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REGIONAL DEVELOPMENT PLANNING STRATEGY: DESIGNING A DYNAMIC INTEGRATED MODEL FRAMEWORK FOR THE SICILY REGION

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ABSTRACT

Over the past decades, Sicily Region has experienced periods of stagnation, recession and sporadic slow economic growth, lagging always behind the national performance. As a consequence of globalization and deregulation, the relevance of regions in national economies has changed considerably in the last decades. Recognizing the importance of the Sicily region in the development process at national level, the purpose of the research is to further explore the dynamics governing the behaviour of the regional economic system.

The goal is achieved by the use of simulation modelling: a model framework for the regional economic system is designed by integrating the System Dynamics (SD) methodology with the Input-Output (IO) approach. System dynamics allows pointing out the key factors of the regional economic system's behavioural pattern, and IO approach integration allows reaching the required level of disaggregation for the analysis to be supportive for the policy design process.

The framework is designed to support the regional government planning process, thus, in order to gain insights about the implementation of the framework, the planning process at regional level is analysed adopting a qualitative research approach.

The contribute of the research is providing a dynamic model framework that can support government action seeking development goal. Furthermore, Sicily region case study confirms previous experiences stating the feasibility and the usefulness of integrating the static IO approach and the dynamic SD modelling method.

Further improvements are required for better specifying the structural differences amongst industries in order to allow for deeper conclusions about the regional economic system behaviour, and also, an higher level of disaggregation of inter-industry interactions is needed in order to enhance the usability of the framework for policy design.

TABLE OFCONTENTS

LIST OF FIGURES AND TABLES

LIST OF ABBREVIATIONS AND ACRONYMS

ABM – Agent Based Modelling

BBN – Bayesian Belief Networks

BPS – Budget and-Programming Service

BTD – Budget and Treasury Division

CGE – Computable General Equilibrium

CLD – Causal Loop Diagram

DEF – Economic and Financial Document

DEFR – Regional Economic and Financial Document

DPM – Dynamic Performance Management

EU – European Union

EUROSTAT – Statistical Office of the European Communities

FORTRAN – Formula Translation Programming Language

FP – Functional Programming

FRB – Federal Reserve Board

GDP – Gross Domestic Product

GIS – Geographic Information Systems

GRP – Gross Regional Product

IO – Input-Output

ISTAT – Italian National Statistic Office

MCA – Multi-Criteria Analysis

MEF – Ministry of Economy and Finance

MM – Mediated Modelling

MMS – Multi-Sector Econometric Model for Sicily

NAMEA – National Accounting Matrix with Environmental Accounts

NPM – New Public Management

OECD – Office of Economic Cooperation and Development

RM – Reference Mode

SAM – Social Accounting Matrix

SD – System Dynamics

SDSS – Spatially Dynamic Systems Support Modelling

SEAS- Statistic and Economic Analysis Service

SFD – Stock and Flow Diagram

SIOT – Symmetric Input-Output table

SNA – System of Nation Accounts

SUT – Supply and Use Table

TFP – Total Factor Productivity

TS – Treasury Service

US – Unites States of America

VA – Value Added

ZGP – Zero Growth Population

1 THE CONTEXT OF THE RESEARCH

1.1 The research purpose

Over the past decades, Sicily – region in the extreme south of Italy – has experienced periods of stagnation, recession and sporadic slow economic growth, lagging always behind the national performance. In 2014, within the demographic segment that groups people between 15 and 24 years old, unemployment rate reached almost 60%[1]. Sicily Island is the widest region amongst the Italian regions, and the forth in terms of population, with more than 5 million inhabitants in 2015.

As a consequence of globalization and deregulation, in the last decades the relevance of regions for national economies has considerably changed. Recognizing the importance of the region in the development process at national level, purpose of the research is further exploring the dynamic of the development pattern in Sicily, and to better understand the relationship between causes and effects of development, in order to support actors responsible for managing regional economic development in the making of strategies, plans and policies.

The theoretical background for the research is the Endogenous Regional Development Theory, which focuses on the endogenous processes in regional economic development as potential explanatory factors for differences in the patterns of regional growth and decline[2]: objective of the analysis is to highlight internal, endogenous factors able to drive development.

The empirical analysis targeted a regional development model, able to show the nature and the role of endogenous factors in regional growth for Sicily. Final purpose is providing a useful tool to define development planning strategies and implementation plans.

In spite of the relevance of Sicily in terms of population and resources within the national scene, at the onset of the development of the research project, it was noticed the lack of similar work tailored to the Sicilian specific case, which could provide a starting point for the modelling process. For this reason, the purpose of the project is defined as

[1] Data source: Italian National Institute of Statistics – ISTAT.
[2] Stimson et al. (2011).

modelling a framework that can account for the performance of the local economy, where improvement proposals can be assessed with a strategic planning approach.

The methodology chosen to carry out the described analysis is System Dynamics (SD): it provides an effective set of conceptual tools to analyse the structure responsible for the dynamics of a complex system, such as a regional economic system.

SD methodology is able to highlight feedbacks responsible for the dynamic of the system, and thus it is expected to give insights on the causes for the actual state of the system, eventually, pointing out factors, both exogenous and endogenous, that are appropriate to regard in development policy making[3].

An attempt is tested to integrate System Dynamics with another methodological approach, specifically used in Regional Science: Input-Output (IO) approach.

Going further on the modelling plan details, the onset of the modelling process is based on the practical approach of the ‘three Ps’ of economic growth, Population, Participation and Productivity, working on a framework already defined for different case studies, both at national and regional level, to be tailored to the specific case of Sicily.

The interim result of this step is an highly aggregated level model, consisting of the demographic sub model, and the industry sub – model: it caters the building blocks that articulate macroeconomics principles within a handy simulation model.

As long as this first step prototype model can be considered valid, the research is pushed further: additional structure is added in order to provide a more disaggregate information about the economy across different economic sectors. In order to obtain a useful tool for policies simulation, an attempt is made to integrate IO approach into the model structure, so that business to business interactions are taken into account.

The last step of the explanatory modelling part is to investigate the way the two sub – models, Demographics and Economics, affect each other.

From the explanatory part of the analysis, the required information is gathered in order to define the purpose of the second part of the analysis: policy design and implementation.

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[3] Forrester J. W. (1992).

Information about the structure of the system, and, specifically, the endogenous factors of regional development, can point out the economic sector, or sectors, that are appropriate to further specify, for policy testing purpose.

In this respect, the public planning process at regional level is analysed, and the models actually implemented by the regional government are explored, to shed lights on the practical value of the framework when used as planning tool.

In summary, this document presents the results of a PhD thesis project, in which System Dynamics methodology is applied to provide a tool that can be used to evaluate regional economy structure and performance, and it is argued it is possible to integrate static IO modelling concepts into a the dynamic modelling framework designed with SD methodology, overcoming acknowledged limitations of a static approach (Input-Output) and reaching an higher level of specifications through disaggregation of the macroeconomic model designed via SD methodology.

1.2 Background context and Research definition

Sicily is the largest island in the Mediterranean Sea. It is one of the autonomous regions[4] in Italy and it is also the most populated island and the fifth most populated region in Italy, holding more than five million out of the sixty million Italian residents.

The natural and cultural resources, and the position into the Mediterranean Sea have contributed to establish Sicily Region as an holiday destination: tourism, together with retails and market service are the core-industries of the regional economy. Within the manufacturing sector, constructions represent almost half of the industry.

Those characteristic features of the regional economy make it particularly dependent on the demographic dynamics.

The economic crisis, that affected Italian economy specifically in the period 2008 – 2013, has strongly extended its consequences to the Sicily region where unemployment has reached peaks of almost 60 % within the demographic segment that groups people between 15 and 24 years old: demographic dynamics has been affected

[4]The Italian Constitution grants to five regions home rule, acknowledging their autonomy relating precise areas of legislation, administration, and finance. Those regions are Sardinia, Sicily, Trentino-Alto Adige/Sudtirol, Aosta Valley and Friuli-Venezia Giulia.

both on the side of net migration, with many young people moving out of the region to match the labour demand, and on the side of fertility rate, that drops as a consequence of the dropping net income level.

It is foreseeable that such a situation shows its effects in the long run, and that policymakers should make their best efforts to design effective policies that foster sustainable economic growth. Such a policy intervention may also take place through a shift in the economy's structure.

In order to design a developing strategy, it is essential to better know the actual shape of the economy, which is responsible for the dynamics it shows.

Within that main idea, the present research project has been developed in order to provide a useful tool to analyse the regional economy.

The Research Topic is then recognizable in Regional Economic Theory. The final Research Objective is an explanatory and policy System Dynamics model for Sicily Regional Economic System. The Research Questions (RQs) are schematised as follow:

1. What are the endogenous and exogenous factors that have determined the behaviour of Sicily Regional Economic System in the last 15 years?
2. Is it possible to point out one or more economic sectors able to foster an endogenous growth path for regional development?
3. Does the case study show that the integration of SD method and IO approach is a useful framework for analysing regional economies?

Furthermore, along the development of the case study, an additional Research Question arises:

4. Can the Integrated IO – SD framework be usefully implemented in the planning process by regional government policymakers in Sicily?

1.3 Thesis Outline

The document is articulated as follow:

- Chapter 2 presents the literature review on the research topic of Regional Theory, and the research methodologies that supported the research project;

- Chapter 3 presents the model framework designed for the case study;
- Chapter 4 presents the Regional Planning Process in Sicily and reports first considerations about the implementation of the model framework;
- Chapter 5 synthesizes results of the research, reports gaps in the research methods and research process and presents possible improvements and future directions for the research.

2 LITERATURE REVIEW ON RESEARCH TOPIC AND METHODS

2.1 Review of the literature on the research topic

The theoretical background of the research project is Regional Economic Theory. The literature on the topic is vast and all the contributions can be generally grouped on three main themes:

1. The theoretical predictions regarding the convergence or the divergence of per capita incomes across regions over time;
2. The assumption regarding the importance of internal and external scale economies to regional economic growth;
3. The role of space in shaping regional labour market outcomes.

Table 1 shows a synthesis matrix of the literature review that has been conducted on regional development theory: it groups the main authors that contributed to the development of the regional science. The matrix is not exhaustive, but the selected works tackle the topics that are considered relevant for developing the research project.

Table 1 - Literature Review Synthesis Matrix

			Exogenous Growth Theory		*Endogenous Growth Theory*		
THEMES	**Isard (1960), Isard et al.(1998)**	**Marshal (1890), Hoover (1937)**	**Roy F. Harrod (1939), Evsey D.Domar (1946), Solow (1956), Swan (1956)**	**Myrdal (1957)**	**Cass (1965), Koopmans (1965)**	**Schumpeter (1947), Arrow (1962), Romer P.M. (1986)**	**Nijkamp and Poot (1998)**
Theoretical predictions regarding the convergence or the divergence of per capita income across regions over time			**Conditional convergence** of growth rates over time across countries and levelling off of per capita incomes within countries. **Absolute convergence** when growth model parameters are equal for all countries.	Divergence outcome is predicted because of the combination of the "spread" effect of innovation and the "backwash" effect of the flow of capital and labour	Divergence prediction; Savings rates are incorporated in the utility function of the Household choice, thus they are endogenous to the model.	Divergence prediction; The "learning by doing" framework allows for incorporating technical change as an endogenous parameter in the model	The empirical implications are indeterminate: depending on the specification of the model: absolute convergence, conditional convergence, and divergence are all theoretical possibilities.
Assumption regarding the importance of internal and external scale economies to regional economic growth	Internal transportation cost economies	Both Internal and External scale economies (localization economies and urbanization economies)	Constant returns to scale	Increasing returns to scale		Increasing returns to scale in the production of consumption goods, decreasing returns to scale in the production of new knowledge	Increasing returns to scale in the production of consumption goods, decreasing returns to scale in the production of new knowledge
Role of space in shaping regional labour market outcomes	Location Theory: consideration of transportation costs leads to the optimal location of industry given the costs of transporting raw materials and final products	Consideration of transportation costs, Labour pooling, knowledge spill overs and economies in the production of intermediate inputs leads to the formation of industrial districts	Assumption of closed economies, most models assume zero interregional factor mobility, zero transportation costs, identical production technologies, identical preferences across regions.	Clustering prediction: the process of growth tends to feed on itself thus generating a process of cumulative causation.			Consideration of factor mobility, spatial diffusion of innovation, and interregional trade. No consideration of transportation costs.

The overview of the overall theoretical literature on regional economic growth is beyond the scope of the present research, but it is useful to point out the main theoretical scene for the research project.

The mainstream neoclassical economic view of regional science is heavily based on the literature of national economic growth developed by Roy F. Harrod[5] and Evsey D. Domar[6]. Neoclassical growth theory does model regional economic growth through supply-side models of investment in regional productive capacity.

At first, the parameters such as saving rates, population growth rates, and technological progress parameters are all determined outside the boundaries of the model: that is the reason why early versions of the Neoclassical growth theory are usually referred to as *Exogenous Growth theory*. All the developed models are sharing features that generate predictions of convergence of the growth rates over time across countries and the levelling off of the income levels within the country.

The main criticism to those models came from the empirical evidence: some regions of the world were not confirming the prediction of convergence, stated by neoclassical growth models. Another criticism was founded on the unrealistic assumptions underlying neoclassical growth theories: constant returns to scale, zero transportation costs, identical production technologies and identical preferences across regions, perfectly competitive markets and homogeneous labour and capital inputs.

Within the area of neoclassical regional growth theory, no significant model was able to overcome these main criticisms in a satisfactory way.

One of the new perspectives that in the second half of the last century attempted to address earlier criticisms of the neoclassical exogenous growth theories, is known as *Endogenous growth theory*.

Within that theoretical stream, many contributions allowed to make endogenous parameters those such as savings rate[7], technological change and innovation[8], and, more recently, also to consider the role of space and geography in shaping patterns of regional growth and decline[9].

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[5]Harrod R. (1939).
[6]Domar E.(1946).
[7] Cass D. (1965), Koopmans T. C. (1965).
[8] Schumpeter J. (1947), Arrow K. J. (1962), Romer P. M. (1986).
[9] Nijkamp P. and Poot J. (1998).

The Endogenous growth theory is the main stream theory which overall drives the modelling process of the research; a more detailed literature review on Regional development theory can be found in Casey J. Dawkins[10].

Rather than on the definition of a new theory, the research project is focused on the method: using System Dynamics to analyse a regional economic system. Consequently, the theoretical background is appropriately defined in order to shed the light on the choices for designing the model structure.

The next chapter provides the methodological framework that explains the choice of the methods used for the research analysis.

2.2 Review of the literature on the Research Methods

2.2.1 Introduction on the Methodologies for the research project

The methodology chosen to carry on the described analysis is System Dynamics: it provides an effective set of conceptual tools to analyse the structure responsible for the dynamics of a complex system, such as a regional economic system.

The structure of the model is based on the Neoclassical Growth Theory, and macroeconomics provides the building blocks for the theoretical framework to be articulated through a SD model and tailored to the Sicilian regional economy.

The literature review shows a wide use of macroeconomic models for economic system analysis at national level: it is a wide-spread practice among economic institution, likewise the FRB/US model of the Unite State Economy[11] used by the Federal Reserve Board staff, for forecasting and analysing macroeconomic issues; or the New-Area-Wide Model of the Euro area[12], designed for use in the Macroeconomic Projection Exercises regularly undertaken by the European Central Bank.

[10]Dawkins C. J. (2003).
[11]Flint B., Tinsley P. (1996).
[12] Christoffel K., Coenen G., Warne A. (2008).

System Dynamics has already showed as an effective alternative to the neo-classical approach[13], and it is already been used to articulate macroeconomic models at national levels[14].

On the contrary, at regional level the use of models to support regional economic development is rather seldom[15].

An overview of the main models usually used as tools by regional level government is offered by Van Den Belt et al. (2010). The report, published by Massey University (NZ), covers eight tools available to the regional level government in New Zealand: Geographic Information Systems (GIS), Mediated Modelling (MM), Spatially Dynamic Systems Support Modelling (SDSS), Computable General Equilibrium Modelling (CGE), Multi-Criteria Analysis (MCA), Agent – Based Modelling (ABM), Input – Output Modelling (IO), and Bayesian Belief Networks (BBN). In the report, all the mentioned models are assessed according to the degree to which they are integrated, dynamic and spatial.

Table 2 shows a synthesis of model types and characterizations relative to three aspects: the dynamicity of the model, the spatial explicitness, and the extent to which they can integrate different variables and contexts.

[13]Godley W. (2004).
[14] Wheat I. D. (2007a), (2007b).
[15] Stimson R. J. et al. (2011).

Table 2 - Overview of Regional Government's support models

	MODEL TYPES							
MODEL CHARACTERISTICS	**Geographic Information System (GIS)**	**Mediated Modelling (MM)**	**Spatially Dynamic Systems Support Modelling (SDSS)**	**Computable General Equilibrium Modelling (CGE)**	**Multi-Criteria Analysis (MCA)**	**Agent-Based Modelling (ABM)**	**Input-Output modelling (IO)**	**Bayesian Belief Networks (BBN)**
Integration		MM models focus on high level integration of trends in different dimensions.	SDSS combines multiple models of demography, economy and environment.	CGE models are used to analyse economic impacts of environmental policies, or vice versa, thus showing just a limited level of integration.	MCA techniques are used to support choices when decision-makers are concerned with multiple dimensions of performance.	ABM is widely used in land use-land change studies.	IO models are used to analyse economic impacts associated with given changes in final demand. IO framework can integrate information on environment.	BBNs are statistical models that integrate probability calculus in GIS.
Dynamicity			SDSS allows for simulating the dynamics of land-use change.	Most of CGE models are comparative-static but more complex dynamic CGE models can trace variables through time.		ABM is a dynamic simulation technique.	IO modelling is used for impact analysis with a comparative-static approach.	
Spatiality	GIS models present numerical data and other elements in a map view, thus allowing for a visual and spatial representation of geographical information.		SDSS allows for simulations at various spatial scale.			ABM is spatially explicit.		BBNs, integrated in GIS, are spatially explicit.

The relevant conclusion of the report is that those models are better used in an integrated fashion: it may happen that, when one problem is met in isolation, another one may arise. An integrated approach may find synergies between modelling techniques, in order to emphasize different aspects of the questions that each model aims to answer, and combining them to solve real complex problems[16].

The literature on regional economic modelling shows many examples for the use of Input – Output models, while more recently, early initiatives involved the use of IO in SD models[17], with the purpose to highlight possible physical and economic consequences under various scenarios. Fewer are the existing works combining macroeconomic modelling approach with SD and IO features for purpose of regional economic impact analysis[18].

The research project that has been conducted is grafted on that stream: it aims to use a neoclassical macroeconomic approach to design an SD regional economic model. The feedbacks captured by the SD methodology allow for making endogenous most of the parameters that usually stay out of the boundaries of the macroeconomic model.

In order to design a more useful tool, an attempt has been made to integrate System Dynamics with another methodological approach widely used in Regional Science: Input-Output approach. The aim of the research is to disaggregate the SD – based macroeconomic model into interconnected and interactive industrial sub- sectors, by the way of the IO approach.

The benefits coming from such an integrated approach are connected with the avoidance of the internal limitations of IO models and SD models when those are used separately for regional economic analysis purpose, but preserving each approach's strengths.

The SD model will gain precision by the way of disaggregation into industrial sub – models, thus capturing the business to business interconnections and dynamics.

The IO approach, typically criticized because of some of its unrealistic assumptions, likewise fixed technology, fixed combination of labour and capital, fixed prices, surplus factors of production, incomplete accounting for induced feedback

[16] Smajgl A. et al. (2009).
[17] Krallman H. (1980), Braden C. (1981), Mc Donald G. (2005), McDonald G. and Patterson M. (2008).
[18] Wheat I. D. and Pawluczuk A. (2014).

effects on the demand side of the economy, will relax most of its limits, and will be able to properly capture the dynamics of the system.

In the next paragraphs, those approaches are fully described, in order to allow for the understanding of the modelling process.

2.2.2 System Dynamics methodology overview

System Dynamics models are useful tools to study and manage problems in complex systems showing feedback effects between the elements of the system, and internal dynamics characterized by accumulation processes. Feedback effects represent the causal links among the variables of a system (fig.1). Feedback loops emerges when, given the directions and polarity of causal relationships amongst variables, the *action*, variable 1, affects the *system*, variable 2, but the altered situation in variable 2, does affect the following decision of the actors, thus generating a closed loop of causality. The + and – signs at the arrowheads indicate that the effects are positively/negatively related to the causes. When all the links in the loop are positive, the dynamic of the system represented is a growing one: the loops are self-reinforcing and are identified by the **R** in the centre of the loop. The other way, the negative loops are self-correcting, or Balancing, since they counteract the changes of the systems; hence the loop polarity identifier **B**.

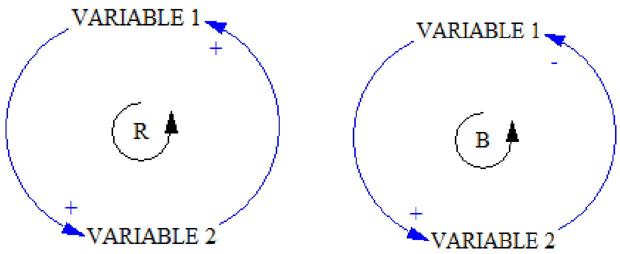

Figure 1 - Reinforcing and Balancing CLDs

Later in the document, the concept of loop is better described with practical examples.

By means of computer simulation, the SD model is able to replicate the dynamics of the system it represents, offering an undeniable advantage in analysing phenomena for which empirical testing is not suitable, such as those occurring in social or economic systems.

SD models are usually presented as Stock and Flow diagrams, which emphasize the underlying physical structure of the system.

Stocks and flows are the conceptual building blocks of the system, together with the feedback loops that involve them.

Stocks represent the accumulation of material or information, and they characterize the state of the system generating the information that will affect the decisions of the policymakers: for instance, stocks are inventories of products, populations, and financial accounts.

Flows are the rates of change in stocks. Examples of flows are production, shipments, births and deaths, investment and depreciation.

The feedback loops are generated by the causal links that transmit the information about the state of the system from the stock, to the decision rule, that is the equation governing the flow. The decision will alter the rates of flows, updating also the stocks.

Into the SD diagram language, stocks are represented by rectangles, flows are represented by pipelines, and feedback effects (information links) are represented by arrows. Exogenous parameters are represented by small circles, and they are constant estimates of values. The same kind of representation is also used for representing exogenous auxiliary variables, whose values are determined by equations.

Figure 2 gives a typical example of stock and flow diagram, representing a stylized demographic system.

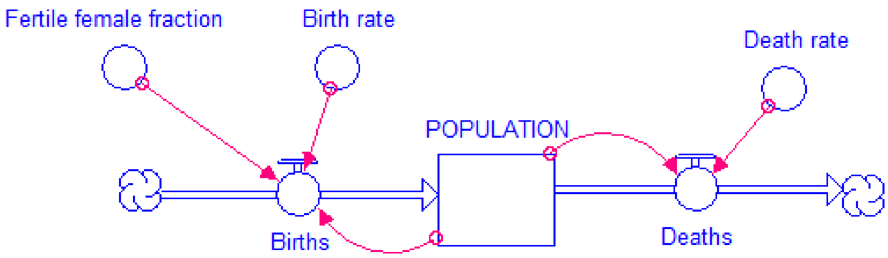

Figure 2 - Simplified SFD for the Demographic System

Deaths and Births are measured in “people per year” and represent the outflow and the inflow to the stock of population, measured in “people”. Birth rate, Fertile female fraction, and Death rate are parameters governing the system. The relevant feature of the SD concept is represented by the links connecting the Population Stock to its own flows. The theory behind this concept is that the accumulation process can affect the dynamics of the system itself: the higher is the number of people in the stock, the higher are both the inflow and the outflow. The dynamic involving the birth rate does accumulate more people in the stock, then the loop connecting the two variables is defined a *Reinforcing Loop*, because it represents a growth mechanism. On the other side, the loop connecting Population and Death rate is a *Balancing Loop,* since it represents a mechanism of equilibrium: the higher is the death rate, the lower is the population stock, but in turn, the lower is the death rate in the following period.

In complex systems, the equations governing the flows are usually differential, typically non – linear and without analytic solutions, relying on analytical integration to generate the simulated dynamic behaviour.

Complex systems, such as economies, contain many stocks that interact endogenously, by the way of multiple feedback loops involving each other.

All the models have boundaries that are depending on the model's purpose, the level of aggregation that the modeller wants to achieve, and the time horizon for the simulation. Outside the boundaries of the model, exogenous influences originate, but the dynamics coming from those external variables does not involve any feedback effects in the model, within the time horizon chosen for the simulation.

Given the SD approach's characteristics described above, in public policy context, the usefulness of SD is clear: policymakers are interested in the state of the systems, stocks, and may be able to manage them to some extent, by affecting the connected flows, by means of driver levers.

The action of affecting the flows usually follows the perception of some kind of discrepancy between the actual state of the stock, and the desired state. The SD model should be able to capture also the time delay it takes for the agent to acknowledge that discrepancy and to take the corrective action. Also material delays may involve the updating of the stock, which follows changes in the connected net flow.

These time-consuming processes governed by the feedback loops, and characterized by specific time delays, are the most important determinants of the system's dynamic behaviour.

With the research purposes as specified in the previous chapters, SD methodology appears to be the proper lens to analyse a regional economic system, since it is able to highlight feedbacks responsible for the dynamic of the system, and it is then expected to give insights on the causes for the actual state of the system, eventually, pointing out factors, both exogenous and endogenous, that are appropriate to regard in development policy making[19].

Specifically in the present project, where SD is used to model a regional economic system, it is important to note that the SD methodology could not stand alone: in fact, it does provide the methodological framework to articulate theories, in this case, drawn from the economic science.

The features of the SD approach make it quite flexible: modelling process is iterative rather than a linear sequence of steps, and, together with the results coming from the simulation, the model formation process can contribute to alter the initial understanding of the investigated problem.

Further information about SD modelling is provided in paragraphs where the model and the modelling process are described. For a deepening about System Dynamics and Stock and Flows diagrams see Sterman J.D. (2000) and Ford (1999).

2.2.3 Input-Output approach overview

The Input-Output (IO) model is a quantitative economic method that represents flows of goods and services across the economic system.

The IO model is widely used for analysing interdependencies between different economic industries, both at national and at regional level.

Generally, the IO model of a Nation is reconcilable with its System of National Accounts, and it uses an internationally recognized system of commodity/industry classification in order to allow for comparisons across space and trough time.

[19]Forrester J.W. (1992).

It was developed for the first time by Wassily Leontief in the 1930s[20] and nowadays it is widely used by governments in developed nations, at regular intervals, to obtain a snapshot of the structure of the inter – industry linkages in the economy.

In order to obtain that, IO models divide the economic system into economic industries characterised by homogeneous production, with a level of disaggregation depending on the purpose of the analysis.

In Italy, the IO table, or SIOT (Symmetric Input Output Table) is built at national level by ISTAT, the National Institute of Statistics: the compiling process of the SIOT starts from the Supply and Use Table (SUT), that describes, in a very detailed manner, the supply of goods and services (both internally produced, and imported) and the way those goods and services are utilised, for final and intermediate consumption. The SUT also shows Value Added (VA) generated from each industry and its composing parts, wages and salaries, which are measures of remunerations for primary production factors, labour and capital.

The SUT collects data directly coming from statistical survey, and the SIOT reviews and modifies those data in order to provide a symmetric table. In order to obtain a SIOT from a SUT, a three steps-process is needed:

1. From the SUPPLY Table, that disaggregate industries by products and services, all collateral productions must be allocated to the industry where those specific products and services are characteristic;

2. From the USE Table, inputs related to collateral productions must be referred to the industry to which productions have been reallocated;

3. In the reviewed USE Table, all the lines referred to different products must be reclassified in the number of industries with homogeneous production.

The IO table built in such a way, will present total flows of goods and services (both produced domestically and imported) across the economic system, in a matrix where the column entries represent inputs to an industrial sector, while row entries represent outputs from a given sector.

[20]Leontief W. W. (1936).

		INDUSTRIES - INPUT						FINAL DEMAND
		1	2	. . .	j	. . .	n	
INDUSTRIES OUTPUT	1	x_{11}	x_{12}	. . .	x_{1j}	. . .	x_{1n}	Z_1
	2	x_{21}	x_{22}	. . .	x_{2j}	. . .	x_{2n}	Z_2
	:	:	: INDUSTRY SECTION		:		:	FINAL USE SECTION
	j	x_{i1}	x_{i2}	. . .	x_{ij}	. . .	x_{in}	Z_i
	:	:	:		:	$\ddots$	:	:
	n	x_{n1}	x_{n2}	. . .	x_{nj}	. . .	x_{nn}	Z_n
VALUE ADDED		Y_1	Y_2	PRIMARY INPUTS SECTION . . .	Y_j	. . .	Y_n	
TOTAL SUPPLY		X_1	X_2	. . .	X_j	. . .	X_n	

Figure 3 - IO Table

More specifically, in an IO table of an Economic System with ***n*** sectors, each of which produces x_i units of a single homogeneous good, it is possible to distinguish three main sections (Fig.3):

1. The Industry Section shows inter-industry flows from those industries who sell intermediate goods and services (reading the line along the rows) to those industries who use them as production inputs (reading the line along the columns);

2.The Final Use Section shows flows of goods and services going from industries to final users (the columns will be articulated in the sectors of Household Consumption, Government Purchases, Fixed Capital Formation, and Exports);

3. The Primary Inputs Section, composed of rows showing value added and its composing parts, reporting the measure of compensation (mainly in the form of wages and salaries) for using primary production factors, labour and capital.

Reading the matrix along the row, it analyses production by describing the way it is utilized and disaggregated according the sectors it is destined to: each row represents the value of each sector's output. Reading the matrix along the column, it shows resources production process, then allowing for analysing the structure of production costs for each industry: each column of the matrix will show the monetary value of inputs to each sector.

For each industry, the total of the row will be equal to the total of the column: the rationale beyond that identity is that the entire production process brings to an output value that is perfectly equal to the total value of compensations for production factors, both primary and intermediate.

Back to the base IO model, in order to use the matrix for analysing interdependencies between business sectors and demand, from the inter-industry table, the matrix of direct coefficients A is to be derived. Each element of matrix **A**, a_{ij}, expresses the amount of units from j sector that is to be used to produce one unit of the i sector. If we call final demand in the ith sector d_i, then it is possible to write the equation for total output of sector i as follow:

$$x_i = a_{i1}x_1 + a_{i2}x_2 + \ldots + a_{in}x_n + d_i$$

In other word, total output equals intermediate output plus final output. If we let x be the vector of total output, and d be the vector of final demand, we can express the entire economic system as follow:

$$x = Ax + d$$

which becomes $(I-A)x=d$ with I being the identity matrix[21], defined as the square matrix in which all the elements of the principal diagonal are ones and all the other elements are zeros. If the matrix $I-A$ is invertible, then the system is a lineal system of equations with a unique solution. Given a final demand vector, the required output can be found as:

$$x = (I-A)^{-1} d$$

The matrix $(I-A)^{-1}$ is called the Leontief Inverse, and it allows for determining the output multipliers and shows how much of each industry's output is needed, in terms of direct and indirect requirements, to produce one unit of a given industry output. The sum of the column gives the multiplier coefficient of the sector in the header, summarizing into a single coefficient the amplitude of the chain of reactions determined by an additional unit of final demand (or any other exogenous shock) for that specific sector, into the economic system.

The model we obtained is also defined as Production –Final Demand Model, but the same process can be followed in order to obtain another type of model, the Cost – Price Model, where production is derived from the costs of intermediate output, instead of the final demand, and from the matrix it will be possible to determine the impact of variations in prices of imported intermediate inputs and primary inputs on production.

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[21]The Identity Matrix is a square matrix in which all the elements in the principal diagonal are ones and all the other elements are zeros. The identity matrix is invertible, being its own inverse.

The described method offers a useful tool for decomposing analysis done at macro level. Prior use of IO models is structural analysis, which ranges from the simple clarification of equations implicit to the table, to the evaluation of the industry-mix for the more significant economic variables, to the measurement of ratios or other specific parameters that allow for ranking economic sectors or for space and time comparisons.

One of the most interesting use of IO analysis is the Impact Analysis. In fact, the model can be used to measure the economic impacts of events, such as public investments or programs that can be introduced into the model, for example, in the form of variations in final demand, or variations in production costs.

Since it gives a picture of interdependency between industries, the IO model measures the economic effect of boosting one or more so-called “key” or “target” industries which are considered crucial because of their capacity to *activate* the economy. In a way which can be described as comparative-static, the model estimates the reactions of the economy at only one point in time: the result of the analysis shows the difference between two alternative future states, with no explicit representation of the process of adjustment to the new equilibrium.

The IO model can be defined also at a regional or inter-regional level for planning policy purpose. In order to build the model, all the flows in terms of intermediate output or final output occurring between regions must be considered. The aim will be to distinguish between internal and external multiplier effects (in case of regional IO models), or measuring inter-regional interactions by analysing and including feedbacks and spill over mechanisms (in case of inter-regional IO models).

Models based on IO matrix pay all the attention to production (Supply) and consumption (Use). There are two conceptual extensions of the IO approach, the Social Accounting Matrix (SAM) and the National Accounting Matrix with Environmental Accounts (NAMEA), that focus on Income Distribution (the first one) and quantify environmental pressure of production process (the latter) but a wider analysis of these two approaches goes beyond the scope of this research.

In spite of the clear diffusion of the method, limitations are widely acknowledged. Most of them are connected to the hypothesis underlining the methodology; others are connected to the modelling process itself.

As regard the first kind of limitations, it is important to note that IO models assume linear relations between inputs and outputs from different sectors, as well as linear relations between outputs and final demand. The hypothesis of constant return to scale and stationary technology appear to be unrealistic: factors are mostly indivisible, and then increases in outputs do not always require proportionate increases in inputs.

When using IO model for Impact Analysis, the effect is determined by evaluating how the economic system does find another equilibrium after an induced external shock such as an increase in demand for a sector: under the assumption of a constant structure of the economy, the model will reallocate the additional production from that specific sector according to the coefficients of the previous inter-industry flows. As a consequence, the IO approach describes an economic system that expands indefinitely, replicating itself while maintaining always the same structure.

In the long run, radical changes in the structure of economic systems may be observed[22]: variations in economic variables often reflect variations in composition and quality too. The main determinant of economic changes is technological progress, and changes in the structure of final demand (and then in the structure of supply) usually follow Engel's law, with lower percentage of increased income spent on essential goods. Impact's measurement based exclusively on IO models cannot capture those changes.

Moreover, the production function adopted by the model assumes fixed combination of labour and capital, then ignoring the possibility of factor substitution, and fixed prices, adopting no mechanism for price adjustments. When used for impact analysis, and then in a dynamic way, IO model cannot reflect phenomena such as bottlenecks or surpluses and shortages in production factors availability, heavily affecting numerical results coming from the model.

Finally, other limitations can be linked to the method's implementation process itself. Data collection and preparation process for the input-output accounts are both labour and capital intensive, and time consuming: IO tables are often published 5-7 years after the year in which data were collected, and the collection is typically run only once every few years[23]. Changes in the industry-mix within one sector will invalidate the estimated coefficients very soon. It is possible to assume that the real actual

[22] The most common structural change is the shift from agriculture-based economy to services-based economy.
[23] The more recent SIOT Table for Italy is dated 2010, while the previous one dates back to 1992.

structure of the economy would be different by the time the IO table is available, eroding the usefulness of the results.

Additional problems arise when the analysis addresses the regional economic system. In fact, the national IO table finds its statistical database in the System of National Accounts, published on a regular basis by ISTAT, while data for regional IO table can be obtained following two different techniques: the direct technique, and the indirect one.

The direct technique is implemented by surveys: it allows catching the specific lines of local production processes, but, on the other side, it is time consuming and capital intensive and, with high percentage of unclaimed questionnaire or with no replies, the statistical significance of results can be strongly affected.

According to other available data, the indirect technique derives the regional table from the disaggregation of the national one. Despite its readiness and cheapness when compared to the direct one, the indirect technique generally assumes an unrealistic assumption: it is possible to use nationally determined coefficients at regional level. Instead, systematic differences in absolute values of regional coefficients, compared to the national ones, are to be linked to the differences in dynamics of industry prices, to the differences in production techniques, and, especially, to the different sectorial combinations of the production structure, at national and regional level.

In conclusion, there is no first choice method, but the final use of data, and the available budget must be considered when designing the data collection technique.

The literature shows different approaches attempting to unleash the IO method from its main limitation: constant technical coefficients. Many of them adjust technical coefficients "along the row" or vary input coefficient "along the column", with an adjustment function, in both cases then introducing biases into the analysis[24].

Considering the high cost of setting up data for survey-based IO table, and the long construction period, the necessity to provide an updating method of IO table has been tackled by EUROSTAT[25] with the proposal of an updating procedure, named

[24] Kratena K. and Zakarias G. (2004).

[25]Eurostat is the Directorate-General of the European Commission, whose main responsibility is to provide statistical information to the Institutions of the EU and to promote the harmonization of statistical methods across the EU Member State.

EURO, that allows for updating data according to official European forecast for main economic variables, at the same time avoiding arbitrary adjustment in coefficients.

EURO adjustment procedure starts from the base year IO table and then estimates for value added with industry level disaggregation, and also estimates for aggregate demand components (Household consumption, Exports, Gross fixed capital formation). Remaining data are estimated with an iterative procedure, aiming to evaluate intermediate consumption, final demand structure, domestic production and imports.

Main advantages of that new procedure are the limited amount of data requirement, the level of consistency coming from the avoidance of arbitrary adjustments in coefficients, and the use of official data only, low costs and high level of automatism for the implementation of the procedure.

Among the weak points are the simple structure, and then, the simple theory underling the updating procedure, and its inability to disclose relative price impact and other economic variables, such as technology progress and productivity level.

In the attempt the tackle some of the limitations of IO methodology described above, the research project aims to provide a case study that shows a way to integrate the IO approach within the SD methodology, thus allowing to relax some of the IO methodology's assumptions.

3 REGIONAL DEVELOPMENT INTEGRATED MODEL FRAMEWORK: A CASE STUDY ON SICILY REGION

The previous paragraphs widely describe the two main methods that offer the methodological background to the modelling part of the project. This chapter gives the detailed picture of the research plan, the modelling process, and the model itself.

The result of the case study wants to be a model framework that can be used for development policy design at regional government level. With this goal in mind the model is designed, the planning process at regional government level is analysed in order to give insights on the possible implementation process of the model, and, finally, a comparison of the framework to the model actually adopted to support the planning process at the regional level is approached.

The modelling part of the project has been articulated following the disciplined specific process proposed by J. Sterman[26]. The starting point is the articulation of the problem to be addressed, following the formulation of a dynamic hypothesis or theory about the causes of the problem itself, the formulation of a simulation model to test the dynamic hypothesis, the testing of the model to check its suitability for the purpose of the study, and, at last, designing and evaluating possible policies to be implemented.

Following paragraphs show all the steps undergone up to the last version of the model, which is considered satisfying for answering the research questions.

3.1 Problem articulation

The first step in the modelling plan is the identification of the specific problem the model aims to cast lights on. In order to do that, it is appropriate to recall the RQs presented in the second chapter, and to translate them into specific modelling results. More specifically, the first two RQs are:

1. What are the endogenous and exogenous factors that have determined the behaviour of Sicily Regional Economic System in the last 15 years?
2. Is it possible to point out one or more economic sectors able to foster an endogenous growth path for regional development?

The answers, in both cases, are interconnected to the analysis of the regional economy structure, to be evaluated in conjunction with its behaviour. Then, the preliminary step in modelling is to give a qualitative measure for the concept of performance of the system that can be linked to the development goal, and to specify the problem that the model aims to investigate.

Macroeconomics considers Gross Domestic Product (GDP) as the usual variable to measure the performance of national economic system. In a specular manner, at regional level and at first sight, Gross Regional Product (GRP) can be considered as the performance measure of the regional economy. It does measure total domestic output of

[26]Sterman J D. (2000)

goods and services, and in the macroeconomic theory and in the National Statistics Account, it is equal to Total Income.

But what Growth Theories, and the political debate, usually point to is the change in percentage of GRP growth, rather than the absolute value, because it expresses the improvement or deterioration of the economy’s performance in a clearer way.

Moreover, rather than the general economic crisis, the more visible problem that drives towards the research questions is the high level of unemployment in Sicily, that is clearly connected to the demographic sector’s dynamics. For that reason, it appears appropriate to link the economic performance to the demographic sector by looking at per capita values of GRP.

As figure 4 shows, over the recent years, per capita income in Sicily has showed a decreasing trend, but the more interesting aspect emerges when comparing the regional trend to the national one.

