Development of a System Dynamics framework for analysing regional economies: The Sunshine Coast case

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1. INTRODUCTION

Technological development and globalisation have posed challenges and opportunities to regions in the world, upon which Policy Makers hinge their decisions so as to improve the well-being of their societies. The outcomes of those decisions will determine the success or failure of regions and the impact will be on thousands of persons. Hence, decisions and policies ought to be analysed and evaluated thoroughly before being implemented.

Policy Makers and stakeholders of the Sunshine Coast, an urban area of South-East Queensland in Australia, are aware of the significance of the current juncture, in which the performance of the economy has been deteriorating over the last years. Consequently, the status quo or laissez-faire is no longer an option and actions must be taken. The result of such acknowledgement is a set of pathways to significantly improve the performance of the local economy over the next 20 years by the support of five game-changer projects and seven key high-value industries proposed in a strategy known as the "The Sunshine Coast Economic Development Strategy".

Dr. Ken Lyons, a local professional, based on his vast experience on large-scale projects in developing and developed countries recognised the complexity of achieving intended goals contained in any public initiative, for that reason he contacted System Dynamics Group at University of Bergen for assistance in the analysis and evaluation of "The Sunshine Coast Economic Development Strategy" by the means of a System Dynamics quantified simulation model. Both parties deemed appropriate a Master Thesis project for meeting that requirement. Furthermore, both parties arranged a visit to the Sunshine Coast of the author of this project that lasted for three months (February 2014 – May 2014) to interact more fully with key personnel from industry and government, and commence development of the simulation model.

Nonetheless, at the onset of the development of this project, it was discovered the scarcity of similar works that could establish a point of departure for the modelling process that could lead to a product in compliance with the requirements in the disaggregation level set by stakeholders. For this reason, and taking into account the duration of the project, the purpose of the simulation model is defined as being a tool that provides a framework that accounts for the performance of local economy, and wherein improvement proposals such as the ones contained "The Sunshine Coast Economic Development Strategy" can be assessed.

Having defined the purpose of the model, it was considered suitable the use of the “3P’s” (population, participation and productivity) approach as a practical concept that caters the building blocks for articulating macroeconomics principles in a simulation model. However, in spite of the simplicity provided by the “3P’s” approach, the phenomenon to be modelled is still complex. Therefore, the modelling process is carried out in an incremental and iterative fashion. The iterative process can be seen as the construction of prototypes likely to be enhanced in a next iteration. Each new prototype gives rise to a causal assumption that integrates greater complexity.

As a result, in this project two prototype models are developed. The first prototype consists of a disaggregated demographic structure that accounts for the dynamics of the population and labour force, and a basic structure that represents employment and overall productivity. This prototype is quantified with numerical data drawn from various sources in order to simulate its structure, and thereby comprehend the reasons that explain the system’s behaviour in the past. Based on these findings, various scenarios are defined so as to identify leverage points aimed at enhancing the performance of the economy and well-being of its residents.

Afterwards, the concept of aggregated demand is incorporated into the model by creating a structure that represents the industries in the Sunshine Coast based on the Australian and New Zealand Standard Industry Classification (ANZSIC). Such incorporation permits the model to account for the dynamics of the employment level and economy’s overall productivity. In addition, during the process, tourism is recognised as a subset of exports that affect some industries of the Sunshine Coast’s economy. These concepts are integrated with the demographics ones, giving rise to the second prototype. At last, this new enriched structure is quantified so as to allow the preliminary evaluation of improvement proposals through simulation.

In summary, in this document is presented the results of a Master thesis project, in which is argued how System Dynamics methodology is able to provide a framework that addresses the evaluation of regional economies and their improvement proposals by the means of two prototype models tailored to the Sunshine Coast specific case.

2. BACKGROUND

The Sunshine Coast is an urban area which forms the northern part of the south-east Queensland corridor and covers an area of 3,126 square kilometres. The region features a pristine 200 kilometre coastline with diverse landscapes including ocean beaches, hinterland, state forests and national parks. These natural resources have contributed substantially to establishing the region as a recognised holiday and lifestyle destination which has shaped the structure of the Sunshine Coast's economy.

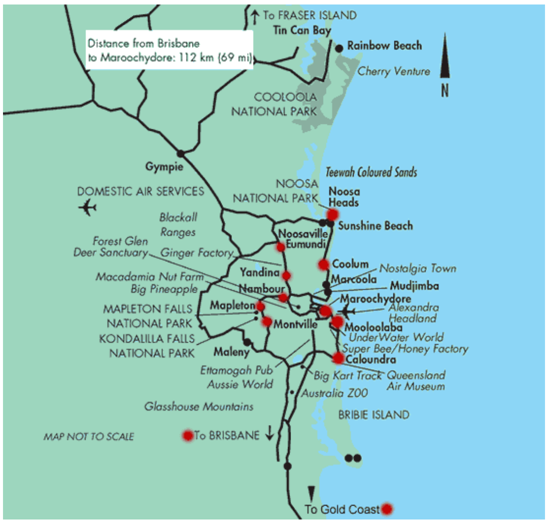


Figure 1 The Sunshine Coast
[Source: www.sunshinecoast-australia.com]

The Sunshine Coast's economy is overly reliant on the construction, retail and tourism. These core industries are 'population-dependent', often low value-adding and highly exposed to changes in external conditions such as variations in migration and tourism patterns.

On one hand, as any region in the world, population growth in the Sunshine Coast relies on the natural increase of its population (births and deaths) and migratory flows (immigration and emigration). In the recent years, net migration has had a larger contribution in population changes than the natural increase. Nevertheless, such a contribution has been declining over the years, having a profound impact on the economic growth through the labour market. In addition, the Sunshine Coast has an ageing population compared with other regions in Australia, which makes it heavily reliant on migratory flows for supplying local industries with the required labour force. As a consequence, reductions in the net gain of migrants undermine the performance of the economy.

On the other hand, the economic crisis of 2008, sometimes called the Great Recession in North America (Stiglitz, 2010) or the Great Financial Crisis (GFC) in Australia (Keen, 2011), has wreaked havoc throughout the world with dire consequences to their societies such as a rising in inequality and poverty, high unemployment rates, stagnation, and so on. In the Sunshine Coast this has been translated into a reduction in tourism, a pillar of the local economy. The outcome has been a decline in the demand for local goods and services, which has reduced the employment level.

Such ailments have encouraged people to demand policymakers to design effective policies that foster sustained and sustainable economic growth that result in well-remunerated jobs for citizens. Leaders and the community of the Sunshine Coast have understood the need for a shift in the economy's structure by the means of effective policies. On account of this demand, in 2013 it was produced "The Sunshine Coast Economic Development Strategy" (Sunshine Coast Economic Development Strategy Taskforce, 2013), a set of pathways to significantly improve the performance of the local economy over the next 20 years.

The Strategy aims to strengthen and extend the construction, retail and tourism industries – all of which are expected to remain significant elements of the regional economy for the foreseeable future. The region will also vigorously seek new investment opportunities associated with seven high-value industries:

- Health and well-being
- Education and research
- Tourism, sport and leisure
- Knowledge industries and professional services
- Agribusiness
- Clean technologies and
- Aviation and aerospace.

According to "The Sunshine Coast Economic Development Strategy", all of these industries have the potential to generate higher-paying, enduring employment opportunities on the back of the region's 'game changer' projects: the development of the Sunshine Coast University

Hospital and the Maroochydore City Centre; upgrade of the Bruce Highway; and expansion of the Sunshine Coast Airport and the University of the Sunshine Coast.

However, having a plan is just the first step of a long process that requires a thorough analysis before implementation takes place, given that public policies are prone to failure. Public policies often fail to achieve their intended result because of the complexity of both the environment and the policy-making process (Ghaffarzadegan, Lyneis, & Richardson, 2010). Specifically, public policies have to cope with certain issues which make resolution difficult using traditional approaches. These issues are:

- Policy resistance occurs when policy actions trigger feedback from the environment that undermines the policy and at times even exacerbates the original problem.
- The need for and cost of experimentation. Experimentation is important because the stakes are high, and it is costly because, once implemented, policies are often not reversible.
- The need to achieve consensus between diverse stakeholders inasmuch as policymaking is not a straightforward process in which a decision maker decides and others immediately implement.
- Overconfidence has an especially important influence on the ability of policymakers to question their assumptions, models of thinking, and strategies.
- The need to have an endogenous perspective for individual and organizational learning.

Aware of the difficulties for implementing public policies and reaching intended goals, Dr. Ken Lyons[1], resident of the Sunshine Coast, contacted System Dynamics Group at University of Bergen (Norway). His purpose was to value add to the work already done by the means of the adoption of System Dynamics as a methodology that facilitate evaluation of the means of

[1] Dr. Ken Lyons is the Principal of Spatial Information Services Pty Ltd. He is: a Professor Emeritus from the University of Queensland; an AURISA Eminent Individual; Spatial Queensland Industry Excellence Award 2005. He has over 40 years experience in working operationally and strategically in Australia, USA & a large number of developing countries.

achieving the strategic goals that have been set in the “The Sunshine Coast Economic Development Strategy”. University of Bergen deemed this initiative suitable for being undertaken under the frame of a Master Thesis project.

3. METHODOLOGY

In the previous chapter it is mentioned that System Dynamics is deemed a suitable methodology for supporting the implementation of the "The Sunshine Coast Economic Development Strategy". This chapter provides the methodological and theoretical frameworks that underpin that selection.

John Sterman (Sterman, 2000) defines System Dynamics as: "*a perspective and set of conceptual tools that enable us to understand the structure and dynamics of complex systems. System dynamics is also a rigorous modelling method that enables us to build formal computer simulations of complex systems and use them to design more effective policies and organizations*". This definition allows defining the scope of System Dynamics: it is appropriate for the analysis of problems is dynamically complex such as the Sunshine Coast's economy, and the analysis of long term solutions such as "The Sunshine Coast Economic Development Strategy". Dynamic complexity is related to potential underlying feedback processes; whereas the concept of effective policies is related its robustness, namely policies that works well in the long term (Vennix, 1996). These features cannot be easily handled without the help of a computer model as those built with System Dynamics.

Moreover, System Dynamics models focus on the representation of the structure that causes problematic behaviour by drawing on its own language of stock and flows. This structure allows Sunshine Coast's Policy Makers and stakeholders to comprehend the current state of affairs from an endogenous perspective. This means the actual situation is the result of local decisions taken in the past, and the future will be the result of current local decisions. Therefore, it is of vital importance the thorough analysis and evaluation of policies so that they yield the expected benefits.

System Dynamics contributes to policy analysis by its principle of "operational thinking". Thinking operationally means thinking in terms of how things really work—not how they theoretically work (Richmond, 1993). Therefore, assumptions and biases are exposed in the context of a simulation model, allowing Sunshine Coast's policymakers to evaluate not only the impact but also the feasibility of the improvement proposals to the economy. In this manner, Policy Makers can validate and champion policies that cater more benefits to the community in a cogent and logical fashion, which is assured by the mathematical formality embedded in System Dynamics models due to its differential equations rationale.

Furthermore, System Dynamics is a methodology that draws on many different information sources for building simulation models. Jay Forrester (Forrester, 1992) categorised information in three large databases: Mental data, written data and numerical data (Figure 2).

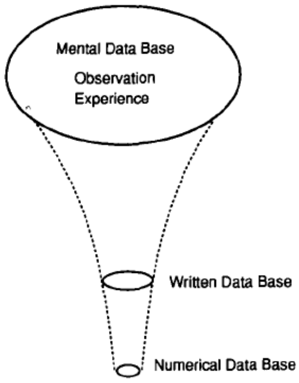


Figure 2 Mental data base and decreasing content of written and numerical data bases

Source: (Forrester, 1992)

Forrester states that the largest source of information resides on people's brains, the so-called "mental models". For this reason, System Dynamics encourages stakeholder's involvement throughout the modelling process in order to elicit their knowledge and produce accurate representations of reality. At last, the involvement of stakeholders results in ownership and commitment on the guidance provided by the model (Vennix, 1996), which increases the probability of implementing the recommendations drawn from it.

In spite of the advantages that System Dynamics offers, it only provides a framework to articulate theories and generate hypotheses (simulation models) that account for a particular phenomenon (Sunshine Coast's economy). Therefore, in this project System Dynamics is used as a methodological framework to articulate theories drawn from the economics science. Nevertheless, economics is a large and broad science with a myriad of approaches for addressing similar issues, whereby it is mandatory to choose a field within economics that suits the nature of this project. It is considered that field is macroeconomics.

Gregory Mankiw (Mankiw, 2012) defines macroeconomics as: "*the study of the economy as a whole, including growth in incomes, changes in prices, and the rate of unemployment. Macroeconomists attempt both to explain economic events and to devise policies to improve economic performance*". In addition, Mankiw recognises the importance of models by asserting: *"To understand the economy, economists use models—theories that simplify reality in order to reveal how exogenous variables influence endogenous variables. The art in the science of economics lies in judging whether a model captures the important economic relationships for the matter at hand".* According to these statements, macroeconomics provides the appropriate building blocks of a theoretical framework to be articulated by the means of a System Dynamics model so as to analyse Sunshine Coast regional economy.

At national level, the use of macroeconomic models is a wide-spread practice among economic institutions. For instance, Federal Reserve Board staff[2] consults the FRB/US model (Flint & Tinsley, 1996), a model of the United States economy, for forecasting and analysing macroeconomic issues, including both monetary and fiscal policy. Likewise, the European Central Bank uses the New-Area-Wide Model (Christoffel, Coenen, & Warne, 2008), a micro-founded open-economy model of the euro area, which is designed for use in the (Broad) Macroeconomic Projection Exercises regularly undertaken by ECB/Eurosystem staff and for policy analysis.

On the contrary, at regional level the use of models for supporting regional economic development is seldom. This view is underpinned by Stimson et al (2011): "*there are few examples of models that have been explicitly developed and empirically tested to actually measure endogenous regional growth or to investigate the determinants of spatial variations in regional performance on an endogenous growth measure"*. Consequently, this project not only aims at supporting Sunshine Coast's decision making but also to contribute in the research for economic regional development through System Dynamics.

[2] The Federal Reserve System (also known as the Federal Reserve, and informally as the Fed) is the central banking system of the United States.

4. PROBLEM DEFINITION

Once the methodological and theoretical frameworks have been selected, the next step is to generate a reference mode of behaviour over time which may represent the performance of the Sunshine Coast's economy.

Gross domestic product, or GDP, is often considered, by macroeconomists, the best measure of how well the economy is performing given that it measures both a nation's total output of goods and services and its total income (Mankiw, 2012). Conceptually equivalent to GDP, gross regional product (GRP) measures total output of goods and services produced by regional production units (or regional residents in short) in the regional economy, be it a state, province or a district. Therefore, Sunshine Coast's GRP is established as an appropriate indicator of economic performance.

