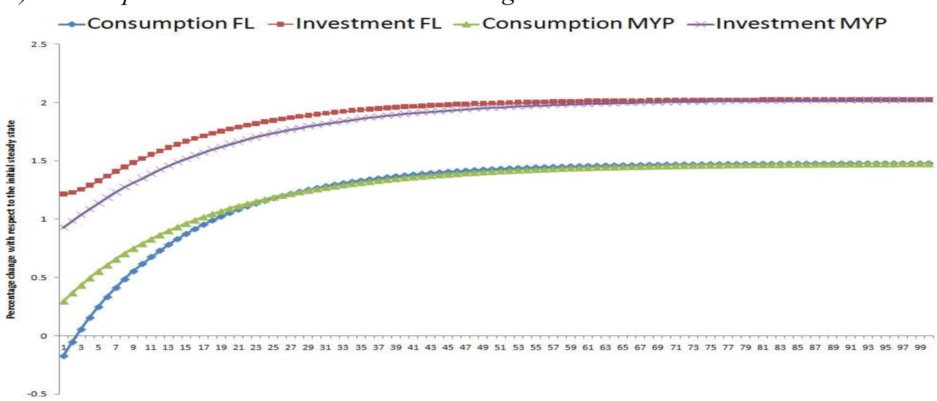
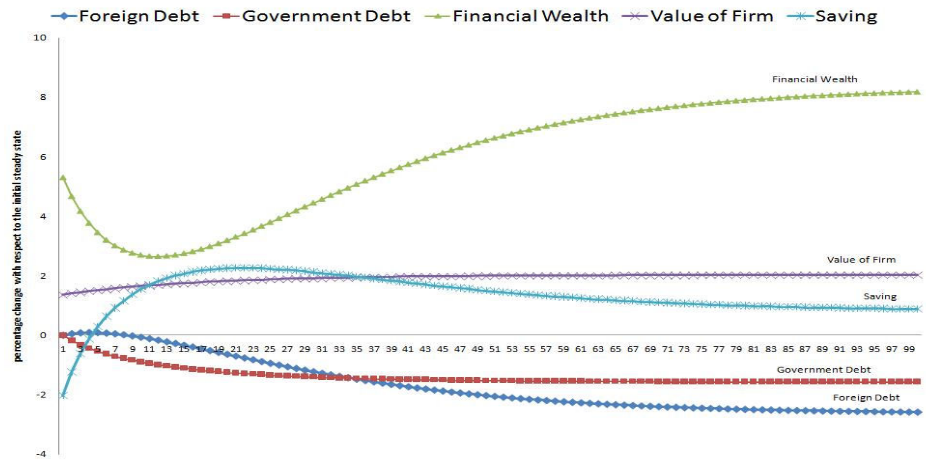


Figure 6
Financial wealth and household savings

a) Model FL2



b) Model MYP2

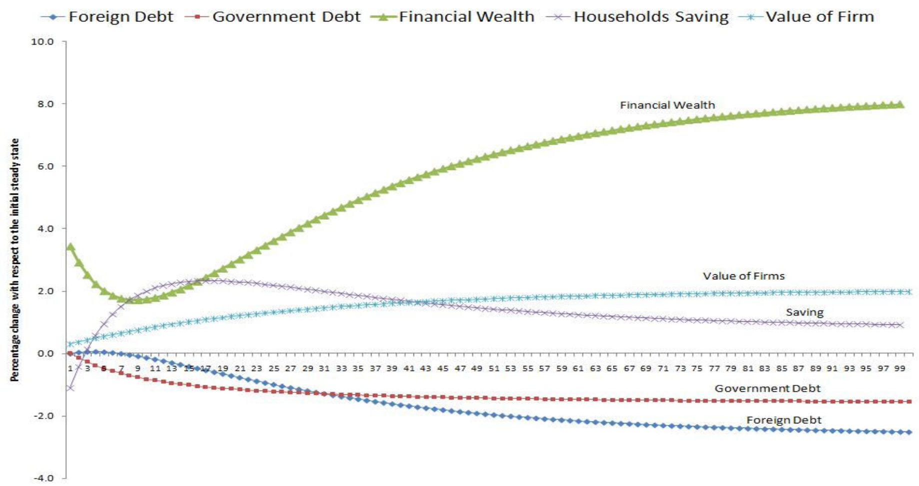


Figure 7
Accumulation rate for different value of the speed of adjustment

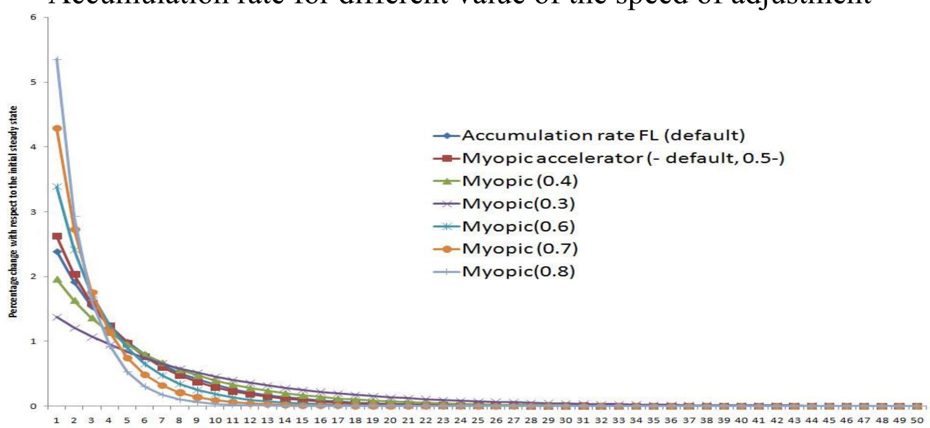
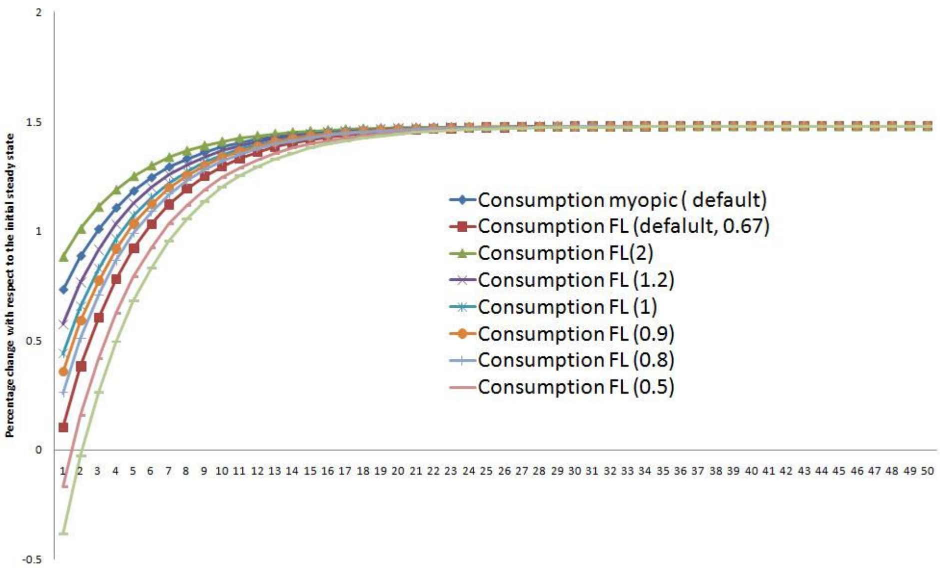