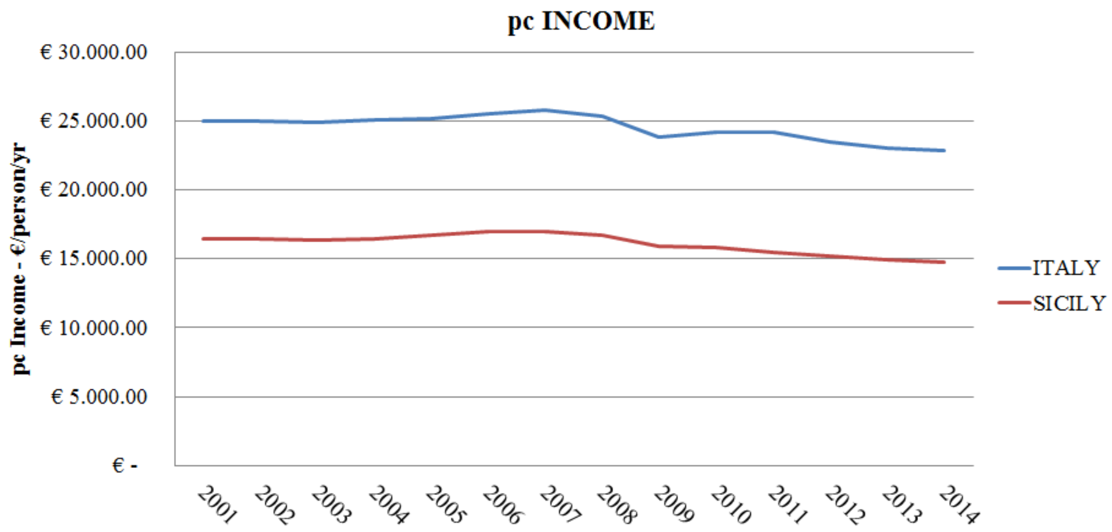

Figure 4 - Per capita Income 2001-2014 Comparing national and regional levels (Data source: ISTAT)

It can be considered appropriate to evaluate the system in a space comparative manner, given the interconnection of development process occurring in different regions, in order to gain insights about the interaction between local system and central policies, but this aspect is beyond the scope of the research at this stage.

Once the problem is identified in the dynamic of per capita income, the second step of the problem articulation is to point to the key variables that we must consider in exploring the problem.

The formula for determining per capita Income gives the way for the research of the relevant variables when looking at the problem: the analysis should be pointed to regional output level, and to the demographic dynamics.

Defining the output level as the result of the regional production process, the attention must be oriented towards the determinants of the production function. From the Macroeconomics underpinning the SD model structure, the modeller's choice is for adopting the Cobb-Douglas production function that, in its most standard form, is expressed as follow:

$$Y=AL^{\beta}K^{\alpha}$$

where Y is the total production, measuring real value of total goods and services produced in a year, L is the labour input, expressed in terms of total number of person-hours worked in a year, K is physical capital stock, measuring the real value of all machinery, equipment, and buildings, A is Total Factor Productivity (TFP), and α and β are the measures of marginal productivity of Capital and Labour, measuring output elasticity of capital and labour, respectively.

Increases in either A, L or K lead to increases in production output.

The production function expressed in such a way can represent the technological relationship between the amounts of production inputs, and the amount of output that can be obtained. In the Cobb-Douglas formula, values of output elasticity to capital and labour, are considered constant, and are expressions of the available level of technology. Furthermore, the sum of α and β tells if the formula is considering constant returns to scale ($\alpha + \beta = 1$), increasing returns to scale ($\alpha + \beta > 1$), or decreasing returns to scale ($\alpha + \beta < 1$).

The more discussed factor of the formula is A. TFP (also called *multi-factor productivity*) is the variable that accounts for the effects in total output growth relative to the growth in labour and capital inputs. It is calculated by dividing output by the weighted average of labour and capital; the exponents α and β are empirically estimated and can vary from one industry to another, and from Country to Country. When all the inputs are accounted for, TFP is considered as a measure of economy's long – term technological change, or in other words, technological dynamism[27]. Main drivers for

[27]Statistical data show that TFP shows high level of variability from one year to another. For that reason it is considered more accurately measured in the long term.

TFP changes are identified in technology growth and efficiency. The measure of TFP lacks of a meaningful unit of measurement, and for that reason it does not admit a simple economic interpretation, appearing the more intangible production factor as it can range from technology to worker's know-how. As a consequence, the concept has been widely criticized as a modelling artefact.

Despite scientific criticism, TFP is often seen as the real driver of economic growth, since studies revealed that whilst labour and capital accumulations is an important contributor, TFP growth accounts for about half of output (and then, income) and growth in OECD countries[28].

For examples, a country specific study for Italy, aiming to investigate differences in productivity levels across Italian regions, showed that differences in level of output per worker can be ascribed more to the efficiency in the use of inputs (expressed by TFP level) rather than to their quantity[29].

As regards the demographic sector, figure 5 shows how population in Sicily has been changing over the past two decades.

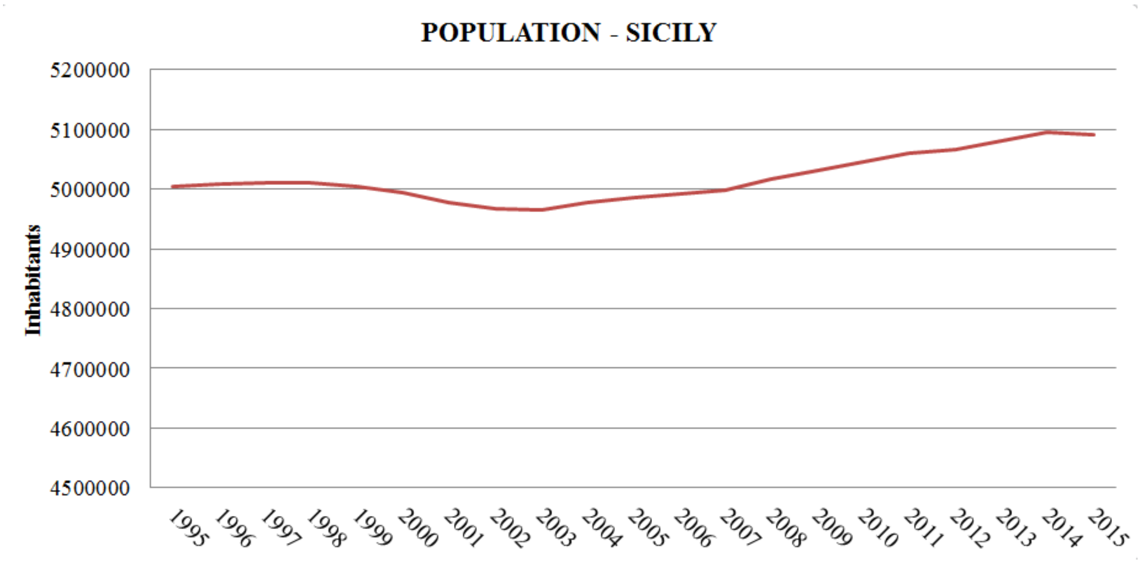

Figure 5 - Population behavioural pattern 1995-2015 (Data Source: ISTAT)

Essentially, the line graph shows how population has followed a steady pattern in the last two decades, and negative growth rate in the very last two years. In order to elicit a qualitative appreciation of that dynamics, the disaggregation of population by age cohorts is helpful.

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28 Esterly W., Levine R. (2001).
29 Aiello F., Scoppa V. (2000).

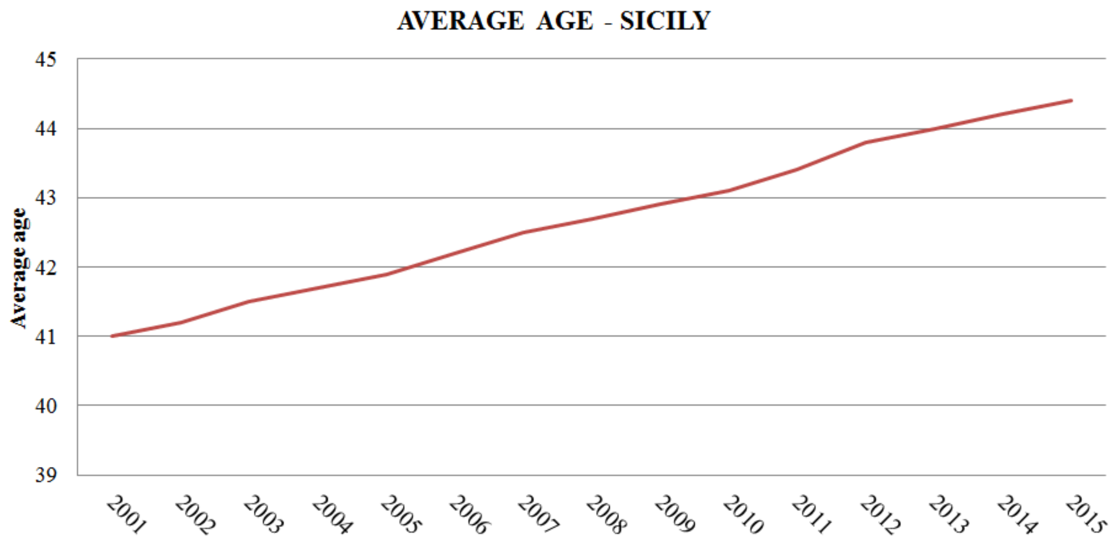

Figure 6 - Average age behavioural pattern 2001-2015 (Data source: ISTAT)

Observing figure 6 displaying average age in Sicily, a clear and drastic phenomenon of ageing population emerges.

From that premise, it is possible to suppose other consequences connected to the implications of demographics dynamics on the economy.

On the demand side, what has been defined the Zero Growth Population (ZGP)[30]undermines domestic demand for local goods and services, affecting then production levels. On the supply side, an ageing population shows decreasing rate of participation to the labour force, putting a constrain to production capacity by limiting labour input availability.

The picture becomes even worse when looking at forecasted demographic index published by ISTAT on the occasion of the last census in 2011 (Fig.7).

[30] Kingsley D. (1967).

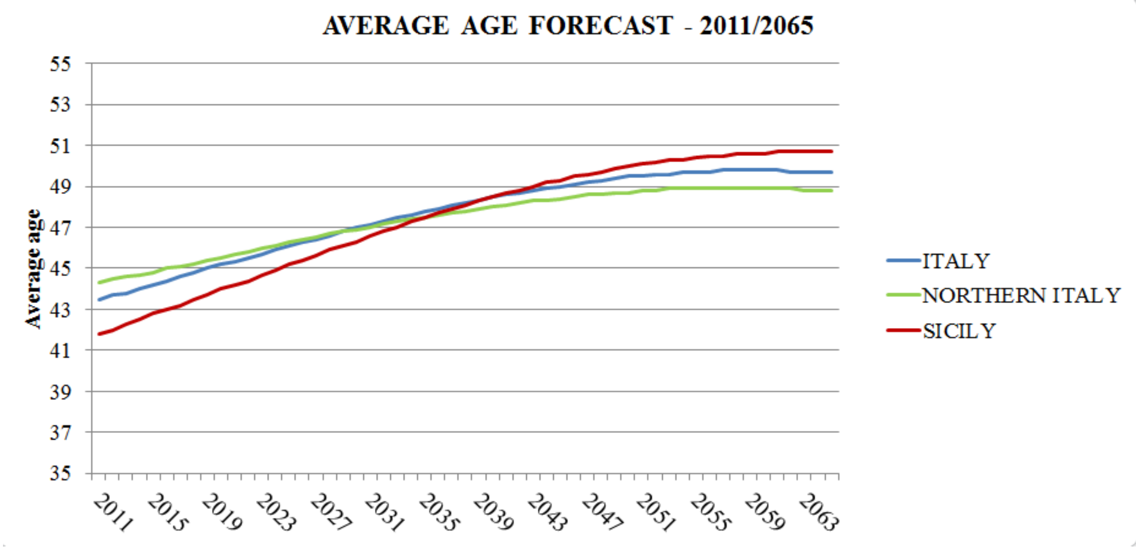

Figure 7 - Average age forecast – Comparing Sicily, Italy and Northern Italy (Data source: ISTAT)

As the figure shows, the demographic performance, in terms of ageing, and then labour force participation, is expected to get worse, both compared to national values and to Northern Italy's values.

The identification of Population, Participation to labour force and Productivity as the key variables to focus on during the modelling process, refers to a framework known as the "3P's approach"[31].

Once boundaries have been put on the definition of the problem to investigate, last part of problem articulation consists of selecting the time horizon, choosing both for how far back in the past it is appropriate to dig for data, and for how far in the future it is realistic to simulate.

That decision involves the consideration about the supposed causes affecting the variables we aim to model. Identifying the root of the problem in the dynamics of population suggests extending the analysis over a span long enough to catch a potential change in the trend of the variable: when talking about development, a long-term perspective is essential. Looking at the past, year 2001 has been considered appropriate as a starting year for the model, and simulation has been pushed up to year 2044: with the simulation running for 30 years in the future, we can assume that the model would display the effects of potential policies, without being influenced by the initial condition of the system itself.

[31]Sunshine Coast Business Council (2013).

At this point, it is possible to develop what is called a *Reference Mode*, meaning a set of graphs showing the development of the problem over time (fig. 8 and fig. 9).

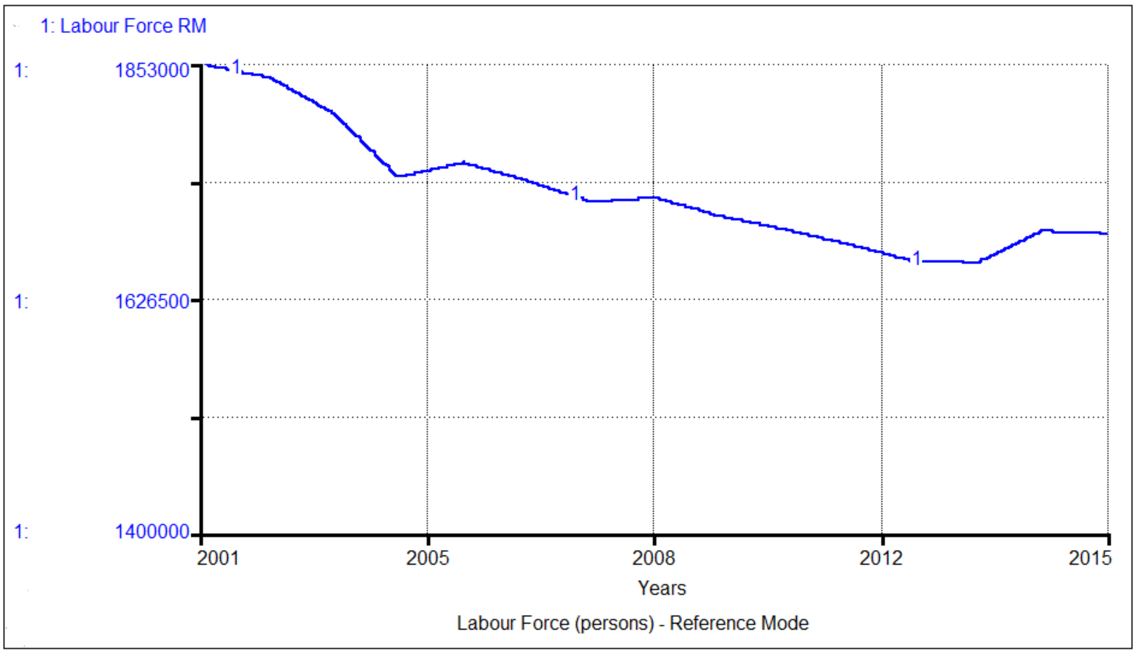

Figure 8 - Labour Force Reference Mode

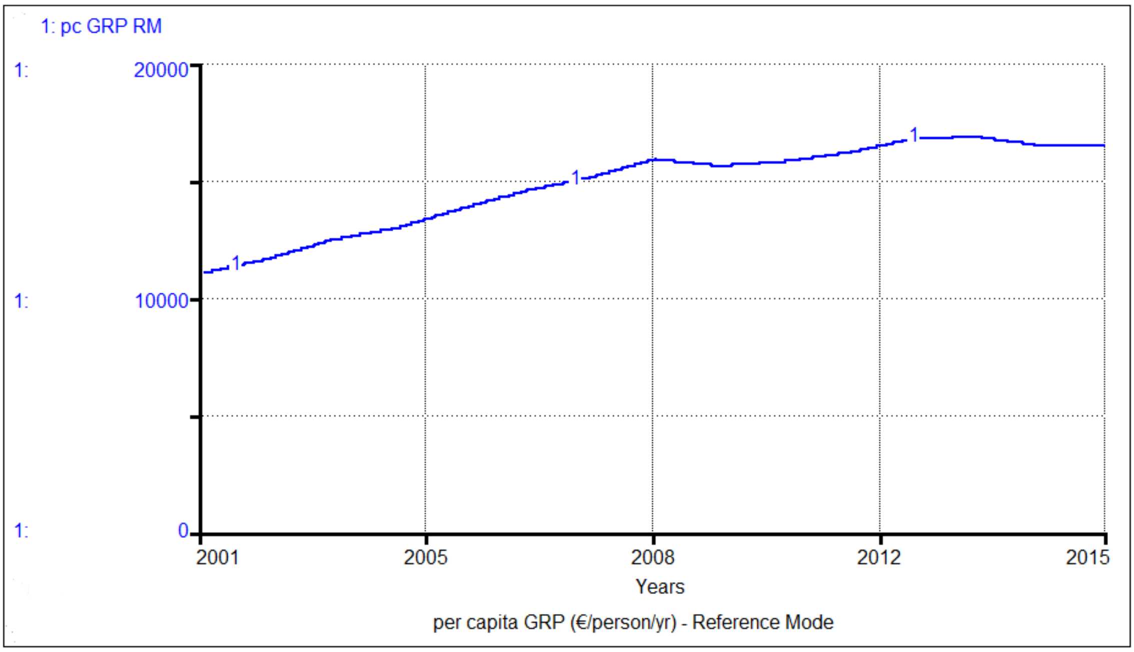

Figure 9 - Per capita GRP Reference Mode

3.2 Formulation of Dynamic Hypothesis

The modelling process proceeds with the generation of the dynamic hypothesis: according to current theories and personal insights about the problematic behaviour, a theory explaining that specific dynamic pattern is formulated. That theory is dynamic because it does explain the problem in terms of stock and flow structure, and underlying feedback structure; it is also an hypothesis because it will probably be adjusted, or even transformed, gradually along the modelling process that catalyses further understanding of the system.

In the generation of the dynamic hypothesis, the attempt is to keep an endogenous focus: consistently with Endogenous Growth Theory, and with the SD methodology itself, it is the feedback structure that, endogenously to the model boundaries, generates the dynamics of the problem.

This formulation takes the shape of an iterative process, with mental models driving towards the definition of the model structure. The complexity of the system suggests a step by step – approach: starting from the problem and its simplified connection to the selected key variables, additional theoretical causal assumptions lead to additional structure blocks and rules of interaction, integrating greater complexity into the modelled system. Simulation at each modelling step will add knowledge about the way the behavioural pattern is created by the feedback structure, and how it can be altered by changing both the structure and the rules. Each exogenous input into the system has been checked to be sure it doesn't hide relevant feedback structure to be considered for further modelling.

Different mapping tools come in help when communicating the boundaries of the model and its causal structure in each step of the modelling process. Among different tools, one is widely appreciated for its flexibility and simplicity: Causal Loop Diagrams (CLDs).

CLDs represent the system as a simple map showing the causal links among variables with arrows from the cause towards the effect. It is specifically useful when the purpose is to emphasize the feedback structure.

The other tool that will be used in the next paragraphs is the Stock and Flow map, which adds visual information about the physical structure underlying the feedback structure[32].

The diagram in figure 10 shows the initial dynamic hypothesis that connect the problematic behaviour of the performance of the economic system (expressed in terms

[32]A brief description of Stock and Flow maps is found in chapter 2 – paragraph 2.2.

of per capita GRP) to the key variables identified in Population, Participation and Productivity. The diagram is designed with straight lines to highlight the fact that only causal relationships are pointed up to this point: variables are related by causal links, represented by arrows, but no feedback loop is identified yet.

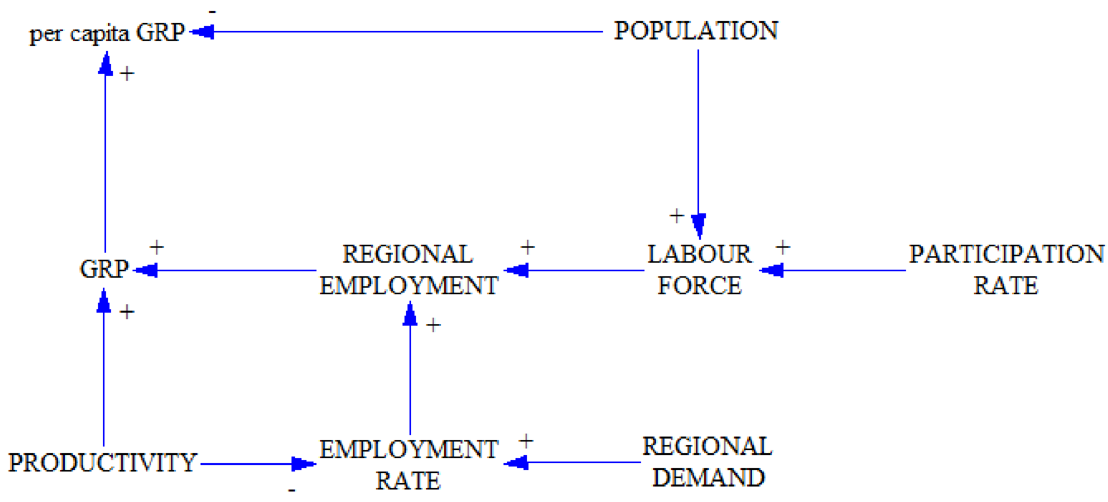

Figure 10 - Dynamic Hypothesis Diagram

Per capita GRP, conceptually and mathematically, derives from the division of total output by total population. According to the neoclassical theory presented in the previous paragraphs, GRP is the results of the Cobb-Douglas production function. All the inputs in the function affect the results: among them are Productivity, and the Labour input, expressed by employed people.

The Employment level is the result of the employment decisions, settled according to the level of production the economy aims to generate, based on aggregated demand, and the productivity level. A constraint to Employment level comes from Labour force, which is measured as the fraction of population that participate to the labour market.

From this basic map, where only simple causal links are showed, the model is gradually built in order to let the feedback structure emerge.

3.3 Formulation of the simulation model

The model building process has led to a final result that cannot be represented in a single page CLD because the model has gained complexity by adding new feedback structure and Stock and Flow structure at each modelling step.

The modelling approach adopted for the analysis suggests to model in the direction of each key variable, by defining a prototype model to be enhanced in a next step, to gradually obtain a final result that can satisfactory replicate the problematic behaviour, and then explaining its causes.

The model is here explained sector by sector, defining a sector as a part of the model that has autonomous significance. All sectors are interconnected between each other by means of feedback structure.

The feedbacks and the Stock and Flow structure within a sector determine the behaviour of variables thus considered as endogenous to that sector. Some of those variables then affect other sectors, in which they are treated as exogenous variables.

In the next paragraph, an high level view of the model is provided: all the sectors are presented, causal links among them are showed, then opening the way to a more detailed description of the specific model within each one of the sector. The overall model is a multi – level map, where, from the first level big picture, each sector offers a more detailed disaggregation every time it is considered appropriate for the purpose of the research, according to the settled boundaries of the system.

3.4 Overview of the model

The model implementation is drawn on existing experience provided by well-known system dynamics models as WORLD2[33], Miniworld[34], World3[35], T21 (threshold 21[36]), a such inclusive macroeconomic systems as Macroeconomics[37], and also, the regional IO integrating SD modelling framework proposed by Wheat and Pawluczuk A.[38].

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[33] Forrester J. W. (1971).
[34] Bossel H., (1994)
[35] Meadows D. H. et al. (2004).
[36] The Millennium Institute, paper.
[37] Wheat I. D. (2007a).
[38] Wheat I. D. and Pawluczuk A. (2014).

The conceptual structure of the system is showed in figure 11.

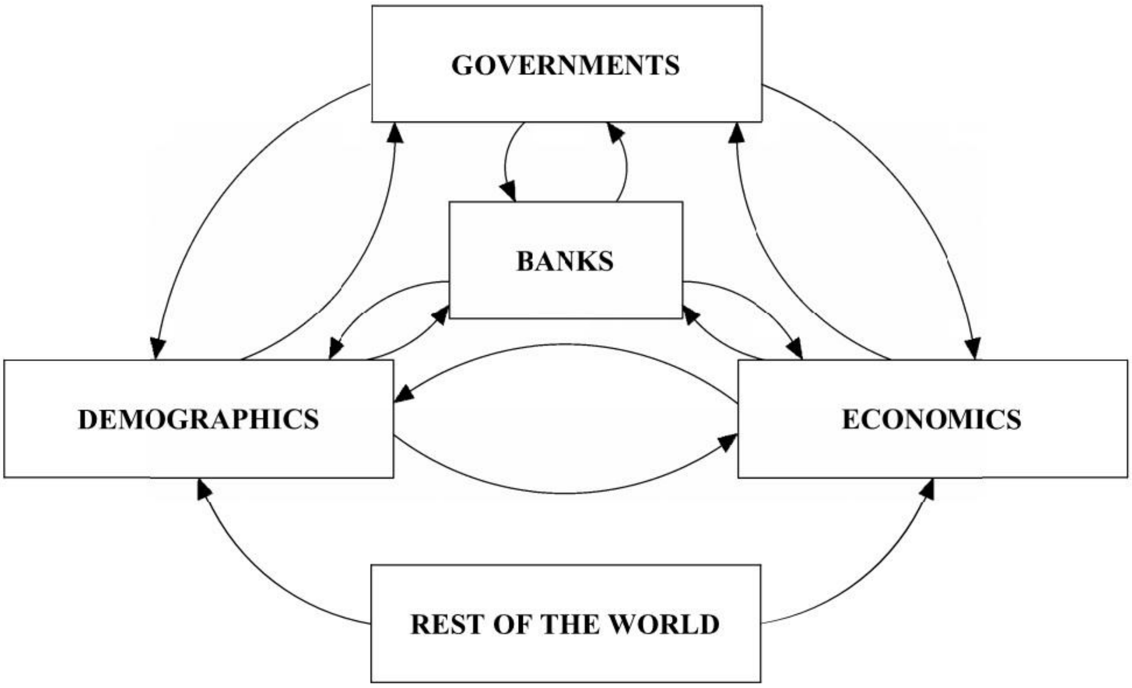

Figure 11 - Conceptual Structure of the system

Here, the model is showed as a subsystems diagram, where the overall architecture of the system can be grasp. All major subsystems show homogeneous types of organizations or agents represented, and are connected to each other by flows of material, money, goods and services, information, and so on. The diagram gives insights on the boundary and the level of aggregation in the model.

The first two sectors that emerge from the dynamic hypothesis are the Demographics and the Economics (fig.12).

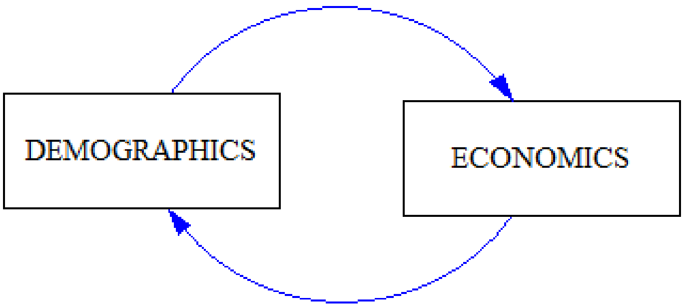

Figure 12 - Demographics and Economics sub models

The two arrows connecting each other let grasp that there is a feedback structure involving variables across the sectors.

Demographics include all the characteristics of population, modelling also the dynamics of labour force. Economics includes the model of the production subsystem, disaggregated in five main industries: Agriculture, Manufacturing, Construction, Market Services and Public Services. Each industry develops the specific dynamics in the variables such as Capital, Employment or Productivity.

The Economics subsystem also includes the module of Firm, which gives as output the decisions taken by the economic agents about new investments in fixed capital.

From the Government Subsystem, information about tax rate, but also government spending, influences the economy. Finally the Bank and the Rest of the World give information about Interest Rate and Export demand, thus affecting investment decisions and the final demand. The only subsystems modelled at this stage are Demographics and Economics, the others affecting the system as exogenous factors. Still, they are represented as modules instead of single variables to set the directions for the future model development.

3.5 Detailed model description

Description of each sector follows the modelling steps that lead the modelling process, and can be schematised as follow:

1. Identification of all variables and establishment of the relevant equations based on the feedback and causal loops, with specification of the structure in terms of stock and flows and causal links created by the interactions of the physical and institutional structure with the decision-making processes of agents acting within it.
2. Estimations of parameters within the equations that rules those causal interactions.
3. Quantification of initial conditions of the variables.
4. Testing to assess the model’s consistency with the purpose and the boundaries of the project.

Each module is resulting from an iterative process, by which, a first tentative model structure, defined upon first hypothetical theory about the system, is progressively enriched by testing and sharpening consequential steps. Powered by additional theoretical or experiential analysis, previously ignored variables and feedback loops are added, providing another prototype model to be tested. Every partial sector of the system, called subsystem, is presented in the following paragraphs. At first, each of them is tested as a single standing model in order to isolate possible mistakes in the modelling process. In order to do that, the subsystem is fed by historical values, corresponding to those variables that act as points of contact to the other subsystems.

Hereinafter, all subsystems are introduced, details of their content and structure are provided, together with the theory lying behind them. The building components, both in terms of variables and causal links created by the interaction of the physical and institutional structure with the decision – making processes of agents acting within it, are presented. The model will be presented in terms of CLDs or SFDs, referring to the appendix mentioned case by case for the list of equations, the sector's boundary, and the extended version of the SFD or CLDs.

Per each sector, main parameters, and exogenous inputs are listed, in order to highlight what affects the dynamics of the sector, and to what extent. When the single subsystem is tested for validation, exogenous inputs to each subsystem are numerically populated by historical values.

After describing all the subsystems in their last version, with focus on the key parameters and feedback loops governing the behaviour of each one of them, linkages among the subsystems are activated: in some cases, variables previously considered as exogenous to the single standing subsystem, are determined as output from another subsystem, then being endogenized to the whole model.

At the final point, it is possible to assume that the dynamic behaviour of the system is created endogenously by the system itself, and by identifying those parameters that can be actually affected by policymakers, the model can be effectively used as a simulation tool for policy design and evaluation.

3.5.1 Demographic Subsystem

The first sector to be modelled is Demographics. It includes the model structure implementing the behavioural aspect of population development. It models, in terms of stock and flows and feedback structure, all the characteristics that can affect the population's behaviour over time, such as age, gender and so on.

The Population variable conceptually is a stock variable; it has been disaggregated in order to allow to characterize it by age distribution. The variable is designed as an ageing chain of 5-year cohorts of people for people between 0 and 84 years old, with the last cohort grouping people older than 85 (fig. 13).

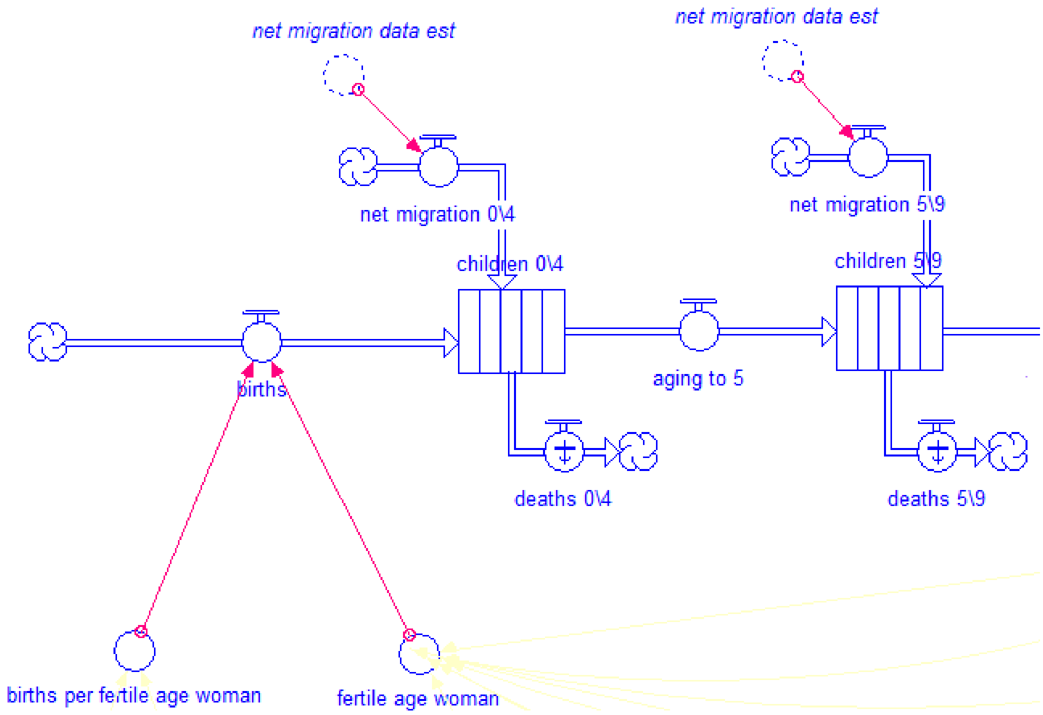

Figure 13 - Details of the Ageing Chain SFD

The dynamic of each stock can be separated into four autonomous processes, two of which connected to biological phenomena, and the others linked to the migratory phenomenon.

Births and Deaths are represented by separated flows, and specifically, an inflow adding to the first stock of the chain, and an outflow reducing each one of the stocks. The value to be added, meaning new born individuals, is determined by two variables: the birth rate, measuring the annual number of births per woman, and the amount of fertile women, measured as a fraction of the female population between 15 and 49 years old.

The value to be subtracted by each stock, meaning deaths reducing the amount of individuals of that specific stock, is determined by the probability of dying, measured by the death rate, and the total amount of individuals in that specific stock. Death rate varies from cohort to cohort because probability of dying changes from cohort to cohort.

As regard the migratory phenomenon, two different processes act as inflow and outflows to the total amount of population: immigration and emigration. The first one is the process of individuals entering and settling in the region, and the second one is the process of leaving the region and settling to another one.

From the modelling point of view, it is appropriate to isolate every single process within a specific flow, since it will be regulated by a specific action rule, governed by its own determinant parameters. In that case, due to the lack of data, and to the fact that migration is not involved by feedbacks at this modelling stage, the modelling choice is to amalgamate both processes into a single flow, called net migration, measured by the difference between the immigration and the emigration. As for Deaths, also for migration, the flow is disaggregated by each cohort.

The last variable linked to the population dynamics, is the labour force, meaning the fraction of population that participates to the labour market.

The variable labour force is measured by the participation rate, meaning the fraction of individuals that take part in the labour market, type the subset of population that can legally be employed, meaning population over 15 years old.

Also for the measurement of the labour force, the participation rate varies across age cohorts, since age factor substantially affects willingness or ability to work.

Figure 14 shows the CLD of the demographic sector. Two feedback loops emerge from the Stock and Flow structure as it is designed, both related to the biological process of births and deaths.

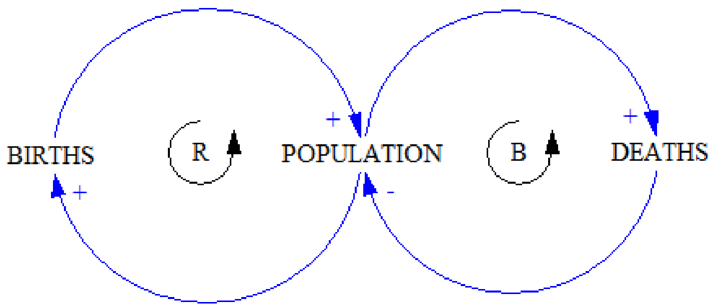

Figure 14 - Details of the CLD Demographic sector

The first loop, the one related to the new born individuals increasing the population stock, is a reinforcing one: new individuals increase the population, that, in turn will produce more individuals through births.

The second loop, is a balancing one since it does involve a negative correlation between the population stock and the deaths outflow, depleting the stock of population as follow: population interacts with mortality rate, thus determining the deaths flow, that subtracts from the population, making it smaller. The following time step, deaths flow will be lower, with a lower subtracting effect on population stock.

The variable Population, by means of participation rate, determines the labour force used to estimate employed people, limited to those working in local industries.

All the variables relevant to the demographics are compressed into one module, whose output are population and labour force. Since it influences the labour input and interacts with productivity, labour force does determine production, and thus GRP, from within the production function. Total output is then linked to the other output of the demographic module, Population, and eventually, per capita GRP is determined.

As it is showed up to this point, the model is simply a map of causal links among variables that build up the hypothetical structure of the system. That hypothesis is to be tested, and the first step of the test procedure in SD is the simulation.

By means of simulation, each variable of the system is quantified, and dynamics of each of them can be displayed over a time span that is the length of simulation.

The first step towards the simulation is populating all variables with numerical data.

The stock variables are initialized with historical data from the first year of the simulation, 2001 in this case.

The parameters determining flows are estimated: births rate and female fraction are assumed by averaging data from 2001 and 2014 (the first and the last years of the reference mode), published by ISTAT. As regards Deaths, average mortality per each cohort of the ageing chain is derived from ISTAT data.

As for migration, information about net migration rate has been used to quantify net migration in terms of individuals. This amount has then been disaggregated by age cohort and each net migration flow has been populated with historical values for the period 2001-2014.

As regards the labour force, participation rate has been quantified according to statistical values published by ISTAT, disaggregated by three major age cohorts: from 15 to 24 years old, from 25 to 64 years old, and from 65 years old on.

After a first step validation of the structural part of the model, consisting of a "operational thinking"[39] check about each variable, along with its quantification, the model's behavioural output has been evaluated. In this case, evaluation is performed by comparing the model's simulation output to time series published by ISTAT, thus allowing for assessment of the accuracy of the model in reproducing historical behaviour of output variables.

By looking at graphical results of simulation for the behaviour of population (Fig. 15) and Labour Force (Fig 16), it is possible to affirm that the model produces a representation of the demographic sector with an acceptable level of approximation, since it reproduces, to a certain extent, the trends in output variables.

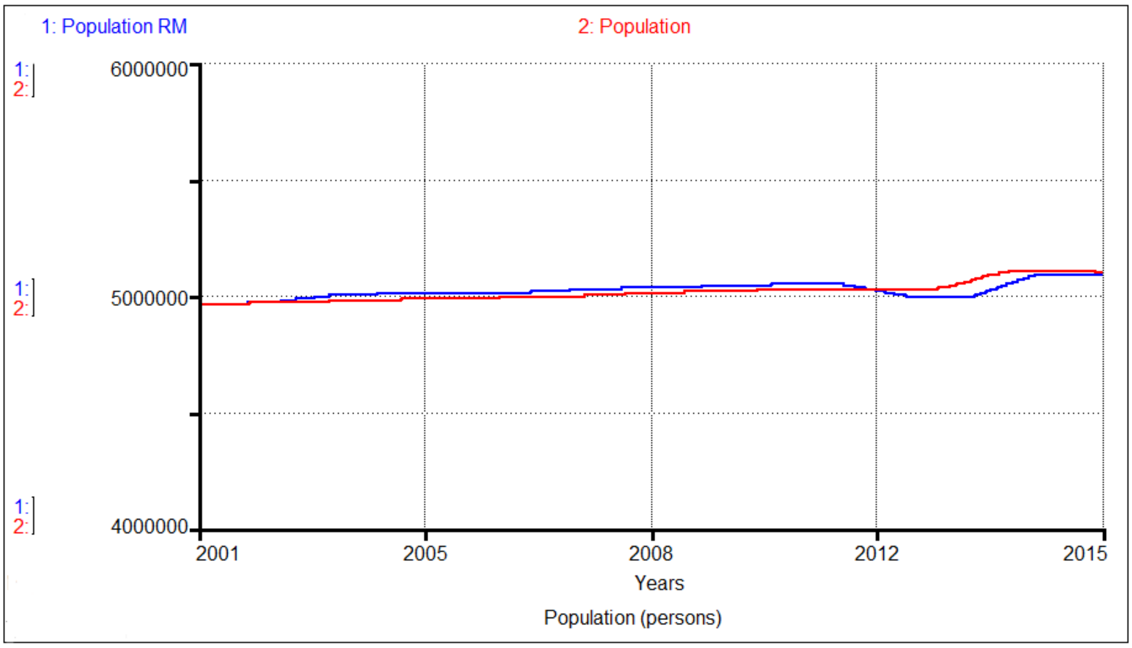

Figure 15 - Behavioural Test - Population

[39] Operational Thinking is meant as the base principle of the system thinking mindset, and offers an analysis approach that is based on the question: *How things work?*.