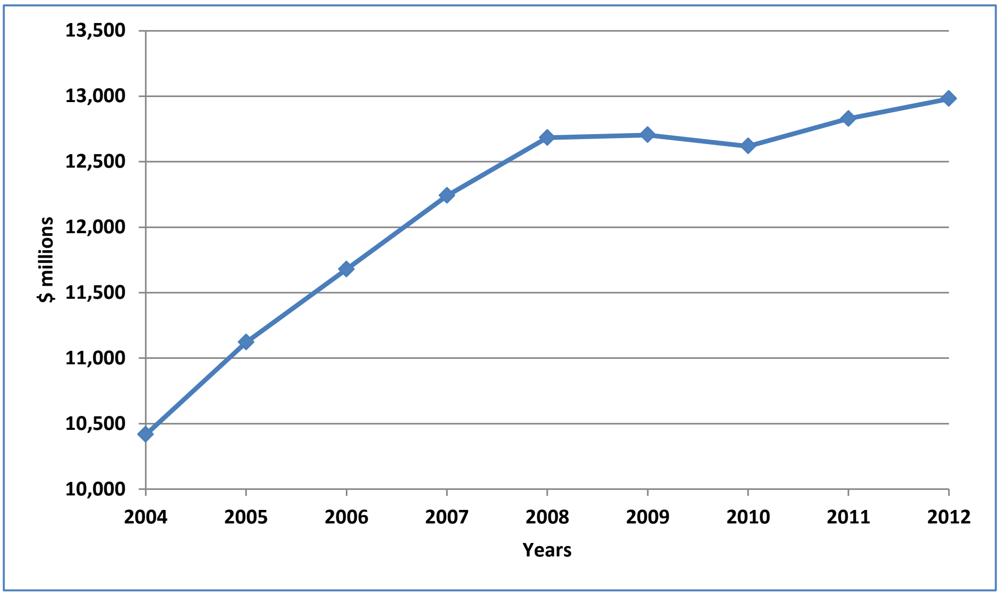


Figure 3 Sunshine Coast GRP

[Source: http://economy.id.com.au/sunshine-coast]

As Figure 3 shows, over the recent years Sunshine Coast's economy has lost the impetus it had before the GFC which has been translated into slow economic growth or even recession. This has resulted in fewer jobs for local residents, less income and so on. Moreover, at all levels of government (federal, state and local) tax revenues are inflicted by lower collection which threatens social programs and infrastructure investments. Consequently, local residents' well-being has deteriorated in the last years. This is confirmed by looking at a more accurate indicator: GRP per capita.

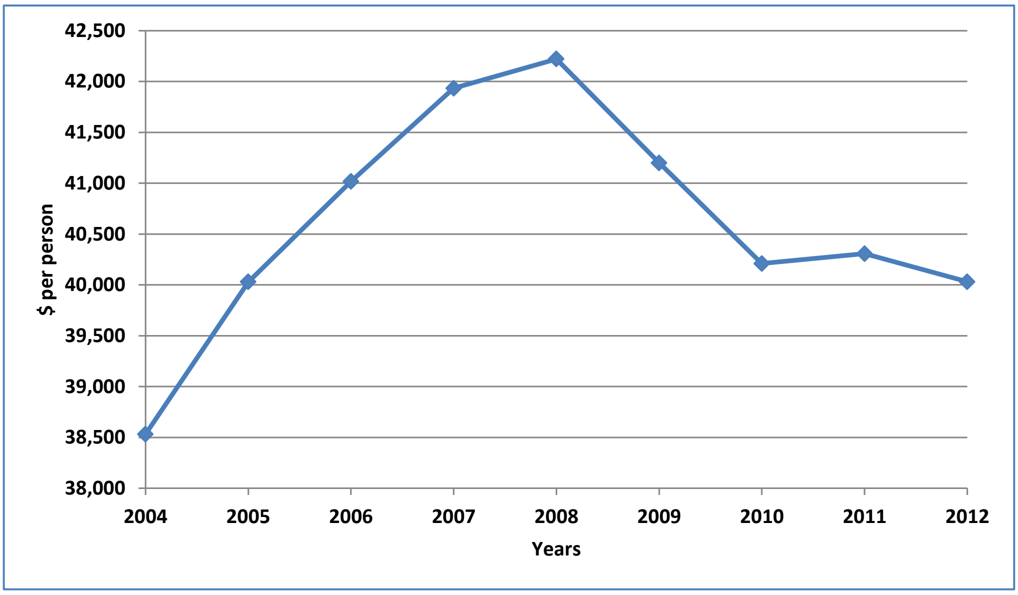


Figure 4 Sunshine Coast GRP per capita
[Source: http://economy.id.com.au/sunshine-coast; www.abs.gov.au]

GRP per capita is a measure that divides regional output by resident population. Inasmuch as population's income derives from local production, GRP per capita is a proper indicator of well-being. In the Sunshine Coast's case, GRP per capita (see Figure 4) grew from 2004 until the onset of the GFC in 2008; thereafter it has experienced a steady decline due to a mixture of factors. A study conducted by the local business council (Sunshine Coast Business Council, 2013) casts some light on the causes for the detriment of the local economy by providing an explanation based on three concepts: population, participation and productivity, known as the "3P's" approach.

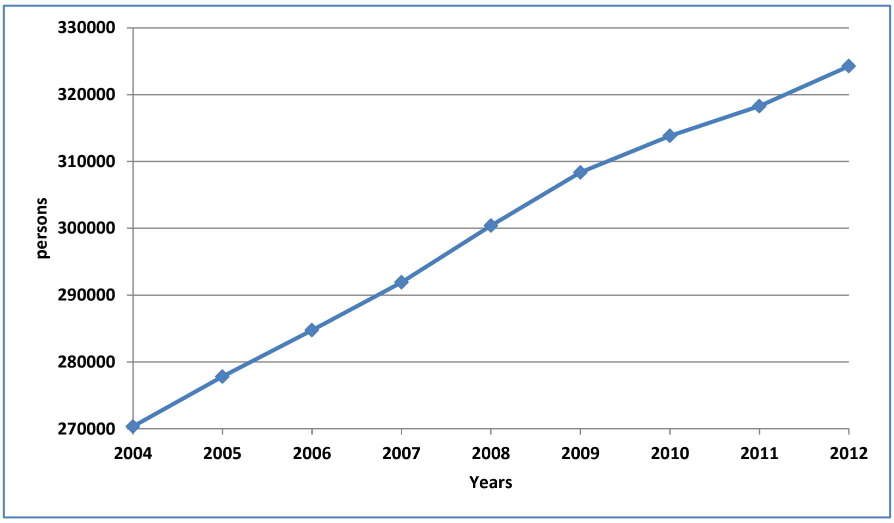


Figure 5 Sunshine Coast population
[Source: www.abs.com]

In regard to population, the Sunshine Coast region has the fourth largest one in South East Queensland (behind Brisbane, Gold Coast and Moreton Bay Region). The Sunshine Coast grew very rapidly in the early part of the decade but slowed markedly over recent years (see Figure 5). This change in population pattern has inflicted on both sides of the local economy, supply and demand. On the supply side, deceleration in population growth has implied less new labour force to local industries that constraints the capacity of production of goods and services; on the demand side, the slowdown in population growth has undermined consumption of local goods and services.

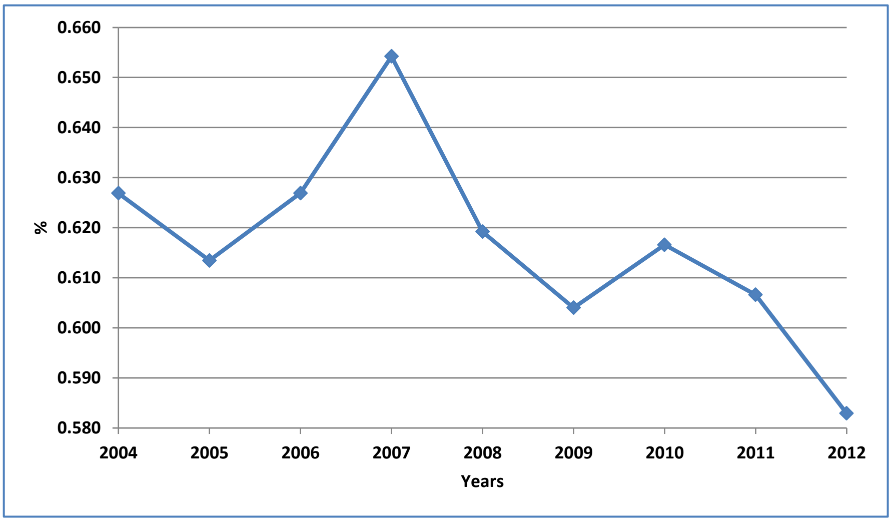


Figure 6 Sunshine Coast participation rate
[Source: www.abs.gov.au]

In addition, with respect to people available for work, the challenges for Australia over the next 40 years are those that the Sunshine Coast will be facing over the next 10-20 years given its relatively old population (Sunshine Coast Business Council, 2013). As the proportion of the population of traditional working age has fallen due to an ageing population, the rate of labour force participation across the whole population has also fallen (see Figure 6). As a consequence, the scarcity of one of the production factors (labour) is aggravated. Hence, it is imperative to understand the dynamics of the Sunshine Coast's population and its implications on the economy.

INDUSTRIES	2012	
	INDUSTRY SIZE ($ millions)	PRODUCTIVITY $('000)
Agriculture, Forestry and Fishing	341	120
Mining	130	236
Manufacturing	767	104
Electricity, Gas, Water and Waste Services	211	204
Construction	1,338	86
Wholesale Trade	643	213
Retail Trade	1,022	54
Accommodation and Food Services	607	45
Transport, Postal and Warehousing	469	107
Information Media and Telecommunications	251	177
Financial and Insurance Services	923	250
Rental, Hiring and Real Estate Services	502	107
Professional, Scientific and Technical Services	720	87
Administrative and Support Services	280	53
Public Administration and Safety	471	102
Education and Training	634	61
Health Care and Social Assistance	1,181	60
Arts and Recreation Services	102	40
Other Services	257	55

Table 1 Structure of the Sunshine Coast economy
[Source: http://economy.id.com.au/sunshine-coast]

At last, productivity is the remaining "P" of the "3P's" approach that underpins long-term economic well-being. Productivity is a measure of the efficiency of a worker in converting inputs into useful outputs. In a regional economy, overall productivity is the composition of the productivity of each industry. Hence, in order to understand the efficiency of a regional economy, it is necessary to enquire into the economy's structure and the size of its industries. Table 1 collects data from 2012 about the Sunshine Coast's industries (size and productivity), organised according to Australia's industry classification (Trewin & Pink, 2006). Based on the information contained in this table, it is possible to confirm the statement enunciated in chapter 1: The Sunshine Coast's economy relies on low value-added industries. By looking at the second and third columns of Table 1, it is revealed the sectors that have the largest contribution to the GRP and its productivity. Construction ($1.3 billions), health care and social assistance ($1.2 billion) and retail trade ($ 1 billion) accounts for about 30% of industries contribution to GRP. However, their productivities are at the bottom when they are compared to the other industries: among 19 industries sectors, construction ranks in the 12th place; health care and social assistance in the 14th place; and retail trade in 16th place. Therefore, structure of the Sunshine Coast's industries is an important component to be investigated.

Consequently, the “3P’s approach” is regarded as the cornerstone for developing a System Dynamics structure, funded in macroeconomics principles, that accounts for the Sunshine Coast’s economy. Therefore, the first research question this project addresses is: What are the dynamic reasons that explain the behaviour of Sunshine Coast’s GRP from 2004 to 2012?

Subsequently, the next step is to unravel the way in which policies such as “The Sunshine Coast Economic Development Strategy” or any other will impact the Sunshine Coast’s economy by the means of a structure that allows the analysis of improvement proposals in a cogent fashion. This issue is summarised in the following research question: How can policies aimed at improving Sunshine Coast’s economy be analysed and evaluated?

In summary, this projects aims to answer sufficiently both research questions through a simulation model.

5. DYNAMIC HYPOTHESIS

This chapter describes the simulation model that intends to provide answers from a System Dynamics perspective to the research questions posed above. The study of a phenomenon from a System Dynamics perspective is a consecutive iteration of the enrichment process of mental models. This implies that understanding the complexity becomes gradually and progressively, which is possible due to the language system provided by System Dynamics to navigate between different levels of abstraction and expression of causality. Namely, the iterative process can be seen as the construction of prototypes likely to be enhanced in a next iteration. Each new prototype gives rise to a causal assumption that integrates greater complexity (Andrade et al, 2001).

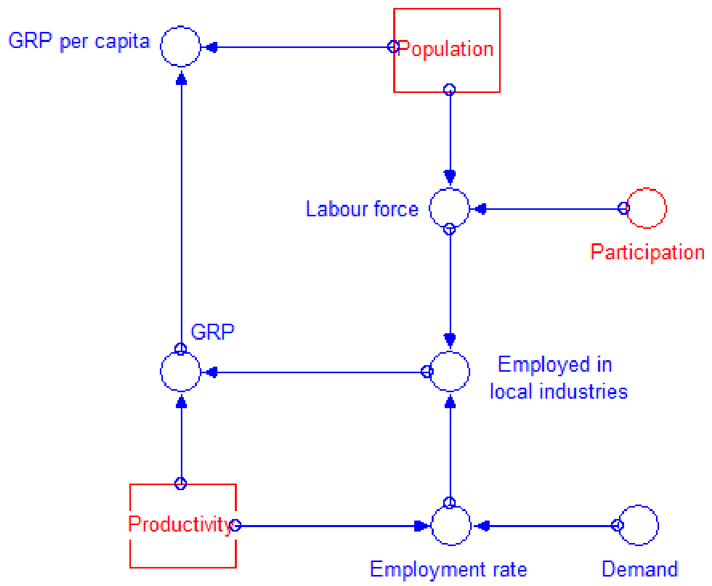


Figure 7 3P's integrated with GRP

To start with, the indicator of economic performance (GRP) and well-being (GRP per capita) are integrated to the "3P's" (population, participation and productivity) by the means of the stock and flow language (Figure 7). GRP per capita is the relationship between Sunshine Coast's GRP and total population. Sunshine Coast's GRP is determined by the number of people employed in local industries and the productivity of such industries.

Employees are sourced from the local people available for work (labour force) which is a fraction of the total population, the so-called "participation rate". Therefore, in order to unravel the dynamics of the production of goods and services, the structure of the Sunshine

Coast's population must be understood. As a consequence, at the onset, the modelling process is focused on discover the causal relations that determine the level of population. The outcome is the first prototype denoted as "Demographics".

Nevertheless, in an economy not all labour force is employed at any point in time, which implies the existence of unemployed people who suffer the plights of being in that condition. The level of employed in a regional economy is determined by the demand of good and services from local residents or agents outside the region, and by the overall productivity in the Sunshine Coast. On one hand, the demand of good and services comprises local consumption and exports, whereas overall productivity is the composition of size and productivity of the industries in the Sunshine Coast. Therefore, it is required a causal explanation that integrates level of employment, demand and productivity. The resulting structure is coupled with the first prototype generating the second prototype.

5.1 First prototype: Demographics

Demographics is defined as the characteristics of a population, such as the age, gender and so on, which shape the behaviour of population over time. In order to capture those characteristics, Sunshine Coast's population is portrayed by an ageing chain of five-year cohorts for people between 0 and 64 years old; in contrast, the last cohort groups people older than 64 years old. Each cohort is represented by a stock and the maturation process by a flow (Figure 8). The sum of all these cohorts is the Sunshine Coast's total resident population.