Figure 8
Consumption for different value of σ



APPENDIX

The mathematical presentation of the model

Prices

$$PM_{i,t} = \varepsilon_t \cdot PWM_i \cdot (1 + MTAX_i) \quad \textbf{(A.1)}$$

$$PE_{i,t} = \varepsilon_t \cdot PWE_i \cdot (1 - TE_i) \quad \textbf{(A.2)}$$

$$PX_{i,t} = \frac{PR_{i,t} \cdot R_{i,t} + PE_{i,t} \cdot E_{i,t}}{R_{i,t} + E_{i,t}} \quad \textbf{(A.3)}$$

$$PQ_{i,t} = \frac{PR_{i,t} \cdot R_{i,t} + PM_{i,t} \cdot M_{i,t}}{R_{i,t} + M_{i,t}} \quad \textbf{(A.4)}$$

$$PIR_{j,t} = \frac{\sum_i VR_{i,j,t} \cdot PR_{j,t} + \sum_i VI_{i,j,t} \cdot \overline{PI}_j}{\sum_i VIR_{i,j,t}} \quad \textbf{(A.5)}$$

$$PY_{j,t} \cdot a_j^Y = \left(PX_{j,t} \cdot \left(1 - btax_j - sub_j - dep_j\right) - \sum_i a_{i,j}^V PQ_{j,t} \right) \quad \textbf{(A.6)}$$

$$UCK_t = Pk_t \cdot (ir + \delta) \quad \textbf{(A.7)}$$

$$PC_t^{1-\sigma^c} = \sum_j \sum_h \delta_{j,h}^f \cdot PQ_{j,t}^{1-\sigma^c} \quad \textbf{(A.8)}$$

$$Pgov_t^{1-\sigma^g} = \sum_j \delta_j^g \cdot PQ_{j,t}^{1-\sigma^g} \quad \textbf{(A.9)}$$

$$w_t^b = \frac{w_t}{(1 + sscee + sscer) \cdot (1 + ire)} \quad \textbf{(A.10)}$$

$$\text{Wage setting} \begin{cases} ln\left[\dfrac{w_t}{cpi_t}\right] = \beta - \varepsilon \ln(u_t) & \text{(Regional Bargaining)} \\ \dfrac{w_t}{cpi_t} = \dfrac{w_{t=0}}{cpi_{t=0}} & \text{(Fixed Real Wage)} \\ w_t = w_{t=0} & \text{(National Bargaining)} \end{cases} \quad \textbf{(A.11)}$$

$$rk_{j,t} = PY_{j,t} \cdot \delta_j^k \cdot A\left(\xi_{j,t}\right)^{\varrho_j} \cdot \left(\frac{Y_{j,t}}{K_{j,t}}\right)^{1-\varrho_j} \quad \textbf{(A.12)}$$

$$Pk_t = \frac{\sum_j PQ_{j,t} \cdot \sum_i KM_{i,j}}{\sum_i \sum_j KM_{i,j}} \quad \textbf{(A.13)}$$

Production technology

$$X_{i,t} = min\left(\frac{Y_{i,t}}{a_i^Y}; \frac{V_{i,j,t}}{a_{i,j}^V}\right) \quad \textbf{(A.14)}$$

$$Y_{i,t} = a_i^Y \cdot X_{i,t} \quad \textbf{(A.15)}$$

$$V_{i,t} = a_{i,j}^V \cdot X_{i,t} \quad \textbf{(A.16)}$$

$$Y_{i,t} = A(\xi_{i,t}) \cdot [\delta_i^k \cdot K_{i,t}^{\rho_i} + \delta_i^l \cdot L_{i,t}^{\rho_i}]^{\frac{1}{\varrho_i}} \quad \textbf{(A.17)}$$

$$L_{j,t} = \left(A(\xi_{j,t})^{\rho_i} \cdot \delta_j^l \cdot \frac{PY_{j,t}}{w_t}\right)^{\frac{1}{1-\rho_j}} \cdot Y_{j,t} \quad \textbf{(A.18)}$$