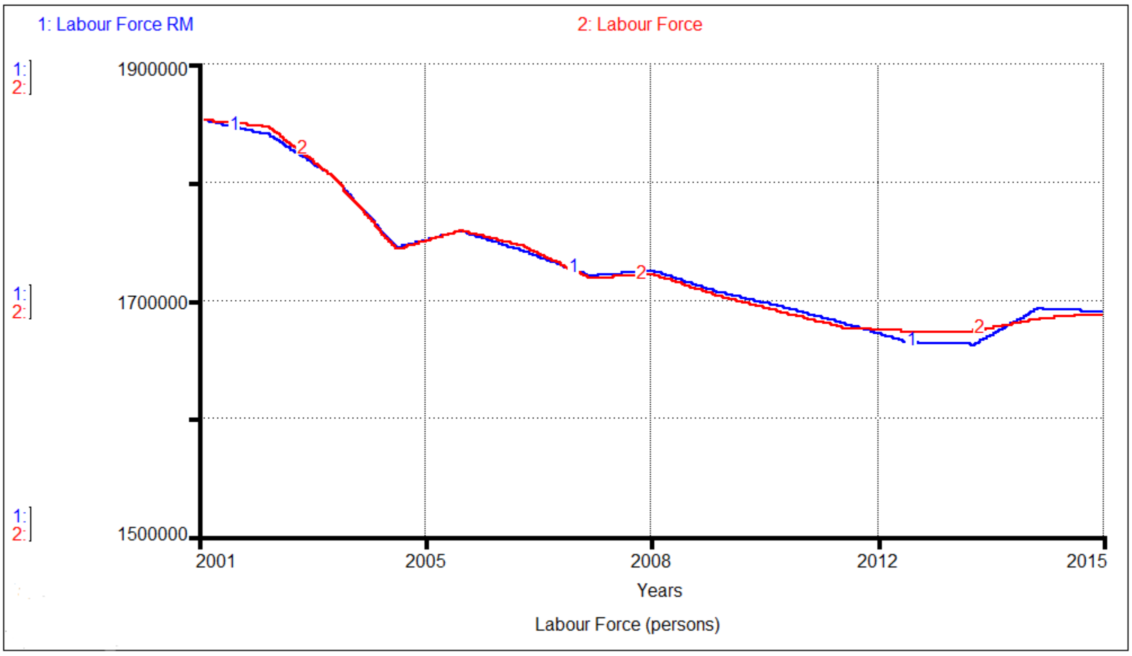

Figure 16 - Behavioural Test - Labour Force

Once the model validity is supported by simulation test, it is possible to use it for investigating the dynamics of the behaviour it represents, by using the model as a tool for producing some conclusions.

From the structure of the model, it is possible to investigate which elements determine the behaviour of the system, and from the simulation and the sensitivity test it is possible to select which factors play a determinant role among all the elements.

Output variables relevant to the research project are thus investigated and results are showed in the next lines.

The variable Labour Force, that affects the employment level (one of the determinants of GRP), is a subset of population. Its behaviour is then affected by the overall dynamics of the Population stock, and also by the participation rate, that acts, in absolute values, depending on the age distribution of population.

Since the ageing of population is a natural phenomenon and its analysis goes beyond the scope of the research, focus is on factors that affect birth flows and net migration flows as the determinants to be further investigated. Those ones can be considered the key parameters governing the behaviour of the stock Population, indirectly affecting the dynamics of the labour force, and thus, the dynamics of employment and GRP.

Up to this point, it is possible to select all relevant parameters, meaning those ones that can be indicated as leverage points to enhance the performance of the system, as it is settled in the dynamic hypothesis: birth rate, net migration rate and participation rate. It is also possible to investigate how the behaviour of the model reacts to variations in those parameters.

However, at this stage, it is not possible to give practical policy's advices on how to affect those drivers for two reasons at least:

1. they are considered as exogenous variables when looking at the demographic subsystem only, meaning that, their determinants are not identified yet;
2. in real world, a change in birth rate, or migration rate or participation rate is not a straightforward process, meaning that a set of more direct and specific policy tools must be identified.

By looking towards the labour force, and how it affects the performance of the system in terms of GRP, that is by determining the employment in local industries, the way is showed towards the second subsystem, the Economic one, where decisions about employment are determined.

3.5.2 Economics Subsystem

The economic subsystem collapses that part of the system that is more directly connected to the production process. It does include all the organizations and agents that play a role in the production game, and is built as a multi-level subsystem: all the organizations or agents are grouped in homogeneous modules, where the same structure can describe the decision making process common to all of the actors within that specific module.

Within the Economic subsystem, the modules identified are BANK, GOVERNMENT, HOUSEHOLDS, REST OF THE WORLD, and PRODUCTION.

PRODUCTION is the only module that has been modelled; other modules are showed as module rather for clarifying purpose than for modelling requirements, because they include only parameters that are treated as exogenous to the whole system.

The first module to be described is PRODUCTION, for the central role it plays in the research project, since it gives as final output the GRP, identified as one of the key results of the regional development planning strategy.

The structure of the model for the Production module and the Industry module that is described in the next paragraph is adapted from Wheat D. and Pawluczuk A. (2014).

GRP is conceptually defined as the Total Value Added of the economy. Since the economy is composed by different industries, consequentially GRP is calculated as the sum of Value Added from each industry.

At the level of our analysis, it is possible to assume the Italian economic system as a market (demand) economy, where production is determined by demand for goods and services, with productivity as external input for the production function, and thus treating the employment and the amount of equipment and structures deployed as dependant variables when resolving the production function.

Variables such as demand, productivity and employment differ among different industries, so different industries adapt differently to same changes in external inputs, thus shaping the structural and behavioural characteristics of the whole regional economy. For that reason, it is considered appropriate to disaggregate the production module in different sub-modules, each of them modelling a specific industry. By treating each industry by itself, the chosen approach does permit to include inter-industry connections when simulating the economic system reaction to possible policies, and then, allows reaching an higher level of detail in analysis.

The whole production system is thus disaggregated in five industries: Agriculture, Manufacturing, Construction, Market Services, and Public Services (fig.17).

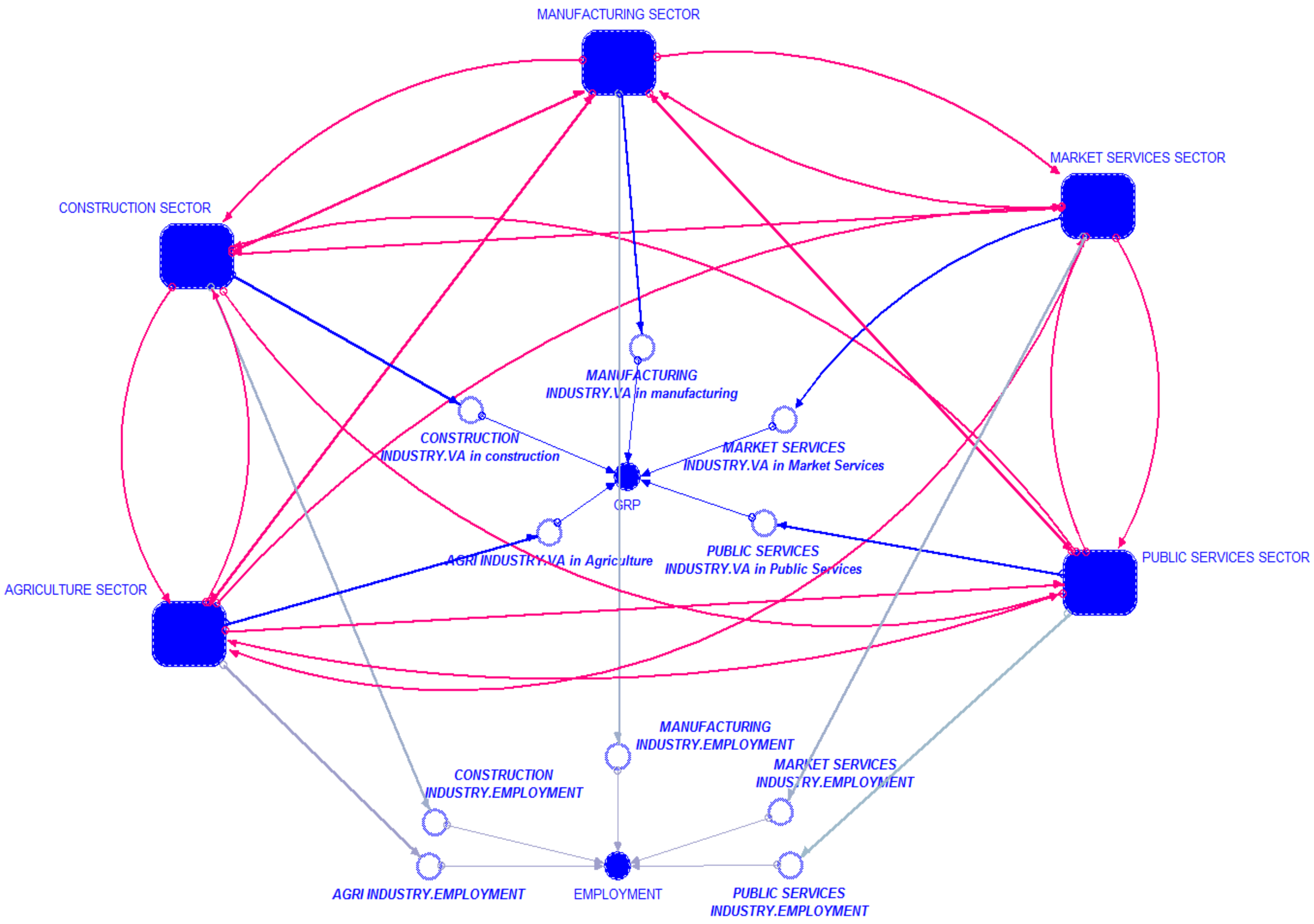

Figure 17 - Production Subsystem

At first, each industry is modelled according to the same structure, but parameters are specific per each one of them, that resulting in different model behaviour coming out from the same model structure.

The choice of the number of industries is determined by balancing two conflicting aspects:

1. The level of disaggregation ought to be enough for the model to be used for policy simulation purposes.
2. The more disaggregated the system is, the more time-consuming will be to dig for data, to estimate industry specific parameters, and to complete the specific industry model calibration and validation.

The chosen level of disaggregation can be considered satisfactory by considering the project as a case study, and by recognizing that it is meant to be used to draw conclusions about the reliability of the final framework for policy analysis purpose. The choice is also acceptable because the model has the flexibility to be easily modified, to allow for further disaggregation, thus adapting to specific policy design and evaluation purposes case by case, without affecting the results of the research project.

Since the first model structure is the same per each industry, hereafter the prototype model for the industry Agriculture is presented. All the industries are fully described in terms of equations in Appendix D.

The modelling solution to include inter-industry connections, derived from the IO approach, consists of including the matrix of direct coefficients as input into the model's structure equation. The integrating method is fully described in the next lines.

The Industry model is a two level system. The first level of the module is showed in figure 18.

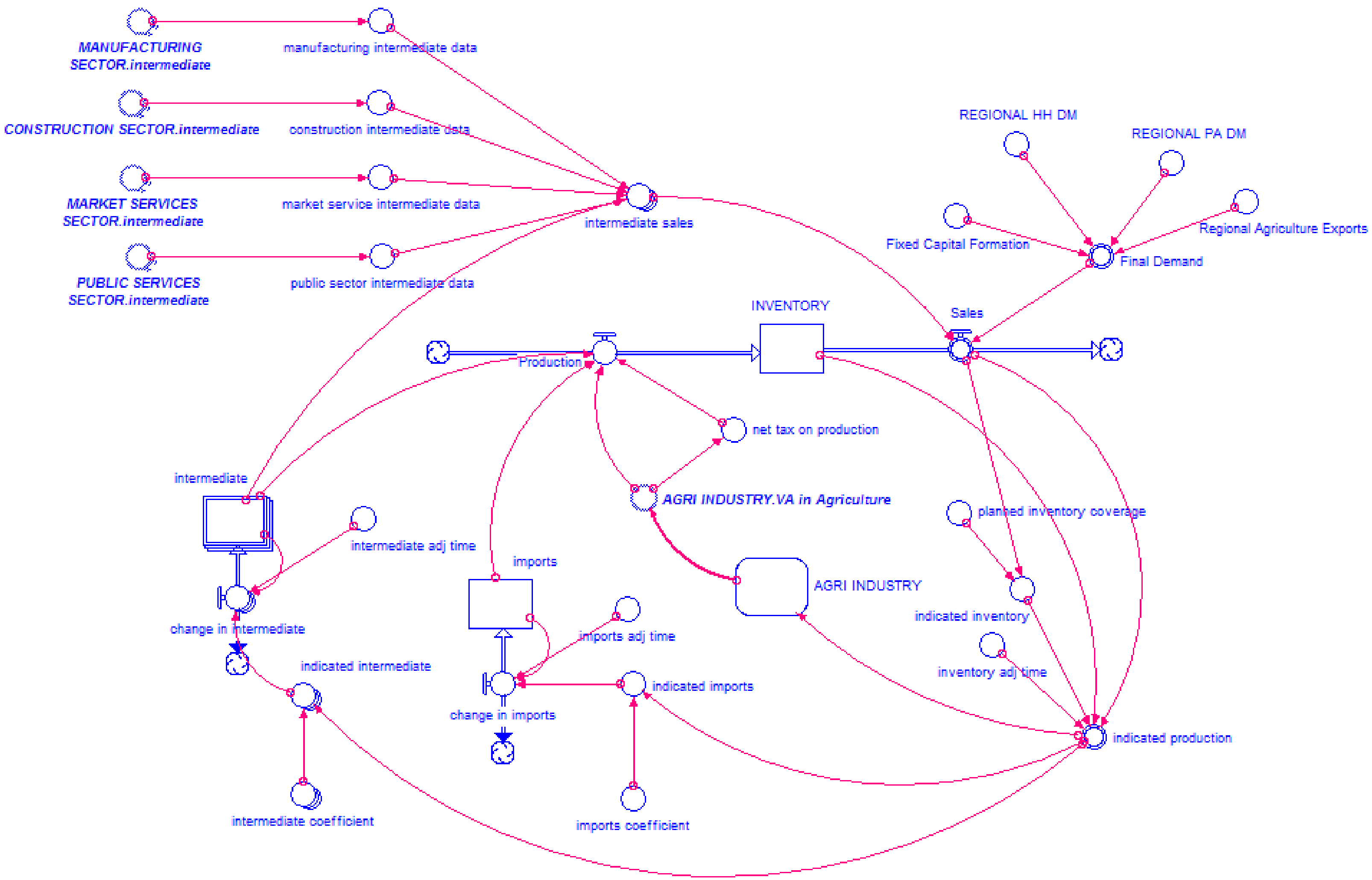

Figure18. Production sub model SFD (adapted from Wheat and Pawluczuk, 2014)

It displays, in terms of stocks and flows, the production process and it shows also the supply-demand balancing structure that is embedded into the IO table. Sales are made up of final and intermediate sales. The first ones are the result of domestic final demand from Households and Government and the demand for export of goods and services from the industry. Since the analysis is performed at regional level, exports include goods and services sold to other regions in Italy, as well as to other nations in the world. The variable is numerically populated with historical values.

The final domestic sales are determined by the total amount of resident population, according to the level of per capita consumption.

The intermediate sales are determined by other industries purchases, depending on their own technical coefficients and production levels.

The production theory, that underlies the structure as it is designed, assumes that each industry has a norm for inventories, which is modelled in the variable named *indicated inventory*. It is a function of a planned coverage of the inventory, and sales, here used as proxy for future demand.

The sum of final and intermediate sales, investment in gross capital formation, and the adjustment to fill the possible gap in between the indicated inventory and the actual one, is the amount that drives the production process, named *indicated production*: all the agents acting on the supply side approximate future demand based on actual sales, and then, based on that expected demand, calibrate their production function in order to obtain that specific output.

Drawing information from the IO table, a specific percentage of demand in the Industry is satisfied by the output generated by domestic labour and capital, measuring the value added coming from the industry. Another part of the final demand is satisfied by imports, and, finally, the remaining part is provided by other industries according to an intermediate input mix that is estimated from the IO table.

The mix of intermediate inputs used by each module is assumed to remain constant over time: this is the consequence of one of the base assumptions of the IO approach, namely, the constant production technology. Letting this mix changing over time can raise completeness of the model, but this step is postponed to further development of the whole model.

Both imports and intermediate purchases are realized with an assumed delay time of six months.

Finally, the value added is determined as output of a second level module, in which all the decisions about the production inputs are taken, namely the level of capital input and the level of labour input.

The core of the production process stays within this module, and value added is determined according to the Cobb-Douglas production function described in paragraph 3.1:

$$\boldsymbol{Y=AL^{\beta}\,K^{\alpha}}$$

Where ***A***, measuring Total factor productivity is an exogenous variables to the model, and $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$, values of elasticity of output to labour and capital, are currently considered constants, and statistically determined per each industry. They sum at 1, assuming constant return to scale.

Figure 19 shows the structure of the model within the prototype industry module Agriculture.

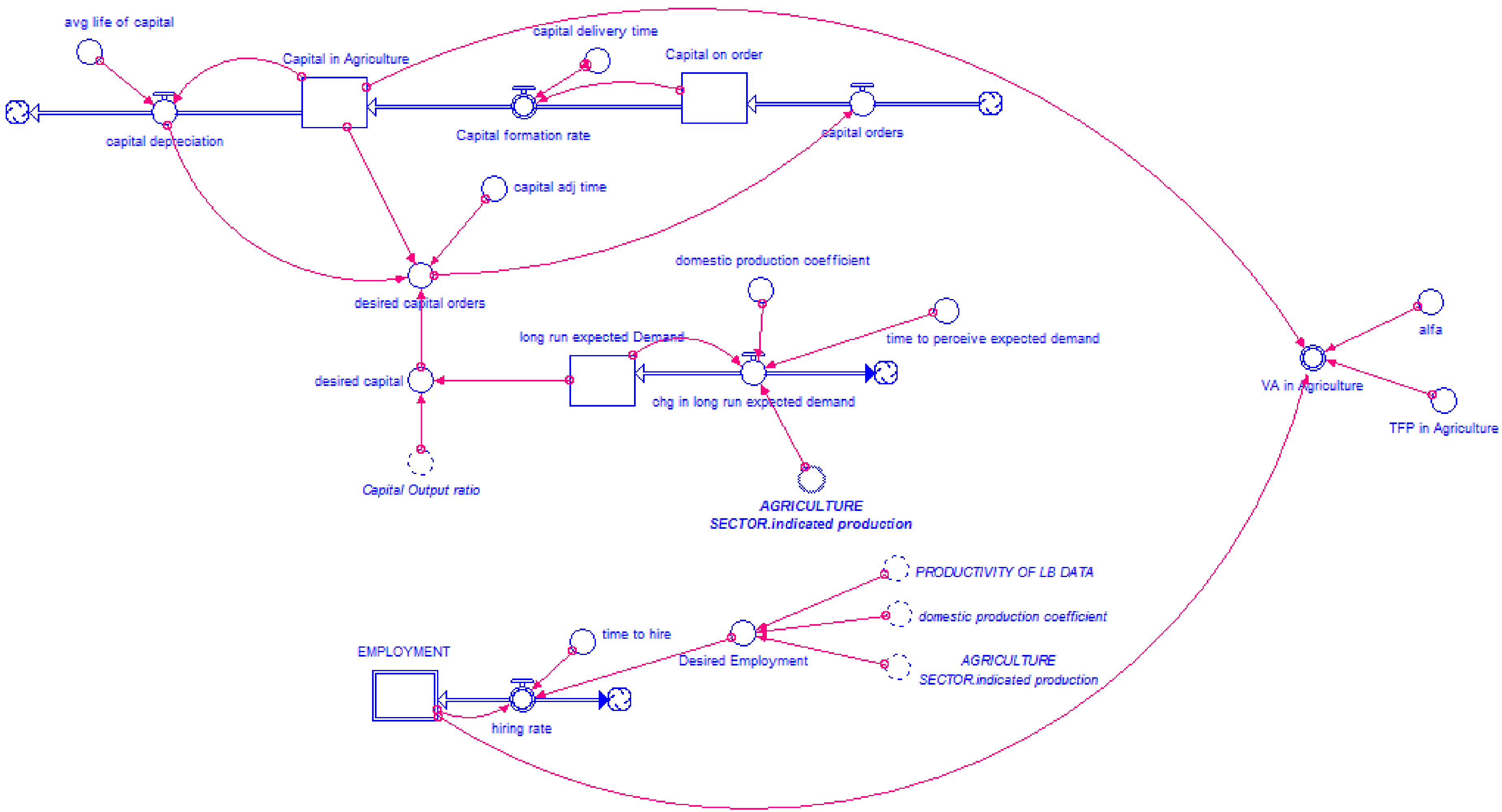

Figure 19- Agriculture Industry Sub model SFD

In the next lines, the structure is described following the operational thinking process that guided the modelling process.

Two main parts can be distinguished: the first one models the flow chart of decision-making process that ends with a final level of capital input, and the second one models the one that ends with a level of employment in the Industry.

The value of all the stocks of equipment and structure in place at a certain point of time in the Agriculture sector is expressed by the level of Capital stock. This value is reduced by the rate of depreciation, whose size is determined by the value of the stock itself and the average life of structures and equipment. The decision to increase the level of Capital reflects in new orders, which generate new capital with a delay introduced by the construction process.

New order's decisions are based upon the decision makers' policy that is firstly oriented to replenish the depreciation rate, and secondly, to cover the gap between the actual level of capital in place, and the desired one.

The decision about the expected output is based on forecasts about demand, adjusted to account also for changes in inventories. Studies[40] show that demand forecasts are usually based upon the historical trend of the variable. For that reason, expressed demand is used as proxy for expected demand. But the kind of expectation that drives capital investments is updated with a certain delay, in order to take into account the usual time horizon for such a kind of decisions.

Once the desired level of output is defined, the amount of capital input is derived from the information of the productivity of capital, measured by a reference value for the Capital/Output ratio.

Before determining the desired capital, the actual value for the Capital/Output ratio can be partially adjusted by considering the opportunity of substituting capital input for labour input.

On one hand, adjustments come from the compared advantage in using capital rather than labour in the production process that is connected to the Labour Cost Index, meaning the cost of the production factor Labour is compared to its productivity.

[40] Barnett W. (1988).

On the other hand, adjustments come from the expected cost of factor capital, which is related to the average duration of capital and the interest rate, measuring the cost of the money invested in capital.

The second part of the model describes the process that leads to the level of employed people within the industry. Every equation is designed to take into account a specific decision rule process that decision makers consider.

Actors in the industry decide the number of people to be employed, whose value is expressed by the variable *Desired Employment*, combining information about total output that decision makers aim to obtain, and the productivity of labour, measured in terms of *output per worker ratio*. This ratio is partially adjusted to consider the Labour's share index, which synthesises the relationship between cost of labour and labour's productivity. The meaning for such a decision rule is that decision makers choose the number of employees not just based on their productivity, but also considering labour's cost: when the labour's share index decreases, meaning that labour's cost diminishes compared to its productivity, then the variable desired employment is adjusted in an increase.

Once the choice of the desired number of employees is expressed, the labour market reacts to a possible difference between the desired number and the actual number. If desired employment diverges from the number of employed people in the industry, the hiring process takes place to close the gap, with a certain time delay caused by the recruiting process, and the training process of the new employees.

Finally the labour input and the capital input feed into the production function, together with the Total Factor Productivity, determining the value added from the Industry.

The value added and the employment values from every single industry are added to determine GRP and Employment for the whole regional economy.

The sum of Value Added, Intermediate Input from other industries, and Imports gives the value of the total Production of the industry.

Total output will enter an idealistic regional industry inventory, and from there, the available output will satisfy requests from the demand side, measured by the sum of Final Domestic Demand, Intermediate purchases expressed by other industries, Exports and Gross fixed capital formation, with a certain amount of output remaining for satisfying inventory's adjustments requirements.

Finally, the whole model is obtained by activating the main feedback effects crossing the two sectors, demographics and economics.

Specifically, the interaction between the demographic sector and the economics sector passes through demand: total population determines the final domestic demand, from which the entire production process starts. It is important to note that, at this stage, the industry- mix of demand is assumed to remain constant over time: this assumption can be considered valid according to the time-horizon of the model.

Furthermore, from the population sector, and specifically from participation rate, we get the labour force, that acts as a limit to the employment process.

3.6 Testing of the model: structure and behaviour

Once the model structure is defined, evaluation of its consistency is processed, in order to assess the model robustness, and thus its reliability to be used as simulation tool. The testing process is designed according to the SD modelling literature[41].

Regarding the structure of the model, performed tests covered the following aspects:

- Boundary adequacy Test
- Model structure Assessment
- Dimensional consistency Test
- Parameter assessment
- Extreme conditions test

The model resulted robust under all the aspects that are tested for the model structure evaluation. Results are reported in appendix A.

The second testing phase addresses the dynamic behaviour of the structure: the behavioural response of the model is analysed by letting the system reaching a steady state equilibrium and checking for its reaction to the so called extreme conditions. This

[41] Forrester J. W. and Senge P. M. (1980), Barlas Y. & Carpenter S. (1990), Barlas Y. (1996).

kind of conditions is characterized by very high or very low values for input parameters, and, in order to prove consistency, the model ought to show a coherent behavioural change. The results from the validation tests of the model's behaviour are reported in appendix B.

After concluding the validation process, it is possible to answer the first and the second research questions.

By analysing the structure of the system, and specifically the results coming from the sensitivity tests, some information can be provided as regard the actual structural shape of the regional economy.

The industry – mix of the GRP gives insights about the extent to which the regional economy relies on a single specific industry.

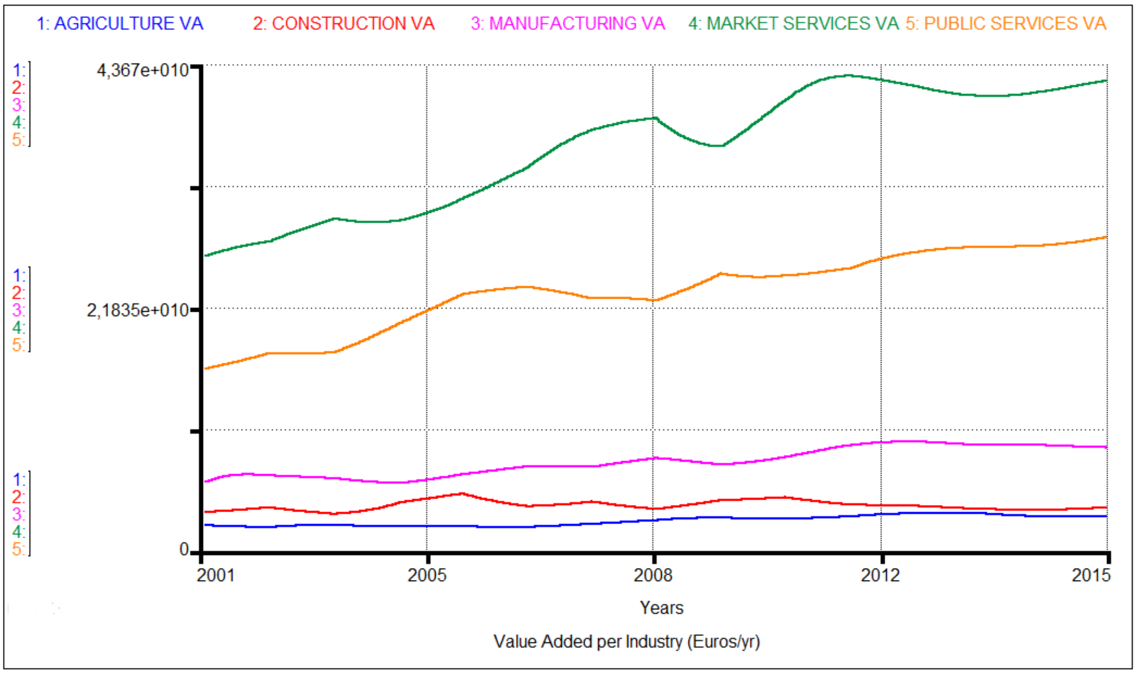

Figure 20 - Value Added per Industry - Simulation result 2001-2015

As the graph shows, the economy in the region is mainly based on the Market Service Industry. The consequences in terms of development are linked to the great dependency of the Market Service Industry from the dynamic of the population. The effect acts along two directions. From the demand side, the request for market services' output is reliant on the consumption expressed by the population: with no change in the condition of the model, it is possible to state that the forecasted demographic decline would highly affect the industry. This assumption is to be coupled with the information obtained by the Inverse Leontief, read on reverse. By knowing the possible dynamics of the population, it is possible to quantify the demand for the industry market services. Any differences from the previous level can be assessed in terms of effects on other industries.

The additional information gained from applying a SD model, compared to the static analysis of statistical data, is obtained thanks to the possibility to display the behaviour of the forecasted analysis.

The timing by which the effects pass from the population towards each industry, and between the industries, can be grasped by the simulation.

Going further on the analysis, information about the main feedback loops that determine the behavioural pattern of the system can be gained; by testing the parameters that govern those feedback loops, the dynamic feature of the model can display its benefit. By simulating the behavioural pattern of the model reacting to changes in policy levers, it is possible to point to the more efficient ones, allowing to identify the policy levers to which the model is more sensitive.

By looking at the big picture of the model, it is possible to connect the dynamics of the two main sub-models: demographics and economy.

As we already explained, demographics is able to affect economics sector by means of Households Demand for goods and services, that, given the specific features of the regional economy under analysis, is the first driver of the production module.

The population’s behavioural pattern is mainly influenced by the value of the parameter Total Fertility Rate.

It is possible to assume that the Total Fertility rate, when it is at such lower level, can be pushed higher by an increasing perceived well-being that has been modelled using two variables as proxies: Unemployment rate and Per capita Income.

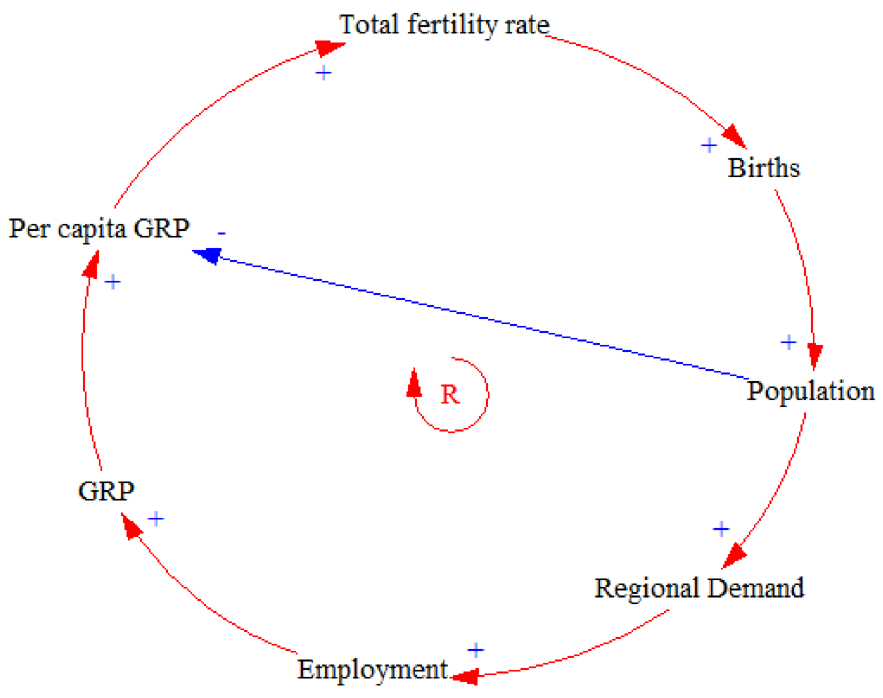

Figure 21 - Economics - Demographics reinforcing loop

The main reinforcing loop described in figure 21, describes the feedback loop responsible for the dynamic that the Sicily Regional System shows in the medium and long run.

The model, as it is specified so far, doesn't allow for a detailed design of public policies. Nevertheless, some simplifications may be accepted in order to show how the framework can effectively support the government planning action.

One of the potentialities of the model is to measure the cost-benefit effect of a possible policy, designed to target a certain variable. Simulation is used to shows the values for the target variable with and without the policy in place. The differences between those values, along the time horizon we are observing, give the measure of the benefits, and by comparing those benefits to the invested resources, the policy evaluator can reply to the question about the convenience of the policy implementation.

The second major potentiality of adopting an SD model for policy design and evaluation, is that, by considering the structural feature of the system where the policy is to be implemented, SD simulation points to potential implementation problems, or side effects connected to the policy implementation. In such a way, SD methodology allows for accomplish policy design in an experimental context, in a kind of sector, such as economics and social science, where real life experiments are quite expensive, and sometimes impossible to perform.

In order to reply to the second research question, a hypothetical public policy is designed, in order to test different reactions in the model behaviour, under different policy scenarios.

The numerical test described in the next lines is an example of using SD for policy design and evaluation purposes.

More specifically, an hypothetical policy consisting of public incentive to investment has been chosen. The policy chosen can approximate the European and national policies' framework actually in place. Being those policies funded by resources that are mainly external to the region, the solution for the simulation is to add resources to the model by means of the export variable. In such a way, the external resources are introduced into the system on the demand side.

The different scenarios are designed to simulate a different mix of sectors receiving those incentives. With the IO approach integrated into the model, the results per each scenario include the multiplicative effect, as it has been described in paragraph 2.2.3.

By hypothesizing an injection of 500 million Euros into the system, on a time lapse of 5 years starting in 2016, the results in terms of per capita GRP can be showed on the simulation time horizon of 10 years.

The net benefits for the investment within each scenario are graphically measured, and comparisons between different scenarios are provided.

In figure 22, line 1, the blue one, shows the pattern of per capita GRP when the injection addresses the Agriculture Sector, and so on, line 2, the red one, traces the pattern for Construction, line 3, the pink line, for Manufacturing, line 4, the green one, for Market Services and line 5, the yellow line, for Public Services.

The results show that Construction Industry, line 2, performs better as catalyst of the public fund injection, compared to other scenarios. According to the multipliers calculated from the Leontief Inverse, the results seem to confirm the IO analysis.

The simulation tool allows investigating the dynamic aspect of the multiplier effect: for instance, the Agricultural industry reaches the higher level both for GRP (fig. 23) and for per capita GRP (fig.22) faster than the other industries, but, in the long run, the effect is rapidly lost.

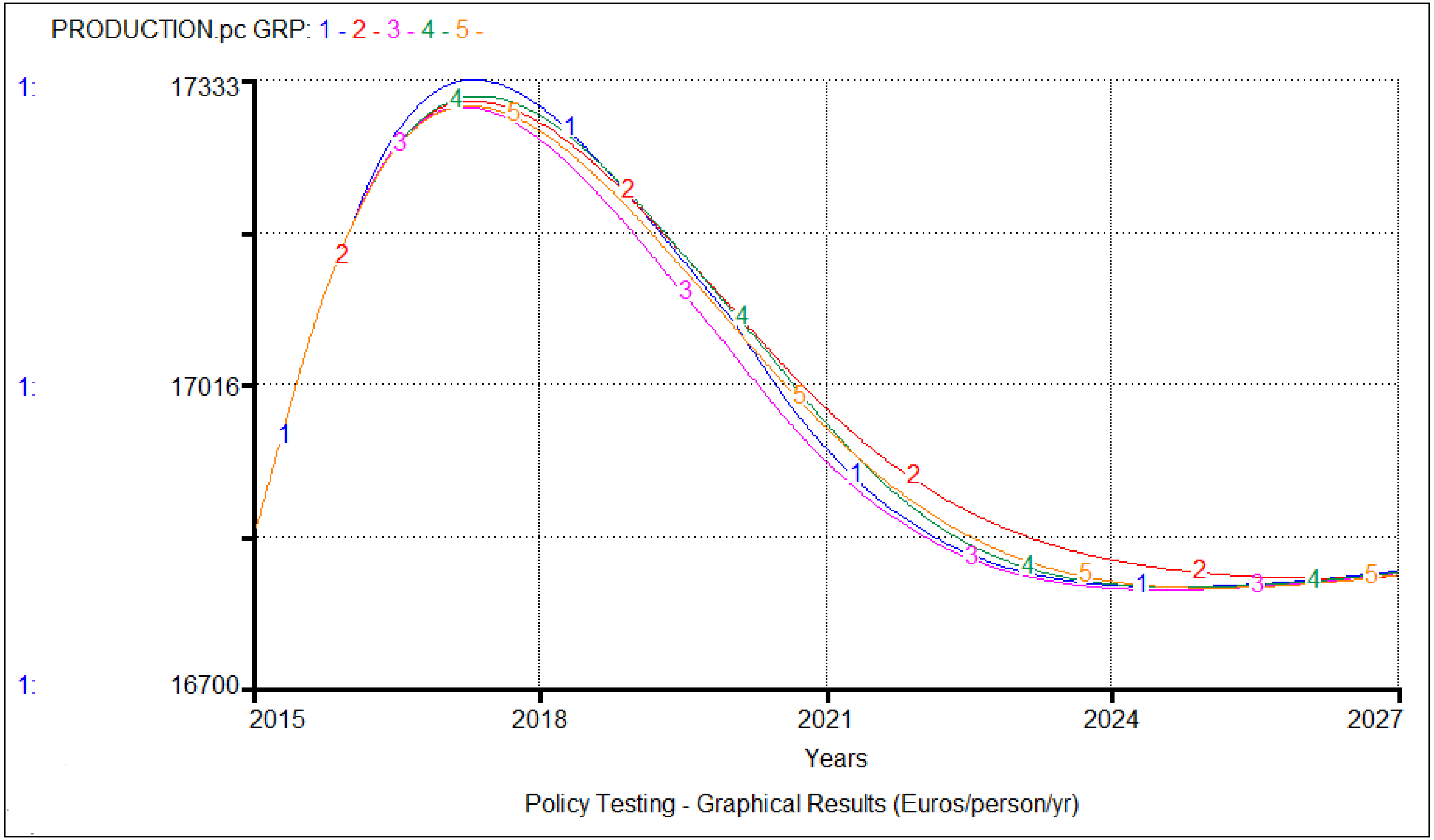

Figure 22 – pc GRP Policy Scenario Analysis - Graphical result

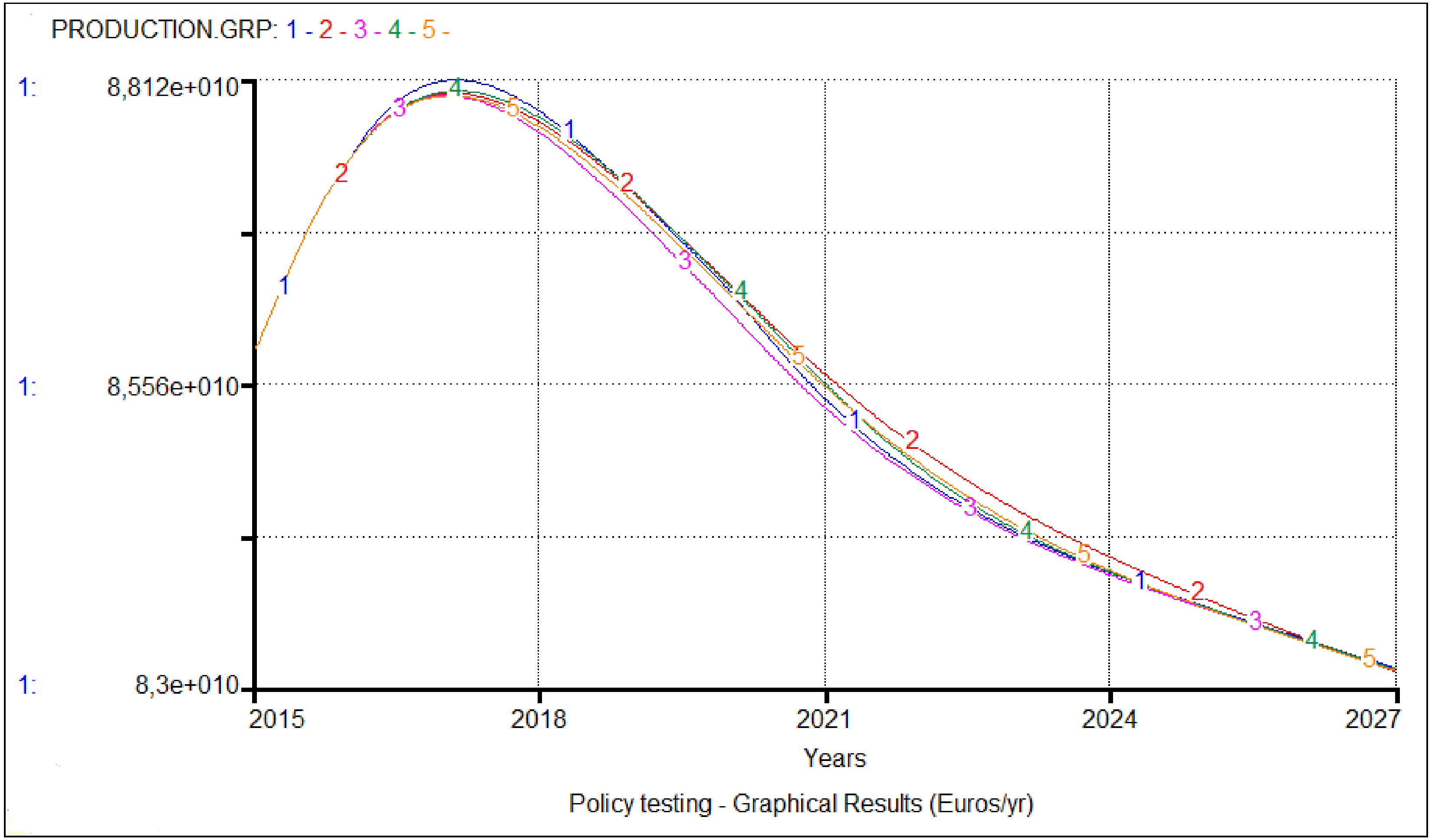

Figure 23 - GRP Policy Scenario Analysis - Graphical result

In this case, the endogenous character of the growth process that follows the stimulus can be recognized in the multiplying amplitude given by the inter-industry connection.