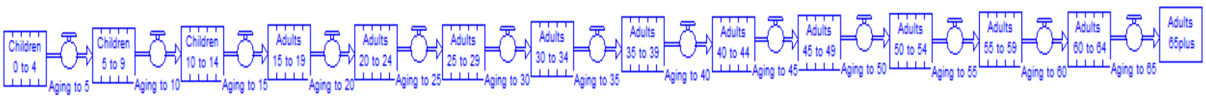


Figure 8 Ageing chain

Having defined the ageing chain, the next step is to identify the flows that determine the level of Sunshine Coast's total resident population. For any city, region or country in the world, there are two kinds of actions (flows) that determine such level: biological and migratory.

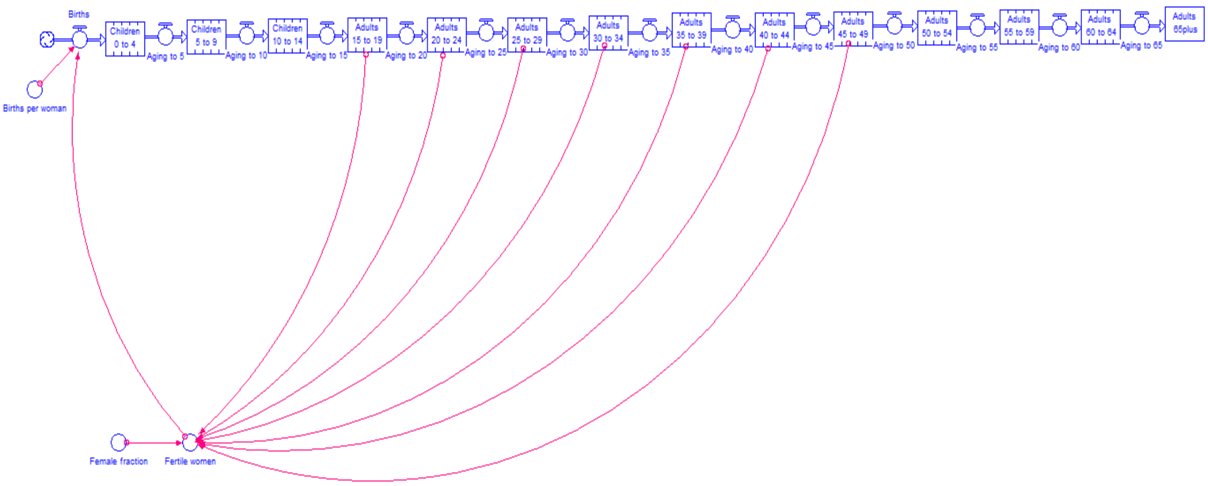


Figure 9 Births

On the biological side, there are two processes that change the level of total population. The first one is the well-known process called births, which adds new individuals and increases population, depicted in Figure 9. Annual births depend on the annual number of births per woman and the amount of fertile women, which is a fraction of the population between 15 and 49 years old. This is an example of the "operational thinking" mentioned in chapter 3.

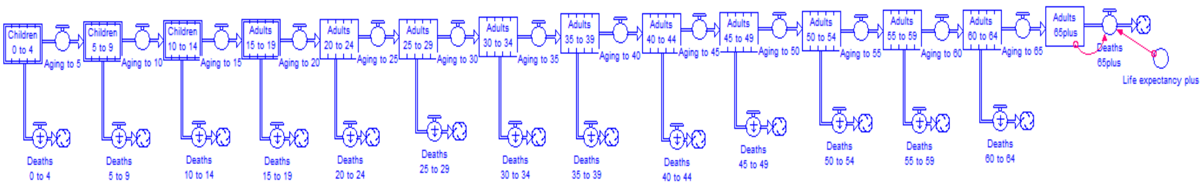


Figure 10 Deaths

Conversely, the second process on the biological side subtracts individuals from the total resident population. This is another well-known process called deaths depicted in Figure 10. Total deaths in the Sunshine Coast are disaggregated in as many cohorts exist in the ageing chain. Such a disaggregation is carried out due to the probability of dying varies from cohort to cohort.

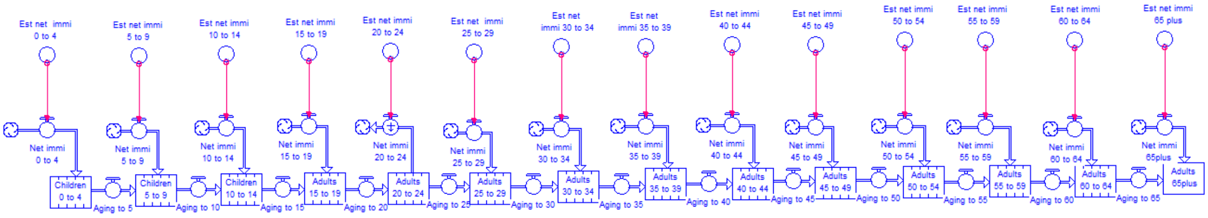


Figure 11 Net migration

On the migratory side, there are two processes that change the level of total population: immigration and emigration. The former is the act of entering and settling in a country or region to which one is not native and increases the total population; whereas the latter is the act of leaving one country or region to settle in another and decreases the total population. In spite of the recommendation of representing each process by a separate flow, this task cannot be undertaken, since there is no data available for doing so. For this reason, both processes are amalgamated into one flow called "net immigration", which is immigration minus emigration. Net immigration is disaggregated in the same manner in as many cohorts exist (Figure 11).

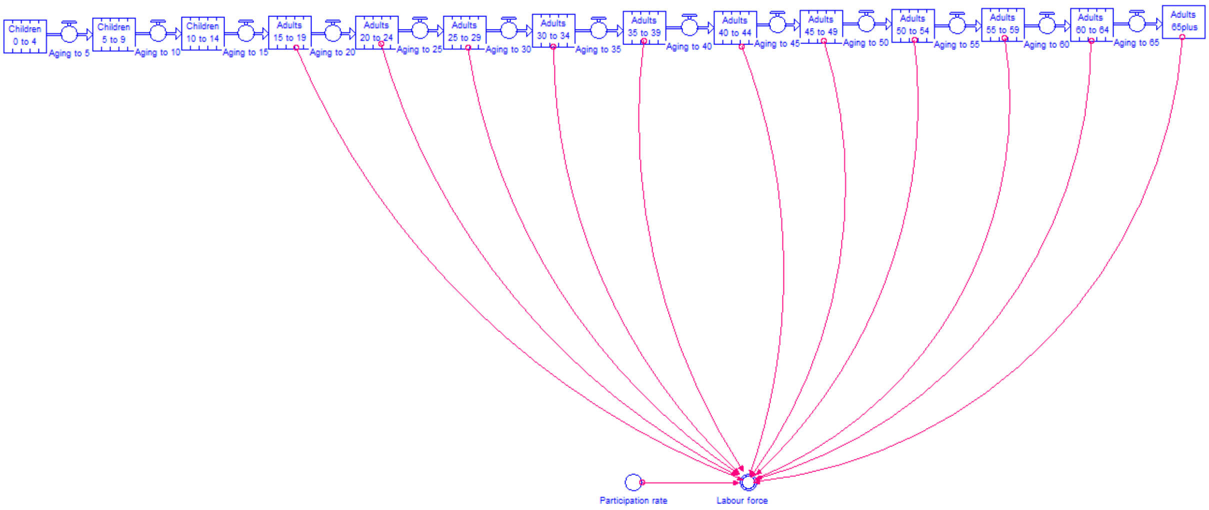


Figure 12 Labour force and participation rate

After defining the flows that shape the dynamics of population, the remaining task is to identify the subset of the population that accounts for labour force. This is a fraction (participation rate) of each cohort over 14 years old (Figure 12). It varies from cohort to cohort given the peculiarities of each segment of the population. For instance, people in the cohort 15 to 19 years old prioritise education over work; whereas cohorts from 20 to 55 years old prioritise work over any other activity.

The incorporation of labour force into the ageing chain completes the demographics structure (Figure 13), which is a complex net of intertwined elements. This makes difficult the identification of feedback processes that determine the behaviour of the system. Hence, the stock and flow diagram is simplified into a causal loop diagram that permits doing so.

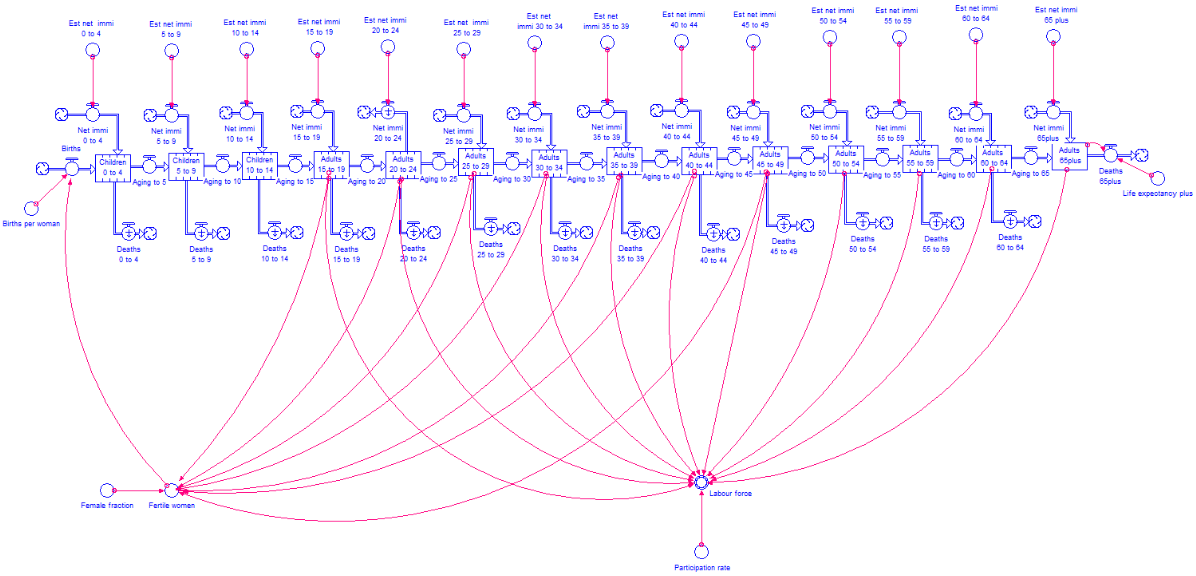


Figure 13 Demographics

Figure 14 is the causal loop diagram of the Sunshine Coast's demographics where it is possible to appreciate the feedback loops present in such subsystem. There are two feedback loops: a reinforcing one and a balancing one. The former relates to the process through which new individuals (births) increases total population, and this one in turn produces more individuals through births; the latter relates to the process in which the augment in the quantity of individuals in the population leads to an augment in the quantity of deaths that occur, giving as a result a reduction in the population.

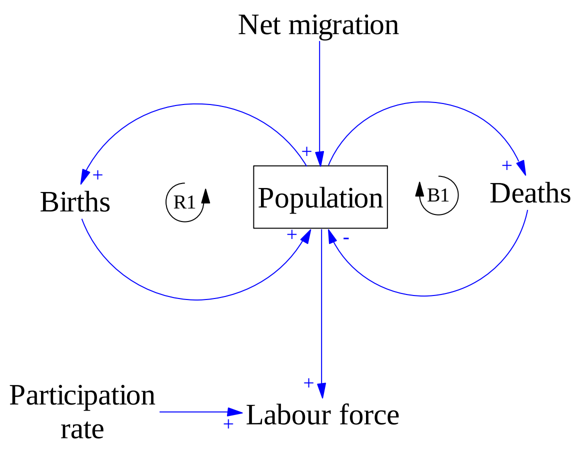


Figure 14 Demographics causal loop diagram

Subsequently, demographics structure is compressed into one module whose outputs are population and labour force (Figure 15). Labour force is used to estimate the amount of resident population employed by assuming a certain fraction. However, not all resident population employed work in the Sunshine Coast region, since several people work in other regions such as Brisbane, Gold Coast, and so on. Therefore, a fraction of the resident population employed works for local industries. This fraction is represented by the means of a stock since it has been changing over time. People employed in local industries along with overall productivity are the inputs that generate the value added of industries, the largest contributor to GRP. The remaining fraction comprises primarily ownership of dwellings. In this manner, the causal relations for the indicator of economic performance (GRP) are established. At last, GRP is linked to the other output of the demographic sector (population), and thereby the indicator of well-being (GRP per capita) is obtained.

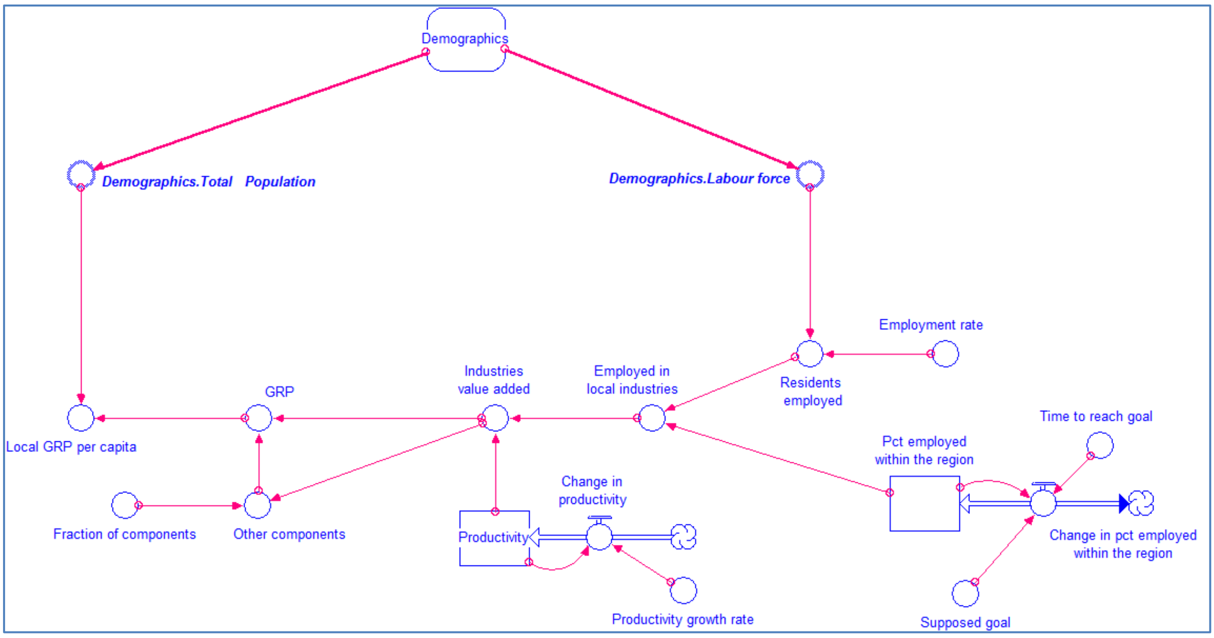


Figure 15 Prototype 1 diagram

Quantification

In spite of the causal and stock and flow diagrams provide valuable insights of the complexity of systems, they are merely a set of causal attributions, initial hypotheses about the structure of a system, which must then be tested. Simulation is the only practical way to test these models, whereby it is required to quantify each variable within the structure.