Trade

$$VV_{i,j,t} = \gamma_{i,j}^{vv} \cdot \left[\delta_{i,j}^{vm} VM_{i,t}^{\rho_i^A} + \delta_{i,j}^{vir} VIR_{i,t}^{\rho_i^A}\right]^{\frac{1}{\rho_i^A}} \quad \textbf{(A.19)}$$

$$\frac{VM_{i,j,t}}{VIR_{i,j,t}} = \left[\left(\frac{\delta_{i,j}^{vm}}{\delta_{i,j}^{vir}}\right) \cdot \left(\frac{PIR_{i,t}}{PM_{i,t}}\right)\right]^{\frac{1}{1-\rho_i^A}} \quad \textbf{(A.20)}$$

$$VIR_{i,j,t} = \gamma_{i,j}^{vir} \cdot \left[\delta_{i,j}^{vi} VI_{i,t}^{\rho_i^A} + \delta_{i,j}^{vr} VR_{i,t}^{\rho_i^A}\right]^{\frac{1}{\rho_i^A}} \quad \textbf{(A.21)}$$

$$\frac{VR_{i,j,t}}{VI_{i,j,t}} = \left[\left(\frac{\delta_{i,j}^{vr}}{\delta_{i,j}^{vi}}\right) \cdot \left(\frac{PI_{i,t}}{PR_{i,t}}\right)\right]^{\frac{1}{1-\rho_i^A}} \quad \textbf{(A.22)}$$

$$E_{i,t} = \bar{E}_i \cdot \left(\frac{PE_{i,t}}{PR_{i,t}}\right)^{\sigma_i^x} \quad \textbf{(A.23)}$$

Regional Demand

$$R_{i,t} = \sum_j VR_{i,j,t} + \sum_h QHR_{i,h,t} + QVR_{i,t} + QGR_{i,t} + QHK_{i,t} \quad \textbf{(A.24)}$$

Total Production

$$X_{i,t} = R_{i,t} + E_{i,t} \quad \textbf{(A.25)}$$

Households and other Domestic Institutions

$$\sum_{t=0}^{\infty}(1+\rho)^{-t}\frac{C_t^{1-\sigma}-1}{1-\sigma} \tag{A.26}$$

$$\frac{C_t}{C_{t+1}}=\left[\frac{PC_t\cdot(1+\rho)}{PC_{t+1}\cdot(1+r)}\right]^{-\left(\frac{1}{\sigma}\right)} \tag{A.27}$$

$$W_t=NFW_t+FW_t \tag{A.28}$$

$$\begin{aligned}NFW_t(1+r_t)=NFW_{t+1}&+\sum_h dtr_h\cdot(ssce+ire)\cdot\sum_j L_{j,t}\cdot w_t\\&+\sum_h\sum_{dnginsp}TRSF_{h,dnginsp,t}+\sum_h TRG_h\cdot PC_t+\sum_h REM_h\\&\cdot\varepsilon_t-\sum_{dnginsp}\sum_h TRSF_{dnginsp,h,t}\end{aligned} \tag{A.29}$$

$$FW_t(1+r_t)=FW_{t+1}+d_{dngins}^{K}\cdot rk_{i,t}\cdot\sum_i K_i-\sum_h SAV_h \tag{A.30}$$

$$\begin{aligned}YNG_{dngins,t}=d_{dngins}^{L}\cdot w_t\cdot\sum_i L_i+d_{dngins}^{K}\cdot rk_{i,t}\cdot\sum_i K_i+d_{dngins}^{h}\cdot rh_{i,t}\sum_i H_i\\+\sum_{dnginsp}TRSF_{dngins,dnginsp,t}+PC_t\cdot TRG_{dngins}+\varepsilon_t\cdot REM_{dngins}\end{aligned} \tag{A.31}$$

$$TRSF_{dngins,dnginsp,t}=PC_t\cdot\overline{TRSF}_{dngins,dnginsp} \tag{A.32}$$

$$SAV_{dngins,t}=mps_{dngins}\cdot YNG_{dngins,t} \tag{A.33}$$

$$QH_{i,h,t}=\delta_{i,h}^{f\ \rho_i^c}\cdot\left(\frac{PC_{i,t}}{PQ_{i,t}}\right)^{\rho_i^c}\cdot C_t \tag{A.34}$$

$$QH_{i,h,t}=\gamma_{i,h}^{f}\cdot\left[\delta_{i,h}^{hr}\cdot QHR_{i,h,t}^{\rho_i^A}+\delta_{i,h}^{hm}\cdot QHM_{i,h,t}^{\rho_i^A}\right]^{\frac{1}{\rho_i^A}} \tag{A.35}$$

$$\frac{QHR_{i,h,t}}{QHM_{i,h,t}}=\left[\left(\frac{\delta_{i,h}^{hr}}{\delta_{i,h}^{hm}}\right)\cdot\left(\frac{PM_{i,t}}{PR_{i,t}}\right)\right]^{\frac{1}{1-\rho_i^A}} \tag{A.36}$$

Government

$$FD_t = \sum_i QG_{i,t} \cdot PQ_{i,t} + \overline{GSAV} + \sum_{dngins} TRG_{dngins,t} \cdot PC_t - \left(d_g^k \cdot \sum_i rk_{i,t} \cdot K_{i,t} + d_g^h \cdot \sum_i rh_{i,t} \cdot H_{i,t} + \sum_i IMT_{i,t} + \sum_h dtr_h \cdot (ssce + ire) \cdot \sum_j L_{j,t} \cdot w_t \ + \overline{FE} \cdot \varepsilon_t \right) \tag{A.37}$$

$$QG_{i,t} = \gamma_i^g \cdot \left[\delta_i^{gr} \cdot QGR_{i,t}^{\rho_i^A} + \delta_i^{gm} \cdot QGM_{i,t}^{\rho_i^A} \right]^{\frac{1}{\rho_i^A}} \tag{A.38}$$

$$\frac{QGR_{i,t}}{QGM_{i,t}} = \left[\left(\frac{\delta_i^{gr}}{\delta_i^{gm}} \right) \cdot \left(\frac{PM_{i,t}}{PR_{i,t}} \right) \right]^{\frac{1}{1-\rho_i^A}} \tag{A.39}$$