Nevertheless, a public policy that acts on the demand side appears not to be effective in slowing down or diverting the behavioural direction of GRP, or Population. The reason may be connected to the fact that the feedback loop determining the depletion of the population stock is more powerful compared to the endogenous stimulus given by a feasible injection of public resources. In this sense, it is better to point to other policy levers, more related to the production module. More specifically, by acting on the productivity, it is possible to reinforce the positive effect produced by increases in Employment level.

An highly disaggregated model would allow for a more precise conclusion, based on a more detailed scenarios' design, but an high precision numerical model is beyond the scope of the research, and the results of the project allow to address the stated research questions.

As regard the answer to the first two research questions, it is important to mention the major methodological gap of the research project. It is connected to the lack of data for the regional level, and specifically, to the lack of an available official regional IO table. In order to perform the project, an approximated regional IO table is estimated, with the indirect method[42].

Nevertheless, also with an imprecise IO table, it is possible to test, and to specify the model framework: once the structure is proved to be robust, it is possible to change the database with a more accurate one, thus producing a more reliable result.

3.7 Integration of SD model and IO approach

This paragraph contains the answer to the third research question: "Does the case study show that the integration of SD method and I-O approach is a useful framework for analysing regional economies?".

[42] Intermediate consumption have been estimated by applying the national coefficients, apart from agriculture, for which ISTAT provide additional disaggregated data. Regional Exports are calculated according to a balancing equation symmetrical to the national one, estimated for the year 2010.

The integration is obtained by including the direct intermediate coefficients determining the purchases pattern of each industry: intermediate inputs influence the output of the purchasing industry, but also the demand side of the same industry and the demand side of all the other industries that produce that inputs.

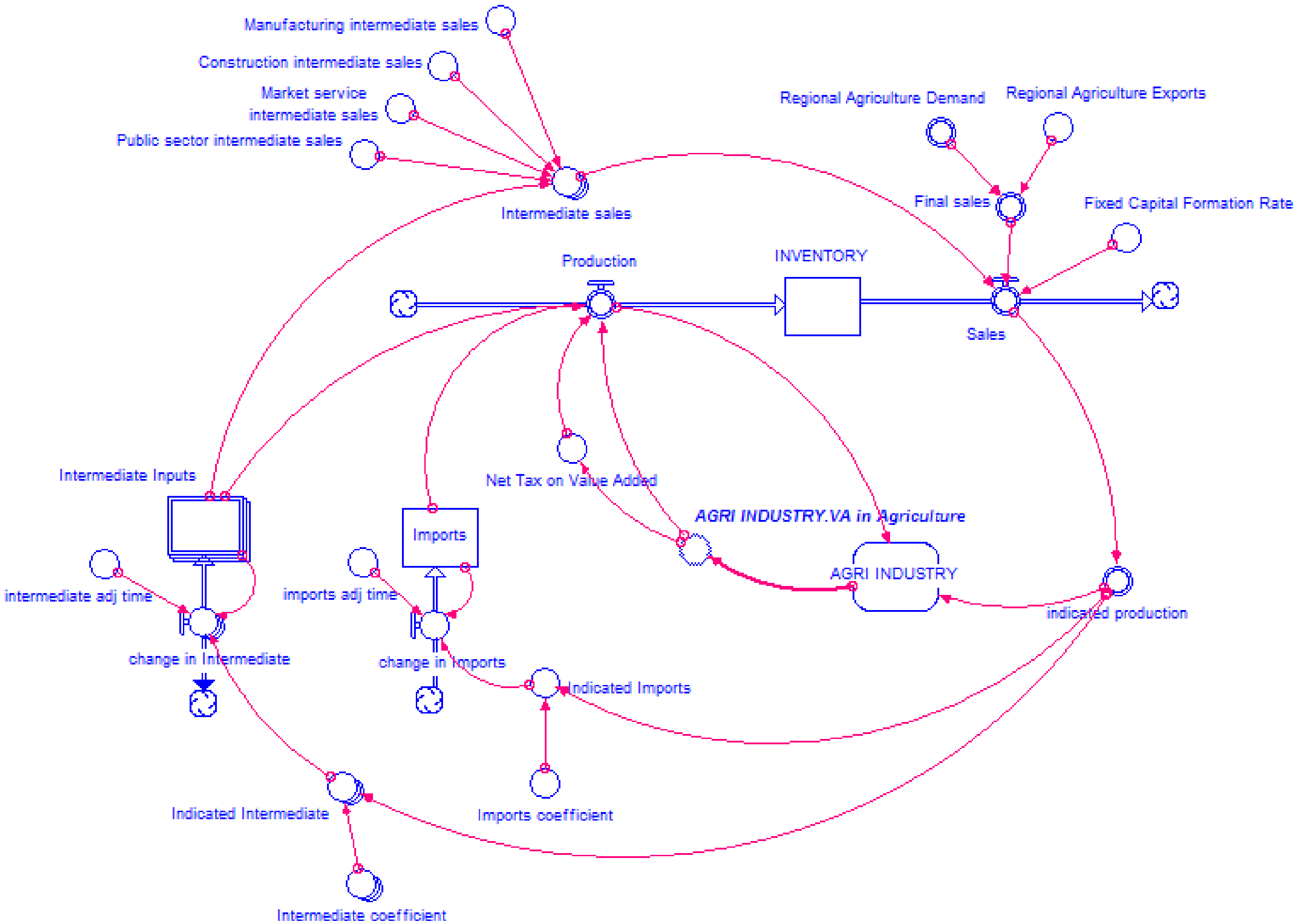

Figure 24 Agriculture sub model SFD (adapted from Wheat and Pawluczuk, 2014)

The figure 24 shows the SFD for the Agriculture module, adapted from Wheat and Pawluczuk (2014), and describes the integration of the direct coefficients into the model structure. The dynamics of the model can be described by following the directions of arrows, starting from the demand side of the structure: Final sales, composed by Final Demand and Regional Exports, sum to Fixed Capital Formation and Sales to other industry, and determine the total agricultural resources consumed by the economy. Based on the sales, the agricultural industry sets its primary inputs (the decision about the deployment of Capital and Labour occurs inside the module named AGRI INDUSTRY) thus determining the Value Added, but also purchases intermediate inputs from other industries. A certain percentage of the production is satisfied by imported products. Production is determined by the sum of Value Added, Intermediate Inputs, and Imports, thus adding to the material stock of Agricultural Products, named INVENTORY. Finally, from the inventory stock, sales of the following period are satisfied.

The answer to the research question comes through a two-steps analysis: the first one addressing the integration method, and the second one addressing the feature of the integrated model as analysis tool.

The first one is connected to the methodological consistency of the integration solution that has been adopted.

In this respect, the consistency has been evaluated in order to assure for the correct integration of the IO approach into the SD model. In order to do that, by stating the same methodological assumptions, the SD integrated model's results are compared to those obtained from the IO table analysis.

The overall model is partially modified to obtain an equilibrium model: by deactivating the feedback effects from the demand side, then the stimulus coming from the demographic sector, by means of consumption, towards the economic sector is set to a zero growth rate. In such a context, the economic sector adjusts the production across all the sectors to an equilibrium point that satisfies the constant sum of consumption, government spending, and investment, with no input limit to the production function: these are the main assumptions of the IO approach.

The initial data feeding the model have also been modified in a way that the equilibrium of the model simulation gives the same snapshot of the system that is statically described by the estimated IO table, based on year 2010.

At this specific point of equilibrium, from the IO table, it is possible to calculate the multiplier coefficients per each sector.

The integration consistency test consists of shocking the model when it is in equilibrium, introducing a single step increase in the demand, by means of the export variable, for one sector at a time. After the shock, the system reaches a new equilibrium, and comparing data before and after the shock, it is possible to calculate the multiplier effect for the industry that has been shocked. By comparing the multiplier calculation from the SD model to the traditional multiplier calculation based on the IO table, it is possible to verify that the addition of the IO structure to the SD model is done correctly.

Table 3 shows the multipliers determined statically from the Leontief Inverse matrix per each sector.

Table 3- Leontief Inverse Matrix for Sicily (base year 2010)

	AGRICOLTURE	MANUFACTURING	CONSTRUCTION	MARKET SERVICES	PUBLIC SERVICES
AGRICULTURE	1.09	0.02	0.01	0.01	0.00
MANUFACTURING	0.25	1.39	0.40	0.18	0.09
CONSTRUCTION	0.02	0.01	1.40	0.02	0.02
MARKET SERVICES	0.13	0.21	0.41	1.44	0.18
PUBLIC SERVICES	0.01	0.01	0.02	0.01	1.05
MULTIPLIERS	**1.50**	**1.63**	**2.25**	**1.67**	**1.34**

Figure 25 shows the graph of the multipliers determined from the results of the model. The multipliers measure the ratio between the amount of the exogenous shock addressing a single industry, and the difference between Production variable values of the overall economy, at the initial equilibrium, and when the system reaches the next equilibrium state. The shock consists of adding 100 million Euros to the constant value of Regional Export Demand variable. It is induced in year 2045, in order to let the model reaching a steady state before the shock occurs, thus assuring a more accurate calculation of the effect of the shock.

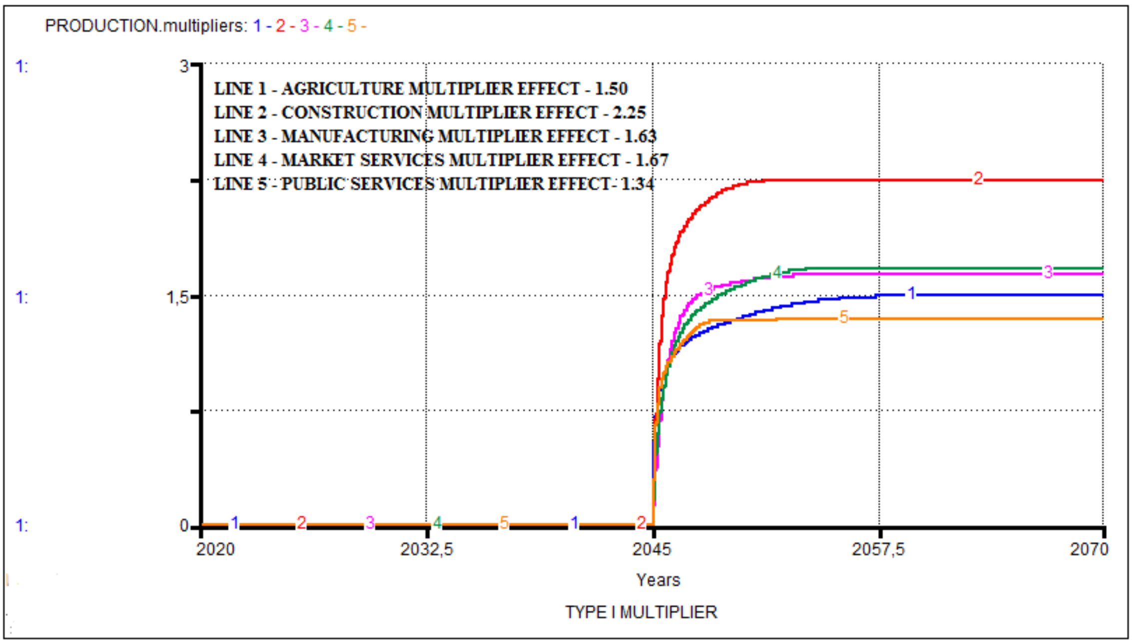

Figure 25 - Graphical result of Integration test

The multipliers determined based on the solution of the model are equal to those determined from the Leontief Inverse based on the inter-industry table.

It is possible to state that the SD model replicates the same solution of the IO table, thus assuring the correct integration of the two methodologies.

Once the consistency of the integration process between the two methodologies is assessed, the second part of the answer to the third RQ passes through the consideration of the additional contributes of such an integrated model, compared both to the SD models and to the IO models.

Since IO methodology's usefulness is already widely recognized by professionals and academics alike, the attention is focused on the limitations of the approach, and the way those limitations are soften or eliminated by the integration of the IO concept into the dynamic modelling framework provided by the methodology of System Dynamics.

The key constraints in the traditional IO models rely in the assumptions of fixed technology, fixed combinations of capital and labour inputs, fixed prices, surplus factors of production, and lack of consideration of induced feedback effect on the demand side of the economy[43].

By integrating the IO coefficients into the SD model, it is possible to model the structure that designs the context in which inter-industry connections happen. Then, the

[43] Wheat I. D., Pawluczuk A. (2014).

final integrated model is able to account for capital and labour shortages, thus limiting the production system's expansion in response to increases in demand.

Also, it allows for changes in the combination of labour and capital, with consideration of productivity levels, and relative prices of production inputs.

In fact, the changing costs cause prices to change in the model, but the dynamics of the change are specific per each sector.

Moreover, the overall feedback structure of the SD model, allows for variables such as consumption, government spending and investment to change over time, as a response to multiple stimulus, rather than a static induced effect as they are modelled through the IO table.

The contributions may be found also the other way around: a System Dynamics Regional Model implemented to perform impact analysis, without considering the inter-industry linkages obtained through the IO table integration, is unable to show how the same shock, in terms of amplitude, can produce different results when targeted to different industries.

Apart from the advantages already mentioned, another one is provided by using the SD model for assessing the responsiveness of the system when a specific industry is stimulated. In fact, when the aim is to evaluate which is the sector that gives the better response to the stimulus, and both methodologies are used in a parallel way, it may be that both models point towards the same direction, in terms of which industry has the higher power to activate the economy, but the IO multipliers resulting from the application of a static model, give no information about the pattern of the dynamic response, that is significantly affected by delays intrinsic to the dynamic system[44].

Synthesizing the results of the analysis, it is possible to assess that the integration process leads to a more complete analysis tool. The integrated model does not show some of the limitations of the IO traditional approach, namely fixed prices, fixed combinations of capital and labour, fixed technology, no account of induced effects on the behaviour of consumers, governments and investors. It also amplifies the potentiality of SD methodology used for modelling regional economy context, allowing for an higher disaggregation, and thus an higher accuracy of the analysis.

[44] Wheat I. D., Pawluczuk A. (2014).

The only assumption at the base of the IO model that stays in the integrated model, at this stage, is fixed technology governing the industry-mix of intermediate inputs. In fact, the intermediate inputs are allocated from each Industry sub-model to all the others, according to the proportion given by the technical coefficient from the IO table. Those coefficients are taken as exogenous variables and kept constant during the time. As it is already been noted[45], fixed technology is not eliminated in such a model framework, but SD additional features allow at least to relax the rigid production process assumption: in fact, most of production is generated by labour and capital, that are determined endogenously from the model structure that adjusts production inputs also to account for changes in productivity and prices.

Under the methodological point of view, one of the critical point in the integration process lies in the consideration that technical coefficients express the level of technology adopted in the production processes within each industry, but at the same time, the technological factor appears in the model structure when the production function is modelled, by interacting with other primary input to generate the value added. Nevertheless, the two concepts of technology are intrinsically different. Technology embedded in TFP is a general concept of efficiency, disconnected from the employed factors. On the other hand, technical coefficients are expressions of the shape that production technology assumes: the same level of technology for the production process can be obtained with different mix of intermediate input. For this reason, it is fair to say that the model is consistent in respect to that point, even though TFP and Technical Coefficients are both included as exogenous variables, the structure is coherent to the theoretical meaning of both concepts.

The possible pathways for the future development of the model could focus on modelling the determinants of the purchases patterns of each industry, including them into the boundaries of the model in order to make the technology inherent the technical coefficients an endogenous parameter.

4 IMPLEMENTATION OF THE IO-SD INTEGRATED FRAMEWORK MODEL FOR SICILY

[45] Wheat I. D., Pawluczuk A. (2014).

4.1 Introduction

The previous paragraphs widely describe the model framework, the benefits in terms of knowledge that may arise from its implementation and some limitations deriving from the assumptions of the theories embedded within the model. The next paragraph aims to identify the specific areas where the model can be usefully implemented.

Given its features, the model framework is meant to be appropriately used, both by professionals and academics, every time the focus of the analysis is the regional economic structure and dynamic behaviour, since it provides a simulation tool that can overcome the well-known experimental problems in social sciences, such as economics.

Being a framework model, it allows for modelling additional stocks and flows and feedback structure in order to satisfy specific analysis requirements, with a flexible approach of gradual specification.

The more relevant feature of a model designed according to the SD modelling methodology is connected to the model's ability to detect the dynamic pattern of the system under analysis. For this reason, one of the more appropriate contexts for such a model to be implemented is the public planning process: with a planning purpose, the trend of the main economic variables is conveniently simulated in order to give insights about the possible scenario according to which public policies can be opportunely designed, and evaluated.

In order to make the framework an appropriate tool for supporting design and evaluation of public policies and plans at regional level, during the modelling process, attempt has been made to ensure a comprehensive scope for the model, sacrificing the level of detail. Nevertheless, scope of the research is to prove the robustness and usefulness of the model as a framework, acknowledging the need to further specify the model structure in order to allow for the practical implementation.

Many are the chances in which a detailed analysis of regional economy can support public government, but, amongst them, there is a specific case in which a wide-ranging model for the regional economy is essential. This is the case of drafting the Budget and the Regional Economic and Financial Document (DEFR).

With the aim of pointing out the regional government levels where the implementation of the framework model can be considered appropriate, in the next lines, an overview of the context of the planning cycle and the budgetary policy is presented to explain how the model can be usefully integrated within that process.

The planning process is also analysed under the point of view of the analytical tools actually implemented to support forecasting and simulations.

4.2 The regional public planning cycle

In the recent years, the economic and financial crisis has led to the adoption of European rules in order to gain an higher level of economic policies' coordination amongst European Union Member States. In 2011, the so called "European Semester" is established to coordinate national policies by introducing a new process for evaluating projects of national budget. In this respect, Law n.196/2009 on Public Finance and Accounting, later modified by Law n. 39/2011, introduces major changes in the Italian cycle of planning and public finance documents, by streamlining contents and setting deadlines for submission to align the national planning process and the timing of the European Semester. This new working method consists of discussing economic and budgetary priorities at the same time every year for each EU Member State[46].

One of the main points of the reformed law is a reinforcing of the centralization of the role of Italian local authorities, with a close connection to the implementation of Article 119 of the Constitution (defined by Law.42/2009) in the area of fiscal federalism, meaning an increased responsibility for regional and local governments.

Figure 26 describes the planning and budgetary cycle at regional level, as it is defined by the legislative reform in 2011. It is described by providing an overview of the main documents drafted during the process.

[46] MEF - Ministry of Economy and Finance - Department of Treasury - The economic planning cycle and documents_ from domestic to European rules.

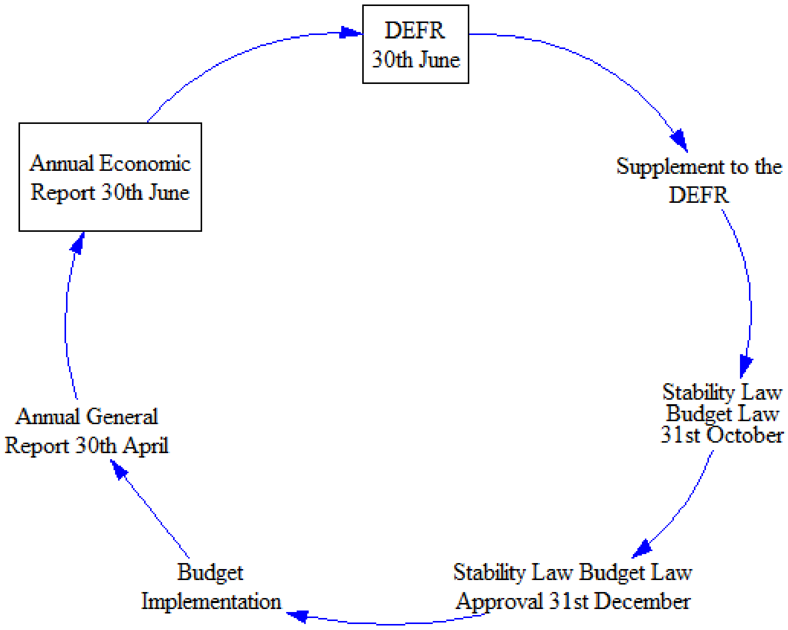

Figure 26 - Planning and Budgetary cycle in Sicily

The economic planning process starts with the presentation of the Regional Economic and Financial Document (DEFR) by the end of June. It draws its main features from the equivalent document at national level (Economic and Financial Document – DEF), and, based on the evaluation of the status and the trend of the social and economic system, at international, national and regional levels, the DEFR contains the general framework in which the regional budget must fit with coherence, both for the annual and the long – term time horizon. In this respect, the DEFR is used to guide the definition and the implementation of regional policies.

By the end of September, an updating note to the DEFR is approved by the regional assembly. The note includes changes that are due to the updates of the macroeconomic and public finance forecasts, the national planning targets, and, most relevantly, the results of the negotiations between the central government and the regional one, regarding the distribution of financial resources, and the matching of European prescription in terms of public deficit and public debt.

On the lines designed by the DEFR, the Budget Law is drafted during the month of October.

Coupled to the Budget Law is the Stability Law: It shows the regional financial compliance with the Stability Programme, that is part of the Stability Agreement signed by EU member states in 1997, with the aim of letting their economies converging towards common economic parameters. Those parameters are mainly focused on the debt – to – GDP ratio, and Deficit – to – GDP ratio. With other words, European government sets the boundaries in terms of planning, results, and eventually, rebalancing actions, thus limiting the national planning and budgetary process.

As a consequence of the big economic crisis in 2011 and 2012, which sees many European members struggling to avoid default, a new stricter version of the Stability Pact is signed, with the aim of limiting the chain of reactions caused by the spreading effect of the financial crisis amongst the European members sharing the Euro currency.

The new Treaty on Stability, Coordination and Governance in the Economic and Monetary Union is also known as Fiscal Compact, to highlight the inflexibility of the budgetary restrictions applied on national decisions, and, consequently, the extent of the limitation of the national sovereignty.

In order to comply with the Fiscal Compact, the Italian Constitutional Law is modified in 2012, and a new general principle is introduced: all the levels of public administration have to respect the obligation for a structural budget balance that is, in other words, the structural balance, corrected for the economic cycle, between revenue and expenditure. As a consequence, the new regulation of fiscal planning and budgeting is introduced to guarantee coordination and control at local level.

The Stability Law approved by the regional assembly includes a description and an assessment of policy measures to achieve the stability programme objectives, the underlying economic assumptions about growth, employment, inflation and other main variables, and, an analysis on how changes in the main economic assumptions would affect the budgetary and debt position. All those information are to be provided for a time span of several years including one year of budgetary execution, the current budgetary year, and the following three-years plan.

The Budget Law indicates expenditures and revenues for the following year based on the current legislation.

The public finance package, including the Stability Law and the Budget Law drafted during the month of October, are approved by the end of the year.

By the month of April, the Annual General Report is approved, showing the results of the regional financial and assets management. It is composed by two documents, the Financial Statement and the Asset and Liability Report. From this report some variations to the budget could derive. Once the annual report is approved, the final budget is set up by the end of June.

The last document to be prepared is the Annual Economic Report, which shows, in a descriptive way, the previous year data, with the aim of supporting the government action. The usual chapters contained in the report are about national economic conjuncture, regional macroeconomic picture, economic activity of the region, demographics and labour market, and public finance.

Along the planning process, many actors are involved. For the purpose of the analysis, the focus is on those steps of the cycle where the regional economic structure and dynamics are investigated to draw up plans and budgets, in order to identify possible users for the framework model that has been designed.

More specifically, two of the steps of the planning cycle (in figure 26, showed in the rectangles) require the analysis of the regional structure with a dynamic approach, namely those activities flowing into the drafting of the Regional Economic and Financial Document (DEFR), and the Annual Economic Report. Both of them are performed by the Statistics and Economics Analysis Service, which is part of the Budget and Treasury Division of the Regional Council Office for Economics.

In order to gain insights about the implementation of the designed framework, the actual implementation of the regional economic system analysis is further investigated, with focus on the models actually implemented and the way the economic system analysis interacts with the overall planning process.

In this respect, possible insights can be obtained regarding potential major benefits coming from the application of the model proposed compared to the models already in use, but also, by analogy, possible implementation obstacles can be detected in advance.

For this purpose, the person in chair of the Statistics and Economic Analysis Service is interviewed.

In the next paragraph, the actual implementation of the economic analysis as part of the government planning process is described. Critical points of the process are highlighted and conclusions are drawn.

4.3 The implementation of the planning process at regional level

From the description of the planning process, it is possible to state that it is essential to assure that all the planning documents are coherent with the regional panorama that the governmental action wants to affect. This requirement is made even stricter by the additional control from the EU.

However, some criticalities emerge when the planning process, described in the previous paragraph, is actually implemented. In this paragraph, the analysis of the implementation of the regional economic system analysis, as part of the regional government planning process, is performed by interviews, which are considered a proper tool for data retrieval for the purpose. Actors involved in the economic analysis for planning purpose are interviewed in order to gain insights about the implementation of the planning process.

With an operational thinking approach, the information gathered by means of interviews is combined with the results from the analysis of published reports and documents.

The choice of fluid and face-to-face conversations, producing meaningful relevant data, particularly relating to the cultural context, sheds lights on the government approach to planning and policy design. The documental analysis addresses the prescribed content, the intention of drafting, and the possible assumptions.

Regarding the DEFR, the document is expected to show how the governmental action aims to affect the regional system. It contains the forecast scenario of the system, shows the planned policies, and gives a picture of the expected results.

The economic analysis performed by the regional government for planning purposes, and reported in the DEFR, focuses on providing reliant forecasts about the economic variables that affect tax collection: namely, GRP and employment. Based on those forecasts, public expenses are budgeted: any variance of the data from the previsions leads to non-compliance with the Stability pact, with consequences in the budgetary policy for the following financial year.

More specifically, the Statistics and Economic Analysis Service defines the forecast about the trend for main economic variables. After the trend has been defined, the governmental action is simulated in order to obtain forecasted variables when the public policy is implemented. The difference between the trend variable and the forecast variable is the effect of the government policies. The intervention of the government for planning purpose is analysed exclusively in the form of public development expenses, consisting of financial incentives, both in current expenses, and fixed capital formation. This expenditure item can be disaggregated over a range of specific policies, addressing specific economic agents, or industries. According to this breakdown, the government action unfolds its effect on the regional system, and previsions on variables such as GRP and employment, based on the forecasted response of regional actors to the government policy, set the boundaries to the regional budgetary policy.

All the information about the articulation of resources among different policies, and the responsiveness of the regional actors to those policies, is gathered from another Service in the Budget and Treasury Division: the Budget and Programming Service.

There is no feedback from results in terms of forecasts and simulation towards the policy design process, and, furthermore, it is difficult to detect any kind of active coordination among different services involved in the planning process. The forecasted variables only affect the budgeting of public expenses, in a linear planning process.

Moreover, there is no proper analysis of the variance of forecasts from the actual data, with no feedback from the accuracy of the forecasts to the forecasting process.

All the attention is drawn by the possible divergence between the forecast resources coming from tax collection, and the actual data. The analysis of the causes for such difference is not performed and the policymakers involved in the planning process are confident in pointing to a single specific cause for the malfunctioning of the planning cycle: the negotiation process about resources' allocation between the national level and the regional level of government.

More specifically, every financial year and according to the national budget balance's obligation, the central government applies a public finance rebalancing contribution to the regional budgets. The amount of the contribution may vary according to the specific requirements at central level, and, even though a negotiated agreement between the national and the regional policymakers is fostered by law, it is not compulsory.

As effect, the regional resources may be withdrawal to satisfy national needs, and the budgeted expenses may be left uncovered, thus generating a deficit at regional level.

As a reaction to the fact that the contribution to the national budget balancing is not a policy lever for the regional government, and that it cannot be budgeted or, generically, driven to reach some results, the actors involved in the planning process miss the causal links between the performance of their single planning activity and the overall performance of the policy and budgeting process. The amount of the contribution is the result of the regional negotiating power, and the constant divergence between the forecast and the actual collection of resources, leads the regional governance to stop relying on those previsions for budgeting the expenses.

In this respect, more often in the recent years, the analysis from the Statistics and Economics analysis Service is simply oriented towards the drafting of the Annual Economic Report and the DEFR, in order to comply with the prescribed requirements; the forecasts of regional tax collection for budgeting purpose are carefully anchored to actual data on tax collection, and they are mainly based on statistical prediction inference, with quarterly updating. The analysis is performed by another Service of the same Division, the Treasury Service, which manages the regional tax collection process.

Furthermore, as it is confirmed by the person in chair of the Statistics and Economic Analysis Service, the lack of interest in analysing the previsions inaccuracy, with no aim of improving the performance of the analysis, has a side effect. When the forecast errors are recognized by the policymakers, the only kind of reaction that has been showed is a formal complain about the numerical divergence, that addresses the person in charge of forecasting, and no room is left for analysing the causes of the variance. As a consequence, the human resources involved in the forecasting process are discouraged from any attempt to fully understand why the forecasting is inaccurate, and also, there is no incentive in looking for a more efficient alternative to the actual process.

With the purpose of drawing conclusions from the considerations resulting from the investigation of the development strategy implementation at regional level, main results are schematized as follow:

- “Government spending on development” is the only policy lever tested for assessment in the planning process[47];
- The effort of the economic analysis is bounded to the legislative requirements, or to support the approval of policies already defined, or, sporadically, to evaluate the effect of policies already implemented;
- The lack of consideration of the essential links among policy, planning and budgeting is confirmed by the absence of a constructive dialogue that would assure the essential coordination[48] between the Services involved in the development process.

To fully analyse the implementation of the regional planning process, the research choice is to further analyse the methods and the models used for forecasting and for supporting policy design, in order to better evaluate the model framework proposed from a practical point of view.

4.4 The Multi-sector Econometric Model for Sicily

The economic forecasts for public planning purpose at regional level are provided by applying a Regional Multi-sector Econometric Model for Sicily (MMS)[49], designed by the Italian company PROMETEIA SPA.

In this paragraph, the main features of the model are presented and the implementation process is further described, in order to drawn considerations about the comparison of the two models both under a methodological and a practical point of view.

The MMS is an econometric model that integrates the IO coefficients to account for the inter – industry production interconnections.

By means of statistical methods, the econometrics estimates the coefficients of the equations that describe the statistical relationship between the various economic quantities. In the simplest terms, by measuring the past relationships among variables

[47] There are also public interventions structured differently from “spending on development”, such as the Business Tax Credit Law, but those measures are considered as standing alone rather than part of the planning process.
[48] Bianchi C., Peters B. G. (2016).
[49] Guagnini M., Nobile G. (2008).

such as consumptions, household income, employment, production and so on, using an econometric model it is possible to forecast how changes in some variables will likely affect the future trend of others. In this sense, econometric models are also used for forecasting.

An econometric model will never predict values for all the variables of all the equations: some of the variables are determined outside the "boundaries" of the model, since the model does not include the equations for determining those variables. Consequently, when using the model for forecasting, the modeller needs to use the best available economic judgement about exogenous factors. Consequently, economic forecast based on econometrics can be wrong for two kinds of reason: the first one is related to imprecise assumptions about the trend of exogenous variables (input errors), and the second one is related to the fact the econometric equations are only statistically – determined approximation to the truth (in this case, they are known as model errors).

Regarding the model used for analysing the Sicily Economic System, it consists of 136 stochastic equations and 396 identities of different kinds (e.g. balancing relationships, variables modifications, and so on). For the parameters estimation, the model manages almost 1000 historical series as inputs, and generates endogenously 400 series more.

Such a broad data base and such a vast model specification can only be managed by means of an econometric program. The MMS is programmed with a FP program[50], built by Ray C. and William R. Parke in 1980, available online. It is written with FORTRAN programming language.

It has not been possible to have access to the detailed list of equations, but the overall logic underlying the model is synthetically described[51].

It is possible to identify specific blocks of equations composing the overall model:

- The Final demand block: it includes all the equations related to Households Consumptions, Government Spending, Fixed Capital Formation, Exports.

[50] FP software and the informative materials are available online at http:/fairmodel.econ.yale.edu.
[51] All the technical and theoretical information about the MMS model are gathered from Purpura A. and Musumeci M. (2011a); Purpura A. and Musumeci M. (2011b); Guagnini M. et al.(2010) and Guagnini M. and Nobile G. (2008).

- The Intermediate demand block: it includes inter – industry relationships based on the regional inter – industry table.
- The Production and Employment block: it includes equations of value added, income, productivity, and employment.
- The Prices block: It includes equation about Consumer Price, and Producer Price.
- The Accounts and Accounts' Closures block: it includes equations related to the Supply and Use Table, distribution of GRP, Households Disposable Income, and an aggregate representation of the Labour Market.

A further note is needed to describe the way interregional exports are measured. In fact, official statistics are not available for the flows of goods and services at interregional level. In Italy, there is a private company that can provide estimated data about regional IO tables accounting for interregional commercial connections, for all the Italian regions: PROMETEIA SPA[52]. The same company is the one that provides the Multi-sector Econometric Model for Sicily.

The available documents allow to explain how interregional imports and exports are estimated: interregional data are defined based on identities linked to national production levels for each industry.

Unfortunately, for the modelling of the regional framework it was not possible to have access to the IO table for Sicily estimated by PROMETEIA SPA: although the table is integrated in the MMS used by the regional government, data from the table are not made available to the Statistics and Economics Analysis Service directly.

As for the integrations of the IO approach with the econometric model, it is reached by a dense integration between the equations' block explaining the dynamics of the main economic variables, and the model block that determines the production of each sector, based on the inter – industry table, from which intermediate demand is inferred.

The forecasting procedure can be described as follow:

- The determinants of Final Demand (Consumptions, Investments, Exports, etc.) are determined based on econometric equations estimated on historical series from official national accounts.

[52] www.prometeia.it

- The Production and the Value Added are determined by applying a regional IO table to the Final Demand evaluation.

The two blocks of equations are solved simultaneously, thus giving the solution to the model, that consists of the set of values for each variable included in the boundaries of the model.

Performing the model consists of assigning the values to the independent (exogenous) variables, then obtaining the values for the dependent ones (endogenous). The core of the model, consisting of stochastic equations, is linear, and the dynamic structure is simple, then the solution of the model is straight forward.

Furthermore, an attempt is made to specify the model in a dynamic manner: the dependent retarded variables[53] feed primarily into the equation of explanatory variables, in order to make the simultaneous relationships as complete as possible. For this reason, some static equations are introduced into the model, thus influencing the short-run previsions accuracy.

In most cases, the equations of the model are formulated by logarithmic transformation. Then the coefficients of the explanatory variables can be easily interpreted as elasticity. Those values are tested in their coherence both to the theory and to the empirical evidence.

The difference of the model structure compared to other previous hybrid models stays in the fact that the single – sector production is usually determined from the final demand, by applying the coefficient of the Leontief Inverse. In the MMS, the process is partially different: by means of the Inter – industry table, the Total Demand is estimated for each industry (Final demand plus Intermediate demand), and the value enters as input into an econometric equation that gives the Value Added as result.

The reason to perform an indirect evaluation of the production level is explained. The choice of using the coefficients of the Leontief Inverse brings major approximations compared to the combination of the direct coefficients from the IO table and the econometric equations determining the value added.

Those approximations are partially connected to the timing of the regional IO tables, and the lack of disaggregated data at regional level (e.g. the use of national

[53] The retarded variable is the value of the variable at the preceding time.

deflators for the reference year IO table). In addition, using econometric equations for determining production is supposed to allow for considering the dynamicity related to the process of adjustment of production to changes in final demand.

The MMS can be solved into three different contexts:

1. A Static mode
2. A Dynamic mode
3. A Predictive mode

When the model is solved in a static mode, the values for the retarded dependent variables are fed to the model from the historical series included in the database. In other words, the initial solution of the model uses the real values for the endogenous variables.

When the model is solved in a dynamic mode, the retarded dependent variables are populated by the final solution of the model in the previous time. But the exogenous variables are still populated by historical values. In this case, when the model is used in a dynamic mode over a 1 – year period of time, the static solution is equal to the dynamic solution.

Finally, when the model is performed in a predictive mode, the initial solution that feeds the exogenous variables is generated by the model itself, in the previous time.

The maintenance of the model consists of embedding the last versions of the official statistic series, in order to update the stochastic estimation of the econometric equations.

As for the validation of the model, the documents analysed do not contain any numerical or graphical validation tests' results, due to the numerous data obtained from the tests.

The comments about the validity of the model that are reported in the next lines rest on the papers presented by PROMETEIA SPA[54].

The validity tests are performed to assess the model both in the static mode solution and in the more dynamic ones.

[54]Guagnini M., Nobile G. (2008), Guagnini M.et al. (2010).

The validity of each equation is performed by means of statistical tests (e.g. *t test*). The general structure of the model is tested for validity by evaluating the model ability to reproduce, with acceptable approximation, the actual trend of the regional economy, thus replicating the behaviour of the main historical series, and to react in a plausible way to changes to main exogenous variables.

When compared to historical data, the model shows minor forecast errors when it is solved in static mode over some years. In this case, the model is fed with the actual values from the series of the retarded variables.

When it is solved in a dynamic mode, or a predictive mode, then errors do accumulate year by year over the forecasting time horizon.

The ability of the model in replicating the historical data is considered by the modellers a sufficient condition to confirm that the model is fairly specified when it is solved in the static mode. However, positive test results are not considered enough to make sure that the model shows acceptable errors in a dynamic context.

In order to further test the model, the multiplier coefficients of the Leontief Inverse are derived from the model and compared to the same coefficients calculated by the IO table. For this purpose, the model is solved two times: the first solution creates the benchmark, and the second solution is simulated after an external shock to an exogenous variable is induced.

The comparison between the benchmark solution and the alternative one allows to calculate the multiplier coefficients. The analysis of the sense, and the strength of the coefficients, together with the analysis of the channel through which the impact of external variables diffuses, thus affecting other variables in the system, is used to detect modelling mistakes in the initial step of the modelling process.

In the last version of the model, additional modules are added, including Institutional sectors, Labour Market and Demographics.

In this formulation, the model supports the forecasting activity of the Statistics and Economic Analysis Service, when the need to forecast the main economic variables trend occurs. The person in chair of the Service, identified as the user of the model, has been interviewed in order to cast light on the model adoption, and the implementation process is described in the next lines.

When the deadline for approving the DEFR approaches, the officer responsible for drafting the document receives from the Budget and the Programming Service information about the different policies to be implemented in the next financial year, together with data collected about the responsiveness of the regional actors to those policies. For the most, governmental interventions consist of financial incentives to specific Industries or actors. From the information about the resources available to be deployed for the policies, and the responsiveness of the economic system, the amount of resources that is expected to be introduced in the system is obtained, setting the forecast for the variable "Government spending on development". Once the amount of government spending is stated, it is introduced as external shock into the MMS to evaluate the way it interacts with the trend of the regional economy, thus giving information about what is called, the programmatic GRP.

The implementation of the model is performed by the company PROMETEIA SPA itself, and the model is never been performed from within the regional office. In fact, from the regional government service, the information about the government spending, together with the articulation in terms of target industries and kinds of incentive (namely, gross fixed capital formation or current spending) is transmitted to PROMETEIA SPA, which sends back the results of the analysis consisting of the model's forecast for the main economic variables, in the two different scenarios: the trend, which describe the actual dynamic in place, and the program, which account for the regional government intervention.

This information exchange occurs in a tight time span and with high pressure to set the final forecast to which the DEFR is to be anchored.

The time to complete the updating process of the model is depending on the time it takes for the official forecast at national level to be published by ISTAT. For instance, the last statistical report regarding an important sector for the regional economy such as Agriculture, is usually published on April. The DEFR is to be approved by the end of June. In the two months span the updating of the model is to be completed, the possible reaction of the model to the government action is to be estimated, and the Document of Regional Economy and Finance is to be drafted by the regional government and approved by the Regional Assembly.

Within such a short time, the economic analysis provided by the implementation of the MMS cannot be supportive of the policy design process, thus limiting the informative value to the forecast and the impact analysis of the policy proposed by the government, with no feedback to the policy design process to measure and improve the effectiveness of the government action.

A part from the yearly recurring occasion of drafting the DEFR, occasionally the MMS is used to provide specific analysis. Reports are published containing the results of the ex-ante impact analysis for a Business Tax Credit Law[55]proposed in 2007 and approved in 2009[56],and an ex-post analysis of a 7year-Incentive Program implemented from 2000 to 2006[57][58].

In both cases, it is possible to state that no feedback process from the impact analysis appears to affect the design of the Tax Credit Law to be implemented, in the case of the ex-ante analysis, and the design of the following Regional Operational Program, in the case of the ex-post analysis.

Beyond the perceived uncompleted integration of the model within the planning and policy design process, there are other reasons why the MMS appears not completely effective in supporting the planning process.

The users of the information gathered from the model solution have no knowledge of the model structure, or functioning of the model itself. The reason is that, within the government division, no one among the officials knows the programming language of FORTRAN, and the model has the usual interface of the econometric programs, then requiring specific technical knowledge for interacting with the model itself.

In order to facilitate the implementation of the model from the final user, PROMETEIA SPA makes available the user manual for the MMS, in order to simplify the use of the FP program. However, the lack of a user – friendly interface, coupled with the very low confidence with computer models and econometrics among the government employees, prevents the direct use of the model itself, thus eliminating any chance of gaining a major knowledge of the system. In other words, the model, that is used to represent the system, is perceived as a Black Box by the final user.