To begin with, variables in the demographics sector are populated with numerical values. Initial values of each cohort in the ageing chain (see Figure 8) are assigned according to data drawn from the Australian Bureau of Statistics (Table 2), the Australia's national statistical agency.

COHORTS	PERSONS
0-4	15670
5-9	17840
10-14	19573
15-19	17567
20-24	13658
25-29	13452
30-34	17203
35-39	18154
40-44	21231
45-49	20250
50-54	18832
55-59	18475

60-64	15411
65 or more	43010
Total population	270326

Table 2 Sunshine Coast population in 2004

[Source: www.abs.gov.au]

Then, parameters' values that determine biological flows (births and deaths) are estimated. In regard to births, female fraction of total population is assumed to be 51% by averaging data from 2004 and 2012 published by Australian Bureau of Statistics (ABS). Likewise, the number of births per woman in the Sunshine Coast is estimated around 1 birth per every 20 women. In regard to deaths, due to the level of disaggregation deemed according to model's purpose, there is no data available for the Sunshine Coast. Therefore, Queensland's data is used as a proxy for estimating Sunshine Coast's mortality. Table 3 shows average mortality rates for each cohort of the ageing chain. These averages are calculated from Queensland's data between 2002 and 2012 drawn from ABS.

COHORTS	MORTALITY RATE
0-4	0.0012
5-9	0.0001
10-14	0.0001
15-19	0.0004
20-24	0.0006
25-29	0.0007
30-34	0.0008
35-39	0.0010
40-44	0.0013
45-49	0.0020
50-54	0.0028
55-59	0.0044
60-64	0.0072
65 or more	0.0393

Table 3 Queensland's average mortality rate between 2002 and 2012

[Source: www.abs.gov.au]

Furthermore, values for migratory flows are figured out. It is mentioned above the scarcity of annual data available for Sunshine Coast's migration processes, whereby they are compressed into a single one called "net immigration". These numbers are derived from annual data of population, births and deaths as shown in the following table:

Year (as of June)	Total population	Year period	Births	Deaths	Natural increase (births minus deaths)	Net immigration[3]
2004	270326	2003/04	2972	1884	1088	
2005	277803	2004/05	3085	1902	1183	6294
2006	284736	2005/06	3209	1902	1307	5626
2007	291904	2006/07	3543	1952	1591	5577
2008	300400	2007/08	3744	2230	1514	6982
2009	308362	2008/09	3782	2133	1649	6313
2010	313823	2009/10	3690	2203	1487	3974
2011	318279	2010/11	3472	2332	1140	3316
2012	324266	2011/12	3468	2381	1087	4900

Table 4 Demographics data from 2004 to 2012

[Source: www.abs.gov.au]

Although total annual net immigration has been calculated, the level of detail in the model requires such figures to be disaggregated to the number of cohorts there exists. Therefore, it is necessary to approximate net migration figures for each cohort. They are derived from ABS data and assumptions about mortality and maturation rates. ABS caters annual data for births and population estimates for each cohort; whereas deaths are the result of population multiplied by mortality fraction (Table 3) and maturation rate is assumed 20 % for each cohort. This is illustrated in the figures and equations below:

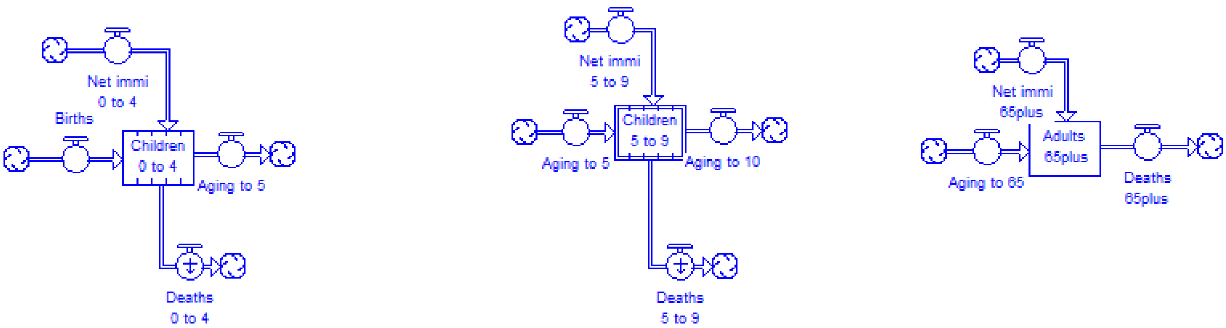


Figure 16 Three kinds of cohorts

[3] The equation for deriving net migration is: Population $_{tn}$ – Population $_{tn-1}$ – Natural Increase $_{tn}$

There are three kinds of cohorts (Figure 16) within the model's ageing chain, thus so as to calculate net migration, it is necessary to take into account features of each one. This is represented by the three equations below to determine net immigration in any year. These equations are used to obtain Table 5.

(1) Net immigration 0 to 4 $_t$ = Children 0 to 4_{t+1} – Children 0 to 4_t – Births $_t$ +Deaths children 0 to 4 $_t$ + Aging to 5 $_t$

(2) [4]Net immigration Cohort N $_t$ = Cohort N $_{t+1}$ – Children Cohort N $_t$ + Deaths Cohort N $_t$ - Aging to Cohort N $_t$ + Aging to cohort N + 1 $_t$

(3) Net immigration 65 or more $_t$ = Adults 65 or more $_{t+1}$ – Adults 65 or more $_t$ + Deaths adults 65 or more $_t$ - Aging to 65 $_t$

Cohorts/Period	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12
0-4	366	347	485	552	494	184	-165	269
5-9	683	688	531	605	631	435	691	766
10-14	723	519	436	639	454	501	405	442
15-19	113	189	260	203	215	-97	-15	117
20-24	-3	36	-312	-331	-160	-488	-889	-252
25-29	96	339	294	543	398	97	-136	180
30-34	935	495	433	398	372	184	1	500
35-39	557	761	1251	1688	1368	946	180	360
40-44	901	600	358	312	331	481	843	1229
45-49	498	579	790	906	934	460	229	-49
50-54	174	349	141	296	285	264	305	713
55-59	756	599	143	352	270	147	326	101
60-64	353	329	846	902	674	662	976	108
65 or more	322	57	208	11	323	504	847	769

Table 5 Sunshine Coast net migration

Finally, variables of the labour market are quantified. These variables are: participation rate, unemployment rate and productivity. In regard to participation rate in the Sunshine Coast, Queensland's data is used as a proxy given that Sunshine Coast's data exhibit some inconsistencies[5]. Table 6 presents average participation rate from 2001 to 2012 in Queensland, which is disaggregated into cohorts according to model's ageing chain.

[4] This equation is used to calculate net migration in cohorts from 5 to 64 years old.
[5] For some cohorts, there are more people in the labour market than resident population.

COHORTS	PARTICIPATION RATE
15-19	0.65
20-24	0.82
25-29	0.81
30-34	0.81
35-39	0.82
40-44	0.84
45-49	0.84
50-54	0.80
55-59	0.67
60-64	0.47
65 or more	0.09

Table 6 Queensland average participation rate from 2001 to 2012

[Source: www.abs.gov.au]

The remaining variables are quantified in the following way: employment rate is set at 94 %; fraction employed in local industries is set at 99 % in 2004 and it is assumed a decrease until 90 % in roughly 15 years. At last, productivity is set at $ 78.000[6] per worker, and it augments by 0.03% per annum and other contributions to GRP is set at 15%.

In summary, the result of quantification is a prototype model able to be simulated.

Simulation

At this stage, since the demographics sector in the prototype model is developed thoroughly and plausible assumptions of labour market can be presumed, it is possible to validate to some extent the prototype model so as to run simulations that cast light on the reasons of the deterioration in the performance of the Sunshine Coast's economy and the well-being of its residents. Once these reasons have been discovered, scenarios ("what ifs") are defined and simulated in order to unravel leverage points that may improve the Sunshine Coast's economy.

Yaman Barlas (Barlas, 1996) states: "*the ultimate objective of system dynamics model validation is to establish the validity of the structure of the model*". Validity relates to "usefulness with respect to some purpose", in this case, the purpose is to provide a framework for analysing and evaluating Sunshine Coast's economy and its improvement

[6] 2010/11 prices

proposals. Validation is important inasmuch as model's output ought to be reliable for guiding decision making.

In regard to the prototype model developed thus far, validation commenced with a rigorous description of each model's variable along with their quantification in order to assure "operational thinking". By doing so, model's structure has gained sufficient confidence for evaluating its output behaviour. This evaluation is performed by assessing the accuracy of model's output in reproducing real behaviour, namely it is checked whether the model produces the "right output behaviour for the right reasons". Such evaluation is accomplished by confronting model's output, obtained through simulation, with time series published by statistical agencies such as ABS or .ID[7]. Total population, labour force and GRP are deemed representative variables of the structure for performing the confrontation in the period between 2004 and 2012.

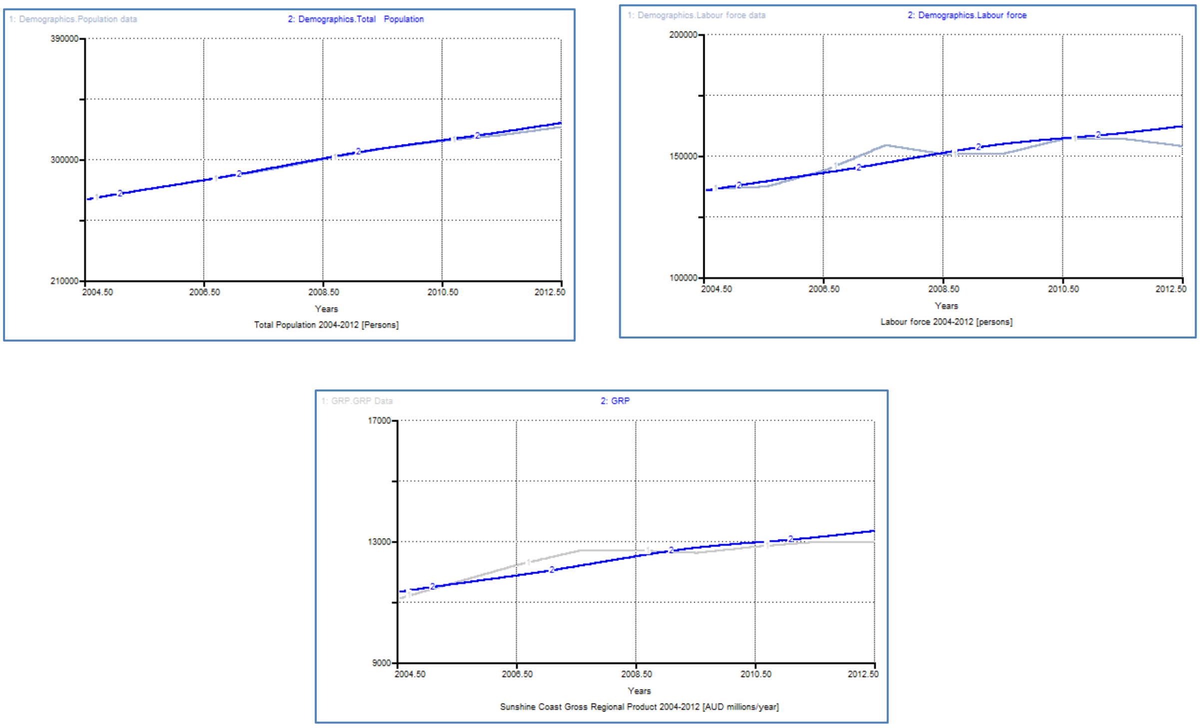


Figure 17 Comparison between model's output and external data

Source: [Author; http://www.abs.gov.au; http://economy.id.com.au/sunshine-coast]

The result of the simulation (Figure 17) indicates that the prototype model is an accurate representation of the phenomenon studied by reproducing to a certain extent trends in total

[7] .id is a company of population experts – demographers, spatial analysts, urban planners, forecasters, census data and IT experts who build demographic information products for Australia & New Zealand.

population, labour force and GRP. Consequently, this prototype is considered a useful tool to identify the causes of the deterioration in the performance of Sunshine Coast's economy and to evaluate scenarios.

With regard to the performance of the Sunshine Coast's economy, previously it has been stated that it is gauged by GRP. Therefore, it is necessary to examine the most proximate elements that determine it. They are productivity and employed labour force. Inasmuch as it is productivity has been increasing over the last years, it is deduced logically the accountability of shaping the dynamics of the Sunshine Coast's GRP lies in the labour force, a subset of population. This deduction is corroborated with the results of a simulation presented in Figure 18, in which it is noted the correlation between GRP, population and labour in the period from 2004 to 2012.

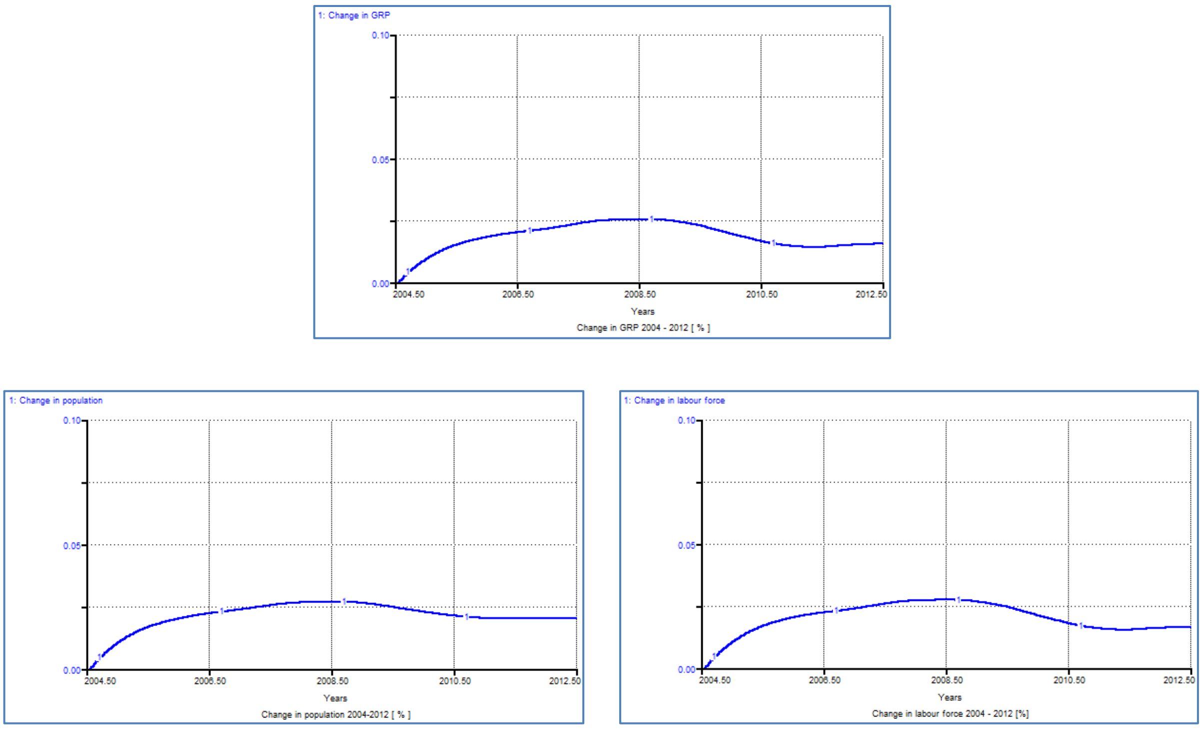


Figure 18 Annual percentage changes in GRP, population and labour force 2004-2012

Moreover, labour force is not only affected by the total changes in population but also by the age distribution of its population. This means that the number of people in each population cohort is crucial to determine the amount of people available for work. For instance, a region or city with a relative young population has more people in the labour market than region with an ageing population, which is the case in the Sunshine Coast. In Figure 19, it is noted the cohort of potential workers in the future (children from o to 14 years old) and the cohort (adults from 15 to 64 years old) that contains the largest portion of workers in an economy have declined over the last years; whereas the cohort that comprises mostly retirees (adults over 65 years old or elderly) has increased in the same period. The effect of this situation is perceived in the participation rate which exhibits a steady decline, which produces a negative impact on the labour force.