Investment Demand

$$QV_{i,t} = \sum_j KM_{i,j} \cdot J_{j,t} \tag{A.40}$$

$$QV_{i,t} = \gamma_i^v \cdot \left[\delta_i^{qvm} \cdot QVM_{i,t}^{\rho_i^A} + \delta_i^{qvir} \cdot QVIR_{i,t}^{\rho_i^A} \right]^{\frac{1}{\rho_i^A}} \tag{A.41}$$

$$\frac{QVM_{i,t}}{QVIR_{i,t}} = \left[\left(\frac{\delta_i^{qvm}}{\delta_i^{qvir}} \right) \cdot \left(\frac{PIR_{i,t}}{PM_{i,t}} \right) \right]^{\frac{1}{1-\rho_i^A}} \tag{A.42}$$

$$QVIR_{i,t} = \gamma_i^{vir} \cdot \left[\delta_i^{qvi} \cdot QVI_{i,t}^{\rho_i^A} + \delta_i^{qvr} \cdot QVR_{i,t}^{\rho_i^A} \right]^{\frac{1}{\rho_i^A}} \tag{A.43}$$

$$\frac{QVR_{i,t}}{QVI_{i,t}} = \left[\left(\frac{\delta_i^{qvr}}{\delta_i^{qvi}} \right) \cdot \left(\frac{PI_{i,t}}{PR_{i,t}} \right) \right]^{\frac{1}{1-\rho_i^A}} \tag{A.44}$$

Time path of investment

$$J_{i,t} = I_{i,t} \left(1 - bb - tk + \frac{\beta}{2} \frac{\left(\frac{I_{i,t}}{K_{i,t}} - \alpha \right)^2}{\frac{I_{i,t}}{K_{i,t}}} \right) \tag{A.45}$$

$$\frac{I_t}{K_t} = \alpha + \frac{1}{\beta} \cdot \left[\frac{\lambda_{i,t}}{Pk_t} - (1 - bb - tk) \right] \tag{A.46}$$

$$\dot{\lambda}_{i,t} = \lambda_{i,t}(r_t + \delta) - R_{i,t}^k \tag{A.47}$$

$$\theta(x_t) = \frac{\beta}{2}\frac{(x_t - \alpha)^2}{x_t}; \text{ and } x_t = \frac{I_t}{K_t} \quad \textbf{(A.48)}$$

$$R^k_{i,t} = rk_t - Pk_t \left[\frac{I_{i,t}}{K_{i,t}}\right]^2 \theta'_t(I/K) \quad \textbf{(A.49)}$$

Factors accumulation

$$KS_{i,t+1} = (1-\delta)\cdot KS_{i,t} + I_{i,t} \quad \textbf{(A.50)}$$

$$LS_{i,t+1} = \left(1 + \left(\varsigma - \nu^u[ln(u_t) - ln\,(\bar{u}^N)] + \nu^w\left[ln\left(\frac{w_t}{cpi_t}\right) - ln\left(\frac{w^N}{cpi^N}\right)\right]\right)\right)\cdot LS_{i,t} \quad \textbf{(A.51)}$$

$$K_{i,t} = KS_{i,t} \quad \textbf{(A.52)}$$

$$LS_t \cdot (1-u_t) = \sum_j L_{j,t} \quad \textbf{(A.53)}$$

Indirect taxes and subsidies

$$IBT_{i,t} = btax_i \cdot X_{i,t} \cdot PX_{i,t} \quad \textbf{(A.54)}$$

$$IMT_{j,t} = \sum_i MTAX_j \cdot VM_{i,j,t} \cdot PM_{i,t} \quad \textbf{(A.55)}$$

$$SUBSY_{i,t} = SUB_i \cdot X_{i,t} \cdot PX_{i,t} \quad \textbf{(A.56)}$$

Total demand for import and current account

$$M_{i,t} = \sum_j VI_{i,j,t} + \sum_j VM_{i,j,t} + \sum_h QHM_{i,h,t} + QGM_{i,t} + QVI_{i,t} + QVM_{i,t} \quad \textbf{(A.57)}$$

$$TB_t = \sum_i M_{i,t}\cdot PM_{i,t} - \sum_i E_{i,t}\cdot PE_{i,t} + \varepsilon_t \cdot \left(\sum_{dngins} \overline{REM}_{dngins} + \overline{FE}\right) \quad \textbf{(A.58)}$$

Assets

$$VF_{i,t} = \lambda_{i,t}\cdot K_{i,t} \quad \textbf{(A.59)}$$

$$D_{t+1} = (1 + r - \tau)\cdot D_t + TB_t \quad \textbf{(A.60)}$$

$$Pgov_{t+1}\cdot GD_{t+1} = \left[1 + r - \tau g + \left(\frac{Pc_{t+1}}{Pc_t} - 1\right)\right]\cdot GD_t \cdot Pgov_t + FD_t \quad \textbf{(A.61)}$$

Steady State conditions

$$KS_{i,T}\delta = I_{i,T} \tag{A.62}$$

$$R^k_{i,T} = \lambda_{i,T}(r_T + \delta) \tag{A.63}$$

$$FD_T = -\left[r - \tau g + \left(\frac{Pc_{t+1}}{Pc_t} - 1\right)\right] \cdot Pgov_T \cdot GD_T \tag{A.64}$$

$$TB_T = -(r - \tau) \cdot D_T \tag{A.65}$$

$$NFW_T \cdot r_T = \sum_h dtr_h \cdot (ssce + ire) \cdot \sum_j L_{j,T} \cdot w_T + \sum_h \sum_{dnginsp} TRSF_{h,dnginsp,T} + \sum_h TRG_h \cdot PC_T + \sum_h REM_h \cdot \varepsilon_T - \sum_{dnginsp} \sum_h TRSF_{dnginsp,h,T} \tag{A.66}$$

$$FW_t \cdot r_T = d^K_{dngins} \cdot rk_{i,t} \cdot \sum_i K_i - \sum_h SAV_{h,T} \tag{A.67}$$

In order to produce short-run results, we have that

$$KS_{i,t=1} = KS_{i,t=0} \tag{A.68}$$

$$LS_{=1} = LS_{t=0} \tag{A.69}$$

$$GD_{t=1} = GD_{t=0} \tag{A.70}$$

$$D_{t=1} = D_{t=0} \tag{A.71}$$

For FL2 equation (A.33) disappear if *dngins=h. We* also add:

$$FW_t = \sum_i VF_{i,t} + Pgov_{t+1} \cdot GD_t + D_t \tag{A.72}$$

$$FW_t(1 + r_t) = FW_{t+1} + \Pi_t - \left(\sum_i J_{i,t} + FD_t - TB_t\right) \tag{A.73}$$