[55]Guagnini M. et al. (2010).
[56] Law 11 del 17/11/2009- Crediti di imposta per i nuovi investimenti e per la crescita dimensionale delle imprese.
[57] Francescon R., et al. (2010).
[58] Regional Operational Program for the Sicily region 2000-2006.

Furthermore, the difficulty of the implementation is made worse due to the combination of cutback in the number of government employees and the lack of required expertise to manage such a model.

The critical points of the implementation process of MMS are schematized as follow:

- The model is structured as a complex system, and difficulties are met when trying to communicate it;
- The updating of the model is a time consuming process, due to the large number of equations and the extensiveness of the database, and conflicts with the timing imposed by the regional planning cycle;
- The user doesn't fully understand the model structure, and the model's functioning, thus perceiving it as a black-box;
- The technical background of the regional officers is not suitable for the direct implementation of the MMS, that is programmed and managed with FORTRAN language.

4.5 Comparison of the IO SD framework model and the MMS

The analysis of the implementation of the MMS within the regional planning process gives the way to an approximate comparison between the two models[59]. The base assumption for such a comparative analysis is that the models are meant to satisfy the same goal: the analysis of the regional economic system for supporting public planning process and policy design.

The levels of comparison includes the method and the implementation process.

As for the method, the focus of the evaluation is the ability of the model to interpret the dynamics of the system.

In this respect, no evidence is found about the MMS's capacity to simulate the behaviour of the system: in order to be more accurate, the model needs to be fed by actual values for endogenous variables, otherwise the forecast shows major errors, which are the more relevant the longer is the time horizon for the forecast.

[59] The comparison is not meant to be exhaustive because of the lack of data about the tests performed to assess the validity of the MMS, and because the two models are based on different data bases.

The SD model, on the other hand, embeds the structure of the system, and for that reason, it is able to generate the behaviour of the system endogenously. The accuracy in doing that is, to some extent, dependant on the calibration of certain parameters: the ones governing the stronger causal loops of the SD model. Nevertheless, selecting and updating those relevant parameters is agile.

At the same time, System Dynamics modelling is considered appropriate for analysis on the medium and long time horizon: SD simulation is able to highlight the behavioural trend of the system, but it is not the proper tool when the highest accuracy of data is required. In this respect, Econometrics may be considered more appropriate for the short run analysis: methods, such as statistical inference, allow to give forecasts that are anchored to the recent trend, and it is proven that this feature allows for an higher accuracy in short run forecasting[60].

Regarding the implementation process, the two models differ substantially from one another. The MMS is implemented far from the final user. In the strict sense, it is not implemented by the final user at all.

The SD methodology focuses on the necessity to build the model together with the final users, in order to give a picture of the system that is as reliable as possible, and to let the actors to be involved and to gain understanding of the system during the modelling process itself[61]. Furthermore, the SD model is more intelligible when communicated both in the Stock and Flow Diagram and in the CLD, compared to hundreds of stochastic equations.

The System Dynamics simulation software also allows for communicating to the final user, by providing features such as STORYTELLING[62]. Moreover, the software ITHINK, used to model the Sicily economic system framework, provides another useful feature that increases the interaction with the user: the graphical interface, that can be tailored to the specific purpose and user. By changing the policy levers from the interface layer (managing the tailored control panel), the user can be engaged, and by means of repeated simulations, he can gain understanding of the feedback structure of the system.

[60] Chambers J. C. et al. (1971).
[61] On facilitating learning using SD see Vennix J. (1996) and Wheat I. D. (2007b).
[62] STORYTELLING is a feature of *IThink* Software that allows to explore the model in a sort of assisted mode.

In order to extend the benefits of this understanding in terms of performance of the planning process, the process itself is to be rethought: from a linear process to a proper planning cycle, including feedbacks from one step upstream towards other steps in an iterative manner (fig.27): essential requirement for implementing an iterative planning, policy design and budgeting is to reach an higher level of coordination between different Services of the same Governmental Division[63].

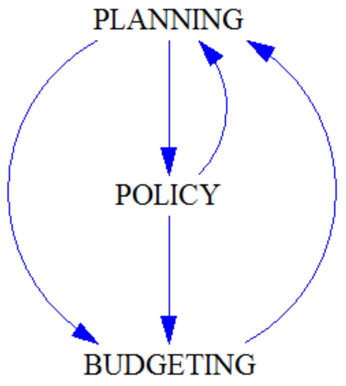

Figure 27 - Iterative Planning and Budgetary cycle

Another difference is related to the data base of the model: the MMS is based on thousands of historical series, to be updated yearly, in a time consuming process that is showed to be one of the reasons for the limited use of the model. The SD Model involves numerous equations too, but data updating can be obtained in a very short time by updating the data source for the variables that are considered external to the boundaries of the system. Moreover, the understanding of the feedback structure allows for selecting the parameters to which the model shows higher sensitivity, thus focusing the effort for better specification or updating requirements to those parameters.

With the same flexibility of updating the data base, also the model (S&F and Feedback structures) can be changed, gradually including parts of the system previously considered exogenous to the model boundaries. This process can involve the actors that are involved in the planning process, and the simulations can show them relationships that were previously ignored.

Finally, together with the ease updating, having the chance to *touch* the model, by means of the interface, increases the occasion to use the model during the year, thus fostering a constant learning process.

[63] On policy coordination see Bianchi C. and Peters B. G. (2016).

The results of the approximate comparison are summarized in the next lines, where each comment is linked to the specific feature under analysis.

Regarding the USABILITY, the MMS misses to engage the actors involved because of the lack of a user-friendly interface, and requires specific technological background. The SD models allow for an interaction of the user with the model by means of the interface layer, that can be tailored to the specific purpose of the simulation.

Regarding the FLEXIBILITY, as far now, the MMS is implemented with obstacles that are connected to the time consuming process of updating the model, coupled to the fact that the model is not implemented directly by the final users.

Regarding the KNOWLEDGE AND LEARNING BENEFITS that can derive from the implementation of the models, the comment is straight forward: the MMS is perceived as a Black-Box, with no perception of the link between the inputs to the model and the results. On the other side, SD modelling, thanks to features such as STORYTELLING and control panels, allows for an higher level of interaction between the model and the user. Moreover, communicative tools such as SFDs and CLDs contribute to make easier the acknowledgment of the model by the final user.

It is important to highlight the limitation of undergoing a comparison evaluation without having actually implemented the SD model in the same context where the MMS is used[64]. In this respect, the conclusions are drawn based on the existing literature of SD model implementation, and on the results of the interviews conducted with the regional officer.

Regarding the comparison of the validity tests, no opinion is expressed about the accuracy of the forecasts resulting from the models: in order to do such a comparison, it is necessary to test both the models whit the same modelling object, in space and time conditions, including time horizon, object of analysis, data base, and boundaries. This is considered a possible future research direction.

The final strategic advice would be to combine the implementation of the two models: the MMS is better suited for the short run previsions, and the SD model framework is better suited for the deep understanding of the system structure, the origins of its behaviour, for medium and long run strategic development purposes.

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[64] Größler A. (2007).

5 CONCLUSIONS

5.1 Summary

The research project aims at designing an Integrated IO/SD model framework that usefully allows for analysing the Regional Economic System, to support the regional government planning process. In this respect, the case study tailored to the Sicilian Region is developed.

Chapter two describes the methodologies chosen to carry out the research process, which are identified in System Dynamics methodology and IO approach to be effectively integrated in the model framework.

Chapter three details the modelling process and the model structure. The adopted solution to obtain an effective integration of the static IO approach and the dynamic SD method is presented and assessed.

Chapter four analyses the planning cycle implemented by government at regional level to foster development in Sicily. The specific context in which the model framework is meant to be implemented is analysed, to shed lights on possible implementation obstacles or difficulties. In order to highlight possible advantages stemming from the adoption of the model framework, a comparison to the Multi-sector Econometric Model implemented for supporting the regional planning process is undergone.

5.2 Findings

The research project undergone allows to answer to the research questions as follow:

RQ1: What are the endogenous and exogenous factors that have determined the behaviour of Sicily Regional Economic System in the last 15 years?

The key factors that govern the feedback loops determining the dynamics of the regional economic system are identified by analysing the feedback structure of the system, and by testing the model to highlight the sensitivity to parameters.

Results can be synthesize as follow: The regional economy is driven by the declining demographics' dynamics, pushed by fertility rate decreasing since 2008, and by the consequent ageing process. The economic sectors, mainly based on market services, suffer the consequence of the decreasing demand, determining a decreasing pattern both for the GRP and the values of per capita Income. Those variables further affect the total fertility rate, thus determining a reinforcing endogenous declining dynamic.

> RQ2: Is it possible to point out one or more economic sectors able to foster an endogenous growth path for regional development?

By means of computer simulation, the model framework allows to test different policy scenarios in order to inform the policy design process towards government actions that make the regional economy less dependent from external factors. In this respects, by confirming the IO analysis, policy scenarios' analysis points to the Construction sector as the booster of GRP. Additional information is obtained by observing the dynamic pattern of the increasing production that follows the simulated implementation of the policy: in fact, although Constructions is the sector that allows to reach an higher net benefit from the policy implemented, another industry, Agriculture, shows a faster response to the stimulus. The reason for this dynamic can be found in the components of the regional agricultural demand, of which exports cover almost one third.

Nevertheless, policy scenarios' analysis also shows that the economic stimulus induced by government intervention in terms of "government expenses" is unable to counteract the reinforcing dynamics that involve population and per capita GRP.

In this respect, in order to foster development, the effort should not address the demand side of the economy, but rather the production sector, by affecting the productivity level, that is able to strengthen any recovery process that can be activated on the demand side. For this purpose, the focus should address the determinants of productivity.

RQ3: Does the case study show that the integration of SD method and IO approach is a useful framework for analysing regional economies?

Sicily region case study, evaluated by means of SD simulation accuracy in replicating the trend in the variables investigated, does respond positively to the research question and confirms previous experiences stating the feasibility and the usefulness of integrating the static IO approach and the dynamic SD modelling method. The accuracy of the integration is tested, then the limitations of the IO approach are eliminated or relaxed by means of SD modelling, thus providing a more reliable tool that integrates and enhances the features singularly provided by the two methodologies when they are adopted standing-alone.

RQ4: Can the Integrated IO/SD framework be usefully implemented in the planning process by regional government policymakers?

The last research question is answered with respect to the case study of Sicily Region. The analysis of the regional government planning process shows that criticalities in the implementation of the process prevent the government to effectively manage its own performance, and thus, to pursue goals settled for economic development. The analysis of the process and tools implemented, and the comparative assessment of the SD model framework allows to state that the framework designed has the potentiality to usefully integrate and enhance the analysis tool set actually adopted for development planning.

5.3 Recommendations

Recommendations can be derived from the findings in order to support the regional development planning process.

The requirement for a plan to be effectively implemented, is to assure the coherence among the plan, the policy and the action of the regional government. It is essential that the planning process is performed in an iterative manner, together with the policy design and budgetary process, by setting a common goal. There are planning tools that act as facilitators for boosting the participation and the coordination between different services that are involved in the same process with different tasks. System dynamics, with the capacity to activate a group learning process, provide an example, and the regional integrated IO SD model offers a framework that can be better specified to be tailored to the regional government requirement.

As for the development strategy, the advice that stems from the project work is to rethink the shape of development government spending: from direct incentive to the single actor to intervention that can affect the productivity of production factors. In this respect, it is useful to further explore and dissect the variable TFP, in order to identify the levers to enhancing it.

5.4 Limitations of the study

Some relevant limitations in the research process are to be mentioned.

Regarding the modelling process, the approximation in parameters estimation is explained by the lack of data availability with regional level disaggregation. However, in order to allow for the project to be carried out, the solution adopted is to gather the information from data available at national level, adapting and integrating the values with different data sources and literature. The most important approximation regards the IO table that has been guesstimated for the Sicily Region.

Nevertheless, it is important to note that data approximation does not affect the results of the project: in fact, the Integrated IO SD model is presented as a framework that is robust in the validation of the model structure, and which can be further sharpened to better fit the specific regional system.

Regarding the comparison between the framework proposed and the MMS currently adopted in the regional planning process, an important gap is considered the lack of direct contact with the modellers responsible for the MMS development and implementation. This gap in the research process is considered influential under, at least, two points of view. Directly interviewing the modeller, and gathering more accurate information or data about the model's validation tests, would have reinforced the effectiveness of the comparison of the two models. Moreover, the contribute of the modeller's point of view in assessing the implementation process, and the users' perspective on the usefulness and potentialities of the simulation tool may affect the considerations stated about the possible benefits/obstacles of the framework's implementation to support regional government public planning.

5.5 Improvements and future directions

The considerations of the gaps in the research project point to the future improvements, that can be identified along different perspectives.

From the methodological perspective regarding the integration of SD and IO, the first direction for further development is towards making endogenous the dynamic of technology, influencing the changes of intermediate purchases pattern for each industry. This achievement would eliminate the only limitation from the IO approach that remains after including the IO concept into the SD framework.

From the practical point of view, the first direction for future work would tackle the reliability of data used for model design and calibration: gathering official or better estimated data should add accuracy to the model's result. In terms of model structure, high priority should go to the specification of the concept of TFP. In fact, despite its relevance in terms of growth, it is not observable, and, statistically, reflects what is not ascribable to the other visible production factors. The more is explained about the technology inherent capital factor, or about the human capital inherent the labour factor, the smaller become the residual, unexplained, TFP.

The second direction for improvement is related to the assessment of the potentiality of the model framework: by adding model structure to further disaggregate and isolate the policy levers of regional government, the model framework would be better tailored to the specific regional government context, thus it would better match the requirements of a planning and policy design tool to be usefully implemented. By testing the model in the field, a proper assessment of its potentialities as planning tool would be undergone. Furthermore, it would be possible to confirm the foreseen side effect of the learning process activated by implementing the SD methodology: the acknowledgment of the opportunity/necessity to measure/manage the performance in the regional development planning process.

APPENDIX A: Model Structure Validation

Tests addressing the model structure are intended to confirm that the model is able to approximate the real system. In order to do that, five tests are performed:

1. Boundary adequacy Test

The model boundary adequacy is tested to confirm that the model includes the feedbacks which are relevant to the purpose of the model itself. The analysis consists of inspecting the CLD of the model to identify constants that might properly be modelled as variables. Those aspects are fully explained in the appendix that shows the model structure. From the test, we can confirm that the model boundaries are settled coherently with the purpose of the model.

2. Model structure Assessment

The model structure assessment is performed to assure the all the equations in the model are coherent with the modeller's knowledge of the real system. In order to do that, the equations are investigated to confirm their coherence to the basic physical realities, and the realism of the decision rules determining the agents' actions. By analysing the coherence of the SFD to the CLD, and then, the coherence of the CLD to the theory and the real world, it is possible to asses that the model structure is valid.

3. Dimensional consistency Test

Dimensional consistency aims to assess the coherence of the unit of measures specified for the variables. The units of measure are specified and tested along the modelling process, because the dimensional inconsistency, when detected, can effectively identify important flaws in the understanding of the structure and the decision rules that are the objects of the modelling. Once the unit consistency is confirmed, the second part of the test consists of verifying that the consistency is obtained without including arbitrary scaling factors, for which it is not possible to identify real world meaning.

The model successfully passes both dimensional consistency tests.

4. Parameter assessment

Parameters assessment aims to confirm the estimation of parameters, when those ones are determined both by formal statistical estimation from numerical data, and by judgmental estimation. Statistically determined parameters are collected from the literature, and official statistics sources are preferred. As for those parameters which are determined by judgmental estimation, the test addresses the conceptual and numerical coherence of the number with the real life. All parameters are assessed in their concepts and numbers.

5. Extreme conditions test

The model is tested in the robustness under extreme conditions: it behaves in a realistic fashion even when inputs are valued with extremely high or low numbers, thus describing an unreal situation. The test is conducted both by direct inspection of the model equations, and by simulation: the model shows plausible behaviour when tested under extreme conditions.

In figure 28, the test addressing the demographic subsystem is reported as an example of the testing procedure. The figure shows the behavioural pattern of population when Total Fertility Rate is endogenously determinate (blue line), compared to the behavioural pattern in case the value for total fertility rate is set to zero (red line): in this case, as expected, the stock of population rapidly depletes.

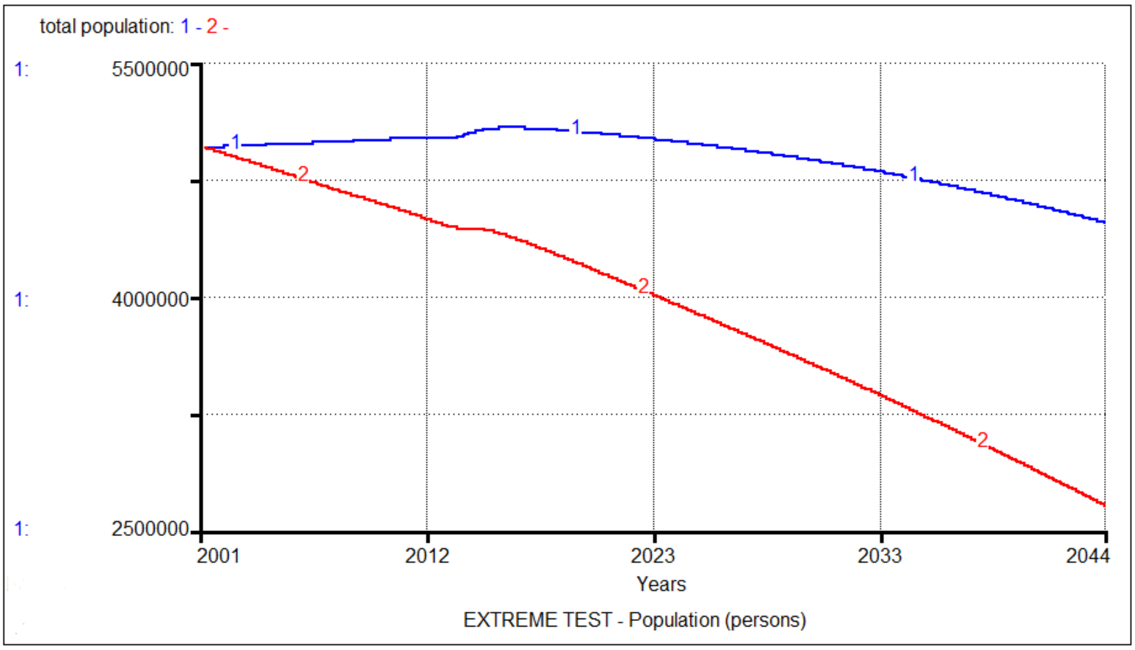

Figure 28 - Population Extreme test

APPENDIX B: Model Behaviour Validation

Once the model structure is validated, it is possible to test the model behaviour, following a two – steps process:

1. The first test addresses the accuracy of the model behaviour in reproducing the major behaviour patterns of real variables. The attention is on the pattern prediction, including trends, frequencies, phase lags, amplitudes, and so on, rather than event prediction. The modules are tested both when simulated standing alone (external parameters of the module populated by historical values), and also when causal links amongst modules are activated, and they show an acceptable approximation of the trends relevant to the purpose of the research.
2. The second test includes the sensitivity analysis, which tests the changes in the behavioural pattern of the simulation when parameters are altered.

In both cases, the model proves robust.

Figures 29, 30, 31, and 32 show the graphical results of the first model validation for the main variables of the system: Population, Per capita Income, Unemployment Rate and Labour Force.

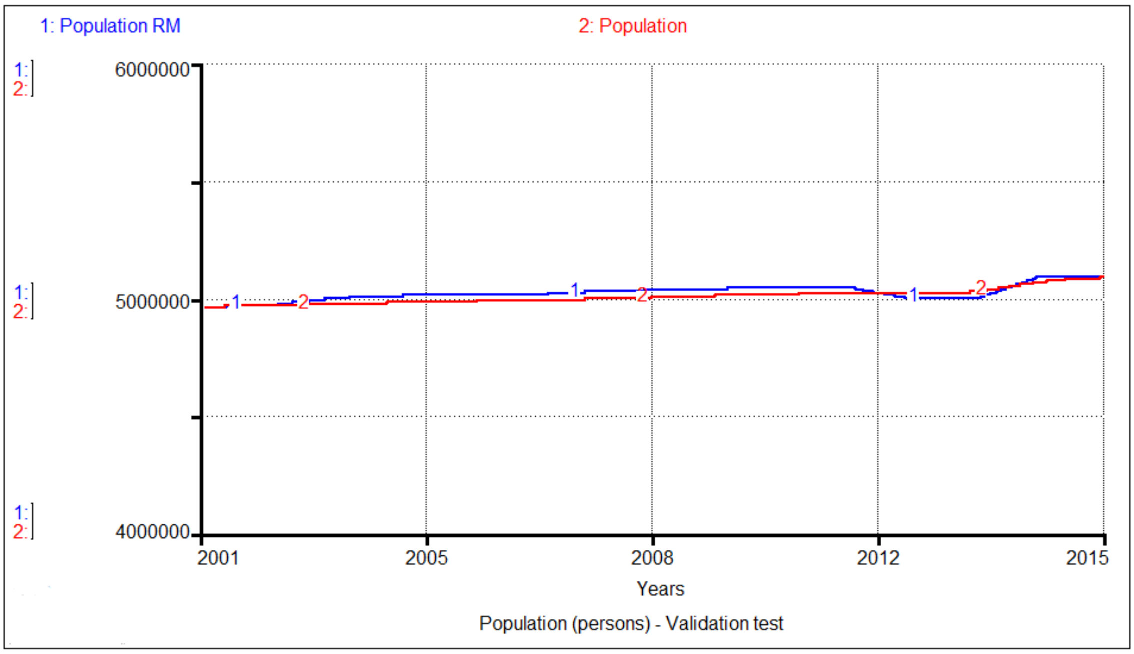

Figure 29 - Population Validation Test

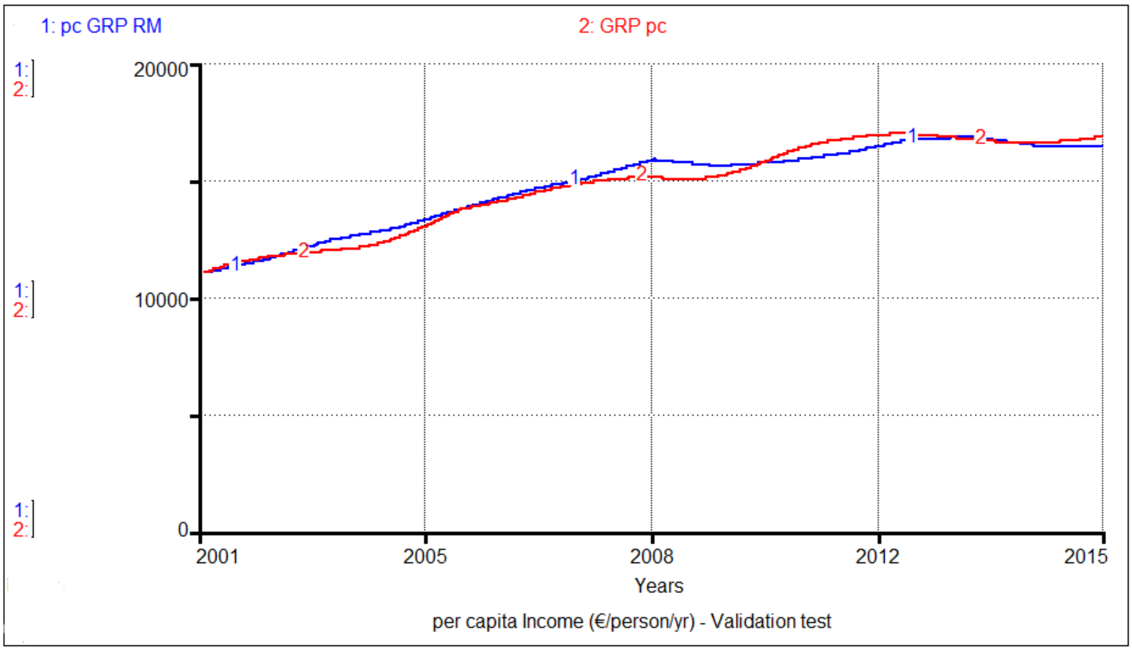

Figure 30 – Per capita Income - Validation test

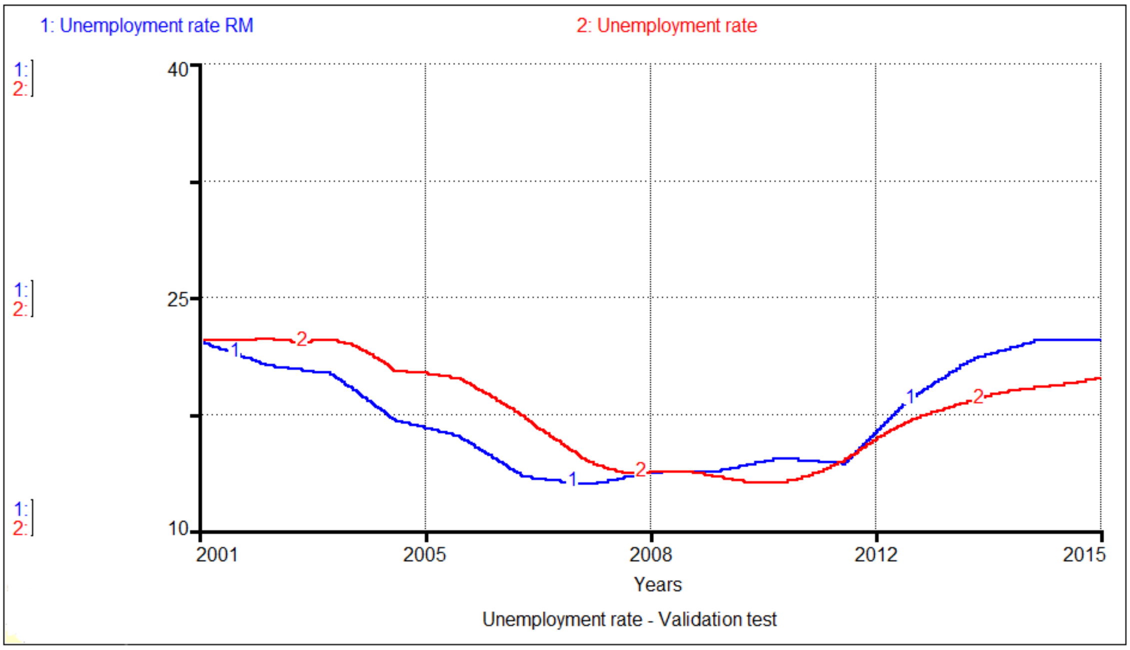

Figure 31 - Unemployment rate - Validation test

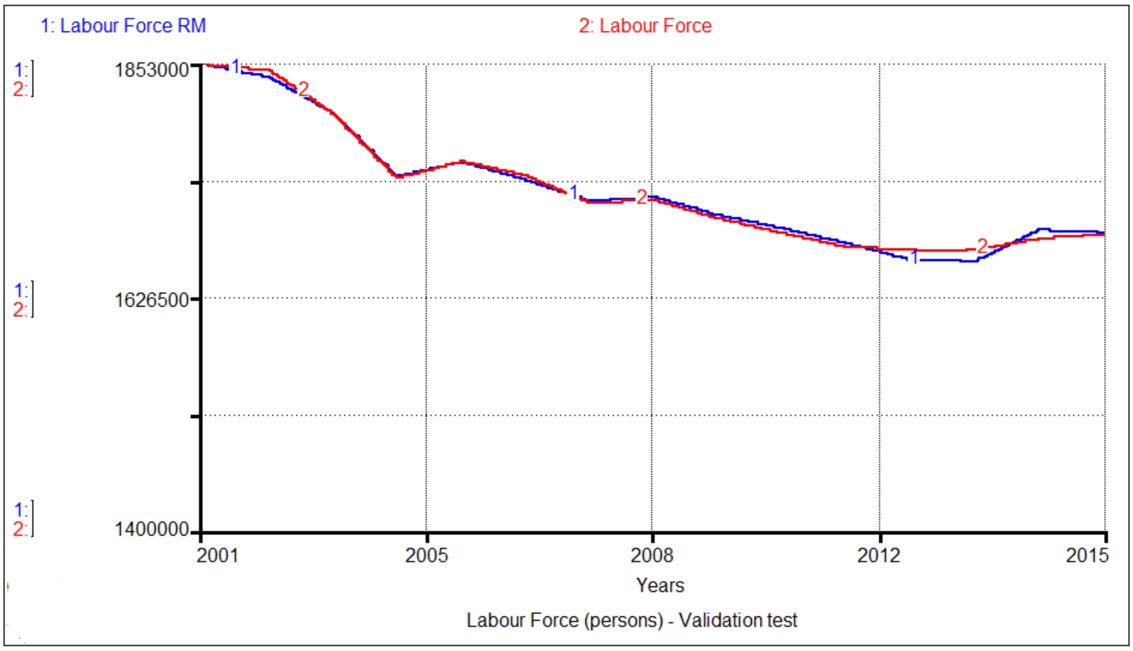

Figure 32 - Labour Force - Validation test

For all the variables, it is possible to say that the model is able to replicate, with an acceptable level of approximation, the real behavioural pattern tendency.

APPENDIX C : Model Structure and Simulation Results

Figure 33 shows a high level view of the overall model, and all the sub-models appear interconnected.

Every level will be described in terms of Stock and Flow structure, or CLD, and boundaries are specified for each module.

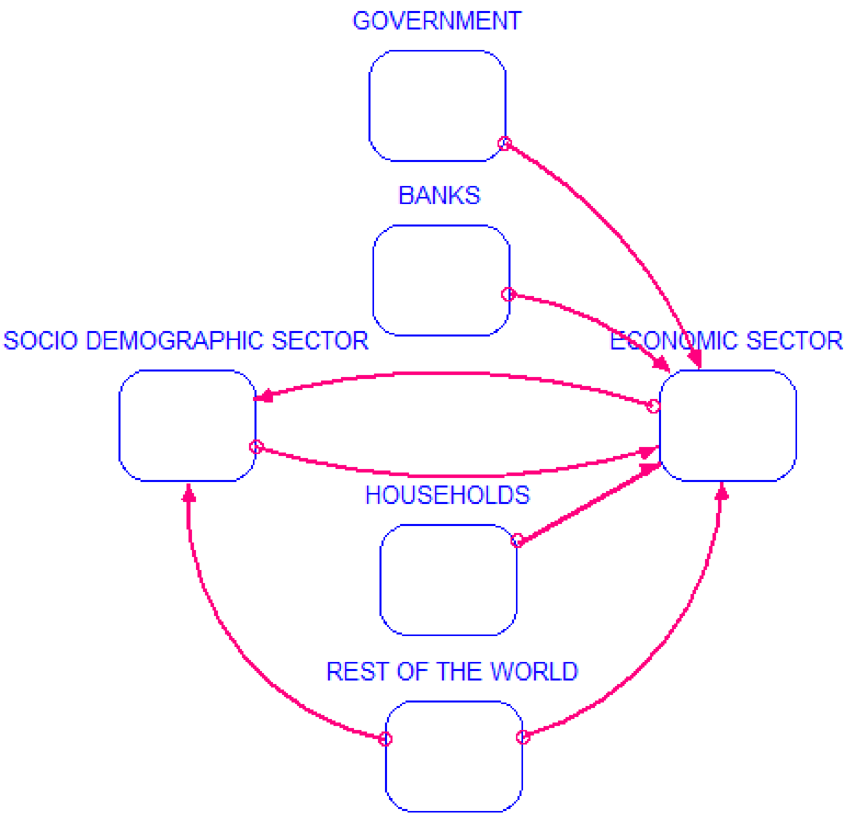

Figure 33 - Overall view of the model

Socio-demographic sector

Socio-demographic sector is governed by three causal loops involving the biological processes of deaths and births and the social process of migration (fig. 34). Parameters governing those feedbacks loops are Total Fertility Rate, Death Rate and Migration Rate. As far now, the only parameter that is determined endogenously to the model is Total Fertility Rate, that is influenced by the perceived per capita Income and by the dynamics of Unemployment rate.

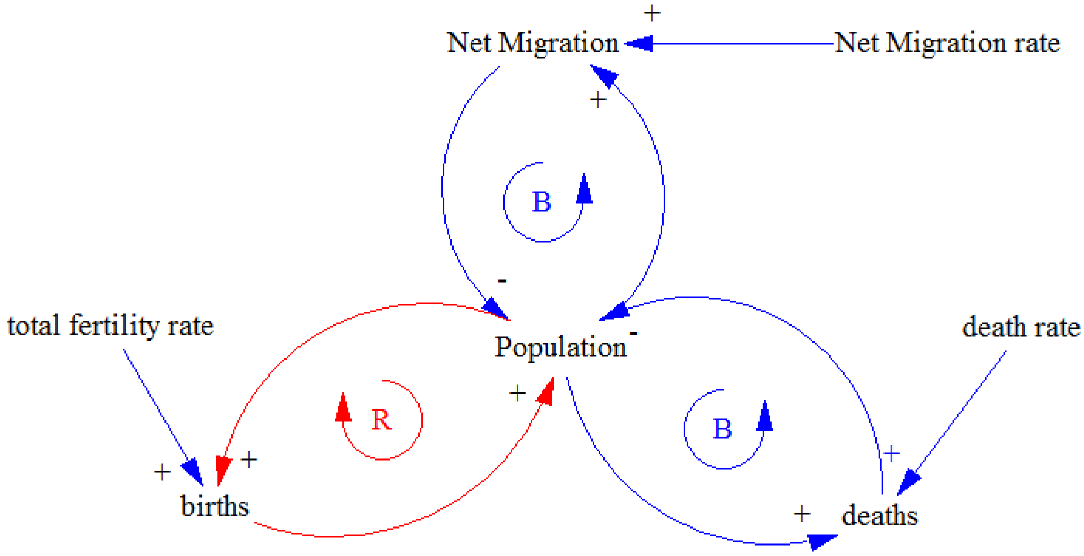

Figure 34 - Socio - demographic sector feedback loops

Population variable is tested for sensitivity to Total Fertility rate, and figure35 shows how the behavioural pattern of Population changes when Total Fertility Rate increases (line 3) or decreases (line 2) by 0.5, compared to the steady state pattern in which Total Fertility rate is 1.4 (line 1).

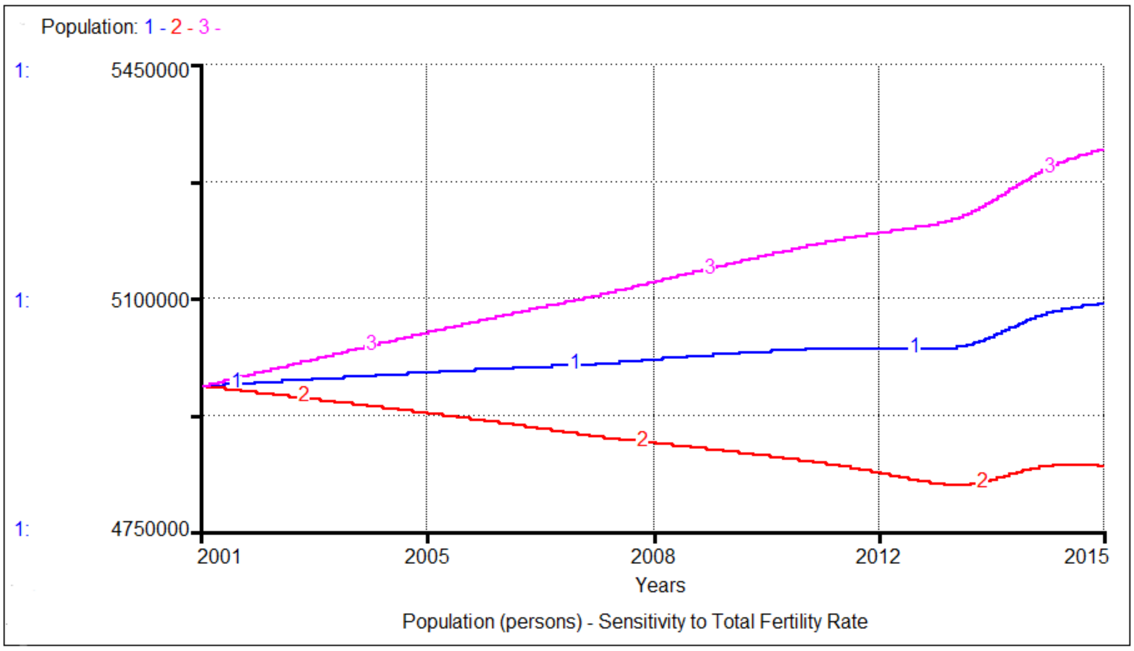

Figure 35 - Population sensitivity test

Economic Sector

Within the Economic Sector, the Production system is modelled as it is described in paragraph 3.5.2. Figure 36 shows the CLD for the first level of the production system, describing the dynamics between regional demand and regional production.

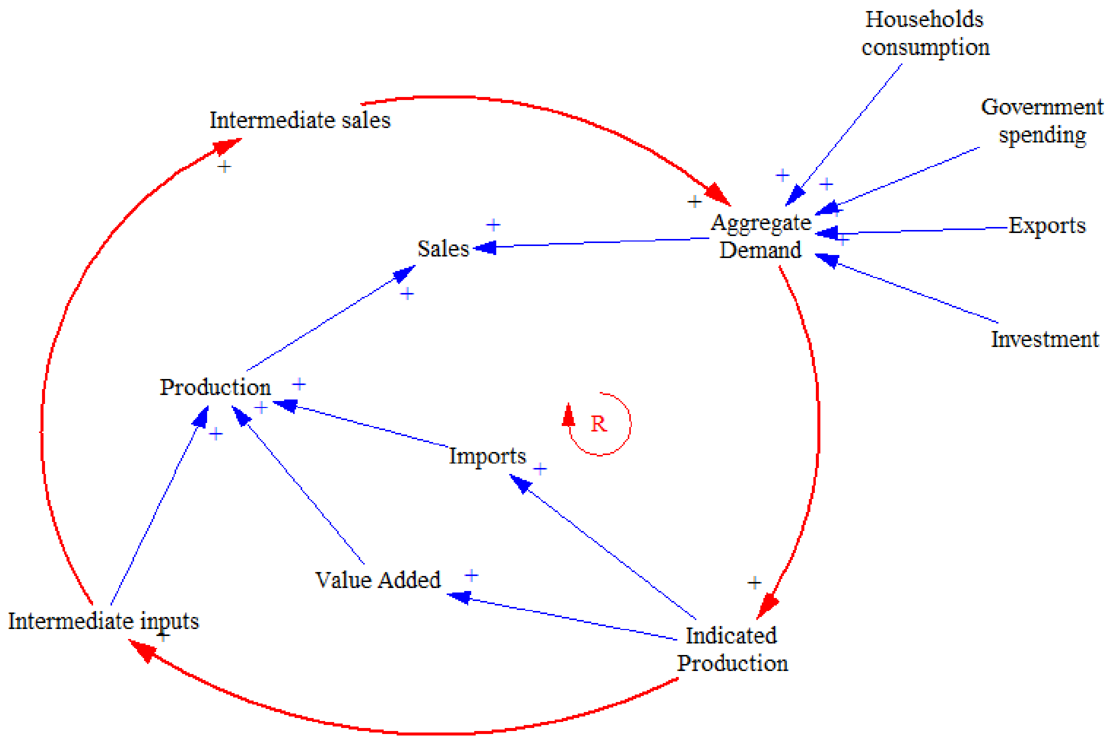

Figure 36 - Inter - Industry reinforcing loop

The main loop governing the system is determined by the intermediate transactions between different industries: increases in Indicated production for a specific sector will affect the demand for production in all the others. The higher is the value of the multiplier for the industry that faces the demand increase, the higher is the reinforcing dynamic it does transmit to the overall production system.

The parameters affecting the dynamic of the production system are: per capita households consumption and per capita Government spending, which are inputs from the Households and the Government modules, and technical coefficients, that determine intermediate transactions, and Import coefficient, that indicate the percentage of the production that is satisfied by Imports goods and services. Both the technical and the import coefficients derive from the IO table.

The second level of the Production system is showed in CLD in figure 37.