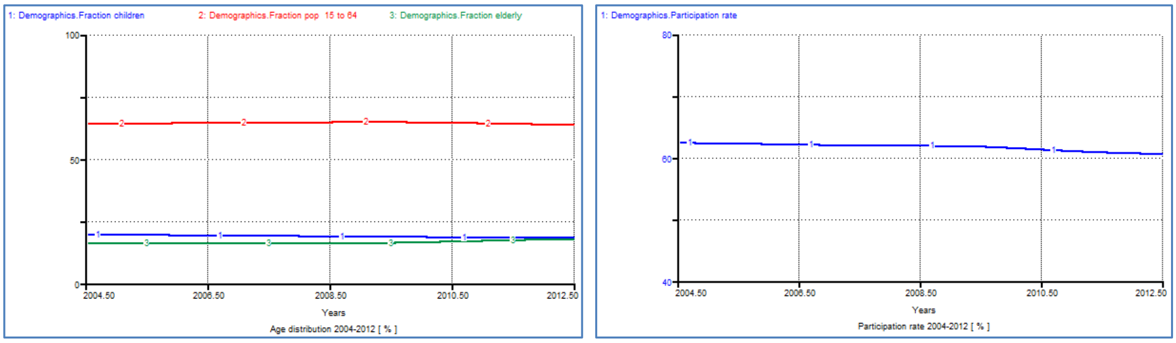


Figure 19 Age distribution and participation rate in the Sunshine Coast 2004-2012

Fundamentally, the reasons of the slowdown in the growth in population and labour force, and the ageing of the population are found in the flows that determine the level of the stocks in the demographic subsystem, namely in births, deaths and net immigration. This hypothesis is tested by simulating such variables in the form of crude rates.

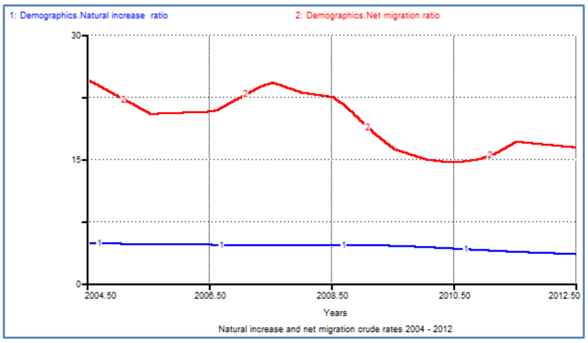


Figure 20 Natural increase and net migration in the Sunshine Coast 2004-2012

The result presented in Figure 20 indicates that both natural increase (births minus deaths) and net migration as proportion of total population has been decreasing over the recent years, which corroborates the hypothesis posited as the causes of the detriment in the performance of the Sunshine Coast's economy.

Based on the findings presented above, it is deemed scenario testing as a proper approach so as to identify leverage points that may enhance the performance of the Sunshine Coast's economy. In System Dynamics, scenario testing is usually performed by changing values to parameters or exogenous variables that affect the system and unfold its dynamics. With respect to the Sunshine Coast's demographics, the process that has the largest contribution to the changes in population is net immigration. For this reason, around this variable three scenarios are defined in the following way:

1. Base case: the model recreates historical data from 2004 to 2011; thereafter it stays <u>constant</u> (0% growth) until 2031, ceteris paribus.
2. High scenario: the model recreates historical data from 2004 to 2011; thereafter it <u>growths</u> at 3.2 % p.a. until 2031, ceteris paribus.
3. Low scenario: the model recreates historical data from 2004 to 2011; thereafter it <u>decreases</u> at 3.2% p.a. until 2031, ceteris paribus.

Subsequently, the three scenarios are simulated (Figure 21) with the purpose of evaluating the effect of the changes in net immigration on population in the coming decades.

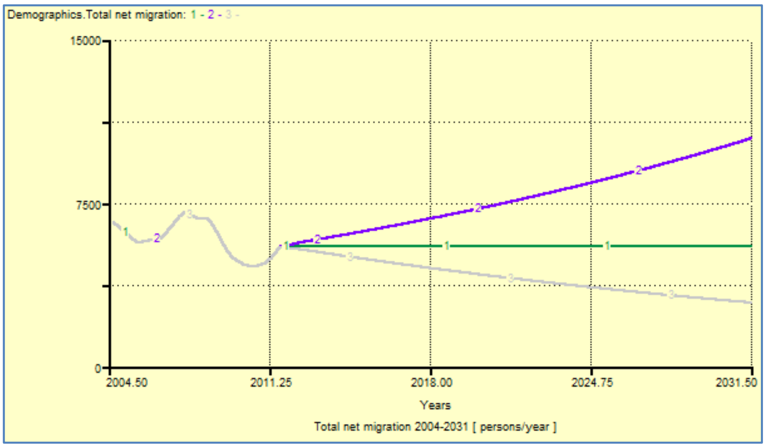


Figure 21 Net migration scenarios

In the simulation presented in Figure 22, it is noted the implications of each scenario. For instance, an augment in 3.2 % p.a. (high scenario) in net migration implies that by 2031 net migration contributes a net gain of 10,500 people to the Sunshine Coast; whereas a decrease in 3.2 % p.a. (low scenario) in net migration implies that by 2031 net migration only contributes a net gain of 5,500 people to the Sunshine Coast.

Furthermore, as it is expected, it is noted higher rates of net migration lead to higher levels of population (Figure 22). However, the simulation does not only offer qualitative insights but also quantitative ones given that it is possible to evaluate the level of population from 2004 to 2031 in the three scenarios. By 2031, the model projects for the Sunshine Coast: 416,000 persons in the low scenario; 446,000 persons in the medium scenario; and 493,000 persons in the high scenario. It is noteworthy to stress these figures are not a prediction, but rather they allow understanding the implications of the assumptions presumed in the simulation.

In addition, these quantitative results can be confronted with official projections, and thereby analyse its foundations. In Figure 23, projections of the Sunshine Coast's population estimated by The Queensland government Office of Economic and Statistical Research (OESR) are presented in three scenarios (low, medium and high). By 2031, these projections estimate Sunshine Coast's population in: 451,000 persons in the low scenario; 486,000 persons in the medium scenario; and 521,000 persons in the high scenario. These results contrast with the ones drawn from simulation of the prototype model inasmuch as OESR's projections exceed to a large extent the prototype's figures. If it is deemed health conditions in the Sunshine Coast linger somewhat similar to what it is nowadays, the differences lies in the migration patterns assumed, which implies in their scenarios, OESR's projections assume higher migration rates than the ones presumed in the prototype model. In both cases, it is the duty of policymakers and stakeholders to assess the feasibility of such assumptions.

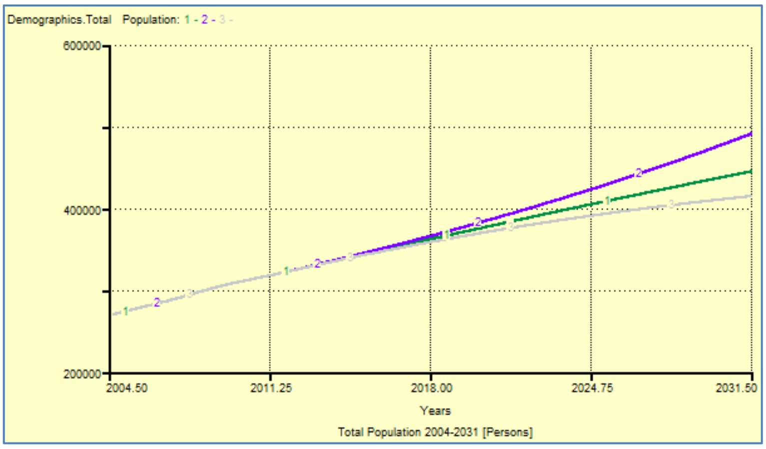


Figure 22 Effect of net migration on population

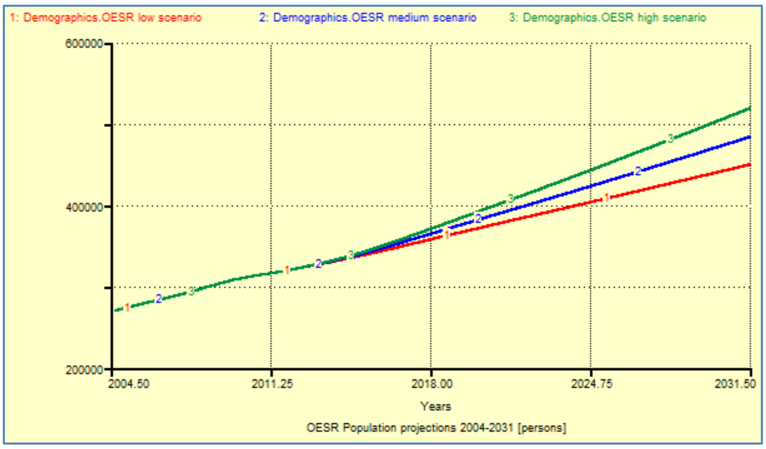
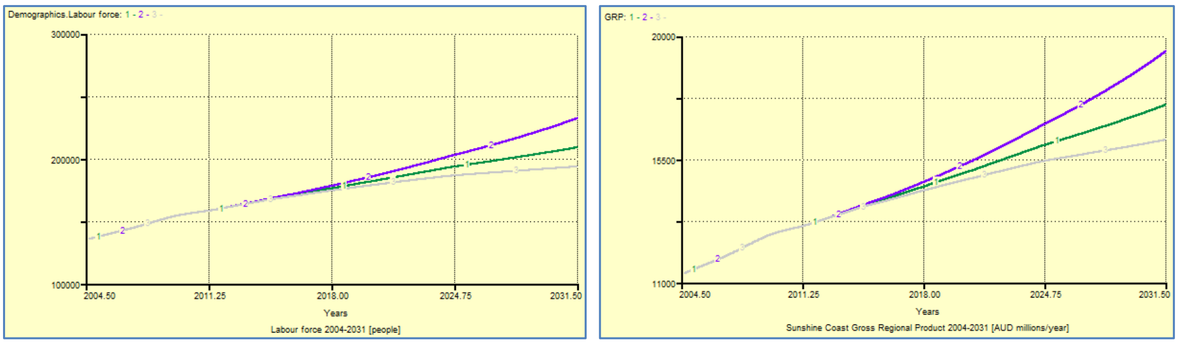


Figure 23 OESR Sunshine Coast population projections

Likewise, it is also tested the effect of net migration on labour force, GRP and GRP per capita in the three scenarios defined above. The results are presented in Figure 24 indicate: on one hand higher rates of net migration lead to higher levels of people available for work and improves the performance of the economy, given that net immigration increases population and in turn labour force, which gives as a result more people employed and more production. Nevertheless, it is important to remark that in reality higher levels of labour lead to more production only when there are available jobs, an issue that has not been discussed thus far.

Conversely, higher rates of net migration do not imply necessarily larger levels of well-being, gauged through the variable “GRP per capita”. Based on the prototype model, notwithstanding population increases production, this one is distributed into a larger portion of people, so that the net gain in GRP per capita is small. Accordingly, it is advisable to identify another alternative or leverage point that permits improving well-being.



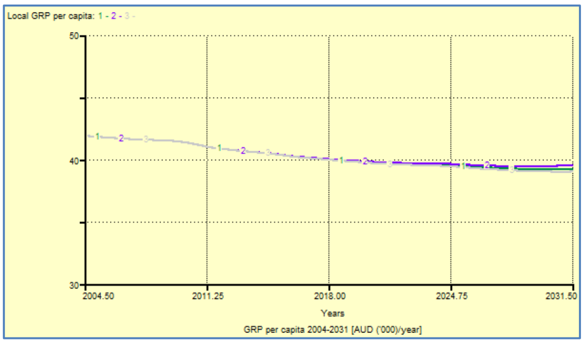


Figure 24 Effect of net migration on labour force, GRP and GRP per capita

At the onset of chapter 4, it is stressed GRP per capita is a variable that depends on population and GRP, which in turn, depends on population (via labour force) and productivity. Previously, it is shown higher levels of population are ineffective for improving GRP per capita; thus the focus switches to productivity. This is accomplished by defining three scenarios around the mentioned variable describe below (Figure 25) and test its effect on GRP per capita through simulation.

1. Base case: the model recreates historical data from 2004 to 2012; thereafter productivity growths at 0.3 % p.a. until 2031, ceteris paribus.
2. High scenario: the model recreates historical data from 2004 to 2012; thereafter productivity growths at 0.5 % p.a. until 2031, ceteris paribus.
3. Low scenario: the model recreates historical data from 2004 to 2011; thereafter productivity growths at 0.1% p.a. until 2031, ceteris paribus.

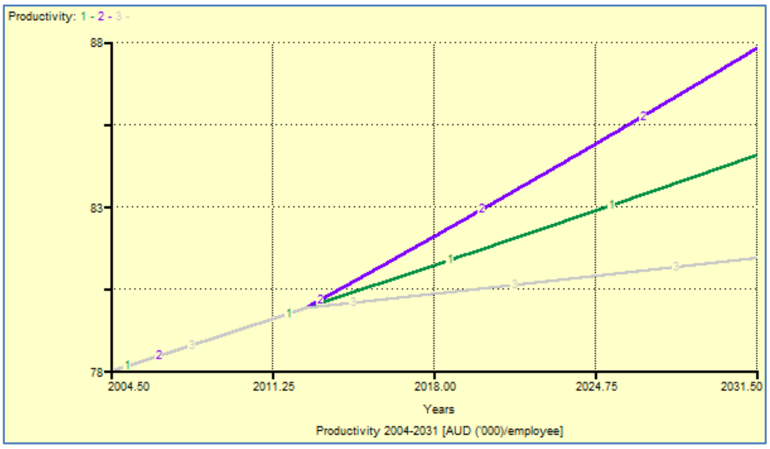


Figure 25 Productivity scenarios

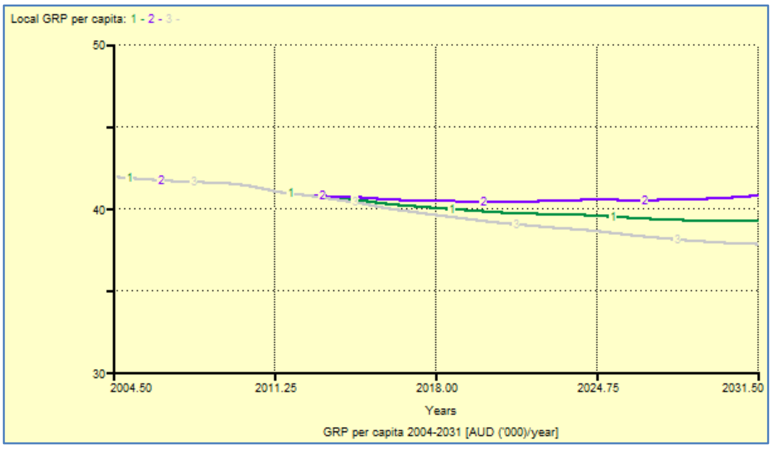


Figure 26 Effect of productivity on GRP per capita

The result of the simulation (Figure 26) indicates that an increase in productivity will likely increase GRP per capita. However, at the moment defining scenarios it is assumed certain values for productivity growth, but it is not stated how they are achieved. By contrast, in the real world the change of such a parameter value is not a straightforward process.