In order to run the myopic model from the consumption side, equations (A.26) and (A.27) are substitute with the following:

$$C_t = \sum_{dngins \in \langle H \rangle} YNG_{dngins,t} - \sum_{dngins \in \langle HH \rangle} SAV_{dngins,t} - HTAX_t - \sum_{dngins} \sum_{h} TRSF_{dngins,h,t} \quad \textbf{(A.74)}$$

To obtain the path of investment equations (A.46 – A.49) disappear and we introduce:

$$I_{i,t} = v \cdot \left[KS_{i,t}^{*} - KS_{i,t}\right] + \delta \quad \cdot KS_{i,t} \quad \textbf{(A.75)}$$

$$KS_{i,j}^{*} = \left(A(\xi_{j,t})^{\rho_i} \cdot \delta_j^k \cdot \frac{PY_{j,t}}{uck_t}\right)^{\frac{1}{1-\rho_j}} \cdot Y_{j,t} \quad \textbf{(A.76)}$$

Alternatively we can use the following

$$\frac{I_{i,t}}{KS_{i,t}} = \delta \quad \cdot \left[\frac{rk_{i,t}}{uck_t}\right]^{v} \quad \textbf{(A.77)}$$

Where v equal 0.5 in (A.75) and 2 in (A.77)

Glossary

i,j	the set of goods or industries
ins	the set of institutions
dins ($\subset ins$)	the set of domestic institutions
dngins ($\subset dins$)	the set of non government institutions
h ($\subset dngins$)	the set of households

Prices

$PX_{i,t}$	output price
$PY_{i,t}$	value added price
$PR_{i,t}$	regional price
$PQ_{i,t}$	commodity price
$PIR_{i,t}$	national commodity price (regional + ROI)
$PI_{i,t}$	ROI price
$rk_{i,t}$	rate of return to capital
w_t	unified nominal wage

w_t^b	after tax wage
Pk_t	capital good price
UCK_t	user cost of capital
$\lambda_{i,t}$	shadow price of capital
PC_t	aggregate consumption price
$PGov_t$	aggregate price of Government consumption goods
ε_t	exchange rate [fixed]
Endogenous Variables	
$X_{i,t}$	total output
$R_{i,t}$	Regional supply
$M_{i,t}$	total import
$E_{i,t}$	total export (interregional + international)
$Y_{i,t}$	value added
$L_{i,t}$	labour demand
$K_{i,t}$	physical capital demand
$KS_{i,t}$	capital stock
$LS_{i,t}$	labour supply
$VV_{i,jt}$	Total intermediate inputs
$VR_{i,jt}$	regional intermediate inputs
$VM_{i,jt}$	ROW intermediate inputs
$VIR_{i,jt}$	national intermediate inputs (REG+ROI)
$VI_{i,jt}$	ROI intermediate inputs
$QGR_{i,t}$	regional government expenditure
$QGM_{i,t}$	government expenditure(ROI+ROW)
C_t	aggregated household consumption
$QH_{i,h,t}$	total households consumption in sector *i* for *h*
$QHR_{i,h,t}$	regional consumption in sector *i* for group *h*
$QHM_{i,h,t}$	import consumption in sector *i* for group *h*
$QV_{i,t}$	total investment by sector of origin i
$QVR_{i,t}$	regional investment by sector of origin i
$QVM_{i,t}$	ROW investment demand
$QVIR_{i,t}$	national investment (REG+ROI)
$QVI_{i,t}$	ROI investment demand

$I_{j,t}$	investment by sector of destination j
$J_{j,t}$	investment by destination j with adjustment cost
u_t	regional unemployment rate
$R_{i,t}^{k}$	marginal net revenue of capital
$SAV_{dngins,t}$	domestic non government saving
$YNG_{dngins,t}$	domestic non government income
$TRSF_{dngins,dnginsp,t}$	transfer among dngins
$HTAX_t$	total household tax
TB_t	current account balance
$SUBSY_t$	production subsidies

Exogenous variables

$\overline{REM}_t$	remittance for dngins
$\overline{FE}_t$	remittance for the Government
$QG_{i,t}$	government expenditure
$GSAV_t$	government saving
r_t	interest rate

Elasticities

σ	constant elasticity of marginal utility
ϱ_j	between labour and capital in sector j
ρ_i^{A}	in Armington function
σ_i^{x}	of export with respect to term of trade
μ	of real wage with respect to unemployment rate

Parameters

$a_{i,j}^{V}$	Input-output coefficients for i used in j
a_j^{Y}	share of value added on production
$\delta_j^{k,l}$	shares in value added function in sector j
$\delta_{i,j}^{vir,vm,vr,vi}$	shares parameters in CES function for intermediate goods
$\delta_{i,j}^{qvir,qvm,qvr,qvi}$	shares parameters in CES function for investment goods
$\delta_{i,h}^{hr,hm}$	shares parameters in CES function for households consumption
$\delta_i^{gr,gm}$	shares parameters in CES function for government consumption

$\gamma_{i,j}^{vv,vir}$	shift parameter in CES functions for intermediate goods
γ_i^f	shift parameter in CES function for households consumption goods
γ_i^g	shift parameter in CES function for government consumption
$btax_i$	business tax
sub_i	rate of production subsidy
$MTAX_i$	rate of import tax
$KM_{i,j}$	physical capital matrix
mps_{dngins}	rate of saving in institutions dngins
$ssce$	rate of social security paid by emploees
$sscer$	rate of social security paid by emploer
ire	rate of income tax
ρ	pure rate of consumer time preference
bb	rate of distortion or incentive to investment
δ	rate of depreciation

Complements

Interconnection between trade deficit and Government deficit.
In this section we consider the case of interconnection between the trade deficit and the Government deficit. We make the extreme hypothesis that the entire interregional and international trade deficit is the result of National and EU financial support respectively. This allows us to consider a simpler case than if a detailed regional balance of payments was available. Thus, interregional and international trade deficits provide resources for regional policy through financial assistance from the national Government and the EU (e.g. European Structural and Social Funds). We preserve a sectoral financial balance equilibrium so that the private sector is in full portfolio equilibrium. Essentially, we hypothesize that the only constraint on regional policy derives from the trade deficit. As we have mentioned elsewhere, such a constraint seems more appropriate for regions than those commonly applied in intertemporal models, where fiscal policy is endogenous because of the imposition of a borrowing constraint, e.g. the ratio of Government debt to GDP must be constant over time (see e.g. McKibbin and Wilcoxen, 1992; Dissou, 2002).