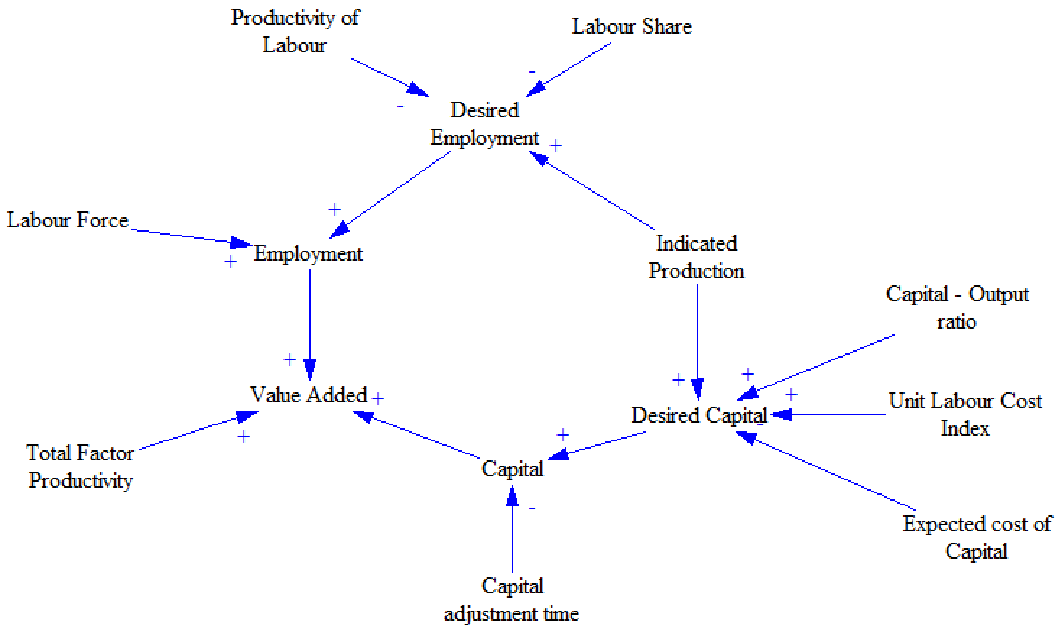

Figure 37 - Production module CLD

The module does not involve any major feedback loops, but within it, the decisions about Employment and Investment are taken. The parameters that affect the dynamics include Interest rate (from the BANK module) and Unit Labour Cost index (both affect the decision about substitutability between capital and labour production factors), and Total Factor Productivity, that is exogenous to the overall system, and accounts for that part of value added that is not explained by material production factors.

The variable Labour Force is exogenous to the module, since it is determined within the demographic module.

The model structure is almost identical across different industries, but they differ in terms of: Total factor productivity, delay times influencing decision rules, and marginal productivity of production factors.

APPENDIX D: List of Variables and Equations

BANKS:

interest_rate = GRAPH(TIME)

(2001, 6.65), (2002, 5.57), (2003, 4.71), (2004, 4.03), (2005, 3.56), (2006, 4.68), (2007, 5.48), (2008, 4.82), (2009, 2.25), (2010, 2.79), (2011, 4.18), (2012, 3.64), (2013, 3.45), (2014, 2.66)

ECONOMIC SECTOR:

GOVERNMENT:

pc_Government_spending = GRAPH(TIME)

(2001, 3954), (2010, 6054)

HOUSEHOLDS:

Per_Capita_Consumption = GRAPH(TIME)

(2001, 8971), (2002, 9388), (2003, 10045), (2004, 10470), (2005, 11037), (2006, 11703), (2007, 12447), (2008, 13036), (2009, 12739), (2010, 13025), (2011, 13589), (2012, 13849), (2013, 13633), (2014, 13653)

REST OF THE WORLD:

net_immigration_rate_DATA = GRAPH(TIME)

(2002, -2.50), (2003, 0.6), (2004, -0.8), (2005, -0.7), (2006, -1.00), (2007, 2.50), (2008, 1.40), (2009, 1.40), (2010, 1.60), (2011, -0.2), (2012, 1.00), (2013, 19.8), (2014, 0.4)

REGIONAL_EXPORT_DATA = GRAPH(TIME)

(2001, 4.3e+009), (2002, 4.1e+009), (2003, 4.4e+009), (2004, 4.9e+009), (2005, 6.5e+009), (2006, 7.3e+009), (2007, 9e+009), (2008, 9.6e+009), (2009, 6.1e+009), (2010, 1.6e+010), (2011, 1.1e+010), (2012, 1.4e+010), (2013, 1.2e+010), (2014, 1e+010)

SOCIO DEMOGRAPHIC SECTOR:

adults_85plus(t) = adults_85plus(t - dt) + (aging_to_85 + net_migration_85plus - deaths_85_plus) * dt

INIT adults_85plus = Population_RM*(0.012+0.004+0.001)

INFLOWS:

aging_to_85 = CONVEYOR OUTFLOW

net_migration_85plus = net_migration_data_est*(1/18)

OUTFLOWS:

deaths_85_plus = adults_85plus/life_exp_85plus

adults_15\19(t) = adults_15\19(t - dt) + (aging_to_15 + net_migration_15\19 - aging_to_20 - deaths_15\19) * dt

INIT adults_15\19 = Population_RM*0.065

TRANSIT TIME = 5

INFLOWS:

aging_to_15 = CONVEYOR OUTFLOW

net_migration_15\19 = net_migration_data_est*(1/18)

OUTFLOWS:

aging_to_20 = CONVEYOR OUTFLOW

deaths_15\19 = LEAKAGE OUTFLOW

LEAKAGE FRACTION = 0.001

LEAK ZONE = 0% to 100%

adults_20\24(t) = adults_20\24(t - dt) + (aging_to_20 + net_migration_20\24 - aging_to_25 - deaths_20\24) * dt

INIT adults_20\24 = Population_RM*0.069

TRANSIT TIME = 5

INFLOWS:

aging_to_20 = CONVEYOR OUTFLOW

net_migration_20\24 = net_migration_data_est*(1/18)

OUTFLOWS:

aging_to_25 = CONVEYOR OUTFLOW

deaths_20\24 = LEAKAGE OUTFLOW

LEAKAGE FRACTION = 0.0014

LEAK ZONE = 0% to 100%

adults_25\29(t) = adults_25\29(t - dt) + (aging_to_25 + net_migration_25\29 - aging_to_30 - deaths_25\29) * dt

INIT adults_25\29 = Population_RM*0.075

TRANSIT TIME = 5

INFLOWS:

aging_to_25 = CONVEYOR OUTFLOW

net_migration_25\29 = net_migration_data_est*(1/18)

OUTFLOWS:

aging_to_30 = CONVEYOR OUTFLOW

deaths_25\29 = LEAKAGE OUTFLOW

LEAKAGE FRACTION = 0.0015

LEAK ZONE = 0% to 100%

adults_30\34(t) = adults_30\34(t - dt) + (aging_to_30 + net_migration_30\34 - aging_to_35 - deaths_30\34) * dt

INIT adults_30\34 = Population_RM*0.076

TRANSIT TIME = 5

INFLOWS:

aging_to_30 = CONVEYOR OUTFLOW

net_migration_30\34 = net_migration_data_est*(1/18)

OUTFLOWS:

aging_to_35 = CONVEYOR OUTFLOW

deaths_30\34 = LEAKAGE OUTFLOW

LEAKAGE FRACTION = 0.0021

LEAK ZONE = 0% to 100%

adults_35\39(t) = adults_35\39(t - dt) + (aging_to_35 + net_migration_35\39 - aging_to_40 - deaths_35\39) * dt

INIT adults_35\39 = Population_RM*0.075

TRANSIT TIME = 5

INFLOWS:

aging_to_35 = CONVEYOR OUTFLOW

net_migration_35\39 = net_migration_data_est*(1/18)

OUTFLOWS:

aging_to_40 = CONVEYOR OUTFLOW

deaths_35\39 = LEAKAGE OUTFLOW

LEAKAGE FRACTION = 0.003

LEAK ZONE = 0% to 100%

adults_40\44(t) = adults_40\44(t - dt) + (aging_to_40 + net_migration_40\44 - aging_to_45 - deaths_40\44) * dt

INIT adults_40\44 = Population_RM*0.069

TRANSIT TIME = 5

INFLOWS:

aging_to_40 = CONVEYOR OUTFLOW

net_migration_40\44 = net_migration_data_est*(1/18)

OUTFLOWS:

aging_to_45 = CONVEYOR OUTFLOW

deaths_40\44 = LEAKAGE OUTFLOW

LEAKAGE FRACTION = 0.0049

LEAK ZONE = 0% to 100%

adults_45\49(t) = adults_45\49(t - dt) + (aging_to_45 + net_migration_45\49 - aging_to_50 - deaths_45\49) * dt

INIT adults_45\49 = Population_RM*0.064

TRANSIT TIME = 5

INFLOWS:

aging_to_45 = CONVEYOR OUTFLOW

net_migration_45\49 = net_migration_data_est*(1/18)

OUTFLOWS:

aging_to_50 = CONVEYOR OUTFLOW

deaths_45\49 = LEAKAGE OUTFLOW

LEAKAGE FRACTION = 0.0082

LEAK ZONE = 0% to 100%

adults_50\54(t) = adults_50\54(t - dt) + (aging_to_50 + net_migration_50\54 - aging_to_55 - deaths_50\54) * dt

INIT adults_50\54 = Population_RM*0.063

TRANSIT TIME = 5

INFLOWS:

aging_to_50 = CONVEYOR OUTFLOW

net_migration_50\54 = net_migration_data_est*(1/18)

OUTFLOWS:

aging_to_55 = CONVEYOR OUTFLOW

deaths_50\54 = LEAKAGE OUTFLOW

LEAKAGE FRACTION = 0.012

LEAK ZONE = 0% to 100%

adults_55\59(t) = adults_55\59(t - dt) + (aging_to_55 + net_migration_55\59 - aging_to_60 - deaths_55\59) * dt

INIT adults_55\59 = Population_RM*0.052

TRANSIT TIME = 5

INFLOWS:

aging_to_55 = CONVEYOR OUTFLOW

net_migration_55\59 = net_migration_data_est*(1/18)

OUTFLOWS:

aging_to_60 = CONVEYOR OUTFLOW

deaths_55\59 = LEAKAGE OUTFLOW

LEAKAGE FRACTION = 0.018

LEAK ZONE = 0% to 100%

adults_60\64(t) = adults_60\64(t - dt) + (aging_to_60 + net_migration_60\64 - aging_to_65 - deaths_60\64) * dt

INIT adults_60\64 = Population_RM*0.052

TRANSIT TIME = 5

INFLOWS:

aging_to_60 = CONVEYOR OUTFLOW

net_migration_60\64 = net_migration_data_est*(1/18)

OUTFLOWS:

aging_to_65 = CONVEYOR OUTFLOW

deaths_60\64 = LEAKAGE OUTFLOW

LEAKAGE FRACTION = 0.03

LEAK ZONE = 0% to 100%

adults_65\69(t) = adults_65\69(t - dt) + (aging_to_65 + net_migration_66\69 - aging_to_70 - deaths_66\69) * dt

INIT adults_65\69 = Population_RM*0.05

TRANSIT TIME = 5

INFLOWS:

aging_to_65 = CONVEYOR OUTFLOW

net_migration_66\69 = net_migration_data_est*(1/18)

OUTFLOWS:

aging_to_70 = CONVEYOR OUTFLOW

deaths_66\69 = LEAKAGE OUTFLOW

LEAKAGE FRACTION = 0.051

LEAK ZONE = 0% to 100%

adults_70\74(t) = adults_70\74(t - dt) + (aging_to_70 + net_migration_70\74 - aging_to_75 - deaths_70\74) * dt

INIT adults_70\74 = Population_RM*0.046

TRANSIT TIME = 5

INFLOWS:

aging_to_70 = CONVEYOR OUTFLOW

net_migration_70\74 = net_migration_data_est*(1/18)

OUTFLOWS:

aging_to_75 = CONVEYOR OUTFLOW

deaths_70\74 = LEAKAGE OUTFLOW

LEAKAGE FRACTION = 0.088

LEAK ZONE = 0% to 100%

adults_75\79(t) = adults_75\79(t - dt) + (aging_to_75 + net_migration_75\79 - aging_to_80 - deaths_75\79) * dt

INIT adults_75\79 = Population_RM*0.037

TRANSIT TIME = 5

INFLOWS:

aging_to_75 = CONVEYOR OUTFLOW

net_migration_75\79 = net_migration_data_est*(1/18)

OUTFLOWS:

aging_to_80 = CONVEYOR OUTFLOW

deaths_75\79 = LEAKAGE OUTFLOW

LEAKAGE FRACTION = 0.16

LEAK ZONE = 0% to 100%

adults_80\84(t) = adults_80\84(t - dt) + (aging_to_80 + net_migration_80\84 - aging_to_85 - Flow_17) * dt

INIT adults_80\84 = Population_RM*0.019

TRANSIT TIME = 5

INFLOWS:

aging_to_80 = CONVEYOR OUTFLOW

net_migration_80\84 = net_migration_data_est*(1/18)

OUTFLOWS:

aging_to_85 = CONVEYOR OUTFLOW

Flow_17 = LEAKAGE OUTFLOW

LEAKAGE FRACTION = 0.288

LEAK ZONE = 0% to 100%

children_0\4(t) = children_0\4(t - dt) + (births + net_migration_0\4 - aging_to_5 - deaths_0\4) * dt

INIT children_0\4 = Population_RM*0.051

TRANSIT TIME = 5

CAPACITY = INF

INFLOW LIMIT = INF

INFLOWS:

births = births_per_ferlile_age_woman*fertile_age_woman

net_migration_0\4 = net_migration_data_est*(1/18)

OUTFLOWS:

aging_to_5 = CONVEYOR OUTFLOW

deaths_0\4 = LEAKAGE OUTFLOW

LEAKAGE FRACTION = 0.007

LEAK ZONE = 0% to 100%

children_10\14(t) = children_10\14(t - dt) + (aging_to_10 + net_migration_10\14 - aging_to_15 - deaths_10\14) * dt

INIT children_10\14 = Population_RM*0.063

TRANSIT TIME = 5

INFLOWS:

aging_to_10 = CONVEYOR OUTFLOW

net_migration_10\14 = net_migration_data_est*(1/18)

OUTFLOWS:

aging_to_15 = CONVEYOR OUTFLOW

deaths_10\14 = LEAKAGE OUTFLOW

LEAKAGE FRACTION = 0.0006

LEAK ZONE = 0% to 100%

children_5\9(t) = children_5\9(t - dt) + (aging_to_5 + net_migration_5\9 - aging_to_10 - deaths_5\9) * dt

INIT children_5\9 = Population_RM*0.057

TRANSIT TIME = 5

INFLOWS:

aging_to_5 = CONVEYOR OUTFLOW

net_migration_5\9 = net_migration_data_est*(1/18)

OUTFLOWS:

aging_to_10 = CONVEYOR OUTFLOW

deaths_5\9 = LEAKAGE OUTFLOW

LEAKAGE FRACTION = 0.0006

LEAK ZONE = 0% to 100%

births_per_ferlile_age_woman = total_fertility_rate/fertile_time

effect_of_relative_perceived_pc_income_on_tfr = GRAPH(relative_perveiced_pc_income)

(0.00, 0.99), (0.5, 0.99), (1.00, 1.00), (1.50, 1.01), (2.00, 1.03)

effect_of_ur_on_fertility_rate = GRAPH(SMTH1(relative__perceived_Unemployment_rate,1))

(0.00, 1.10), (0.333, 1.10), (0.667, 1.07), (1.00, 1.00), (1.33, 0.921), (1.67, 0.813), (2.00, 0.571)

female_fraction = 0.5

fertile_age_woman = female_fraction*(adults_15\19+adults_20\24+adults_25\29+adults_30\34+adults_35\39+adults_40\44+adults_45\49)

fertile_time = 35

initial_perceived_pc_income = INIT(perceived_pc_income)

initial_total_fertility_rate = 1.4

life_exp_85plus = 5

net_migration_data_est = Population_RM*SMTH1(REST_OF_THE_WORLD.net_immigration_rate_DATA,1)/1000

Participation = ((adults_15\19*participation_rate_data_15_24)+(adults_20\24*participation_rate_data_15_24)+(adults_25\29*participation_rate_data_25_64)+(adults_30\34*participation_rate_data_25_64)+(adults_35\39*participation_rate_data_25_64)+(adults_40\44*participation_rate_data_25_64)+(adults_45\49*participation_rate_data_25_64)+(adults_50\54*participation_rate_data_25_64)+(adults_55\59*participation_rate_data_25_64)+(adults_60\64*participation_rate_data_25_64)+(adults_65\69*participation_rate_data_65_plus)+(adults_70\74*participation_rate_data_65_plus)+(adults_75\79*participation_rate_data_65_plus)+(adults_80\84*participation_rate_data_65_plus)+(adults_85plus*0))/Population_15plus

participation_rate_data_15_24 = GRAPH(TIME)

(2001, 36.0), (2002, 34.5), (2003, 32.7), (2004, 30.3), (2005, 28.6), (2006, 27.3), (2007, 25.3), (2008, 24.7), (2009, 23.0), (2010, 23.8), (2011, 22.8)

participation_rate_data_25_64 = GRAPH(TIME)

(2001, 60.8), (2002, 60.7), (2003, 59.7), (2004, 57.7), (2005, 58.5), (2006, 58.1), (2007, 57.5), (2008, 57.5), (2009, 57.1), (2010, 56.1), (2011, 55.6)

participation_rate_data_65_plus = GRAPH(TIME)

(2001, 3.30), (2002, 3.40), (2003, 2.10), (2004, 2.10), (2005, 2.10), (2006, 2.00), (2007, 1.80), (2008, 2.00), (2009, 1.70), (2010, 2.00), (2011, 2.10)

perceived_pc_income = SMTH1(PRODUCTION.GRP_pc,1)

Population_RM = GRAPH(TIME)

(2001, 5e+006), (2002, 5e+006), (2003, 5e+006), (2004, 5e+006), (2005, 5e+006), (2006, 5e+006), (2007, 5e+006), (2008, 5e+006), (2009, 5e+006), (2010, 5.1e+006), (2011, 5e+006), (2012, 5e+006), (2013, 5e+006), (2014, 5.1e+006), (2015, 5.1e+006)

relative_perveiced_pc_income = perceived_pc_income/initial_perceived_pc_income

relative__perceived_Unemployment_rate = PRODUCTION.Unemployment_rate/HISTORY(PRODUCTION.Unemployment_rate,(time-1))

total_fertility_rate = initial_total_fertility_rate*effect_of_ur_on_fertility_rate*effect_of_relative_perceived_pc_income_on_tfr

total_fertility_rate_RF = GRAPH(TIME)

(2001, 1.40), (2002, 1.40), (2003, 1.43), (2004, 1.44), (2005, 1.43), (2006, 1.43), (2007, 1.42), (2008, 1.45), (2009, 1.45), (2010, 1.44), (2011, 1.42), (2012, 1.41), (2013, 1.36), (2014, 1.38)

Population = children_0\4 + adults_15\19 + adults_20\24 + adults_25\29 + adults_30\34 + adults_35\39 + adults_40\44 + adults_45\49 + adults_50\54 + adults_55\59 + adults_60\64 + adults_65\69 + adults_70\74 + adults_75\79 + adults_80\84 + adults_85plus + children_10\14 + children_5\9

Population_15plus = adults_15\19 + adults_20\24 + adults_25\29 + adults_30\34 + adults_35\39 + adults_40\44 + adults_45\49 + adults_50\54 + adults_55\59 + adults_60\64 + adults_65\69 + adults_70\74 + adults_75\79 + adults_80\84 + adults_85plus

ECONOMIC SECTOR.FIRMS:

CAPITAL_FORMATION_TOTAL_DATA = GRAPH(TIME)

(2001, 1.2e+010), (2002, 1.3e+010), (2003, 1.4e+010), (2004, 1.5e+010), (2005, 1.6e+010), (2006, 1.7e+010), (2007, 1.8e+010), (2008, 1.7e+010), (2009, 1.6e+010), (2010, 1.6e+010), (2011, 1.6e+010)

ECONOMIC SECTOR.PRODUCTION:

AGRICULTURE_VA = AGRI_INDUSTRY.VA_in_Agriculture

avg_part_data = LB_data/pop_15plus

avg_wage = regional_tot_wages/reg_employment

capital_formation_agriculture = capital_formation_per_industry_est[Agriculture]

capital_formation_construction = capital_formation_per_industry_est[Construction]

capital_formation_manufacturing = capital_formation_per_industry_est[Manufacturing]

capital_formation_market_services = capital_formation_per_industry_est[Market_services]

capital_formation_per_industry[Agriculture] = 0.002167

capital_formation_per_industry[Construction] = 0.450308

capital_formation_per_industry[Manufacturing] = 0.313842

capital_formation_per_industry[Market_services] = 0.225644

capital_formation_per_industry[Public_Services] = 0.008039

capital_formation_per_industry_est[Agriculture] = capital_formation_per_industry[Agriculture]*FIRMS.CAPITAL_FORMATION_TOTAL_DATA

capital_formation_per_industry_est[Construction] = FIRMS.CAPITAL_FORMATION_TOTAL_DATA*capital_formation_per_industry[Construction]

capital_formation_per_industry_est[Manufacturing] = FIRMS.CAPITAL_FORMATION_TOTAL_DATA*capital_formation_per_industry[Manufacturing]

capital_formation_per_industry_est[Market_services] = FIRMS.CAPITAL_FORMATION_TOTAL_DATA*capital_formation_per_industry[Market_services] capital_formation_per_industry_est[Public_Services] = FIRMS.CAPITAL_FORMATION_TOTAL_DATA*capital_formation_per_industry[Public_Services]

capital_formation_public_services = capital_formation_per_industry_est[Public_Services]

CONSTRUCTION_VA = CONSTRUCTION__INDUSTRY.VA_in_construction

domestic_employment = total_employment_data*(1-perc_non_domestic_labour)

employment_per_industry_data[Agriculture] = GRAPH(TIME)

(2001, 109000), (2002, 107000), (2003, 111000), (2004, 109000), (2005, 110000), (2006, 132000), (2007, 120000), (2008, 110000), (2009, 105000), (2010, 105000)

employment_per_industry_data[Construction] = GRAPH(TIME)

(2001, 122000), (2002, 119000), (2003, 122000), (2004, 136000), (2005, 136000), (2006, 129000), (2007, 145000), (2008, 150000), (2009, 135000), (2010, 120000)

employment_per_industry_data[Manufacturing] = GRAPH(TIME)

(2001, 133000), (2002, 147000), (2003, 154000), (2004, 143000), (2005, 146000), (2006, 143000), (2007, 144000), (2008, 137000), (2009, 128000), (2010, 122000)

employment_per_industry_data[Market_services] = GRAPH(TIME)

(2001, 504200), (2002, 501900), (2003, 448300), (2004, 456000), (2005, 459000), (2006, 468600), (2007, 458700), (2008, 472700), (2009, 488700), (2010, 493200)

employment_per_industry_data[Public_Services] = GRAPH(TIME)

(2001, 572800), (2002, 584100), (2003, 594700), (2004, 592000), (2005, 611000), (2006, 621400), (2007, 613300), (2008, 608300), (2009, 607300), (2010, 601800)

GRP = CONSTRUCTION__INDUSTRY.VA_in_construction+PUBLIC_SERVICES_INDUSTRY.VA_in_Public_Services+AGRI_INDUSTRY.VA_in_Agriculture+MANUFACTURING_INDUSTRY.VA_in_manufacturing+MARKET_SERVICES_INDUSTRY.VA_in_Market_Services

GRP_pc = GRP/SOCIO_DEMOGRAPHIC_SECTOR.Population

GRP_pc_RM = AGRI_INDUSTRY.GRP_data/SOCIO_DEMOGRAPHIC_SECTOR.Population_RM

inactivity_rate = (1-(Labour_Force/SOCIO_DEMOGRAPHIC_SECTOR.Population_15plus))*100

Labour_Force = (SOCIO_DEMOGRAPHIC_SECTOR.Population_15plus*(SOCIO_DEMOGRAPHIC_SECTOR.Participation/100))

Labour_Force_RM = SOCIO_DEMOGRAPHIC_SECTOR.Participation*pop_15plus/100

LB_data = GRAPH(TIME)

(2001, 1.8e+006), (2002, 1.8e+006), (2003, 1.8e+006), (2004, 1.7e+006), (2005, 1.7e+006), (2006, 1.7e+006), (2007, 1.7e+006), (2008, 1.7e+006), (2009, 1.7e+006), (2010, 1.7e+006), (2011, 1.7e+006), (2012, 1.7e+006), (2013, 1.7e+006), (2014, 1.7e+006), (2015, 1.7e+006)

MANUFACTURING_VA = MANUFACTURING_INDUSTRY.VA_in_manufacturing

MARKET_SERVICES_VA = MARKET_SERVICES_INDUSTRY.VA_in_Market_Services

national_agriculture = national_production_excl_import[Agriculture]

national_construction = national_production_excl_import[Construction]

national_manufacturing = national_production_excl_import[Manufacturing]

national_market_services = national_production_excl_import[Market_services]

national_production_excl_import[Agriculture] = GRAPH(TIME)

(2001, 4.2e+010), (2002, 4.3e+010), (2003, 4.6e+010), (2004, 4.8e+010), (2005, 4.5e+010), (2006, 4.7e+010), (2007, 4.9e+010), (2008, 5.3e+010), (2009, 5e+010), (2010, 5.1e+010), (2011, 5.8e+010), (2012, 6.1e+010), (2013, 6.4e+010), (2014, 6.1e+010)

national_production_excl_import[Construction] = GRAPH(TIME)

(2001, 1.6e+011), (2002, 1.8e+011), (2003, 1.9e+011), (2004, 2.1e+011), (2005, 2.3e+011), (2006, 2.4e+011), (2007, 2.6e+011), (2008, 2.7e+011), (2009, 2.5e+011), (2010, 2.5e+011), (2011, 2.6e+011), (2012, 2.4e+011), (2013, 2.3e+011), (2014, 2.1e+011)

national_production_excl_import[Manufacturing] = GRAPH(TIME)

(2001, 7.4e+011), (2002, 7.6e+011), (2003, 8e+011), (2004, 8.4e+011), (2005, 9e+011), (2006, 9.9e+011), (2007, 1.1e+012), (2008, 1.3e+012), (2009, 9.1e+011), (2010, 1e+012), (2011, 1.1e+012), (2012, 1.1e+012), (2013, 1.1e+012), (2014, 1.1e+012)

national_production_excl_import[Market_services] = GRAPH(TIME)

(2001, 8.8e+011), (2002, 9.3e+011), (2003, 1e+012), (2004, 1.1e+012), (2005, 1.1e+012), (2006, 1.2e+012), (2007, 1.3e+012), (2008, 1.3e+012), (2009, 1.3e+012), (2010, 1.3e+012), (2011, 1.4e+012), (2012, 1.4e+012), (2013, 1.4e+012), (2014, 1.5e+012)

national_production_excl_import[Public_Services] = GRAPH(TIME)

(2001, 2.7e+011), (2002, 2.9e+011), (2003, 3.2e+011), (2004, 3.4e+011), (2005, 3.6e+011), (2006, 3.8e+011), (2007, 3.9e+011), (2008, 4.2e+011), (2009, 4.4e+011), (2010, 4.5e+011), (2011, 4.7e+011), (2012, 4.8e+011), (2013, 4.8e+011), (2014, 4.8e+011)

national_public_services = national_production_excl_import[Public_Services]

perc_non_domestic_labour = GRAPH(TIME)

(2004, 0.0137), (2005, 0.019), (2006, 0.0217), (2007, 0.0249), (2008, 0.029), (2009, 0.0322), (2010, 0.0377), (2011, 0.0416), (2012, 0.0444), (2013, 0.048), (2014, 0.0526), (2015, 0.0551)

per_pop_under_15 = GRAPH(TIME)

(2002, 17.1), (2003, 16.9), (2004, 16.6), (2005, 16.4), (2006, 16.2), (2007, 15.9), (2008, 15.7), (2009, 15.5), (2010, 15.3), (2011, 15.1), (2012, 14.9), (2013, 14.8), (2014, 14.6), (2015, 14.5)

pop_15plus = SOCIO_DEMOGRAPHIC_SECTOR.Population_RM*(100-per_pop_under_15)/100

PUBLIC_SERVICES_VA = PUBLIC_SERVICES_INDUSTRY.VA_in_Public_Services

regional_avg_wage = regional_tot_wages/reg_employment

Regional_DM_from_HH_&_Gov = PUBLIC_SERVICES_SECTOR.Regional_Public_Serviices_DM+AGRICULTURE_SECTOR.Regional_Agriculture_DM+MANUFACTURING_SECTOR.Regional_Manufacturing_DM+MARKET_SERVICES_SECTOR.Regional_Market_Serviices_DM+CONSTRUCTION_SECTOR.Regional_Construction_DM

regional_tot_wages = MANUFACTURING_INDUSTRY.total_wages+CONSTRUCTION__INDUSTRY.total_wages+PUBLIC_SERVICES_INDUSTRY.total_wages+MARKET_SERVICES_INDUSTRY.total_wages+AGRI_INDUSTRY.total_wages

reg_employment = MANUFACTURING_INDUSTRY.EMPLOYMENT+PUBLIC_SERVICES_INDUSTRY.EMPLOYMENT+CONSTRUCTION__INDUSTRY.EMPLOYMENT+MARKET_SERVICES_INDUSTRY.EMPLOYMENT+AGRI_INDUSTRY.EMPLOYMENT

relative_perceived_employment = (reg_employment/history(reg_employment,(time-1)))

total_employment_data = SUM(employment_per_industry_data)

tot_employ_data_est = (100-Unemployment_rate_RM)/100*LB_data

Unemployment_rate = max(0,(1-reg_employment/Labour_Force)*100)

Unemployment_rate_RM = GRAPH(TIME)

(2001, 22.0), (2002, 20.6), (2003, 20.0), (2004, 17.1), (2005, 16.0), (2006, 13.4), (2007, 12.9), (2008, 13.7), (2009, 13.8), (2010, 14.6), (2011, 14.3), (2012, 18.4), (2013, 21.0), (2014, 22.2)

UR_DOMESTIC = 100-(domestic_employment/LB_data*100)

PRODUCTION.AGRICULTURE SECTOR:

imports(t) = imports(t - dt) + (change_in_imports) * dt

INIT imports = 138176854

INFLOWS:

change_in_imports = (indicated_imports-imports)/imports_adj_time

intermediate[Agriculture](t) = intermediate[Agriculture](t - dt) + (change_in_intermediate[INDUSTRY]) * dt

INIT intermediate[Agriculture] = 324866969 intermediate[Construction](t) = intermediate[Construction](t - dt) + (change_in_intermediate[INDUSTRY]) * dt

INIT intermediate[Construction] = 37484650

intermediate[Manufacturing](t) = intermediate[Manufacturing](t - dt) + (change_in_intermediate[INDUSTRY]) * dt

INIT intermediate[Manufacturing] = 637239055

intermediate[Market_services](t) = intermediate[Market_services](t - dt) + (change_in_intermediate[INDUSTRY]) * dt

INIT intermediate[Market_services] = 237402785

intermediate[Public_Services](t) = intermediate[Public_Services](t - dt) + (change_in_intermediate[INDUSTRY]) * dt

INIT intermediate[Public_Services] = 12494883

INFLOWS:

change_in_intermediate[INDUSTRY] = (indicated_intermediate-intermediate)/intermediate_adj_time

INVENTORY(t) = INVENTORY(t - dt) + (Production - Sales) * dt

INIT INVENTORY = sales*planned_inventory_coverage

INFLOWS:

Production = AGRI_INDUSTRY.VA_in_Agriculture+imports+SUM(intermediate[*])+net_tax_on_production

OUTFLOWS:

Sales = Final_sales+SUM(intermediate_sales)+PRODUCTION.capital_formation_agriculture

construction_intermediate_data = CONSTRUCTION_SECTOR.intermediate[Agriculture]

EXPORT_SUBDIVISION_PER_SECTOR[Agriculture] = 0.0667

EXPORT_SUBDIVISION_PER_SECTOR[Construction] = 0

EXPORT_SUBDIVISION_PER_SECTOR[Manufacturing] = 0.93287

EXPORT_SUBDIVISION_PER_SECTOR[Market_services] = 0.00016

EXPORT_SUBDIVISION_PER_SECTOR[Public_Services] = 0.00027

Final_sales = Regional_Agriculture_DM+Regional_Agriculture_Exports+Policy*SWITCH

imports_adj_time = 0.5

imports_coefficient = 0.049648443

indicated_imports = indicated_production*imports_coefficient

indicated_intermediate[INDUSTRY] = indicated_production*intermediate_coefficient

indicated_inventory = Sales*planned_inventory_coverage

indicated_production = Sales+MAX((indicated_inventory-INVENTORY)/inventory_adjustment_time,0)

intermediate_adj_time = 0.5

intermediate_coefficient[Agriculture] = 0.07988645

intermediate_coefficient[Construction] = 0.009218

intermediate_coefficient[Manufacturing] = 0.156700345

intermediate_coefficient[Market_services] = 0.058379

intermediate_coefficient[Public_Services] = 0.003073

intermediate_sales[Agriculture] = intermediate[Agriculture]

intermediate_sales[Construction] = construction_intermediate_data

intermediate_sales[Manufacturing] = manufacturing_intermediate_data

intermediate_sales[Market_services] = market_service_intermediate_data

intermediate_sales[Public_Services] = public_sector_intermediate_data

inventory_adjustment_time = 1

manufacturing_intermediate_data = MANUFACTURING_SECTOR.intermediate[Agriculture]

market_service_intermediate_data = MARKET_SERVICES_SECTOR.intermediate[Agriculture]

national_export = PRODUCTION.national_agriculture*0.92*nat_export_ratio

nat_export_ratio = 0.02685

net_tax_on_production = AGRI_INDUSTRY.VA_in_Agriculture*0.11

PB_DM_per_sector[Agriculture] = 0.14683/100

PB_DM_per_sector[Construction] = 0.39908/100

PB_DM_per_sector[Manufacturing] = 2.02996/100

PB_DM_per_sector[Market_services] = 5.48977/100

PB_DM_per_sector[Public_Services] = 91.93436/100

planned_inventory_coverage = 0.5

Policy = if time<2016 then 0 else if time >2020 then 0 else 500000000 public_sector_intermediate_data = PUBLIC_SERVICES_SECTOR.intermediate[Agriculture]

PV_DM_SUBDIVISION_PER_SECTOR[Agriculture] = 0.02

PV_DM_SUBDIVISION_PER_SECTOR[Construction] = 0.01

PV_DM_SUBDIVISION_PER_SECTOR[Manufacturing] = 0.2

PV_DM_SUBDIVISION_PER_SECTOR[Market_services] = 0.45

PV_DM_SUBDIVISION_PER_SECTOR[Public_Services] = 0.33

Regional_Agriculture_DM = REGIONAL_HH_DM+REGIONAL_PB__DM

Regional_Agriculture_Exports = SMTH1(REST_OF_THE_WORLD.REGIONAL_EXPORT_DATA,1)*EXPORT_SUBDIVISION_PER_SECTOR[Agriculture]+national_export

REGIONAL_HH_DM = (SOCIO_DEMOGRAPHIC_SECTOR.Population*HOUSEHOLDS.Per_Capita_Consumption)*PV_DM_SUBDIVISION_PER_SECTOR[Agriculture]

REGIONAL_PB__DM = (GOVERNMENT.pc_Government_spending*SOCIO_DEMOGRAPHIC_SECTOR.Population)*PB_DM_per_sector[Agriculture]/100

SWITCH = 0

PRODUCTION.CONSTRUCTION SECTOR:

imports(t) = imports(t - dt) + (change_in_imports) * dt

INIT imports = indicated_imports

INFLOWS:

change_in_imports = (indicated_imports-imports)/imports_adj_time

intermediate[INDUSTRY](t) = intermediate[INDUSTRY](t - dt) + (change_in_intermediate[INDUSTRY]) * dt

INIT intermediate[INDUSTRY] = CONSTRUCTION_INTERMEDIATE_INITIAL_VALUE

INFLOWS:

change_in_intermediate[INDUSTRY] = (indicated_intermediate-intermediate)/intermediate_adj_time

INVENTORY(t) = INVENTORY(t - dt) + (Production - Sales) * dt

INIT INVENTORY = sales*planned_inventory_coverage

INFLOWS:

Production = CONSTRUCTION__INDUSTRY.VA_in_construction+imports+SUM(intermediate[*])+net_tax_on_VA

OUTFLOWS:

Sales = Final_sales+SUM(intermediate_sales)+PRODUCTION.capital_formation_construction

agriculture_intermediate_data = AGRICULTURE_SECTOR.intermediate[Construction]

CONSTRUCTION_INTERMEDIATE_INITIAL_VALUE[Agriculture] = 4242445.23

CONSTRUCTION_INTERMEDIATE_INITIAL_VALUE[Construction] = 3172574720.29

CONSTRUCTION_INTERMEDIATE_INITIAL_VALUE[Manufacturing] = 2066449112.35

CONSTRUCTION_INTERMEDIATE_INITIAL_VALUE[Market_services] = 1985358935.68

CONSTRUCTION_INTERMEDIATE_INITIAL_VALUE[Public_Services] = 89053440.37

DM_PB_per_sector[Agriculture] = 0.14683/100

DM_PB_per_sector[Construction] = 0.39908/100

DM_PB_per_sector[Manufacturing] = 2.02996/100

DM_PB_per_sector[Market_services] = 5.48977/100

DM_PB_per_sector[Public_Services] = 91.93436/100

Final_sales = Regional_Construction_DM+Regional_Construction_Exports+Policy*SWITCH

imports_adj_time = 0.5

imports_coefficient = 0

indicated_imports = indicated_production*imports_coefficient

indicated_intermediate[INDUSTRY] = intermediate_coefficient*indicated_production

indicated_inventory = Sales*planned_inventory_coverage

indicated_production = Sales+MAX((indicated_inventory-INVENTORY)/inventory_adjustment_time,0)

intermediate_adj_time = 0.5

intermediate_coefficient[Agriculture] = 0.000379463

intermediate_coefficient[Construction] = 0.283731276

intermediate_coefficient[Manufacturing] = 0.184806326

intermediate_coefficient[Market_services] = 0.177554359

intermediate_coefficient[Public_Services] = 0.007964898

intermediate_sales[Agriculture] = agriculture_intermediate_data

intermediate_sales[Construction] = intermediate[Construction]

intermediate_sales[Manufacturing] = manufacturing_intermediate_data intermediate_sales[Market_services] = market_service_intermediate_data

intermediate_sales[Public_Services] = public_sector_intermediate_data

inventory_adjustment_time = 3

manufacturing_intermediate_data = MANUFACTURING_SECTOR.intermediate[Construction]

market_service_intermediate_data = MARKET_SERVICES_SECTOR.intermediate[Construction]

national_exp_ratio = 0.002743615

net_tax_on_VA = CONSTRUCTION__INDUSTRY.VA_in_construction*0.11

planned_inventory_coverage = 0.6

Policy = if time<2016 then 0 else if time >2020 then 0 else 500000000

public_sector_intermediate_data = PUBLIC_SERVICES_SECTOR.intermediate[Construction]

PV_DM_per_sector[Agriculture] = 0.02

PV_DM_per_sector[Construction] = 0.01

PV_DM_per_sector[Manufacturing] = 0.2

PV_DM_per_sector[Market_services] = 0.45

PV_DM_per_sector[Public_Services] = 0.33

Regional_Construction_DM = REGIONAL_PV_DM+REGIONAL_PB_DM

Regional_Construction_Exports = smth1(REGIONAL_EXPORT_DATA,1)*AGRICULTURE_SECTOR.EXPORT_SUBDIVISION_PER_SECTOR[Construction]+PRODUCTION.national_construction*national_exp_ratio*0

REGIONAL_EXPORT_DATA = GRAPH(TIME)

(2001, 4.3e+009), (2002, 4.1e+009), (2003, 4.4e+009), (2004, 4.9e+009), (2005, 6.5e+009), (2006, 7.3e+009), (2007, 9e+009), (2008, 9.6e+009), (2009, 6.1e+009), (2010, 1.6e+010), (2011, 1.1e+010), (2012, 1.4e+010), (2013, 1.2e+010), (2014, 1e+010)

REGIONAL_PB_DM = DM_PB_per_sector[Construction]*(GOVERNMENT.pc_Government_spending*SOCIO_DEMOGRAPHIC_SECTOR.Population)

REGIONAL_PV_DM = HOUSEHOLDS.Per_Capita_Consumption*SOCIO_DEMOGRAPHIC_SECTOR.Population*PV_DM_per_sector[Construction]

SWITCH = 0

summing_agr_inter_initial_data =
CONSTRUCTION_INTERMEDIATE_INITIAL_VALUE[Agriculture] +
CONSTRUCTION_INTERMEDIATE_INITIAL_VALUE[Construction] +
CONSTRUCTION_INTERMEDIATE_INITIAL_VALUE[Manufacturing] +
CONSTRUCTION_INTERMEDIATE_INITIAL_VALUE[Market_services] +
CONSTRUCTION_INTERMEDIATE_INITIAL_VALUE[Public_Services]

PRODUCTION.MANUFACTURING SECTOR:

imports(t) = imports(t - dt) + (change_in_imports) * dt

INIT imports = indicated_imports

INFLOWS:

change_in_imports = (indicated_imports-imports)/imports_adj_time

intermediate[INDUSTRY](t) = intermediate[INDUSTRY](t - dt) +
(change_in_intermediate[INDUSTRY]) * dt

INIT intermediate[INDUSTRY] = CONSTRUCTION_INTERMEDIATE_INITIAL_VALUE

INFLOWS:

change_in_intermediate[INDUSTRY] = (indicated_intermediate-
intermediate)/intermediate_adj_time

INVENTORY(t) = INVENTORY(t - dt) + (Production - Sales) * dt

INIT INVENTORY = sales*planned_inventory_coverage*0.5

INFLOWS:

Production =
MANUFACTURING_INDUSTRY.VA_in_manufacturing+imports+SUM(intermediate[*])+NET_TAX_ON_VA

OUTFLOWS:

Sales =
Final_sales+SUM(intermediate_sales)+PRODUCTION.capital_formation_manufacturing

agriculture_intermediate_data = AGRICULTURE_SECTOR.intermediate[Manufacturing]

construction_intermediate_data = CONSTRUCTION_SECTOR.intermediate[Manufacturing]

CONSTRUCTION_INTERMEDIATE_INITIAL_VALUE[Agriculture] = 604047559.72

CONSTRUCTION_INTERMEDIATE_INITIAL_VALUE[Construction] = 167859760.64

CONSTRUCTION_INTERMEDIATE_INITIAL_VALUE[Manufacturing] = 11560390258.92

CONSTRUCTION_INTERMEDIATE_INITIAL_VALUE[Market_services] = 4581080128.77

CONSTRUCTION_INTERMEDIATE_INITIAL_VALUE[Public_Services] = 160587043.22

Final_sales =
Regional_Manufacturing_DM+Regional_Manufacturing_Exports+policy*SWITCH

imports_adj_time = 0.5

imports_coefficient = 0.45974

indicated_imports = indicated_production*imports_coefficient

indicated_intermediate[INDUSTRY] = intermediate_coefficient*indicated_production

indicated_inventory = Sales*planned_inventory_coverage

indicated_production = (Sales+MAX((indicated_inventory-INVENTORY)/inventory_adjustment_time,0))*(1+0.08)

intermediate_adj_time = 0.5

intermediate_coefficient[Agriculture] = 0.013645468

intermediate_coefficient[Construction] = 0.003791837

intermediate_coefficient[Manufacturing] = 0.261152603

intermediate_coefficient[Market_services] = 0.10348782

intermediate_coefficient[Public_Services] = 0.003627713

intermediate_sales[Agriculture] = agriculture_intermediate_data

intermediate_sales[Construction] = construction_intermediate_data

intermediate_sales[Manufacturing] = intermediate[Manufacturing]

intermediate_sales[Market_services] = market_service_intermediate_data

intermediate_sales[Public_Services] = public_sector_intermediate_data

inventory_adjustment_time = 2

market_service_intermediate_data =
MARKET_SERVICES_SECTOR.intermediate[Manufacturing]

NET_TAX_ON_VA = MANUFACTURING_INDUSTRY.VA_in_manufacturing*0.11

planned_inventory_coverage = 0.5

policy = if time<2016 then 0 else if time >2020 then 0 else 500000000

public_sector_intermediate_data =
PUBLIC_SERVICES_SECTOR.intermediate[Manufacturing]

PV_DM_PER_SECTOR[Agriculture] = 0.02

PV_DM_PER_SECTOR[Construction] = 0.01

PV_DM_PER_SECTOR[Manufacturing] = 0.2

PV_DM_PER_SECTOR[Market_services] = 0.45

PV_DM_PER_SECTOR[Public_Services] = 0.33

REGIONAL_EXPORT_DATA = GRAPH(TIME)

(2001, 4.3e+009), (2002, 4.1e+009), (2003, 4.4e+009), (2004, 4.9e+009), (2005, 6.5e+009), (2006, 7.3e+009), (2007, 9e+009), (2008, 9.6e+009), (2009, 6.1e+009), (2010, 1.6e+010), (2011, 1.1e+010), (2012, 1.4e+010), (2013, 1.2e+010), (2014, 1e+010)

Regional_Manufacturing_DM = REGIONAL_PV_DM+Regional_PB_DM

Regional_Manufacturing_Exports = smth1(REGIONAL_EXPORT_DATA,1)*AGRICULTURE_SECTOR.EXPORT_SUBDIVISION_PER_SECTOR[Manufacturing]

Regional_PB_DM = SOCIO_DEMOGRAPHIC_SECTOR.Population*GOVERNMENT.pc_Government_spending*AGRICULTURE_SECTOR.PB_DM_per_sector[Manufacturing]

REGIONAL_PV_DM = HOUSEHOLDS.Per_Capita_Consumption*SOCIO_DEMOGRAPHIC_SECTOR.Population*PV_DM_PER_SECTOR[Manufacturing]

SWITCH = 0

intermediate_sales_total = intermediate_sales[Agriculture] + intermediate_sales[Construction] + intermediate_sales[Manufacturing] + intermediate_sales[Market_services] + intermediate_sales[Public_Services]

summing_agr_inter_initial_data = CONSTRUCTION_INTERMEDIATE_INITIAL_VALUE[Agriculture] + CONSTRUCTION_INTERMEDIATE_INITIAL_VALUE[Construction] + CONSTRUCTION_INTERMEDIATE_INITIAL_VALUE[Manufacturing] + CONSTRUCTION_INTERMEDIATE_INITIAL_VALUE[Market_services] + CONSTRUCTION_INTERMEDIATE_INITIAL_VALUE[Public_Services]

total_indicated_intermediate = indicated_intermediate[Agriculture] + indicated_intermediate[Construction] + indicated_intermediate[Manufacturing] + indicated_intermediate[Market_services] + indicated_intermediate[Public_Services]

total_intermediate = intermediate[Agriculture] + intermediate[Construction] + intermediate[Manufacturing] + intermediate[Market_services] + intermediate[Public_Services]

PRODUCTION.MARKET SERVICES SECTOR:

imports(t) = imports(t - dt) + (change_in_imports) * dt

INIT imports = 2450969

INFLOWS:

change_in_imports = (indicated_imports-imports)/imports_adj_time intermediate[INDUSTRY](t) = intermediate[INDUSTRY](t - dt) + (change_in_intermediate[INDUSTRY]) * dt

INIT intermediate[INDUSTRY] = MARKET_SERVICES_INTERMEDIATE_INITIAL_VALUE

INFLOWS:

change_in_intermediate[INDUSTRY] = (indicated_intermediate-intermediate)/intermediate_adj_time

INVENTORY(t) = INVENTORY(t - dt) + (Production - Sales) * dt

INIT INVENTORY = sales*planned_inventory_coverage

INFLOWS:

Production = MARKET_SERVICES_INDUSTRY.VA_in_Market_Services+imports+SUM(intermediate[*])+NET_TAX_ON_VA

OUTFLOWS:

Sales = Final_sales+SUM(intermediate_sales)+PRODUCTION.capital_formation_market_services

agriculture_intermediate = AGRICULTURE_SECTOR.intermediate[Market_services]

ARTICOLAZIONE_DM_PER_BRANCA[Agriculture] = 0.02

ARTICOLAZIONE_DM_PER_BRANCA[Construction] = 0.01

ARTICOLAZIONE_DM_PER_BRANCA[Manufacturing] = 0.2

ARTICOLAZIONE_DM_PER_BRANCA[Market_services] = 0.45

ARTICOLAZIONE_DM_PER_BRANCA[Public_Services] = 0.33

construction_intermediate_data = CONSTRUCTION_SECTOR.intermediate[Market_services]

Final_sales = Regional_Market_Serviices_DM+Regional_Market_Services_Exports+Policy*SWITCH

imports_adj_time = 0.5

imports_coefficient = 7.47e-05

indicated_imports = indicated_production*imports_coefficient

indicated_intermediate[INDUSTRY] = intermediate_coefficient*indicated_production

indicated_inventory = Sales*planned_inventory_coverage

indicated_production = Sales+MAX((indicated_inventory-INVENTORY)/inventory_adjustment_time,0)

intermediate_adj_time = 0.5

intermediate_coefficient[Agriculture] = 0.004087

intermediate_coefficient[Construction] = 0.008843

intermediate_coefficient[Manufacturing] = 0.089637

intermediate_coefficient[Market_services] = 0.289972

intermediate_coefficient[Public_Services] = 0.008814

intermediate_sales[Agriculture] = agriculture_intermediate

intermediate_sales[Construction] = construction_intermediate_data

intermediate_sales[Manufacturing] = manufacturing_intermediate_data

intermediate_sales[Market_services] = intermediate[Market_services]

intermediate_sales[Public_Services] = public_sector_intermediate_data

inventory_adjustment_time = 0.3

manufacturing_intermediate_data = MANUFACTURING_SECTOR.intermediate[Market_services]

MARKET_SERVICES_INTERMEDIATE_INITIAL_VALUE[Agriculture] = 201213790.95

MARKET_SERVICES_INTERMEDIATE_INITIAL_VALUE[Construction] = 435376442.82

MARKET_SERVICES_INTERMEDIATE_INITIAL_VALUE[Manufacturing] = 4413292470.32

MARKET_SERVICES_INTERMEDIATE_INITIAL_VALUE[Market_services] = 14276783536.91

MARKET_SERVICES_INTERMEDIATE_INITIAL_VALUE[Public_Services] = 433937172.85

natinoal_exp_ratio = 0.000907991

NET_TAX_ON_VA = MARKET_SERVICES_INDUSTRY.VA_in_Market_Services*0.11

planned_inventory_coverage = 0.025

Policy = if time<2016 then 0 else if time >2020 then 0 else 500000000

public_sector_intermediate_data = PUBLIC_SERVICES_SECTOR.intermediate[Market_services]

REGIONAL_EXPORT_DATA = GRAPH(TIME)

(2001, 4.3e+009), (2002, 4.1e+009), (2003, 4.4e+009), (2004, 4.9e+009), (2005, 6.5e+009), (2006, 7.3e+009), (2007, 9e+009), (2008, 9.6e+009), (2009, 6.1e+009), (2010, 1.6e+010), (2011, 1.1e+010), (2012, 1.4e+010), (2013, 1.2e+010), (2014, 1e+010)

Regional_Market_Services_Exports = smth1(REGIONAL_EXPORT_DATA,1)*AGRICULTURE_SECTOR.EXPORT_SUBDIVISI

ON_PER_SECTOR[Market_services]+natinoal_exp_ratio*PRODUCTION.national_market_services

Regional_Market_Serviices_DM = REGIONAL_PV_DM+REGIONAL_PB_DM

REGIONAL_PB_DM = (GOVERNMENT.pc_Government_spending*SOCIO_DEMOGRAPHIC_SECTOR.Population)*AGRICULTURE_SECTOR.PB_DM_per_sector[Market_services]

REGIONAL_PV_DM = SOCIO_DEMOGRAPHIC_SECTOR.Population*HOUSEHOLDS.Per_Capita_Consumption*ARTICOLAZIONE_DM_PER_BRANCA[Market_services]

SWITCH = 0

summing_agr_inter_initial_data =
MARKET_SERVICES_INTERMEDIATE_INITIAL_VALUE[Agriculture] +
MARKET_SERVICES_INTERMEDIATE_INITIAL_VALUE[Construction] +
MARKET_SERVICES_INTERMEDIATE_INITIAL_VALUE[Manufacturing] +
MARKET_SERVICES_INTERMEDIATE_INITIAL_VALUE[Market_services] +
MARKET_SERVICES_INTERMEDIATE_INITIAL_VALUE[Public_Services]

PRODUCTION.PUBLIC SERVICES SECTOR:

imports(t) = imports(t - dt) + (change_in_imports) * dt

INIT imports = indicated_imports

INFLOWS:

change_in_imports = (indicated_imports-imports)/imports_adj_time

intermediate[INDUSTRY](t) = intermediate[INDUSTRY](t - dt) + (change_in_intermediate[INDUSTRY]) * dt

INIT intermediate[INDUSTRY] = PUBLIC_SERVICES_INTERMEDIATE_INITIAL_VALUE

INFLOWS:

change_in_intermediate[INDUSTRY] = (indicated_intermediate-intermediate)/intermediate_adj_time

INVENTORY(t) = INVENTORY(t - dt) + (Production - Sales) * dt

INIT INVENTORY = sales*planned_inventory_coverage

INFLOWS:

Production = NET_TAX_ON_VA+PUBLIC_SERVICES_INDUSTRY.VA_in_Public_Services+imports+SUM(intermediate[*])

OUTFLOWS:

Sales =
Final_sales+SUM(intermediate_sales)+PRODUCTION.capital_formation_public_services

agriculture_intermediate_data = AGRICULTURE_SECTOR.intermediate[Public_Services]

construction_intermediate_data = CONSTRUCTION_SECTOR.intermediate[Public_Services]

Final_sales =
Regional_Public_Serviices_DM+Regional_Public_Services_Exports+Policy*SWITCH

imports_adj_time = 0.5

imports_coefficient = 0.231313

indicated_imports = indicated_production*imports_coefficient

indicated_intermediate[INDUSTRY] = indicated_production*intermediate_coefficient

indicated_inventory = Sales*planned_inventory_coverage

indicated_production = Sales+MAX((indicated_inventory-INVENTORY)/inventory_adjustment_time,0)

intermediate_adj_time = 0.5

intermediate_coefficient[Agriculture] = 0.000482235

intermediate_coefficient[Construction] = 0.009298859

intermediate_coefficient[Manufacturing] = 0.047621132

intermediate_coefficient[Market_services] = 0.110855643

intermediate_coefficient[Public_Services] = 0.041741759

intermediate_sales[Agriculture] = agriculture_intermediate_data

intermediate_sales[Construction] = construction_intermediate_data

intermediate_sales[Manufacturing] = manufacturing_intermediate_data

intermediate_sales[Market_services] = Market_Services_intermediate_data

intermediate_sales[Public_Services] = intermediate[Public_Services]

inventory_adjustment_time = 3

manufacturing_intermediate_data =
MANUFACTURING_SECTOR.intermediate[Public_Services]

Market_Services_intermediate_data =
MARKET_SERVICES_SECTOR.intermediate[Public_Services]

NET_TAX_ON_VA = PUBLIC_SERVICES_INDUSTRY.VA_in_Public_Services*0.11

planned_inventory_coverage = 0.15

Policy = if time<2016 then 0 else if time >2020 then 0 else 500000000

PUBLIC_SERVICES_INTERMEDIATE_INITIAL_VALUE[Agriculture] = 15702357.80

PUBLIC_SERVICES_INTERMEDIATE_INITIAL_VALUE[Construction] = 302571190.97

PUBLIC_SERVICES_INTERMEDIATE_INITIAL_VALUE[Manufacturing] = 1549532830.91

PUBLIC_SERVICES_INTERMEDIATE_INITIAL_VALUE[Market_services] = 3607144312.87

PUBLIC_SERVICES_INTERMEDIATE_INITIAL_VALUE[Public_Services] = 1358259551.16

REGIONAL_EXPORT_DATA = GRAPH(TIME)

(2001, 4.3e+009), (2002, 4.1e+009), (2003, 4.4e+009), (2004, 4.9e+009), (2005, 6.5e+009), (2006, 7.3e+009), (2007, 9e+009), (2008, 9.6e+009), (2009, 6.1e+009), (2010, 1.6e+010), (2011, 1.1e+010), (2012, 1.4e+010), (2013, 1.2e+010), (2014, 1e+010)

REGIONAL_PB_DM = AGRICULTURE_SECTOR.PB_DM_per_sector[Public_Services]*GOVERNMENT.pc_Government_spending*SOCIO_DEMOGRAPHIC_SECTOR.Population

Regional_Public_Services_Exports = SMTH1(REGIONAL_EXPORT_DATA,1)*AGRICULTURE_SECTOR.EXPORT_SUBDIVISION_PER_SECTOR[Public_Services]

Regional_Public_Serviices_DM = REGIONAL_PV_DM+REGIONAL_PB_DM

REGIONAL_PV_DM = SOCIO_DEMOGRAPHIC_SECTOR.Population*HOUSEHOLDS.Per_Capita_Consumption*AGRICULTURE_SECTOR.PV_DM_SUBDIVISION_PER_SECTOR[Public_Services]

SWITCH = 0

summing_agr_inter_initial_data = PUBLIC_SERVICES_INTERMEDIATE_INITIAL_VALUE[Agriculture] + PUBLIC_SERVICES_INTERMEDIATE_INITIAL_VALUE[Construction] + PUBLIC_SERVICES_INTERMEDIATE_INITIAL_VALUE[Manufacturing] + PUBLIC_SERVICES_INTERMEDIATE_INITIAL_VALUE[Market_services] + PUBLIC_SERVICES_INTERMEDIATE_INITIAL_VALUE[Public_Services]

AGRICULTURE SECTOR.AGRI INDUSTRY:

avg_wage(t) = avg_wage(t - dt) + (chg_in_wages) * dt

INIT avg_wage = avg_wage_data

INFLOWS:

chg_in_wages = (indicated_wage-avg_wage)/time_to_chg_wages

Capital_on_order(t) = Capital_on_order(t - dt) + (capital_orders - Capital_formation_rate) * dt

INIT Capital_on_order = desired_capital_orders*capital_delivery_time*4

INFLOWS:

capital_orders = desired_capital_orders

OUTFLOWS:

Capital_formation_rate = Capital_on_order/capital_delivery_time

long_run_expected_Demand(t) = long_run_expected_Demand(t - dt) + (chg_in_long_run_expected_demand) * dt

INIT long_run_expected_Demand = VA_in_Agriculture_data

INFLOWS:

chg_in_long_run_expected_demand = (AGRICULTURE_SECTOR.indicated_production*domestic_prod_coeff-long_run_expected_Demand)/time_to_perceive_expected_demand

Capital_in_Agriculture(t) = Capital_in_Agriculture(t - dt) + (Capital_formation_rate - capital_depreciation) * dt

INIT Capital_in_Agriculture = Gross_Capital_Srock_in_Agriculture_data

INFLOWS:

Capital_formation_rate = Capital_on_order/capital_delivery_time

OUTFLOWS:

capital_depreciation = Capital_in_Agriculture/avg_life_of_capital

EMPLOYMENT(t) = EMPLOYMENT(t - dt) + (hiring_rate) * dt

INIT EMPLOYMENT = PRODUCTION.employment_per_industry_data[agriculture]

INFLOWS:

hiring_rate = IF (PRODUCTION.Labour_Force>HISTORY(PRODUCTION.reg_employment, (time-1)))THEN (desired_employment-EMPLOYMENT)*(1-PRODUCTION.perc_non_domestic_labour)/time_to_hire ELSE MIN(0,(desired_employment-EMPLOYMENT)*(1-PRODUCTION.perc_non_domestic_labour)/time_to_hire)

Actual_Capital_Output_Ratio = Capital_in_Agriculture/VA_in_Agriculture

alfa = GRAPH(TIME)

(2001, 0.7), (2002, 0.67), (2003, 0.74), (2004, 0.72), (2005, 0.67), (2006, 0.63), (2007, 0.63), (2008, 0.64), (2009, 0.63), (2010, 0.62)

avg_life_of_capital = 14

avg_wage_data = total_wages_data/PRODUCTION.employment_per_industry_data[Agriculture] capital_adj_time = 2

capital_delivery_time = 4

delay_in_wage_changes = 2

desired_capital = long_run_expected_Demand*des_capital_output_ratio

desired_capital_orders = capital_depreciation+((desired_capital-Capital_in_Agriculture)/capital_adj_time)

desired_employment = (AGRICULTURE_SECTOR.indicated_production*domestic_prod_coeff)/productivity_of_Labour*1+0*(desired_Labour_share/Labour_share)

desired_Labour_share = GRAPH(TIME)

(2001, 0.3), (2010, 0.43)

des_capital_output_ratio = Actual_Capital_Output_Ratio*(history(expected_cost_of_capital,(time-1))/expected_cost_of_capital)*history(expected_labour_cost_productivity_ratio,(time-1))/expected_labour_cost_productivity_ratio

domestic_prod_coeff = 0.579263062

Employment_in_Agriculture_data = PRODUCTION.employment_per_industry_data[agriculture]

expected_cost_of_capital = SMTH1(interest_rate,time_to_perceive_cost_of_capital)+1/avg_life_of_capital

expected_labour_cost_productivity_ratio = SMTH1(unit_labour_cost_index/init(unit_labour_cost_index),1)

Gross_Capital_Srock_in_Agriculture_data = Gross_Capital_Stock_per_Industry_data[Agriculture]

Gross_Capital_Stock_CURRENT[Agriculture] = GRAPH(TIME)

(2001, 1.3e+010), (2002, 1.4e+010), (2003, 1.6e+010), (2004, 1.7e+010), (2005, 1.7e+010), (2006, 1.8e+010), (2007, 2e+010), (2008, 2.7e+010), (2009, 2.2e+010), (2010, 2.1e+010), (2011, 2.1e+010)

Gross_Capital_Stock_CURRENT[Construction] = GRAPH(TIME)

(2001, 5.1e+009), (2002, 5.1e+009), (2003, 8.2e+009), (2004, 4.2e+009), (2005, 3.3e+009), (2006, 6e+009), (2007, 4.7e+009), (2008, 6.7e+009), (2009, 5.3e+009), (2010, 4.2e+009), (2011, 5.7e+009)

Gross_Capital_Stock_CURRENT[Manufacturing] = GRAPH(TIME)

(2001, 4.2e+010), (2002, 5.1e+010), (2003, 4.6e+010), (2004, 5.6e+010), (2005, 4.9e+010), (2006, 4.8e+010), (2007, 5.7e+010), (2008, 5.6e+010), (2009, 5.2e+010), (2010, 5.4e+010), (2011, 4.5e+010)

Gross_Capital_Stock_CURRENT[Market_services] = GRAPH(TIME)

(2001, 2.3e+011), (2002, 2.2e+011), (2003, 2.4e+011), (2004, 2.7e+011), (2005, 2.9e+011), (2006, 3.1e+011), (2007, 3.2e+011), (2008, 2.9e+011), (2009, 3.4e+011), (2010, 3.5e+011), (2011, 3.6e+011)

Gross_Capital_Stock_CURRENT[Public_Services] = GRAPH(TIME)

(2001, 6.5e+010), (2002, 6.2e+010), (2003, 7.1e+010), (2004, 6.9e+010), (2005, 7.1e+010), (2006, 8e+010), (2007, 9.1e+010), (2008, 9.6e+010), (2009, 8.5e+010), (2010, 9e+010), (2011, 9.8e+010)

Gross_Capital_Stock_per_Industry_data[INDUSTRY] = Gross_Capital_Stock_CURRENT*IPC_DATA/100

GRP_data = VA_per_Industry_data[Agriculture]+VA_per_Industry_data[Construction]+VA_per_Industry_data[Manufacturing]+VA_per_Industry_data[Market_services]+VA_per_Industry_data[Public_Services]

indicated_wage = desired_Labour_share*SMTH1(productivity_of_Labour,delay_in_wage_changes)

interest_rate = GRAPH(TIME)

(2001, 6.65), (2002, 5.57), (2003, 4.71), (2004, 4.03), (2005, 3.56), (2006, 4.68), (2007, 5.48), (2008, 4.82), (2009, 2.25), (2010, 2.79), (2011, 4.18), (2012, 3.64), (2013, 3.45), (2014, 2.66)

IPC_DATA = GRAPH(TIME)

(2001, 82.9), (2002, 85.0), (2003, 88.0), (2004, 89.2), (2005, 90.9), (2006, 92.8), (2007, 94.5), (2008, 97.7), (2009, 98.5), (2010, 100), (2011, 103), (2012, 106), (2013, 107), (2014, 107)

k_output_ratio_data = Gross_Capital_Srock_in_Agriculture_data/VA_in_Agriculture_data

LABOR_SHARE_DATA = IF (PRODUCTIVITY_OF_LB_DATA=0) THEN 0 ELSE (avg_wage_data/PRODUCTIVITY_OF_LB_DATA)

Labour_share = avg_wage/productivity_of_Labour

productivity_of_Labour = VA_in_Agriculture/EMPLOYMENT

PRODUCTIVITY_OF_LB_DATA = VA_in_Agriculture_data/PRODUCTION.employment_per_industry_data[Agriculture]

TFP_in_Agriculture_est = (VA_in_Agriculture_data/Employment_in_Agriculture_data)/((Gross_Capital_Srock_in_Agriculture_data/Employment_in_Agriculture_data)^(1-alfa))

time_to_chg_wages = 1

time_to_hire = 0.6

time_to_perceive_cost_of_capital = 0.3

time_to_perceive_expected_demand = 2

total_wages = EMPLOYMENT*avg_wage

total_wages_data = Total_Wages_per_Industry_data[Agriculture]

Total_Wages_per_Industry_data[Agriculture] = GRAPH(TIME)

(2001, 6.8e+008), (2002, 7.4e+008), (2003, 8e+008), (2004, 8.4e+008), (2005, 9.6e+008), (2006, 1.1e+009), (2007, 1e+009), (2008, 1.1e+009), (2009, 1e+009), (2010, 1.1e+009), (2011, 1.3e+009), (2012, 1.3e+009), (2013, 1.3e+009), (2014, 1.4e+009)

Total_Wages_per_Industry_data[Construction] = GRAPH(TIME)

(2001, 1.3e+009), (2002, 1.7e+009), (2003, 2.1e+009), (2004, 2.3e+009), (2005, 2.2e+009), (2006, 2.4e+009), (2007, 2.9e+009), (2008, 3.2e+009), (2009, 2.5e+009), (2010, 2.3e+009), (2011, 2.3e+009), (2012, 2.1e+009), (2013, 1.9e+009), (2014, 1.8e+009)

Total_Wages_per_Industry_data[Manufacturing] = GRAPH(TIME)

(2001, 2.6e+009), (2002, 2.8e+009), (2003, 2.9e+009), (2004, 3.1e+009), (2005, 3.2e+009), (2006, 3.6e+009), (2007, 3.7e+009), (2008, 3.9e+009), (2009, 3.7e+009), (2010, 3.6e+009), (2011, 3.7e+009), (2012, 3.9e+009), (2013, 3.9e+009), (2014, 4e+009)

Total_Wages_per_Industry_data[Market_services] = GRAPH(TIME)

(2001, 6.1e+009), (2002, 6.7e+009), (2003, 7.2e+009), (2004, 7.8e+009), (2005, 8.2e+009), (2006, 8.8e+009), (2007, 9.3e+009), (2008, 9.9e+009), (2009, 1e+010), (2010, 1e+010), (2011, 1.1e+010), (2012, 1.1e+010), (2013, 1.1e+010), (2014, 1.1e+010)

Total_Wages_per_Industry_data[Public_Services] = GRAPH(TIME)

(2001, 1.2e+010), (2002, 1.3e+010), (2003, 1.4e+010), (2004, 1.5e+010), (2005, 1.6e+010), (2006, 1.8e+010), (2007, 1.8e+010), (2008, 1.9e+010), (2009, 1.9e+010), (2010, 2e+010), (2011, 2e+010), (2012, 2e+010), (2013, 2e+010), (2014, 2e+010)

unit_labor_cost_index = total_wages_data/VA_in_Agriculture_data

unit_labour_cost_index = total_wages/VA_in_Agriculture

VA_in_Agriculture = TFP_in_Agriculture_est*((Capital_in_Agriculture/EMPLOYMENT)^(1-alfa))*EMPLOYMENT

VA_in_Agriculture_data = VA_per_Industry_data[Agriculture]

VA_per_Industry_data[Agriculture] = GRAPH(TIME)

(2001, 2.3e+009), (2002, 2.3e+009), (2003, 3.1e+009), (2004, 3e+009), (2005, 2.9e+009), (2006, 2.9e+009), (2007, 2.8e+009), (2008, 3e+009), (2009, 2.8e+009), (2010, 2.9e+009), (2011, 3e+009), (2012, 3.4e+009), (2013, 3.5e+009), (2014, 3.2e+009)

VA_per_Industry_data[Construction] = GRAPH(TIME)

(2001, 3.5e+009), (2002, 3.9e+009), (2003, 4.3e+009), (2004, 4.2e+009), (2005, 4.5e+009), (2006, 4.8e+009), (2007, 5e+009), (2008, 5.3e+009), (2009, 5.2e+009), (2010, 4.5e+009), (2011, 4.4e+009), (2012, 4.3e+009), (2013, 4e+009), (2014, 3.7e+009)

VA_per_Industry_data[Manufacturing] = GRAPH(TIME)

(2001, 6.2e+009), (2002, 6.8e+009), (2003, 6.9e+009), (2004, 6.9e+009), (2005, 7.2e+009), (2006, 7.6e+009), (2007, 8.2e+009), (2008, 8.5e+009), (2009, 7.4e+009), (2010, 7.6e+009), (2011, 7.5e+009), (2012, 7.8e+009), (2013, 7.9e+009), (2014, 8.1e+009)

VA_per_Industry_data[Market_services] = GRAPH(TIME)

(2001, 2.7e+010), (2002, 2.8e+010), (2003, 2.9e+010), (2004, 3.1e+010), (2005, 3.2e+010), (2006, 3.4e+010), (2007, 3.6e+010), (2008, 3.7e+010), (2009, 3.7e+010), (2010, 3.8e+010), (2011, 4e+010), (2012, 4.1e+010), (2013, 4.1e+010), (2014, 4.1e+010)

VA_per_Industry_data[Public_Services] = GRAPH(TIME)

(2001, 1.6e+010), (2002, 1.7e+010), (2003, 1.9e+010), (2004, 2e+010), (2005, 2.2e+010), (2006, 2.4e+010), (2007, 2.4e+010), (2008, 2.6e+010), (2009, 2.6e+010), (2010, 2.7e+010), (2011, 2.7e+010), (2012, 2.7e+010), (2013, 2.8e+010), (2014, 2.8e+010)

CONSTRUCTION SECTOR.CONSTRUCTION INDUSTRY:

long_run_expected_Demand(t) = long_run_expected_Demand(t - dt) + (chg_in_long_run_expected_demand) * dt

INIT long_run_expected_Demand = VA_in_Construction_data

INFLOWS:

chg_in_long_run_expected_demand = (CONSTRUCTION_SECTOR.indicated_production*domestic_production_coeff-long_run_expected_Demand)/time_to_perceive_expected_demand

avg_wage(t) = avg_wage(t - dt) + (chg_in_wages) * dt

INIT avg_wage = avg_wage_data

INFLOWS:

chg_in_wages = (Indicated_wage-avg_wage)/time_to_chg_wages

Capital_in_Construction(t) = Capital_in_Construction(t - dt) + (Capital_formation_rate - capital_depreciation) * dt

INIT Capital_in_Construction = Gross_Capital_Stock_in_Construction_data

INFLOWS:

Capital_formation_rate = Capital_on_order/capital_delivery_time

OUTFLOWS:

capital_depreciation = Capital_in_Construction/avg_life_of_capital

Capital_on_order(t) = Capital_on_order(t - dt) + (capital_orders - Capital_formation_rate) * dt

INIT Capital_on_order = capital_delivery_time*desired_capital_orders

INFLOWS:

capital_orders = desired_capital_orders

OUTFLOWS:

Capital_formation_rate = Capital_on_order/capital_delivery_time

EMPLOYMENT(t) = EMPLOYMENT(t - dt) + (hiring_rate) * dt

INIT EMPLOYMENT = PRODUCTION.employment_per_industry_data[construction]

INFLOWS:

hiring_rate = IF (PRODUCTION.Labour_Force> HISTORY(PRODUCTION.reg_employment,(time-1))) THEN (desired_employment-EMPLOYMENT)*(1-PRODUCTION.perc_non_domestic_labour)/time_to_hire ELSE MIN(0,(desired_employment-EMPLOYMENT)*(1-PRODUCTION.perc_non_domestic_labour)/time_to_hire)

Actual_Capital_Output_Ratio = Capital_in_Construction/VA_in_construction

alfa_est = GRAPH(TIME)

(2001, 0.63), (2002, 0.56), (2003, 0.52), (2004, 0.46), (2005, 0.51), (2006, 0.49), (2007, 0.41), (2008, 0.4), (2009, 0.51), (2010, 0.49)

avg_life_of_capital = 14

avg_wage_data = Total_wages_data/PRODUCTION.employment_per_industry_data[Construction]

capital_adj_time = 2

capital_delivery_time = 1.5

Converter_3 = Gross_Capital_Stock_in_Construction_data/VA_in_Construction_data

delay_in_wage_changes = 1

desired_capital = long_run_expected_Demand*SMTH3(desired_capital_output_ratio,2)

desired_capital_orders = capital_depreciation+((desired_capital-Capital_in_Construction)/capital_adj_time)

desired_capital_output_ratio = SMTH1(Actual_Capital_Output_Ratio,1)/SMTH1(history(expected_cost_of_capital,(time-1))/expected_cost_of_capital,1)*expected_labour_cost_productivity_ratio

desired_employment = (CONSTRUCTION_SECTOR.indicated_production*domestic_production_coeff/productivity_of_LB)*(Desired_Labour_share/labor's_share)

Desired_Labour_share = GRAPH(TIME)

(2001, 0.37), (2004, 0.52), (2007, 0.59), (2010, 0.52)

domestic_production_coeff = 0.3112

Employment_in_Construction_data =
PRODUCTION.employment_per_industry_data[Construction]

expected_cost_of_capital =
SMTH1(interest_rate,time_to_perceive_cost_of_capital)+1/avg_life_of_capital

expected_labour_cost_productivity_ratio =
SMTH1(unit_labour_cost_index/init(unit_labour_cost_index),2)

Gross_Capital_Stock_CURRENT[Agriculture] = GRAPH(TIME)

(2001, 1.3e+010), (2002, 1.4e+010), (2003, 1.6e+010), (2004, 1.7e+010), (2005, 1.7e+010), (2006, 1.8e+010), (2007, 2e+010), (2008, 2.7e+010), (2009, 2.2e+010), (2010, 2.1e+010), (2011, 2.1e+010)

Gross_Capital_Stock_CURRENT[Construction] = GRAPH(TIME)

(2001, 5.1e+009), (2002, 5.1e+009), (2003, 8.2e+009), (2004, 4.2e+009), (2005, 3.3e+009), (2006, 6e+009), (2007, 4.7e+009), (2008, 6.7e+009), (2009, 5.3e+009), (2010, 4.2e+009), (2011, 5.7e+009)

Gross_Capital_Stock_CURRENT[Manufacturing] = GRAPH(TIME)

(2001, 4.2e+010), (2002, 5.1e+010), (2003, 4.6e+010), (2004, 5.6e+010), (2005, 4.9e+010), (2006, 4.8e+010), (2007, 5.7e+010), (2008, 5.6e+010), (2009, 5.2e+010), (2010, 5.4e+010), (2011, 4.5e+010)

Gross_Capital_Stock_CURRENT[Market_services] = GRAPH(TIME)

(2001, 2.3e+011), (2002, 2.2e+011), (2003, 2.4e+011), (2004, 2.7e+011), (2005, 2.9e+011), (2006, 3.1e+011), (2007, 3.2e+011), (2008, 2.9e+011), (2009, 3.4e+011), (2010, 3.5e+011), (2011, 3.6e+011)

Gross_Capital_Stock_CURRENT[Public_Services] = GRAPH(TIME)

(2001, 6.5e+010), (2002, 6.2e+010), (2003, 7.1e+010), (2004, 6.9e+010), (2005, 7.1e+010), (2006, 8e+010), (2007, 9.1e+010), (2008, 9.6e+010), (2009, 8.5e+010), (2010, 9e+010), (2011, 9.8e+010)

Gross_Capital_Stock_in_Construction_data =
Gross_Capital_Stock_per_Industry_data[Construction]

Gross_Capital_Stock_per_Industry_data[INDUSTRY] =
Gross_Capital_Stock_CURRENT*IPC_DATA/100

GRP_data =
VA_per_Industry_data[Agriculture]+VA_per_Industry_data[Construction]+VA_per_Industry_data[Manufacturing]+VA_per_Industry_data[Market_services]+VA_per_Industry_data[Public_Services]

Indicated_wage =
Desired_Labour_share*SMTH3(productivity_of_LB,delay_in_wage_changes)

interest_rate = GRAPH(TIME)

(2001, 6.65), (2002, 5.57), (2003, 4.71), (2004, 4.03), (2005, 3.56), (2006, 4.68), (2007, 5.48), (2008, 4.82), (2009, 2.25), (2010, 2.79), (2011, 4.18), (2012, 3.64), (2013, 3.45), (2014, 2.66)

IPC_DATA = GRAPH(TIME)

(2001, 82.9), (2002, 85.0), (2003, 88.0), (2004, 89.2), (2005, 90.9), (2006, 92.8), (2007, 94.5), (2008, 97.7), (2009, 98.5), (2010, 100), (2011, 103), (2012, 106), (2013, 107), (2014, 107)

labor's_share = IF (productivity_of_LB=0) THEN 0 ELSE (avg_wage/productivity_of_LB)

LABOR_SHARE_DATA = IF (PRODUCTIVITY_OF_LB_DATA=0) THEN 0 ELSE (avg_wage_data/PRODUCTIVITY_OF_LB_DATA)

productivity_of_LB = VA_in_construction/EMPLOYMENT

PRODUCTIVITY_OF_LB_DATA = VA_in_Construction_data/PRODUCTION.employment_per_industry_data[Construction]

TFP = GRAPH(TIME)

(2001, 596), (2010, 179)

TFP_in_construction_est = (VA_in_Construction_data/Employment_in_Construction_data)/((Gross_Capital_Stock_in_Construction_data/Employment_in_Construction_data)^(1-alfa_est))

time_to_chg_wages = 1

time_to_hire = 1

time_to_perceive_cost_of_capital = 1

time_to_perceive_expected_demand = 2

Total_Resources_in_Construction_data = GRAPH(TIME)

(2001, 1.1e+010), (2002, 1.2e+010), (2003, 1.3e+010), (2004, 1.3e+010), (2005, 1.4e+010), (2006, 1.5e+010), (2007, 1.5e+010), (2008, 1.7e+010), (2009, 1.6e+010), (2010, 1.4e+010), (2011, 1.4e+010), (2012, 1.3e+010), (2013, 1.2e+010), (2014, 1.2e+010)

total_wages = EMPLOYMENT*avg_wage

Total_wages_data = Total_Wages_per_Industry_data[Construction]

Total_Wages_per_Industry_data[Agriculture] = GRAPH(TIME)

(2001, 6.8e+008), (2002, 7.4e+008), (2003, 8e+008), (2004, 8.4e+008), (2005, 9.6e+008), (2006, 1.1e+009), (2007, 1e+009), (2008, 1.1e+009), (2009, 1e+009), (2010, 1.1e+009), (2011, 1.3e+009), (2012, 1.32), (2013, 1.3e+009), (2014, 1.4e+009)

Total_Wages_per_Industry_data[Construction] = GRAPH(TIME)

(2001, 1.3e+009), (2002, 1.7e+009), (2003, 2.1e+009), (2004, 2.3e+009), (2005, 2.2e+009), (2006, 2.4e+009), (2007, 2.9e+009), (2008, 3.2e+009), (2009, 2.5e+009), (2010, 2.3e+009), (2011, 2.3e+009), (2012, 2.1e+009), (2013, 1.9e+009), (2014, 1.8e+009)

Total_Wages_per_Industry_data[Manufacturing] = GRAPH(TIME)

(2001, 2.6e+009), (2002, 2.8e+009), (2003, 2.9e+009), (2004, 3.1e+009), (2005, 3.2e+009), (2006, 3.6e+009), (2007, 3.7e+009), (2008, 3.9e+009), (2009, 3.7e+009), (2010, 3.6e+009), (2011, 3.7e+009), (2012, 3.9e+009), (2013, 3.9e+009), (2014, 4e+009)

Total_Wages_per_Industry_data[Market_services] = GRAPH(TIME)

(2001, 6.1e+009), (2002, 6.7e+009), (2003, 7.2e+009), (2004, 7.8e+009), (2005, 8.2e+009), (2006, 8.8e+009), (2007, 9.3e+009), (2008, 9.9e+009), (2009, 1e+010), (2010, 1e+010), (2011, 1.1e+010), (2012, 1.1e+010), (2013, 1.1e+010), (2014, 1.1e+010)

Total_Wages_per_Industry_data[Public_Services] = GRAPH(TIME)

(2001, 1.2e+010), (2002, 1.3e+010), (2003, 1.4e+010), (2004, 1.5e+010), (2005, 1.6e+010), (2006, 1.8e+010), (2007, 1.8e+010), (2008, 1.9e+010), (2009, 1.9e+010), (2010, 2e+010), (2011, 2e+010), (2012, 2e+010), (2013, 2e+010), (2014, 2e+010)

UNeMPLOYMENT_RATE_DATA = GRAPH(TIME)

(2001, 22.0), (2002, 20.6), (2003, 20.0), (2004, 17.1), (2005, 16.0), (2006, 13.4), (2007, 12.9), (2008, 13.7), (2009, 13.8), (2010, 14.6), (2011, 14.3), (2012, 18.4), (2013, 21.0), (2014, 22.2)

unit_labor_cost_index = Total_wages_data/Total_Resources_in_Construction_data

unit_labour_cost_index = total_wages/VA_in_construction

VA_in_construction = TFP_in_construction_est*(Capital_in_Construction/EMPLOYMENT)^(1-alfa_est)*EMPLOYMENT

VA_in_Construction_data = VA_per_Industry_data[Construction]

VA_per_Industry_data[Agriculture] = GRAPH(TIME)

(2001, 2.3e+009), (2002, 2.3e+009), (2003, 3.1e+009), (2004, 3e+009), (2005, 2.9e+009), (2006, 2.9e+009), (2007, 2.8e+009), (2008, 3e+009), (2009, 2.8e+009), (2010, 2.9e+009), (2011, 3e+009), (2012, 3.4e+009), (2013, 3.5e+009), (2014, 3.2e+009)

VA_per_Industry_data[Construction] = GRAPH(TIME)