In summary, at this stage the prototype model is limited to provide answers that account for employment levels and productivity, which requires refinement in order to cater more useful insights.

5.2 Second prototype: Industries

In the Sunshine Coast, the quantity of employees that the economy requires is determined by the demand of value added. Value adding is the process of transforming inputs[8] into finished goods and services for local consumption or exports. The efficiency of transforming those inputs relies on the tools and the "know how" workers possess, represented by the so called variable "productivity". As a result, the relationship between employment and productivity is the total value added of the economy (Figure 27) or GRP.

[8] Input costs are intermediate goods and services required for producing new ones.

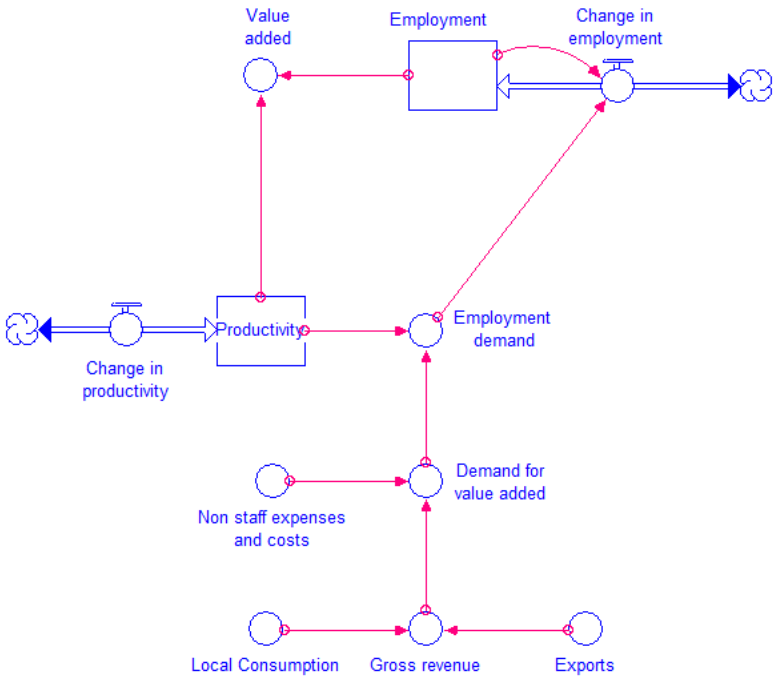


Figure 27 Value added structure

However, given that the Sunshine Coast's economy consists of more than one industry, GRP is the sum of the value added of each industry. This implies that the level of productivity, employment and demand varies from industry to industry, elements that shape the economy as a whole. Consequently, it is necessary to consider a level of disaggregation that allows the analysis of the dynamics of industries and improvement proposals such as "The Sunshine Coast Economic Development Strategy".

The Australian and New Zealand standard industry classification (ANZSIC) is an appropriate framework for the disaggregation level required in the model, on account of the detail and flexibility that provides. It is a hierarchical classification with four levels, namely Divisions (the broadest level), Subdivisions, Groups and Classes (the finest level). At the Divisional level, the main purpose is to provide a limited number of categories which provide a broad overall picture of the economy and are suitable for the publication of summary tables in official statistics. The Subdivision, Group and Class levels provide increasingly detailed dissections of these categories for the compilation of more specific and detailed statistics (Trewin & Pink, 2006).

In the development of this prototype, it is adopted a top-down approach. First, GRP is disaggregated into Divisions and, then if it deemed useful, it is broken down into subdivisions, groups and classes. ANZSIC Divisions are listed below in Table 7. In addition, in System Dynamics language each level is depicted as a module that contributes to GRP which is represented as module as well (Figure 28).

Division	***Title***
A	Agriculture, Forestry and Fishing
B	Mining
C	Manufacturing
D	Electricity, Gas, Water and Waste Services
E	Construction
F	Wholesale Trade
G	Retail Trade
H	Accommodation and Food Services
I	Transport, Postal and Warehousing
J	Information Media and Telecommunications
K	Financial and Insurance Services
L	Rental, Hiring and Real Estate Services
M	Professional, Scientific and Technical Services
N	Administrative and Support Services
O	Public Administration and Safety
P	Education and Training
Q	Health Care and Social Assistance
R	Arts and Recreation Services
S	Other Services

Table 7 ANZSIC classification at division level

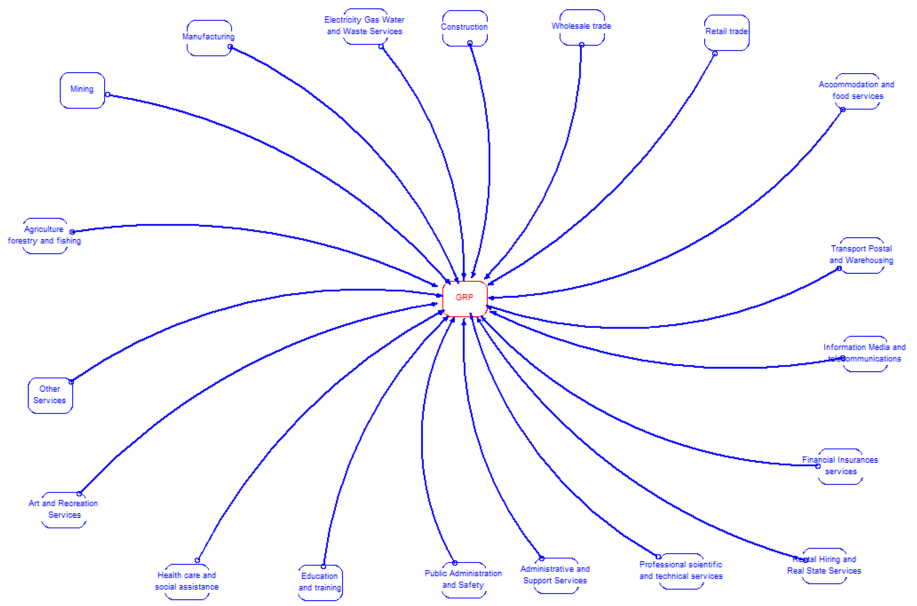


Figure 28 Industry structure

In addition, the disaggregation level must be consistent with “The Sunshine Coast Economic Development Strategy” inasmuch as it proposes seven key industries and five game-changer projects as pillars of the Sunshine Coast's economy in the coming decades. Hence, various industry modules at the division level are broken down into subdivision levels so as to identify the boundaries of the seven key industries, and thereby estimate their performance over time. In spite of the effort for providing a framework to evaluate the seven key industries, not all of them can be related to ANZSIC industries due to their vague definition; in the future, it is duty of stakeholders to provide a more accurate one.

Subsequently, each division is described thoroughly by presenting its structure in each module and if applies, its disaggregation into subdivisions. Afterwards, divisions and subdivisions are clustered in accordance with the seven key industries.

A. Agriculture, Forestry and Fishing

According to ANZSIC classification, this division comprises the following subdivisions:

01 Agriculture

02 Aquaculture

03 Forestry and Logging

04 Fishing, Hunting and Trapping

05 Agriculture, Forestry and Fishing Support Services

Since agribusiness is a key industry for the Sunshine Coast, it is deemed subdivision "01 Agriculture" as part of such industry, so that division A is broken down into two modules: one related to subdivision 01; and the other one clusters subdivisions 02 to 05 called "Other agriculture, forestry and fishing". The outputs of each module are value added and employment (Figure 29).

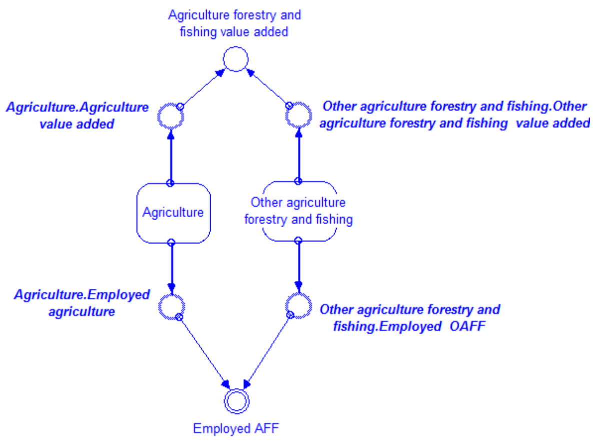


Figure 29. Agriculture, forestry and fishing

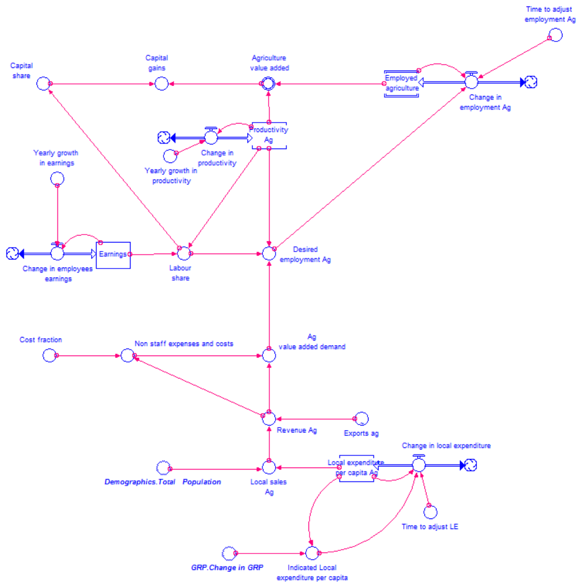


Figure 30 Agriculture subdivision

The structure presented at the onset of this chapter (see Figure 27) it is the rationale for deriving the structure within each module. Figure 30 is the structure that accounts for the agriculture subdivision. On one hand, it is noted that “earnings” is incorporated into the prototype model, which represents employees’ retribution for selling their work to industries. By comparing earnings with productivity, it is possible to estimate profits obtained by capital owners. On the other hand, local consumption or sales is expanded to include the effect of population and the income effect. Changes in population imply the more people in the region the more people who purchase goods and services and vice versa. In regard to the income effect, the change in an individual's income impacts the quantity demanded of a good or service. The relationship between income and the quantity demanded is a positive one, as income increases, so does the quantity of goods and services demanded per person.

Likewise, structure for “Other agriculture, forestry and fishing” is developed. The result is a common structure within the two modules, wherein the difference lies in their numerical values. This structure is classified as “Type I”.

B. Mining

This module is not disaggregated. The structure within the module is Type I.

C. Manufacturing

According to ANZSIC classification, this division comprises the following subdivisions:

11 Food Product Manufacturing
12 Beverage and Tobacco Product Manufacturing
13 Textile, Leather, Clothing and Footwear Manufacturing
14 Wood Product Manufacturing
15 Pulp, Paper and Converted Paper Product Manufacturing
16 Printing (including the Reproduction of Recorded Media)
17 Petroleum and Coal Product Manufacturing
18 Basic Chemical and Chemical Product Manufacturing
19 Polymer Product and Rubber Product Manufacturing
20 Non-Metallic Mineral Product Manufacturing
21 Primary Metal and Metal Product Manufacturing
22 Fabricated Metal Product Manufacturing
23 Transport Equipment Manufacturing
24 Machinery and Equipment Manufacturing
25 Furniture and Other Manufacturing

With the aim of assembling the modules within this division, it is assumed key industry "agribusiness" includes, too, the transformation of agricultural products into processed ones. Subdivision 11 is related to that stage in the supply chain. Therefore, division C is broken down into two modules: the first one is related to subdivision 11; whereas the second one clusters subdivisions 12 to 25 (Figure 31). The structure in each module is "Type I".

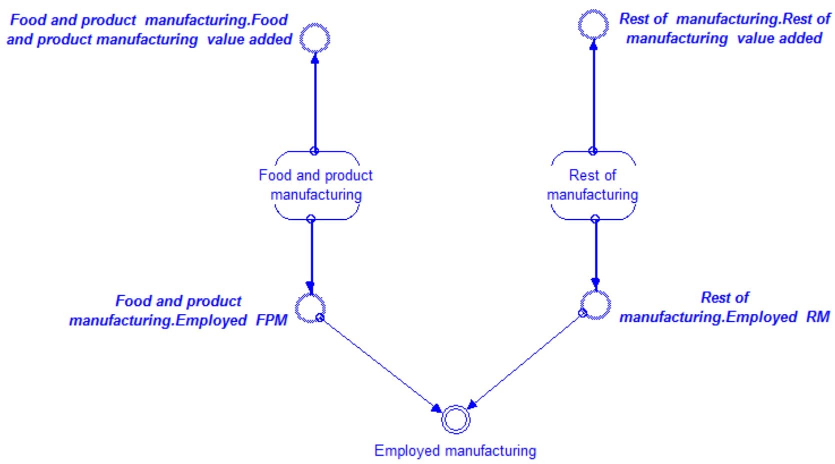


Figure 31 Manufacturing division

D. Electricity, Gas, Water and Waste Services

This module is not disaggregated. The structure within the module is Type I.

E. Construction

Due to game-changer projects are developed by the construction industry represented by this division, it is necessary to recognise the nature of their impact throughout the industry. According to ANZSIC classification, this division comprises the following subdivisions:

30 Building Construction
31 Heavy and Civil Engineering Construction
32 Construction Services

Accordingly, division E is broken down into three modules, as many as subdivisions there exist (Figure 32). Then, it is presented the structure of each subdivision by using as an example Building Construction Subdivision (Figure 33). This new structure differs from “type I” given that it does not take into account the income effect because the lack of statistical support to include such a relationship. This structure is classified as “Type II”.