In this section, we analyze the likely impact of an increase in interregional competitiveness but change the adjustment mechanism for the balance of payments. Full portfolio balance for the private sector is imposed, and the Government deficit equals the trade deficit through adjustment in Government expenditure. Then the resources available for regional policy will depend on the current account balance. Here, we do not impose any constraints on borrowing: any demand for credit is satisfied by an endogenous supply, or any request for capital inflow can be easily supplied by the interregional and international capital market. This kind of adjustment is also applied to the myopic model. As can be seen, we do not need to introduce artificial differences into our myopic model, such as fixing investment or making it passive (that is, equal to savings which are determined in turn as a fixed share of income) since the myopic model allows for a different treatment of investment which is very close to a Tobin's q adjustment.

We again simulate a 10% increase in interregional exports but, at this time, two components of aggregate demand are involved: interregional exports and Government expenditure. The former increases by 10% over time and the latter is determined endogenously. If the trade deficit increases, resources for regional policy increase as well. Indeed, the increase in interregional competitiveness may not be sufficient to provide overall current account improvement, thus more capital inflow will be devoted to regional policy. The percentage change variation from the base values of some key variables are reported on Table 3 below.

In the short run, prices increase whilst in the long run we get Leontief results as prices return to their initial values. In fact, even though regional policy is now endogenous, supply side effects are still neglected in these simulations.

According to simulations seen in the preceding sections, in the long run the exogenous positive shift in interregional competitiveness outweighs the negative terms of trade effect occurring as a consequence of an increase in aggregate demand. In this simulation instead, change in the whole current account is positive (5.89%), implying a negative trade balance. The main concern here is that, whilst interregional competitiveness rises, a positive change in Government expenditure increases the level of economic activity. This, in turn, requires a high level of imports to meet firm's production needs due to the high propensity of regional economies such as Sardinia to import. So, even a potential improvement in the current account through a reduced interregional trade deficit (-4.78%) is totally offset by an increase in the international deficit (12.91%). Given, also, that capital inflow will always be available at regional level.

Immediately we notice that, with respect to the simulations above where Government expenditure is fixed, the level of GRP is more than double for every period and for all labour market closures. In the LR we get a GRP variation of 1.91% in FL1 and 2.06 % in FL2 whilst here the percentage change in GRP is above the base year by 6.64%. This is related to a positive shift in the Government balance equation implying an increase in Government consumption which creates more output and increases imports to sustain production. This weakens the trade deficit as regional price increases contribute to producing more resources for regional policy.

Increases in domestic prices immediately raise firms' profit expectations and so investment, tempered to some extent by a higher replacement cost of capital. Contrary to the previous simulations (FL1 and FL2) the impact on sectoral investment is somewhat different and we need to differentiate between labour market regimes. For regional bargaining and fixed real wage, of the three sectors, the Service sector receives a permanent benefit. This sector is also the only one where output and investment increase in the short run. With respect to the previous exercise, we need to consider the regional Government's high propensity to consume services which raises its domestic prices relatively more than the other sectors, encouraging firms' investment. For national bargaining, all three sectors experience a permanent increase in investment, whereas, in the short run, investment rises more in the service sector than in the primary and manufacturing sectors.

Price changes and the rate of intertemporal substitution will affect the dynamic path of real wealth and consumption. From the figures presented in Table 3, we see that consumption changes become positive in the long run, however in the initial period, consumption is below the benchmark equilibrium. Of course, period by period, as the increase in price is gradually dampened down by the increase in supply, consumption will rise from the initial fall moving to its long run steady state (4.93%).

There are no significant differences in the direction of the effect in the myopic and intertemporal models. The main differences are in the short run impact on sectoral output and investment and on trade. These are especially the results of the implication of the sectoral fixity capacity that has produced some differences in the short run response between the two models. With regard to the impact on output, we see that in the MYP the Primary sector experiences the greatest impact, thereby becoming the most profitable sector, since firms are investing more in Primary than Manufacturing and Services. It is here that we see a greater relative increase in the return to capital. In the FL model, the Service sector benefits more than the others from an increase in interregional competitiveness.

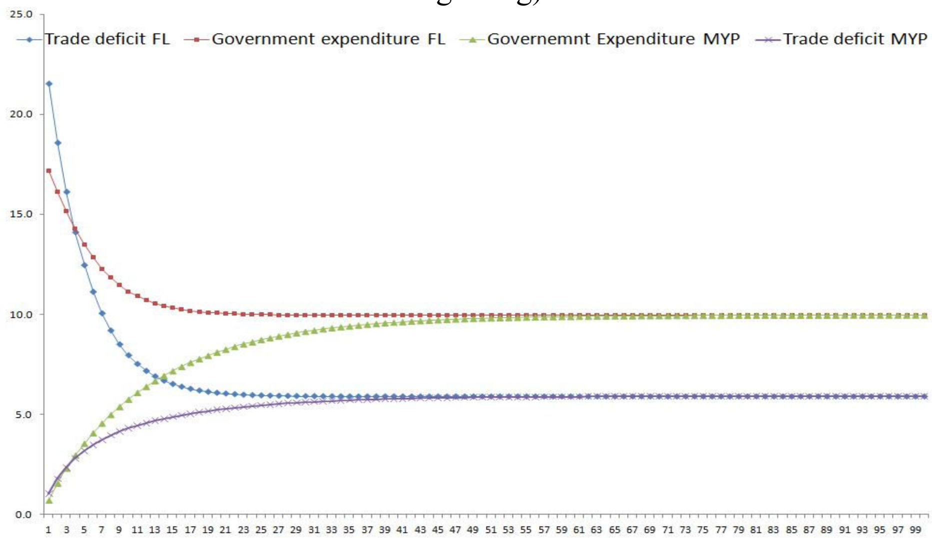
Table 3 - Forward-looking and myopic models. The short-run and long-run impact of 10% increase in interregional export. Interconnection between trade deficit and government deficit.