(2001, 3.5e+009), (2002, 3.9e+009), (2003, 4.3e+009), (2004, 4.2e+009), (2005, 4.5e+009), (2006, 4.8e+009), (2007, 5e+009), (2008, 5.3e+009), (2009, 5.2e+009), (2010, 4.5e+009), (2011, 4.4e+009), (2012, 4.3e+009), (2013, 4e+009), (2014, 3.7e+009)

VA_per_Industry_data[Manufacturing] = GRAPH(TIME)

(2001, 6.2e+009), (2002, 6.8e+009), (2003, 6.9e+009), (2004, 6.9e+009), (2005, 7.2e+009), (2006, 7.6e+009), (2007, 8.2e+009), (2008, 8.5e+009), (2009, 7.4e+009), (2010, 7.6e+009), (2011, 7.5e+009), (2012, 7.8e+009), (2013, 7.9e+009), (2014, 8.1e+009)

VA_per_Industry_data[Market_services] = GRAPH(TIME)

(2001, 2.7e+010), (2002, 2.8e+010), (2003, 2.9e+010), (2004, 3.1e+010), (2005, 3.2e+010), (2006, 3.4e+010), (2007, 3.6e+010), (2008, 3.7e+010), (2009, 3.7e+010), (2010, 3.8e+010), (2011, 4e+010), (2012, 4.1e+010), (2013, 4.1e+010), (2014, 4.1e+010)

VA_per_Industry_data[Public_Services] = GRAPH(TIME)

(2001, 1.6e+010), (2002, 1.7e+010), (2003, 1.9e+010), (2004, 2e+010), (2005, 2.2e+010), (2006, 2.4e+010), (2007, 2.4e+010), (2008, 2.6e+010), (2009, 2.6e+010), (2010, 2.7e+010), (2011, 2.7e+010), (2012, 2.7e+010), (2013, 2.8e+010), (2014, 2.8e+010)

MANUFACTURING SECTOR.MANUFACTURING INDUSTRY:

long_run_expected_Demand(t) = long_run_expected_Demand(t - dt) + (chg_in_long_run_expected_demand) * dt

INIT long_run_expected_Demand = VA_in_Manufacturing_data

INFLOWS:

chg_in_long_run_expected_demand = (MANUFACTURING_SECTOR.indicated_production*domestic_coeff-long_run_expected_Demand)/time_to_perceive_expected_demand

avg_wage(t) = avg_wage(t - dt) + (chg_in_wages) * dt

INIT avg_wage = avg_wage_data

INFLOWS:

chg_in_wages = (Indicated_wage-avg_wage)/time_to_chg_wages

Capital_in_Manufacturing(t) = Capital_in_Manufacturing(t - dt) + (Capital_formation_rate - capital_depreciation) * dt

INIT Capital_in_Manufacturing = Gross_Capital_Srock_in_Manufacturing_data

INFLOWS:

Capital_formation_rate = Capital_on_order*capital_delivery_time

OUTFLOWS:

capital_depreciation = Capital_in_Manufacturing/avg_life_of_capital

Capital_on_order(t) = Capital_on_order(t - dt) + (capital_orders - Capital_formation_rate) * dt

INIT Capital_on_order = desired_capital*capital_delivery_time*0.5

INFLOWS:

capital_orders = desired_capital_orders

OUTFLOWS:

Capital_formation_rate = Capital_on_order*capital_delivery_time

EMPLOYMENT(t) = EMPLOYMENT(t - dt) + (hiring_rate) * dt

INIT EMPLOYMENT = Employment_in_Manufacturing_data

INFLOWS:

hiring_rate = IF (PRODUCTION.Labour_Force> HISTORY(PRODUCTION.reg_employment,(time-1))) THEN (desired_employment-EMPLOYMENT)*(1-PRODUCTION.perc_non_domestic_labour)/time_to_hire ELSE MIN(0,(desired_employment-EMPLOYMENT)*(1-PRODUCTION.perc_non_domestic_labour)/time_to_hire)

Actual_Capital_Output_Ratio = Capital_in_Manufacturing/VA_in_manufacturing

alfa_est = GRAPH(TIME)

(2001, 0.58), (2002, 0.58), (2003, 0.57), (2004, 0.55), (2005, 0.55), (2006, 0.53), (2007, 0.55), (2008, 0.54), (2009, 0.5), (2010, 0.53)

avg_life_of_capital = 14

avg_wage_data = total_wages_data/PRODUCTION.employment_per_industry_data[Manufacturing]

capital_adj_time = 2

capital_delivery_time = 1.5

delay_in_wage_changes = 0.2

desired_capital = desired_capital_output_ratio*long_run_expected_Demand

desired_capital_orders = capital_depreciation+((desired_capital-Capital_in_Manufacturing)/capital_adj_time)

desired_capital_output_ratio = SMTH1(Actual_Capital_Output_Ratio,1)*SMTH1(history(expected_cost_of_capital,(time-1))/expected_cost_of_capital,1)*expected_labour_cost_productivity_ratio

desired_employment = ((MANUFACTURING_SECTOR.indicated_production*domestic_coeff)/productivity_of_LB)*(Desired_Labour_share/labor's_share)

Desired_Labour_share = GRAPH(TIME)

(2001, 0.419), (2006, 0.5), (2011, 0.49)

domestic_coeff = 0.13921

Employment_in_Manufacturing_data = PRODUCTION.employment_per_industry_data[Manufacturing]

expected_cost_of_capital = SMTH1(interest_rate,time_to_perceive_cost_of_capital)+1/avg_life_of_capital

expected_labour_cost_productivity_ratio =
SMTH1(unit_labour_cost_index/init(unit_labour_cost_index),2)

Gross_Capital_Srock_in_Manufacturing_data =
Gross_Capital_Stock_per_Industry_data[Manufacturing]

Gross_Capital_Stock_CURRENT[Agriculture] = GRAPH(TIME)

(2001, 1.3e+010), (2002, 1.4e+010), (2003, 1.6e+010), (2004, 1.7e+010), (2005, 1.7e+010), (2006, 1.8e+010), (2007, 2e+010), (2008, 2.7e+010), (2009, 2.2e+010), (2010, 2.1e+010), (2011, 2.1e+010)

Gross_Capital_Stock_CURRENT[Construction] = GRAPH(TIME)

(2001, 5.1e+009), (2002, 5.1e+009), (2003, 8.2e+009), (2004, 4.2e+009), (2005, 3.3e+009), (2006, 6e+009), (2007, 4.7e+009), (2008, 6.7e+009), (2009, 5.3e+009), (2010, 4.2e+009), (2011, 5.7e+009)

Gross_Capital_Stock_CURRENT[Manufacturing] = GRAPH(TIME)

(2001, 4.2e+010), (2002, 5.1e+010), (2003, 4.6e+010), (2004, 5.6e+010), (2005, 4.9e+010), (2006, 4.8e+010), (2007, 5.7e+010), (2008, 5.6e+010), (2009, 5.2e+010), (2010, 5.4e+010), (2011, 4.5e+010)

Gross_Capital_Stock_CURRENT[Market_services] = GRAPH(TIME)

(2001, 2.3e+011), (2002, 2.2e+011), (2003, 2.4e+011), (2004, 2.7e+011), (2005, 2.9e+011), (2006, 3.1e+011), (2007, 3.2e+011), (2008, 2.9e+011), (2009, 3.4e+011), (2010, 3.5e+011), (2011, 3.6e+011)

Gross_Capital_Stock_CURRENT[Public_Services] = GRAPH(TIME)

(2001, 6.5e+010), (2002, 6.2e+010), (2003, 7.1e+010), (2004, 6.9e+010), (2005, 7.1e+010), (2006, 8e+010), (2007, 9.1e+010), (2008, 9.6e+010), (2009, 8.5e+010), (2010, 9e+010), (2011, 9.8e+010)

Gross_Capital_Stock_per_Industry_data[INDUSTRY] =
Gross_Capital_Stock_CURRENT*IPC_DATA/100

GRP_data =
VA_per_Industry_data[Agriculture]+VA_per_Industry_data[Construction]+VA_per_Industry_data[Manufacturing]+VA_per_Industry_data[Market_services]+VA_per_Industry_data[Public_Services]

Indicated_wage =
Desired_Labour_share*SMTH1(productivity_of_LB,delay_in_wage_changes)

interest_rate = GRAPH(TIME)

(2001, 6.65), (2002, 5.57), (2003, 4.71), (2004, 4.03), (2005, 3.56), (2006, 4.68), (2007, 5.48), (2008, 4.82), (2009, 2.25), (2010, 2.79), (2011, 4.18), (2012, 3.64), (2013, 3.45), (2014, 2.66)

IPC_DATA = GRAPH(TIME)

(2001, 82.9), (2002, 85.0), (2003, 88.0), (2004, 89.2), (2005, 90.9), (2006, 92.8), (2007, 94.5), (2008, 97.7), (2009, 98.5), (2010, 100), (2011, 103), (2012, 106), (2013, 107), (2014, 107)

ko_ratio_data = Gross_Capital_Srock_in_Manufacturing_data/VA_in_Manufacturing_data

labor's_share = avg_wage/productivity_of_LB

LABOR_SHARE_DATA = IF (PRODUCTIVITY_OF_LB_DATA=0) THEN 0 ELSE (avg_wage_data/PRODUCTIVITY_OF_LB_DATA)

productivity_of_LB = VA_in_manufacturing/EMPLOYMENT

PRODUCTIVITY_OF_LB_DATA = VA_in_Manufacturing_data/PRODUCTION.employment_per_industry_data[Manufacturing]

total_wages_data = Total_Wages_per_Industry_data[Manufacturing]

TFP_in_construction_est = (VA_in_Manufacturing_data/Employment_in_Manufacturing_data)/((Gross_Capital_Srock_in_Manufacturing_data/Employment_in_Manufacturing_data)^(1-alfa_est))

time_to_chg_wages = 0.5

time_to_hire = 0.6

time_to_perceive_cost_of_capital = 1

time_to_perceive_expected_demand = 1.5

total_wages = EMPLOYMENT*avg_wage

Total_Wages_per_Industry_data[Agriculture] = GRAPH(TIME)

(2001, 6.8e+008), (2002, 7.4e+008), (2003, 8e+008), (2004, 8.4e+008), (2005, 9.6e+008), (2006, 1.1e+009), (2007, 1e+009), (2008, 1.1e+009), (2009, 1e+009), (2010, 1.1e+009), (2011, 1.3e+009), (2012, 1.3e+009), (2013, 1.3e+009), (2014, 1.4e+009)

Total_Wages_per_Industry_data[Construction] = GRAPH(TIME)

(2001, 1.3e+009), (2002, 1.7e+009), (2003, 2.1e+009), (2004, 2.3e+009), (2005, 2.2e+009), (2006, 2.4e+009), (2007, 2.9e+009), (2008, 3.2e+009), (2009, 2.5e+009), (2010, 2.3e+009), (2011, 2.3e+009), (2012, 2.1e+009), (2013, 1.9e+009), (2014, 1.8e+009)

Total_Wages_per_Industry_data[Manufacturing] = GRAPH(TIME)

(2001, 2.6e+009), (2002, 2.8e+009), (2003, 2.9e+009), (2004, 3.1e+009), (2005, 3.2e+009), (2006, 3.6e+009), (2007, 3.7e+009), (2008, 3.9e+009), (2009, 3.7e+009), (2010, 3.6e+009), (2011, 3.7e+009), (2012, 3.9e+009), (2013, 3.9e+009), (2014, 4e+009)

Total_Wages_per_Industry_data[Market_services] = GRAPH(TIME)

(2001, 6.1e+009), (2002, 6.7e+009), (2003, 7.2e+009), (2004, 7.8e+009), (2005, 8.2e+009), (2006, 8.8e+009), (2007, 9.3e+009), (2008, 9.9e+009), (2009, 1e+010), (2010, 1e+010), (2011, 1.1e+010), (2012, 1.1e+010), (2013, 1.1e+010), (2014, 1.1e+010)

Total_Wages_per_Industry_data[Public_Services] = GRAPH(TIME)

(2001, 1.2e+010), (2002, 1.3e+010), (2003, 1.4e+010), (2004, 1.5e+010), (2005, 1.6e+010), (2006, 1.8e+010), (2007, 1.8e+010), (2008, 1.9e+010), (2009, 1.9e+010), (2010, 2e+010), (2011, 2e+010), (2012, 2e+010), (2013, 2e+010), (2014, 2e+010)

unit_labor_cost_index = total_wages_data /VA_in_Manufacturing_data

unit_labour_cost_index = total_wages/VA_in_manufacturing

VA_in_manufacturing = TFP_in_construction_est*(Capital_in_Manufacturing/EMPLOYMENT)^(1-alfa_est)*EMPLOYMENT

VA_in_Manufacturing_data = VA_per_Industry_data[Manufacturing]

VA_per_Industry_data[Agriculture] = GRAPH(TIME)

(2001, 2.3e+009), (2002, 2.3e+009), (2003, 3.1e+009), (2004, 3e+009), (2005, 2.9e+009), (2006, 2.9e+009), (2007, 2.8e+009), (2008, 3e+009), (2009, 2.8e+009), (2010, 2.9e+009), (2011, 3e+009), (2012, 3.4e+009), (2013, 3.5e+009), (2014, 3.2e+009)

VA_per_Industry_data[Construction] = GRAPH(TIME)

(2001, 3.5e+009), (2002, 3.9e+009), (2003, 4.3e+009), (2004, 4.2e+009), (2005, 4.5e+009), (2006, 4.8e+009), (2007, 5e+009), (2008, 5.3e+009), (2009, 5.2e+009), (2010, 4.5e+009), (2011, 4.4e+009), (2012, 4.3e+009), (2013, 4e+009), (2014, 3.7e+009)

VA_per_Industry_data[Manufacturing] = GRAPH(TIME)

(2001, 6.2e+009), (2002, 6.8e+009), (2003, 6.9e+009), (2004, 6.9e+009), (2005, 7.2e+009), (2006, 7.6e+009), (2007, 8.2e+009), (2008, 8.5e+009), (2009, 7.4e+009), (2010, 7.6e+009), (2011, 7.5e+009), (2012, 7.8e+009), (2013, 7.9e+009), (2014, 8.1e+009)

VA_per_Industry_data[Market_services] = GRAPH(TIME)

(2001, 2.7e+010), (2002, 2.8e+010), (2003, 2.9e+010), (2004, 3.1e+010), (2005, 3.2e+010), (2006, 3.4e+010), (2007, 3.6e+010), (2008, 3.7e+010), (2009, 3.7e+010), (2010, 3.8e+010), (2011, 4e+010), (2012, 4.1e+010), (2013, 4.1e+010), (2014, 4.1e+010)

VA_per_Industry_data[Public_Services] = GRAPH(TIME)

(2001, 1.6e+010), (2002, 1.7e+010), (2003, 1.9e+010), (2004, 2e+010), (2005, 2.2e+010), (2006, 2.4e+010), (2007, 2.4e+010), (2008, 2.6e+010), (2009, 2.6e+010), (2010, 2.7e+010), (2011, 2.7e+010), (2012, 2.7e+010), (2013, 2.8e+010), (2014, 2.8e+010)

MARKET SERVICES SECTOR.MARKET SERVICES INDUSTRY:

long_run_expected_Demand(t) = long_run_expected_Demand(t - dt) + (chg_in_long_run_expected_demand) * dt

INIT long_run_expected_Demand = VA_in_Market_Services_data

INFLOWS:

chg_in_long_run_expected_demand = (MARKET_SERVICES_SECTOR.indicated_production*domestic_production_coefficient-long_run_expected_Demand)/time_to_perceive_expected_demand

avg_wage(t) = avg_wage(t - dt) + (chg_in_wages) * dt

INIT avg_wage = avg_wage_data

INFLOWS:

chg_in_wages = (Indicated_wage-avg_wage)/time_to_chg_wages

Capital_in_Market_Services(t) = Capital_in_Market_Services(t - dt) + (Capital_formation_rate - capital_depreciation) * dt

INIT Capital_in_Market_Services = Gross_Capital_Srock_in_Market_Services_data

INFLOWS:

Capital_formation_rate = Capital_on_order/capital_delivery_time

OUTFLOWS:

capital_depreciation = Capital_in_Market_Services/avg_life_of_capital

Capital_on_order(t) = Capital_on_order(t - dt) + (capital_orders - Capital_formation_rate) * dt

INIT Capital_on_order = desired_capital*capital_delivery_time*0.1

INFLOWS:

capital_orders = desired_capital_orders

OUTFLOWS:

Capital_formation_rate = Capital_on_order/capital_delivery_time

EMPLOYMENT(t) = EMPLOYMENT(t - dt) + (hiring_rate) * dt

INIT EMPLOYMENT = PRODUCTION.employment_per_industry_data[Market_services]

INFLOWS:

hiring_rate = IF(PRODUCTION.Labour_Force>HISTORY(PRODUCTION.reg_employment,(time-1))) THEN (desired_employment-EMPLOYMENT)*(1-PRODUCTION.perc_non_domestic_labour)/time_to_hire ELSE MIN(0,(desired_employment-EMPLOYMENT)*(1-PRODUCTION.perc_non_domestic_labour)/time_to_hire)

Actual_Capital_Output_Ratio = Capital_in_Market_Services/VA_in_Market_Services

alfa_est = GRAPH(TIME)

(2001, 0.77), (2002, 0.76), (2003, 0.75), (2004, 0.75), (2005, 0.74), (2006, 0.74), (2007, 0.74), (2008, 0.73), (2009, 0.73), (2010, 0.73) avg_life_of_capital = 14

avg_wage_data = Total_wages_data/PRODUCTION.employment_per_industry_data[Market_services]

capital_adj_time = 0.6

capital_delivery_time = 1

delay_in_wage_changes = 0.09

desired_capital = long_run_expected_Demand*desired_capital_output_ratio

desired_capital_orders = capital_depreciation+((desired_capital-Capital_in_Market_Services)/capital_adj_time)

desired_capital_output_ratio = SMTH1(Actual_Capital_Output_Ratio,1)*SMTH1(history(expected_cost_of_capital,(time-1))/expected_cost_of_capital,1)*expected_labour_cost_productivity_ratio

desired_employment = smth1((MARKET_SERVICES_SECTOR.indicated_production*domestic_production_coefficient),1)/productivity_of_LB*(Desired_Labour_share/labor's_share)

Desired_Labour_share = LABOR_SHARE_DATA

domestic_production_coefficient = 0.539277

Employment_in_Market_Services_data = PRODUCTION.employment_per_industry_data[Market_services]

expected_cost_of_capital = SMTH1(interest_rate,time_to_perceive_cost_of_capital)+1/avg_life_of_capital

expected_labour_cost_productivity_ratio = SMTH1(unit_labour_cost_index/init(unit_labour_cost_index),1)

Gross_Capital_Srock_in_Market_Services_data = Gross_Capital_Stock_per_Industry_data[Market_services]

Gross_Capital_Stock_CURRENT[Agriculture] = GRAPH(TIME)

(2001, 1.3e+010), (2002, 1.4e+010), (2003, 1.6e+010), (2004, 1.7e+010), (2005, 1.7e+010), (2006, 1.8e+010), (2007, 2e+010), (2008, 2.7e+010), (2009, 2.2e+010), (2010, 2.1e+010), (2011, 2.1e+010)

Gross_Capital_Stock_CURRENT[Construction] = GRAPH(TIME)

(2001, 5.1e+009), (2002, 5.1e+009), (2003, 8.2e+009), (2004, 4.2e+009), (2005, 3.3e+009), (2006, 6e+009), (2007, 4.7e+009), (2008, 6.7e+009), (2009, 5.3e+009), (2010, 4.2e+009), (2011, 5.7e+009)

Gross_Capital_Stock_CURRENT[Manufacturing] = GRAPH(TIME)

(2001, 4.2e+010), (2002, 5.1e+010), (2003, 4.6e+010), (2004, 5.6e+010), (2005, 4.9e+010), (2006, 4.8e+010), (2007, 5.7e+010), (2008, 5.6e+010), (2009, 5.2e+010), (2010, 5.4e+010), (2011, 4.5e+010)

Gross_Capital_Stock_CURRENT[Market_services] = GRAPH(TIME)

(2001, 2.3e+011), (2002, 2.2e+011), (2003, 2.4e+011), (2004, 2.7e+011), (2005, 2.9e+011), (2006, 3.1e+011), (2007, 3.2e+011), (2008, 2.9e+011), (2009, 3.4e+011), (2010, 3.5e+011), (2011, 3.6e+011)

Gross_Capital_Stock_CURRENT[Public_Services] = GRAPH(TIME)

(2001, 6.5e+010), (2002, 6.2e+010), (2003, 7.1e+010), (2004, 6.9e+010), (2005, 7.1e+010), (2006, 8e+010), (2007, 9.1e+010), (2008, 9.6e+010), (2009, 8.5e+010), (2010, 9e+010), (2011, 9.8e+010)

Gross_Capital_Stock_per_Industry_data[INDUSTRY] = Gross_Capital_Stock_CURRENT*IPC_DATA/100

GRP_data = VA_per_Industry_data[Agriculture]+VA_per_Industry_data[Construction]+VA_per_Industry_data[Manufacturing]+VA_per_Industry_data[Market_services]+VA_per_Industry_data[Public_Services]

Indicated_VA = domestic_production_coefficient*MARKET_SERVICES_SECTOR.indicated_production

Indicated_wage = desired_Labour_share*SMTH1(productivity_of_LB,delay_in_wage_changes)

interest_rate = GRAPH(TIME)

(2001, 6.65), (2002, 5.57), (2003, 4.71), (2004, 4.03), (2005, 3.56), (2006, 4.68), (2007, 5.48), (2008, 4.82), (2009, 2.25), (2010, 2.79), (2011, 4.18), (2012, 3.64), (2013, 3.45), (2014, 2.66)

IPC_DATA = GRAPH(TIME)

(2001, 82.9), (2002, 85.0), (2003, 88.0), (2004, 89.2), (2005, 90.9), (2006, 92.8), (2007, 94.5), (2008, 97.7), (2009, 98.5), (2010, 100), (2011, 103), (2012, 106), (2013, 107), (2014, 107)

k_output_ratio_data = Gross_Capital_Srock_in_Market_Services_data/VA_in_Market_Services_data

labor's_share = avg_wage/productivity_of_LB

LABOR_SHARE_DATA = IF (PRODUCTIVITY_OF_LB_DATA=0) THEN 0 ELSE (avg_wage_data/PRODUCTIVITY_OF_LB_DATA)

productivity_of_LB = VA_in_Market_Services/EMPLOYMENT

PRODUCTIVITY_OF_LB_DATA = VA_in_Market_Services_data/PRODUCTION.employment_per_industry_data[Market_services]

tfp = GRAPH(TIME)

(2001, 2.70), (2011, 4.30)

TFP_in_Market_Services_est = (VA_in_Market_Services_data/Employment_in_Market_Services_data)/((Gross_Capital_Srock_in_Market_Services_data/Employment_in_Market_Services_data)^(1-alfa_est))

time_to_chg_wages = 0.1

time_to_hire = 0.6

time_to_perceive_cost_of_capital = 0.5

time_to_perceive_expected_demand = 2

total_wages = EMPLOYMENT*avg_wage

Total_wages_data = Total_Wages_per_Industry_data[Market_services]

Total_Wages_per_Industry_data[Agriculture] = GRAPH(TIME)

(2001, 6.8e+008), (2002, 7.4e+008), (2003, 8e+008), (2004, 8.4e+008), (2005, 9.6e+008), (2006, 1.1e+009), (2007, 1e+009), (2008, 1.1e+009), (2009, 1e+009), (2010, 1.1e+009), (2011, 1.3e+009), (2012, 1.3e+009), (2013, 1.3e+009), (2014, 1.4e+009)

Total_Wages_per_Industry_data[Construction] = GRAPH(TIME)

(2001, 1.3e+009), (2002, 1.7e+009), (2003, 2.1e+009), (2004, 2.3e+009), (2005, 2.2e+009), (2006, 2.4e+009), (2007, 2.9e+009), (2008, 3.2e+009), (2009, 2.5e+009), (2010, 2.3e+009), (2011, 2.3e+009), (2012, 2.1e+009), (2013, 1.9e+009), (2014, 1.8e+009)

Total_Wages_per_Industry_data[Manufacturing] = GRAPH(TIME)

(2001, 2.6e+009), (2002, 2.8e+009), (2003, 2.9e+009), (2004, 3.1e+009), (2005, 3.2e+009), (2006, 3.6e+009), (2007, 3.7e+009), (2008, 3.9e+009), (2009, 3.7e+009), (2010, 3.6e+009), (2011, 3.7e+009), (2012, 3.9e+009), (2013, 3.9e+009), (2014, 4e+009)

Total_Wages_per_Industry_data[Market_services] = GRAPH(TIME)

(2001, 6.1e+009), (2002, 6.7e+009), (2003, 7.2e+009), (2004, 7.8e+009), (2005, 8.2e+009), (2006, 8.8e+009), (2007, 9.3e+009), (2008, 9.9e+009), (2009, 1e+010), (2010, 1e+010), (2011, 1.1e+010), (2012, 1.1e+010), (2013, 1.1e+010), (2014, 1.1e+010)

Total_Wages_per_Industry_data[Public_Services] = GRAPH(TIME)

(2001, 1.2e+010), (2002, 1.3e+010), (2003, 1.4e+010), (2004, 1.5e+010), (2005, 1.6e+010), (2006, 1.8e+010), (2007, 1.8e+010), (2008, 1.9e+010), (2009, 1.9e+010), (2010, 2e+010), (2011, 2e+010), (2012, 2e+010), (2013, 2e+010), (2014, 2e+010)

unit_labour_cost_index = total_wages/VA_in_Market_Services

unit_labour_cost_index_data = Total_wages_data/VA_in_Market_Services_data

VA_in_Market_Services = TFP_in_Market_Services_est*((Capital_in_Market_Services/EMPLOYMENT)^(1-alfa_est))*EMPLOYMENT

VA_in_Market_Services_data = VA_per_Industry_data[Market_services]

VA_per_Industry_data[Agriculture] = GRAPH(TIME)

(2001, 2.3e+009), (2002, 2.3e+009), (2003, 3.1e+009), (2004, 3e+009), (2005, 2.9e+009), (2006, 2.9e+009), (2007, 2.8e+009), (2008, 3e+009), (2009, 2.8e+009), (2010, 2.9e+009), (2011, 3e+009), (2012, 3.4e+009), (2013, 3.5e+009), (2014, 3.2e+009)

VA_per_Industry_data[Construction] = GRAPH(TIME)

(2001, 3.5e+009), (2002, 3.9e+009), (2003, 4.3e+009), (2004, 4.2e+009), (2005, 4.5e+009), (2006, 4.8e+009), (2007, 5e+009), (2008, 5.3e+009), (2009, 5.2e+009), (2010, 4.5e+009), (2011, 4.4e+009), (2012, 4.3e+009), (2013, 4e+009), (2014, 3.7e+009)

VA_per_Industry_data[Manufacturing] = GRAPH(TIME)

(2001, 6.2e+009), (2002, 6.8e+009), (2003, 6.9e+009), (2004, 6.9e+009), (2005, 7.2e+009), (2006, 7.6e+009), (2007, 8.2e+009), (2008, 8.5e+009), (2009, 7.4e+009), (2010, 7.6e+009), (2011, 7.5e+009), (2012, 7.8e+009), (2013, 7.9e+009), (2014, 8.1e+009)

VA_per_Industry_data[Market_services] = GRAPH(TIME)

(2001, 2.7e+010), (2002, 2.8e+010), (2003, 2.9e+010), (2004, 3.1e+010), (2005, 3.2e+010), (2006, 3.4e+010), (2007, 3.6e+010), (2008, 3.7e+010), (2009, 3.7e+010), (2010, 3.8e+010), (2011, 4e+010), (2012, 4.1e+010), (2013, 4.1e+010), (2014, 4.1e+010)

VA_per_Industry_data[Public_Services] = GRAPH(TIME)

(2001, 1.6e+010), (2002, 1.7e+010), (2003, 1.9e+010), (2004, 2e+010), (2005, 2.2e+010), (2006, 2.4e+010), (2007, 2.4e+010), (2008, 2.6e+010), (2009, 2.6e+010), (2010, 2.7e+010), (2011, 2.7e+010), (2012, 2.7e+010), (2013, 2.8e+010), (2014, 2.8e+010)

PUBLIC SERVICES SECTOR.PUBLIC SERVICES INDUSTRY:

long_run_expected_Demand(t) = long_run_expected_Demand(t - dt) + (chg_in_long_run_expected_demand) * dt

INIT long_run_expected_Demand = VA_in_Public_Services_data

INFLOWS:

chg_in_long_run_expected_demand = (PUBLIC_SERVICES_SECTOR.indicated_production*domestic_coeff-long_run_expected_Demand)/time_to_perceive_expected_demand

avg_wage(t) = avg_wage(t - dt) + (chg_in_wages) * dt

INIT avg_wage = avg_wage_data

INFLOWS:

chg_in_wages = ((avg_wage*(1+Converter_6))-avg_wage)/time_to_chg_wages

Capital_in_Public_Services(t) = Capital_in_Public_Services(t - dt) + (Capital_formation_rate - capital_depreciation) * dt

INIT Capital_in_Public_Services = Gross_Capital_Srock_in__Public_Services_data

INFLOWS:

Capital_formation_rate = Capital_on_order/capital_delivery_time

OUTFLOWS:

capital_depreciation = Capital_in_Public_Services/avg_life_of_capital

Capital_on_order(t) = Capital_on_order(t - dt) + (capital_orders - Capital_formation_rate) * dt

INIT Capital_on_order = capital_delivery_time*desired_capital_orders

INFLOWS:

capital_orders = desired_capital_orders

OUTFLOWS:

Capital_formation_rate = Capital_on_order/capital_delivery_time

EMPLOYMENT(t) = EMPLOYMENT(t - dt) + (hiring_rate) * dt

INIT EMPLOYMENT = PRODUCTION.employment_per_industry_data[Public_services]

INFLOWS:

hiring_rate = IF(PRODUCTION.Labour_Force>HISTORY(PRODUCTION.reg_employment,(time-1))) THEN (desired_employment-EMPLOYMENT)*(1-PRODUCTION.perc_non_domestic_labour)/time_to_hire ELSE MIN(0,(desired_employment-EMPLOYMENT)*(1-PRODUCTION.perc_non_domestic_labour)/time_to_hire)

Actual_Capital_Output_Ratio = Capital_in_Public_Services/VA_in_Public_Services

alfa_est = GRAPH(TIME)

(2001, 0.26), (2002, 0.25), (2003, 0.26), (2004, 0.27), (2005, 0.28), (2006, 0.26), (2007, 0.26), (2008, 0.25), (2009, 0.26), (2010, 0.27)

avg_life_of_capital = 14

avg_wage_data = total_wages_data/PRODUCTION.employment_per_industry_data[Public_Services]

capital_adj_time = 1

capital_delivery_time = 1.5

Converter_1 = Gross_Capital_Srock_in__Public_Services_data/VA_in_Public_Services_data

Converter_6 = TREND(avg_wage_data,1)

delay_in_wage_changes = 0.5

desired_capital = long_run_expected_Demand*desired_capital_output_ratio desired_capital_orders = capital_depreciation+((desired_capital-Capital_in_Public_Services)/capital_adj_time)

desired_capital_output_ratio = SMTH1(Actual_Capital_Output_Ratio,1)*SMTH1(history(expected_cost_of_capital,(time-1))/expected_cost_of_capital,1)+expected_labour_cost_productivity_ratio*0

desired_employment = ((PUBLIC_SERVICES_SECTOR.indicated_production*domestic_coeff/productivity_of_LB)*(Desired_Labour_share/labor's_share))

Desired_Labour_share = 0.74

domestic_coeff = 0.503232725

Employment_in_Public_Services_data = PRODUCTION.employment_per_industry_data[Public_Services]

expected_cost_of_capital = SMTH1(interest_rate,time_to_perceive_cost_of_capital)+1/avg_life_of_capital

expected_labour_cost_productivity_ratio = SMTH1(unit_labour_cost_index/init(unit_labour_cost_index),2)

Gross_Capital_Srock_in__Public_Services_data = Gross_Capital_Stock_per_Industry_data[Public_Services]

Gross_Capital_Stock_CURRENT[Agriculture] = GRAPH(TIME)

(2001, 1.3e+010), (2002, 1.4e+010), (2003, 1.6e+010), (2004, 1.7e+010), (2005, 1.7e+010), (2006, 1.8e+010), (2007, 2e+010), (2008, 2.7e+010), (2009, 2.2e+010), (2010, 2.1e+010), (2011, 2.1e+010)

Gross_Capital_Stock_CURRENT[Construction] = GRAPH(TIME)

(2001, 5.1e+009), (2002, 5.1e+009), (2003, 8.2e+009), (2004, 4.2e+009), (2005, 3.3e+009), (2006, 6e+009), (2007, 4.7e+009), (2008, 6.7e+009), (2009, 5.3e+009), (2010, 4.2e+009), (2011, 5.7e+009)

Gross_Capital_Stock_CURRENT[Manufacturing] = GRAPH(TIME)

(2001, 4.2e+010), (2002, 5.1e+010), (2003, 4.6e+010), (2004, 5.6e+010), (2005, 4.9e+010), (2006, 4.8e+010), (2007, 5.7e+010), (2008, 5.6e+010), (2009, 5.2e+010), (2010, 5.4e+010), (2011, 4.5e+010)

Gross_Capital_Stock_CURRENT[Market_services] = GRAPH(TIME)

(2001, 2.3e+011), (2002, 2.2e+011), (2003, 2.4e+011), (2004, 2.7e+011), (2005, 2.9e+011), (2006, 3.1e+011), (2007, 3.2e+011), (2008, 2.9e+011), (2009, 3.4e+011), (2010, 3.5e+011), (2011, 3.6e+011)

Gross_Capital_Stock_CURRENT[Public_Services] = GRAPH(TIME)

(2001, 6.5e+010), (2002, 6.2e+010), (2003, 7.1e+010), (2004, 6.9e+010), (2005, 7.1e+010), (2006, 8e+010), (2007, 9.1e+010), (2008, 9.6e+010), (2009, 8.5e+010), (2010, 9e+010), (2011, 9.8e+010)

Gross_Capital_Stock_per_Industry_data[INDUSTRY] = Gross_Capital_Stock_CURRENT*IPC_DATA/100

GRP_data = VA_per_Industry_data[Agriculture]+VA_per_Industry_data[Construction]+VA_per_Industry_data[Manufacturing]+VA_per_Industry_data[Market_services]+VA_per_Industry_data[Public_Services]

Indicated_wage = Desired_Labour_share*SMTH3(productivity_of_LB,4*delay_in_wage_changes)

interest_rate = GRAPH(TIME)

(2001, 6.65), (2002, 5.57), (2003, 4.71), (2004, 4.03), (2005, 3.56), (2006, 4.68), (2007, 5.48), (2008, 4.82), (2009, 2.25), (2010, 2.79), (2011, 4.18), (2012, 3.64), (2013, 3.45), (2014, 2.66)

IPC_DATA = GRAPH(TIME)

(2001, 82.9), (2002, 85.0), (2003, 88.0), (2004, 89.2), (2005, 90.9), (2006, 92.8), (2007, 94.5), (2008, 97.7), (2009, 98.5), (2010, 100), (2011, 103), (2012, 106), (2013, 107), (2014, 107)

labor's_share = IF (productivity_of_LB=0) THEN 0 ELSE (avg_wage/productivity_of_LB)

LABOR_SHARE_DATA = IF (PRODUCTIVITY_OF_LB_DATA=0) THEN 0 ELSE (avg_wage_data/PRODUCTIVITY_OF_LB_DATA)

productivity_of_LB = VA_in_Public_Services/EMPLOYMENT

PRODUCTIVITY_OF_LB_DATA = VA_in_Public_Services_data/PRODUCTION.employment_per_industry_data[Public_Services]

total_wages_data = Total_Wages_per_Industry_data[Public_Services]

TFP_in_Market_Services_est = (VA_in_Public_Services_data/Employment_in_Public_Services_data)/((Gross_Capital_Srock_in__Public_Services_data/Employment_in_Public_Services_data)^(1-alfa_est))

time_to_chg_wages = 0.9

time_to_hire = 2

time_to_perceive_cost_of_capital = 1

time_to_perceive_expected_demand = 1

total_wages = EMPLOYMENT*avg_wage

Total_Wages_per_Industry_data[Agriculture] = GRAPH(TIME)

(2001, 6.8e+008), (2002, 7.4e+008), (2003, 8e+008), (2004, 8.4e+008), (2005, 9.6e+008), (2006, 1.1e+009), (2007, 1e+009), (2008, 1.1e+009), (2009, 1e+009), (2010, 1.1e+009), (2011, 1.3e+009), (2012, 1.3e+009), (2013, 1.3e+009), (2014, 1.4e+009)

Total_Wages_per_Industry_data[Construction] = GRAPH(TIME)

(2001, 1.3e+009), (2002, 1.7e+009), (2003, 2.1e+009), (2004, 2.3e+009), (2005, 2.2e+009), (2006, 2.4e+009), (2007, 2.9e+009), (2008, 3.2e+009), (2009, 2.5e+009), (2010, 2.3e+009), (2011, 2.3e+009), (2012, 2.1e+009), (2013, 1.9e+009), (2014, 1.8e+009)

Total_Wages_per_Industry_data[Manufacturing] = GRAPH(TIME)

(2001, 2.6e+009), (2002, 2.8e+009), (2003, 2.9e+009), (2004, 3.1e+009), (2005, 3.2e+009), (2006, 3.6e+009), (2007, 3.7e+009), (2008, 3.9e+009), (2009, 3.7e+009), (2010, 3.6e+009), (2011, 3.7e+009), (2012, 3.9e+009), (2013, 3.9e+009), (2014, 4e+009)

Total_Wages_per_Industry_data[Market_services] = GRAPH(TIME)

(2001, 6.1e+009), (2002, 6.7e+009), (2003, 7.2e+009), (2004, 7.8e+009), (2005, 8.2e+009), (2006, 8.8e+009), (2007, 9.3e+009), (2008, 9.9e+009), (2009, 1e+010), (2010, 1e+010), (2011, 1.1e+010), (2012, 1.1e+010), (2013, 1.1e+010), (2014, 1.1e+010)

Total_Wages_per_Industry_data[Public_Services] = GRAPH(TIME)

(2001, 1.2e+010), (2002, 1.3e+010), (2003, 1.4e+010), (2004, 1.5e+010), (2005, 1.6e+010), (2006, 1.8e+010), (2007, 1.8e+010), (2008, 1.9e+010), (2009, 1.9e+010), (2010, 2e+010), (2011, 2e+010), (2012, 2e+010), (2013, 2e+010), (2014, 2e+010)

unit_labor_cost_index_data = total_wages_data/VA_in_Public_Services_data

unit_labour_cost_index = total_wages/VA_in_Public_Services

VA_in_Public_Services = TFP_in_Market_Services_est*((Capital_in_Public_Services/EMPLOYMENT)^(1-alfa_est))*EMPLOYMENT

VA_in_Public_Services_data = VA_per_Industry_data[Public_Services]

VA_per_Industry_data[Agriculture] = GRAPH(TIME)

(2001, 2.3e+009), (2002, 2.3e+009), (2003, 3.1e+009), (2004, 3e+009), (2005, 2.9e+009), (2006, 2.9e+009), (2007, 2.8e+009), (2008, 3e+009), (2009, 2.8e+009), (2010, 2.9e+009), (2011, 3e+009), (2012, 3.4e+009), (2013, 3.5e+009), (2014, 3.2e+009)

VA_per_Industry_data[Construction] = GRAPH(TIME)

(2001, 3.5e+009), (2002, 3.9e+009), (2003, 4.3e+009), (2004, 4.2e+009), (2005, 4.5e+009), (2006, 4.8e+009), (2007, 5e+009), (2008, 5.3e+009), (2009, 5.2e+009), (2010, 4.5e+009), (2011, 4.4e+009), (2012, 4.3e+009), (2013, 4e+009), (2014, 3.7e+009)

VA_per_Industry_data[Manufacturing] = GRAPH(TIME)

(2001, 6.2e+009), (2002, 6.8e+009), (2003, 6.9e+009), (2004, 6.9e+009), (2005, 7.2e+009), (2006, 7.6e+009), (2007, 8.2e+009), (2008, 8.5e+009), (2009, 7.4e+009), (2010, 7.6e+009), (2011, 7.5e+009), (2012, 7.8e+009), (2013, 7.9e+009), (2014, 8.1e+009)

VA_per_Industry_data[Market_services] = GRAPH(TIME)

(2001, 2.7e+010), (2002, 2.8e+010), (2003, 2.9e+010), (2004, 3.1e+010), (2005, 3.2e+010), (2006, 3.4e+010), (2007, 3.6e+010), (2008, 3.7e+010), (2009, 3.7e+010), (2010, 3.8e+010), (2011, 4e+010), (2012, 4.1e+010), (2013, 4.1e+010), (2014, 4.1e+010)

VA_per_Industry_data[Public_Services] = GRAPH(TIME)

(2001, 1.6e+010), (2002, 1.7e+010), (2003, 1.9e+010), (2004, 2e+010), (2005, 2.2e+010), (2006, 2.4e+010), (2007, 2.4e+010), (2008, 2.6e+010), (2009, 2.6e+010), (2010, 2.7e+010), (2011, 2.7e+010), (2012, 2.7e+010), (2013, 2.8e+010), (2014, 2.8e+010)

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