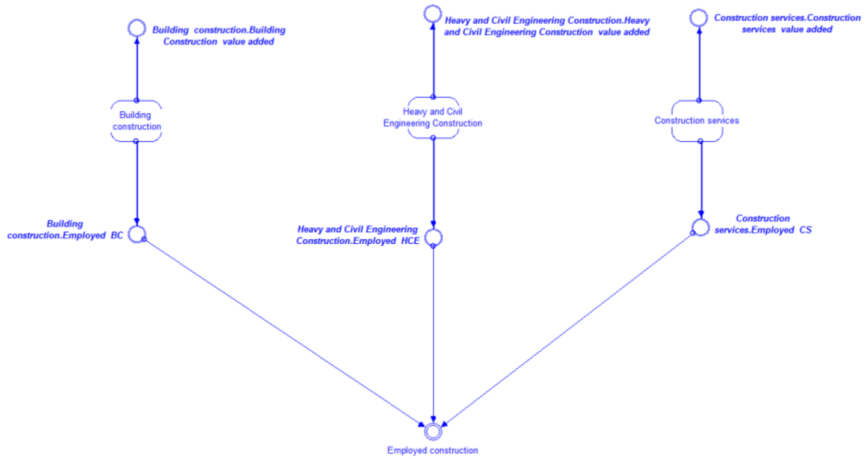


Figure 32 Construction division

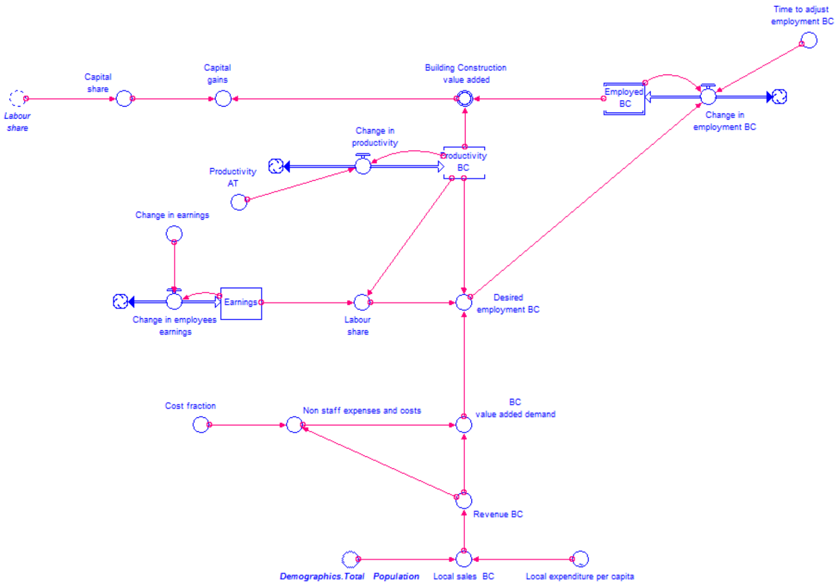


Figure 33 Building construction subdivision

F. Wholesale Trade

This module is not disaggregated. The structure within the module is Type I.

G. Retail Trade

This division and the next one (accommodation and food services) are related to one of the key industries: tourism. However, tourism is not an industry itself but rather an activity that has an effect on industries. The United Nations World Tourism Organization (UNWTO) defines tourism as: "*a social, cultural and economic phenomenon which entails the movement* *of people to countries or places outside their usual environment for personal or business/professional purposes. These people are called visitors (which may be either tourists or excursionists; residents or non-residents) and tourism has to do with their activities, some of which imply tourism expenditure".* The last part of this definition provides the key for unravelling the implication of tourism in the economy. In this prototype model, tourism is considered as the economic activity of non-residents, in which they expend money on Sunshine Coast's goods and services regarded as exports. Moreover, this approach has been explored before in a research (Pham et al, 2010) conducted by the Sustainable Tourism Cooperative Research Centre about tourism in Queensland, wherein it has been pointed out visitors expenditure goes mainly to retail trade and food and accommodation services (Figure 34).

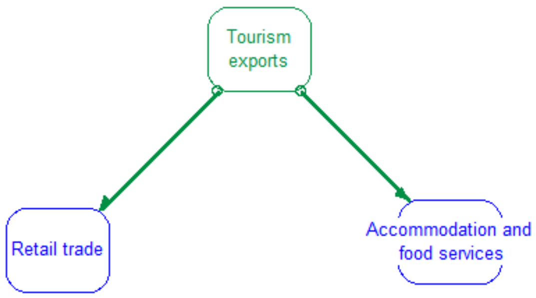


Figure 34 Tourism exports

Such expenditure depends on the annual tourism to the Sunshine Coast, which is usually gauged by the quantity of total nights people stay per annum. That stay is decomposed in the three kinds of visitors there exist: day trip visitors, overnight domestic visitors and international visitors (Figure 35).

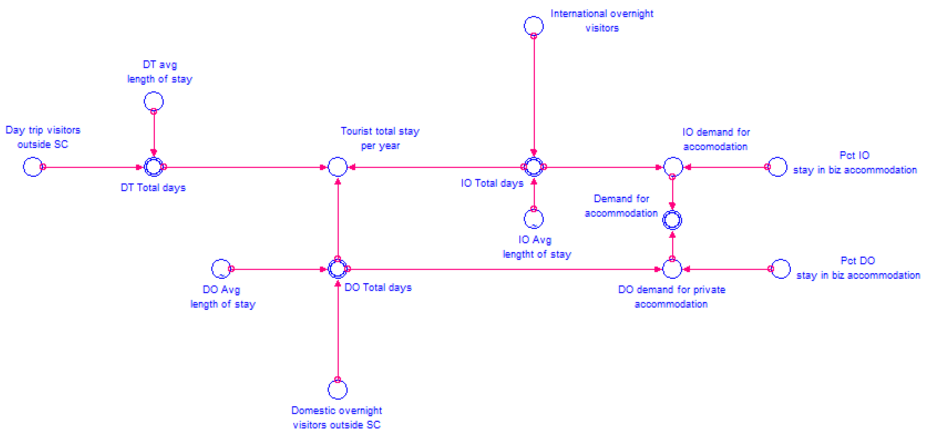


Figure 35 Tourism

Therefore, retail trade division is tailored to include the effects of tourism exports. In Figure 36 it is noted that exports have been expanded to include the expenditure of each kind of tourist or visitor. This type of structure is clasiffied as “Type III”.

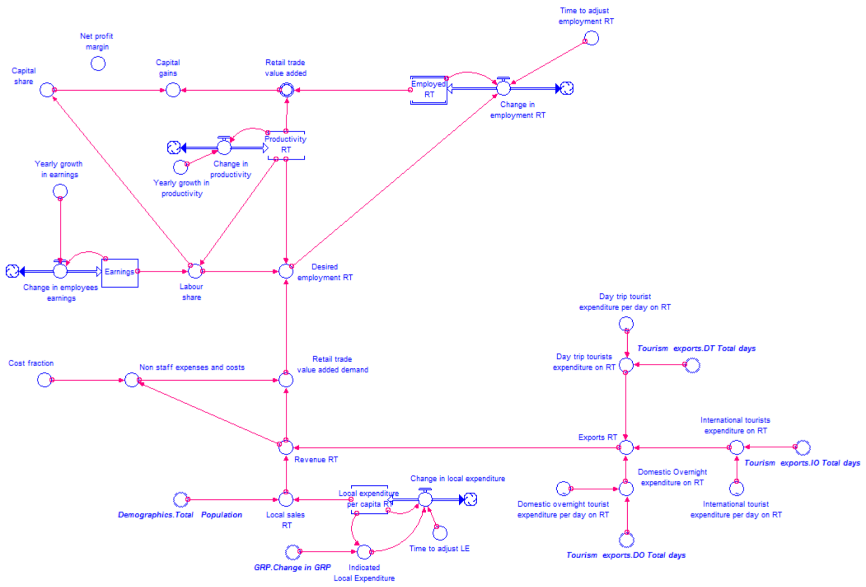


Figure 36 Retail trade subdivision

H. Accommodation and Food Services

In spite of it is stated that visitors expend their money on accommodation or food services, it does not necessarily imply all visitors purchase services from both industries. On the contrary, their expenditure is based on the kind of visitor they are. Regarding this industry division, if the visitor is a day tripper, he or she expends his or her money on food services but not on accommodation services; whereas if he or she is an overnight visitor, whether domestic or international, he or she expends his or her money on both industries. For this reason, this division is broken down into two modules according to its ANZSIC subdivisions (Figure 37):

44 Accommodation

45 Food and Beverage Services

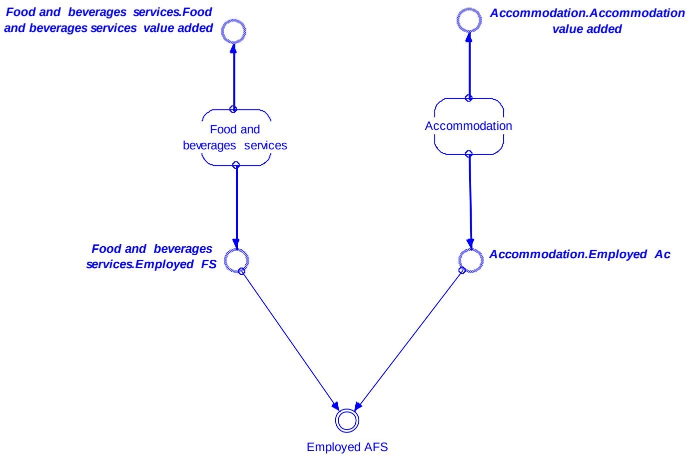


Figure 37 Accommodation and food services division

After defining the disaggregation level for this division, the structure in each module is explained. On one hand, the structure of the accommodation subdivision is tailored to encompass exports generated by overnight visitors. This structure is classified as “Type IV”. On the other hand, the structure in food and services subdivision is “Type III”.

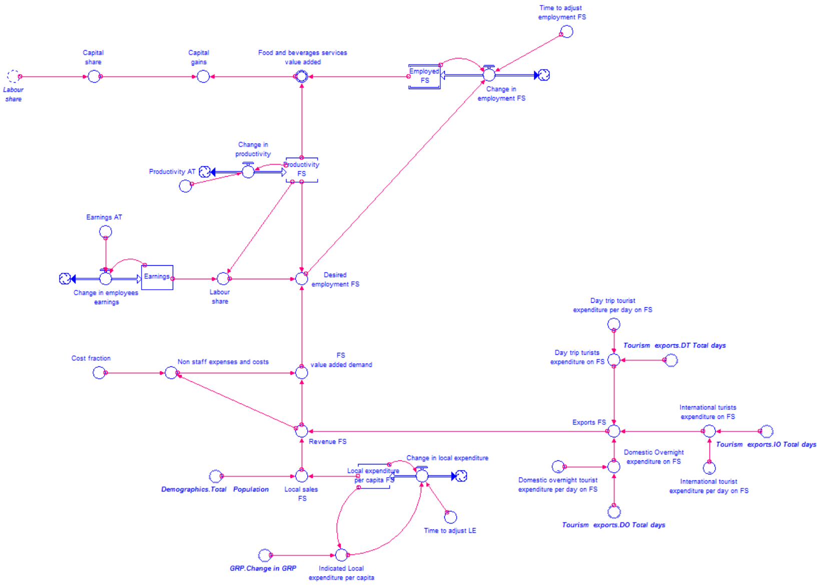


Figure 38 Food Services subdivision

I. Transport, Postal and Warehousing

This module is not disaggregated. The structure within the module is Type I.

J. Information Media and Telecommunications

This module is not disaggregated. The structure within the module is Type I.

K. Financial and Insurance Services

This module is not disaggregated. The structure within the module is Type I.

L. Rental, Hiring and Real Estate Services

This module is not disaggregated. The structure within the module is Type I.

M. Professional, Scientific and Technical Services

This module is not disaggregated. The structure within the module is Type I.

N. Administrative and Support Services

This module is not disaggregated. The structure within the module is Type I.

O. Public Administration and Safety

This module is not disaggregated. The structure within the module is Type I.

P. Education and Training

According to the ANZSIC classification, this division comprises the following subdivisions:

80 Preschool and School Education
81 Tertiary Education
82 Adult, Community and Other Education

Since education and research is a key industry in “The Sunshine Coast Economic Development Strategy”, it is indispensable to disaggregate this division at the subdivision level with the purpose of relating the key industry with ANZSIC levels. Consequently, this division is broken down into three modules, one for each subdivision (Figure 39). The structure for subdivision "Preschool and School Education" is tailored to its own peculiarity (Figure 40). Unlike other structures, wherein local sales are determined by the total population; in this subdivision local sales are determined by a specific segment of the population: children and adolescents. This new structure is classified as "Type V". On the other hand, the structure present in the other two modules is Type I.

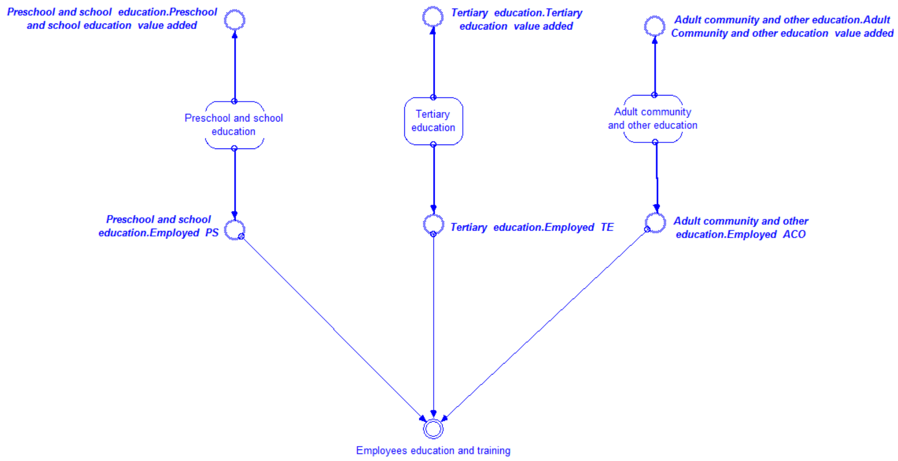


Figure 39 Education and training division

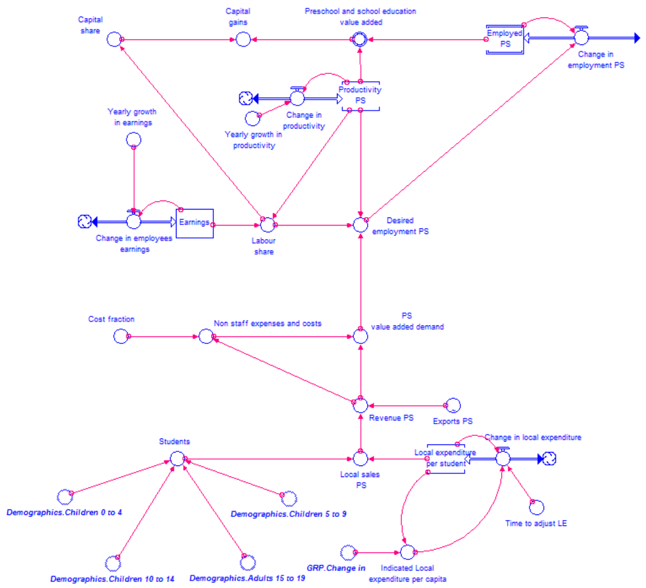


Figure 40 Preschool and school education division

Q. Health Care and Social Assistance

This module is not disaggregated. The structure within the module is Type I.

R. Arts and Recreation Services

This module is not disaggregated. The structure within the module is Type I.