	Short-Run			Long-Run	Short-Run			Long-Run
	RB	NB	FRW	RB=NB=FRW	RB	NB	FRW	RB=NB=FRW
GRP Factor Cost	0.198	1.153	0.225	6.643	0.059	0.268	0.065	6.643
Consumer Price Index	4.018	4.133	4.080	0.000	1.410	0.989	1.397	0.000
Unemployment Rate	-3.001	-17.512	-3.412	0.000	-0.896	-4.069	-0.990	0.000
Total Employment	0.750	4.378	0.853	6.638	0.224	1.017	0.247	6.638
Nominal Wage	4.124	0.000	4.080	0.000	1.440	0.000	1.397	0.000
Real Wage	0.101	-3.969	0.000	0.000	0.030	-0.979	0.000	0.000
Capital Good Price	4.137	4.291	4.202	0.000	1.385	0.944	1.371	0.000
Foreign Debt	0.000	0.000	0.000	5.893	0.000	0.000	0.000	5.892
Government Debt	-4.501	-4.788	-4.574	5.893	-1.363	-0.863	-1.349	5.892
Labour Supply	0.000	0.000	0.000	6.638	0.000	0.000	0.000	6.638
Households Cons	-1.061	-1.223	-1.149	4.931	0.117	0.015	0.114	4.931
Households Saving	0.000	0.000	0.000	0.000	2.381	3.686	2.419	5.634
Financial Wealth	4.944	6.380	5.081	6.645	0.367	0.568	0.373	6.645
Non Financial Wealth	4.851	4.722	4.858	4.743	2.792	3.503	2.846	4.743
Total Wealth	4.861	4.886	4.880	4.931	2.552	3.213	2.601	4.931
Gov. Expenditure	10.477	17.172	10.918	9.938	0.557	0.699	0.561	9.938
Value of Firm	4.944	6.380	5.081	6.645	0.367	0.568	0.373	6.645
Current Account ROI+ROW	15.317	21.539	15.831	5.893	1.694	1.041	1.675	5.893
Current Account ROI	12.155	20.014	12.895	-4.781	-8.383	-9.702	-8.423	-4.781
Current Account ROW	17.398	22.542	17.762	12.916	8.326	8.110	8.319	12.916
Investment	3.545	10.387	3.916	6.621	0.917	2.777	0.972	6.621
Value Added								
Prymary	-0.535	2.395	-0.492	7.148	0.838	1.786	0.866	7.148
Manufacturing	-0.281	2.232	-0.221	6.164	0.270	1.014	0.292	6.164
Service	0.707	2.926	0.776	6.720	0.084	0.525	0.097	6.720
Interregional export								
Prymary	3.739	5.945	3.746	10.000	6.000	6.934	6.028	10.000
Manufacturing	2.068	2.691	1.988	10.000	5.694	6.400	5.715	10.000
Service	-1.001	-1.688	-1.175	10.000	6.609	7.849	6.646	10.000
International exports								
Prymary	-5.692	-3.687	-5.686	0.000	-3.637	-2.787	-3.611	0.000
Manufacturing	-7.211	-6.644	-7.284	0.000	-3.915	-3.273	-3.896	0.000
Service	-10.001	-10.626	-10.159	0.000	-3.082	-1.955	-3.049	0.000
Investment demand								
Prymary	-2.776	6.395	-2.422	7.148	3.829	7.078	4.152	7.148
Manufacturing	-1.725	6.158	-1.349	6.164	1.459	4.276	1.707	6.164
Service	5.560	11.929	5.932	6.720	0.551	2.029	0.470	6.720
Shadow Price of Capital								
Prymary	3.568	5.598	3.706	0.000	5.119	7.881	5.201	0.000
Manufacturing	3.791	5.521	3.932	0.000	2.767	5.008	2.833	0.000
Service	5.202	6.565	5.339	0.000	1.885	2.784	1.911	0.000
Value Added Price								
Prymary	3.611	2.298	3.609	0.000	2.237	1.699	2.221	0.000
Manufacturing	3.693	3.456	3.741	0.000	1.848	1.533	1.838	0.000
Service	5.541	5.934	5.637	0.000	1.601	1.006	1.583	0.000

Output increases more in this sector where firms are willing to invest more given that the real shadow price of capital experiences the greatest change. Furthermore, the huge increase in Government expenditure in FL has the effect of increasing output in the Service sector since almost 75% of total Government consumption is focused on this sector. In contrast, in the MYP model the increase in Government expenditure is not enough to generate the highest increase in Services; the Primary sector is the greatest beneficiary.

Figure 9

Government Expenditure and trade deficit for MYP and FL (National Bargaining)



When considering the impact on trade, the current account, and consequently the behaviour of Government expenditure, have a different transitional pathway as we show with the aid of Figure 9. This gives the time path of adjustment of Government expenditure and the trade deficit for FL and MYP where, for simplicity, only national bargaining is considered. We note that the trade deficit in FL increases immediately and then gradually decreases, maintaining a positive change in all periods. So Government expenditure immediately rises in the SR then gradually diminishes until it settles at its LR steady state (9.94%). In the MYP, the trade deficit gradually increases in each period and so does Government expenditure. In both models, FL and MYP, prices increase in the short run, so limiting the real increase in interregional exports and contributing to the substitution effect lowering international exports. But this increase in domestic prices has a limited effect on trade under MYP where the total trade deficit rise to 1.04%, and a significant effect under FL where the trade deficit rises steeply to 21.54%. Such differences are the result of different impacts on regional prices in the two models. This means that in this simulation, the model response to factor constraints is somewhat different, making the forward-looking model more sensitive to sectoral fixity capacity than the myopic model. This can be seen by comparing the increase in value added price for both models.

Government borrowing constraint.

As we have seen in FL2, since savings and investment are separately determined, the equilibrium condition is obtained through foreign savings. These enter into the household consumption decision allowing us to avoid fiscal policy given that are there no borrowing constraints (the same has been done in Devarajan and Go, 1994). However, it is also quite common in intertemporal CGE models to introduce fiscal closures that put some constraint on Government debt. The implication of such a constraint is based on the sustainability of the Government deficit: if the Government is running a budget deficit today, it must run an appropriate budget surplus in the future. To guarantee that the intertemporal budget constraint holds at every point in time one may assume, for example, that the Government levies taxes in each period that are equal to the value of interest payments on the outstanding debt (see e.g. McKibbin and Wilcoxen, 1994, 1998). In this case, it seems plausible to use a non-distortionary lump sum tax. One may also think about other financial closures, such as those requiring the ratio of Government debt to GDP to be constant over time (see e.g. McKibbin and Wilcoxen, 1994, 1998; Dissou, 2002). To ensure that the intertemporal budget constraint holds, we may endogenize fiscal policy through adjustment in Government consumption or lump sum taxes or transfers. Even in this case, the easiest way is to introduce a non-distortionary adjustment. For instance, an endogenous adjustment in the tax rate that significantly changes the real consumption wage by producing supply side effects might be unwelcome since it would complicate the interpretation of the main policy implemented.

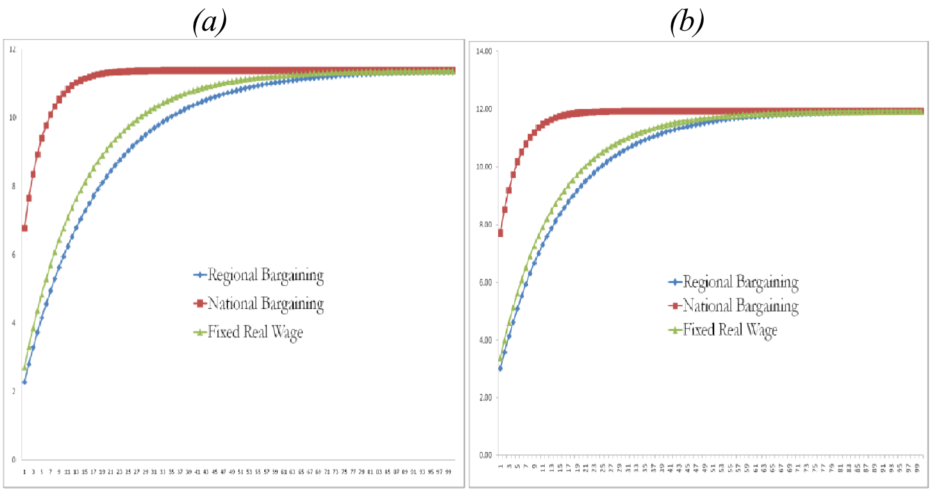
In this section we again simulate a 10% increase in interregional exports, but this time introducing some endogenous fiscal policy adjustment. We have already discussed the sustainability of fiscal deficit and the related regional inconsistency of the no-Ponzi games requirement. In the light of this, we may introduce an upper limit for outstanding Government debt, maintaining the ratio of debt to GDP constant, period by period, and endogenising either Government spending or transfers to household. The former would also represent an additional counterfactual to be compared with the previous one, where Government spending was endogenous to ensure compliance with the Government budget constraint.

As in both simulations we avoid supply side effects, a type of adjustment already explained in the other sections. What we would expect to be different is the ultimate impact that occurs as a result of a change in the free variables. When Government expenditure is endogenous a shift in the Government budget occurs producing more resources for regional policy and so increasing Government consumption, whilst a shift in the household budget arises since human wealth increases as a result of an increase in transfers to households. In both cases, the change in Government expenditure or transfers will be enough to accommodate the imposed constraint.

The charts below draw up the paths of Government expenditure and transfer. Both variables increase over time and, in the long run, they reach approximately the same proportionate change: 11.38% for Government expenditure and 11.93% for transfers. However their macroeconomic impact is different in magnitude. For passive Government expenditure, the change in real GRP in the long run is 7.10% whilst for passive transfers the real GRP, change is about 4.91%. Thus there is an asymmetric effect from endogenous fiscal expansion. A change in Government consumption has a multiplier effect upon equilibrium output greater than that of a lump sum transfer. This is happening because households have a higher propensity to import than the Government.

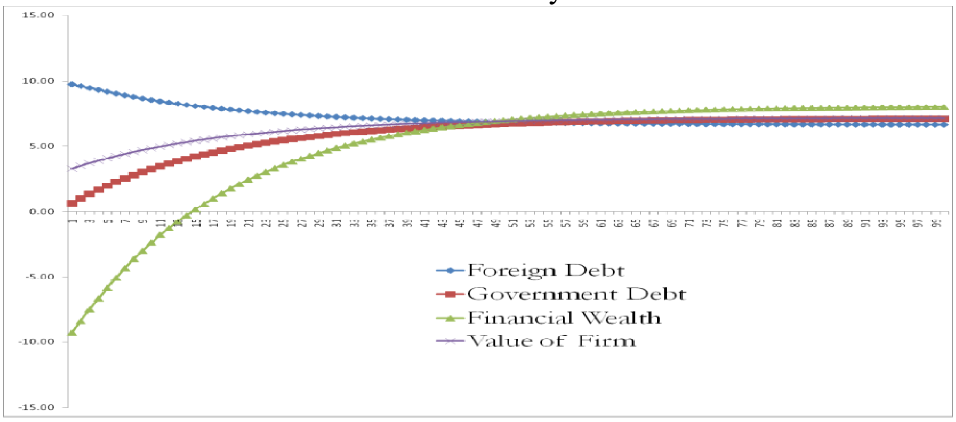
Figure 10

The impact of 10% increase in interregional export on government consumption (a) and transfers (b)



One thing which seems worthy of note is the behaviour of households' financial wealth. In both simulations, financial wealth decreases in the short run, then it gradually rises, assuming positive change, until it settles at its long run equilibrium. In the short run, although firm values are increasing, the rise in Government debt is not sufficient to compensate for the rise in external debt. Some point after the shock, the increase in competitiveness accompanied by an expansive fiscal policy yields to an opposite situation where the increase of the external debt is totally offset by the rise in value of firms and Government debt.

Figure 11
Path of the assets hold by household



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