S. Other Services

This module is not disaggregated. The structure within the module is Type I.

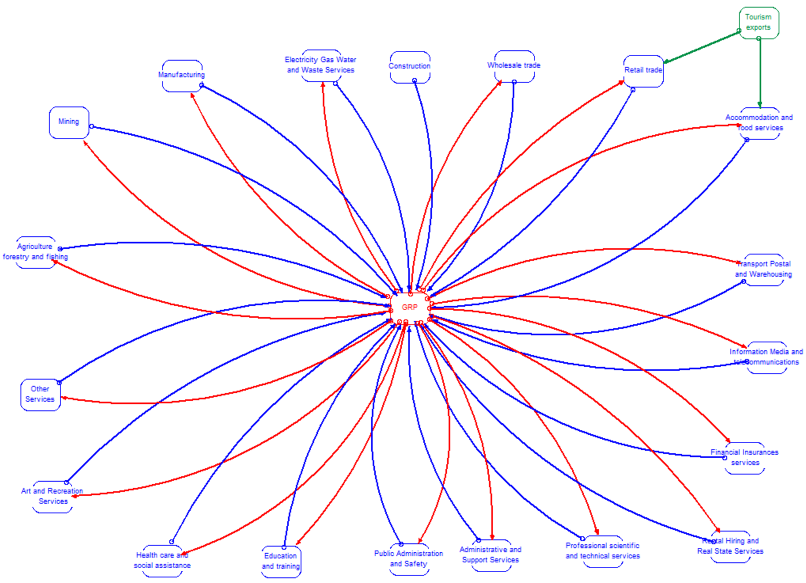


Figure 41 Regional economy

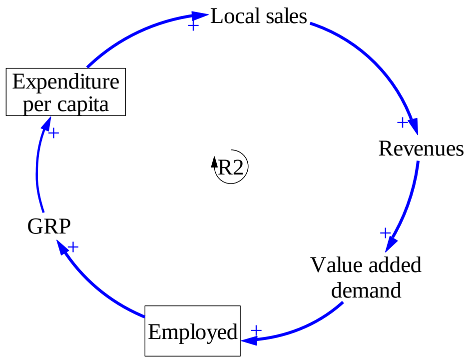


Figure 42 Income effect

As a result, the basic structure presented in Figure 28 is completed with the incorporation of the relationships that appeared during the description of each industry. It can be appreciated in Figure 41, the feedback effect between the GRP module and industries mentioned before as the income effect. The nature of this feedback (Figure 42) is a reinforcing one, an increase in employment entails an augment in the production of goods and services (GRP) and in turn in resident's income. A portion of this money is expended in local products, thus more employment is created in the region. Consequently, a potential leverage point has been recognised for testing policies that could benefit the economy. To conclude with the modelling process, all the industry sectors and GRP are amalgamated into one module called "economy", which is linked to the module "demographics" built in the first prototype, and thereby giving rise to the second prototype (Figure 43).

Figure 43 Prototype 2

At last, in order to allow assessment of the impact of "The Sunshine Coast Economic Development Strategy" on the economy, it is proposed a preliminary way of relating five out the seven key industries posited as economy's pillars in the future with the ANZSIC. The vague definition of the other two industries does not permit such linking.

Key Industry	Division	Subdivision
Health and well-being	Q. Health care and social assistance	Do not apply
Education and research	P. Education and training	81 Tertiary education
Tourism, sport and leisure	G. Retail trade H. Accommodation and food services R. Art and recreation services	44 Accommodation 45 Food and Beverage Services
Knowledge industries and professional services	M. Professional, Scientific and Technical Services	Do not apply
Agribusiness	A. Agriculture, Forestry and Fishing C. Manufacturing	01 Agriculture 11 Food Product Manufacturing
Clean technologies	To be defined	To be defined
Aviation and aerospace	To be defined	To be defined

Table 8 Key industries related to ANZSIC

Quantification

In the same way that simulation is deemed pertinent in the first prototype, simulation for the second one is argued fundamental for testing the effect of policies on in each industry and the economy as a whole. For this reason, each variable in the second prototype is quantified. Due to homogeneity in the structure of industries within the prototype model, the demonstration of one division or subdivision is sufficient for explaining the fashion variables are populated with quantitative data. The division considered for the explanation is "Retail trade" given that it shares the basic structure of the other divisions and subdivisions, and furthermore it is an industry affected by tourism exports. Since it has been established simulation runs from 2004, stocks' initial values and constants are assigned based on such year. In Table 9 is presented retail trade's data, which is obtained mainly from Economy ID[9], and the remaining from ABS and Tourism Research Australia.

Variable	Value	Source
Employed	19,059 persons	Economy ID
Productivity	46000 AUD per employee	Economy ID
Growth in productivity	0.025 per annum	Economy ID
Earnings	45000 AUD per employee	ABS
Cost fraction	0.4	Economy ID
Local expenditure per capita	4000 AUD per person per annum	Economy ID and ABS
Expenditure per tourist	26 AUD per person on average[10]	Economy ID and Tourism Research Australia

Table 9 Retail trade 2004

Scenario testing

At the onset of this document it has been stated the ultimate goal of this project is to provide a framework for analysing and evaluating Sunshine Coast's economy and its improvement proposals. This goal is one step shy of being achieved, which is the inclusion of policies such as the five game-changer projects proposed in "The Sunshine Coast Economic Development Strategy" for testing its likely effect on the economy via simulation. Despite the recommendation of designing and testing new stock-and-flow structures policies structures

[9] This data may differ with the original source inasmuch as at the moment of quantifying the model Economy ID did not have specific data for the Sunshine Coast Region that includes Noosa, whereby estimates had to be calculated.
[10] In the model this data is assigned by the means of a time series.

(Wheat, 2010), in this project policy analysis is performed by testing parameter changes due to constraints in time for creating detailed structures for each game-changer project. Nevertheless, parameter testing allows understanding to some extent the order of magnitude of the game-changers' likely impact on the Sunshine Coast's economy.

Based on the discussions held in the Sunshine Coast with stakeholders during development of this project, there seems to be a certain consensus on the possible effects of Bruce Highway upgrade and the Sunshine Coast's Airport expansion on the Sunshine Coast's tourims. Hence, these two game-changer projects are deemed adequate for scenario testing. Therefore, it is needed to identify the parameters that these game-changers will change once they are built.

On the Bruce Highway side, several people expect this upgrade will increase the stay of domestic overnight visitors, since nowadays the Bruce Highway at peak hours is so crowded that tourists leave the Sunshine Coast before noon so as to avoid traffic jam, which results in loses for the industries involved in tourism such as retail trade and food services. Consequently, this issue can be evaluated by the means of the parameter contained in the tourism exports sector called "Domestic Overnight average length of stay".

On the Sunshine Coast's Airport side, several people expect this upgrade will increase the quantity of international visitors, since it is believed the airport increases the attractiveness of the region. Consequently, this issue can be evaluated by the means of the parameter contained in the tourism exports sector called "International Overnight visitors".

The effects of the changes in those parameters are analysed in the context of two industries and the economy as whole. On one hand, the two industries considered for the analysis are Retail Trade and Accommodation and Food Services due to they are the sectors affected by tourism exports. The performance of these industries is gauged by the variables "Retail trade value added" and "Accommodation and Food Services value added". On the other hand, the analysis of the economy as a whole comprises its performance (GRP), efficiency (productivity) and residents' well-being (GRP per capita).

Foremost, the variables chosen for the impact analysis are simulated in the period from 2004 to 2012 and compared with their historical data in order to gain confidence in the results produced by prototype model. In Figure 44 three curves of the Sunshine Coast's GRP, productivity and GRP per capita are presented: (1) its historical data from 2004 to 2012; (2) the behaviour produced by the structure of the first prototype; (3) and the behaviour produced by the structure of the second prototype. By looking at the graphs, it is noted that the second prototype generates a more accurate result than the first one. As it is expected, more disaggregated structures not only facilitate the analysis of systems but also mimic the system with more accuracy.

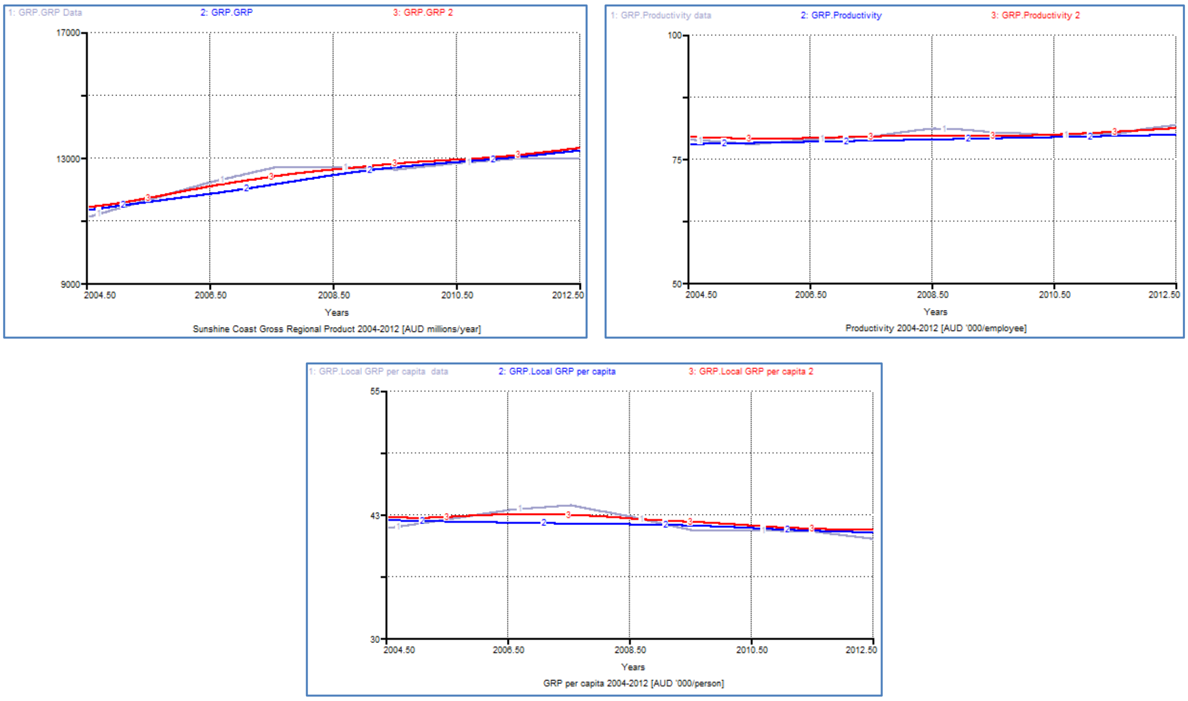


Figure 44 Sunshine Coast GRP, productivity and GRP per capita from 2004 to 2012

On the other hand, in Figure 45 is presented the simulation of the variables that represent the value added by retail trade, accommodation and food services to the economy and their historical data. In there is possible to appreciate the model does not replicate completely the behaviour of the phenomenon, but it is close enough for assuring its usefulness in the analysis process.

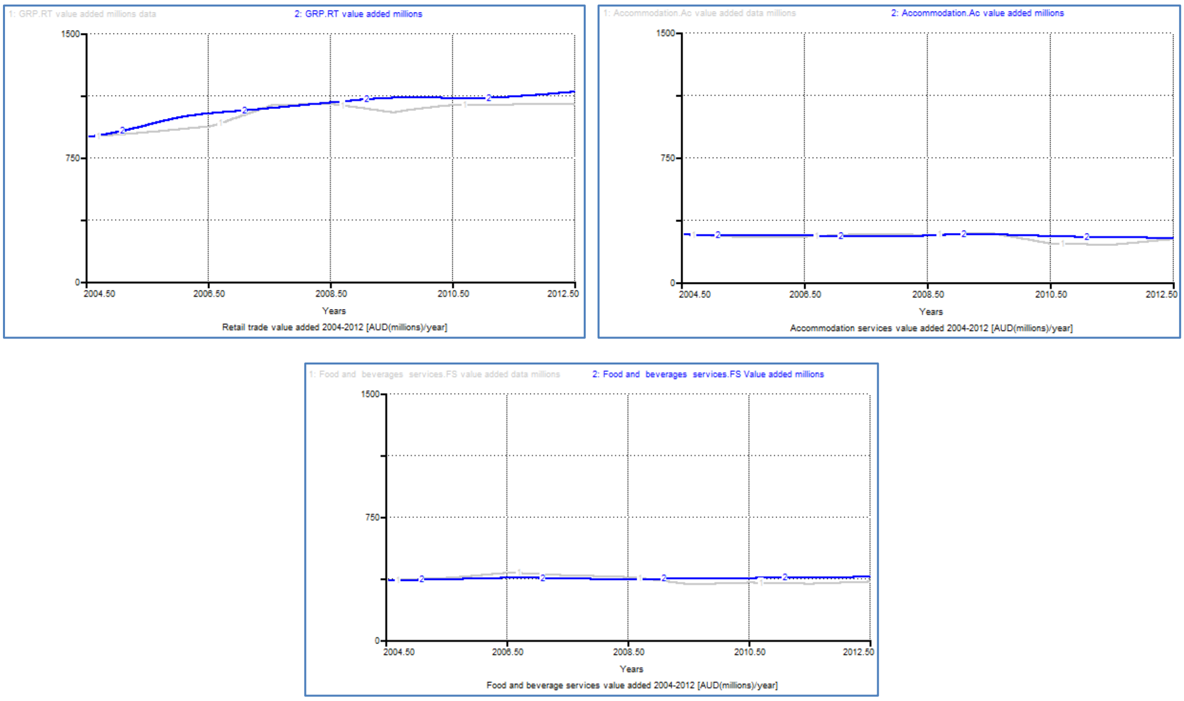


Figure 45 Retail trade, accommodation and food services value added from 2004 to 2012

After establishing certain level of confidence in the results provided by the prototype model, four scenarios are defined to demonstrate the manner game-changer projects can be evaluated. These scenarios are simulated in the period that runs from 2004 to 2031. Be

- The first scenario is known as the base case, in which it is assumed the economy continues as it is nowadays until 2031.

- For the second scenario, it is supposed the Sunshine Coast’s airport will be finished in ten years from now (by 2024) so that its effect on international visitors will take place until then. The effect assumed is a 10% annual increase in international visitors.

- For the third scenario, it is supposed the Bruce Highway upgrade will be completed by 2024. It is presumed that by this time domestic overnight visitors will stay half a day longer than their usual stay (four days) given that traffic jam issues are solved on account of upgrading the Bruce Highway.

- For the fourth scenario, the assumptions of the second and third scenario are combined.

In all four scenarios it is assumed net migration stays constant (the base case in the previous simulation). The assumptions in each scenario are summarised in Table 10.

Scenario	Yearly growth in international tourists (%)	Nights that domestic overnight visitors stay	Year game changers become effective
1	0%	4 days to 2031	N/A
2	0% to 2024 10% from 2024 to 2031	4 days to 2031	2024
3	0% to 2031	4 days to 2024 4.5 day from 2024 to 2031	2024
4	0% to 2024 10% from 2031	4 days to 2024 4.5 day from 2024 to 2031	2024

Table 10 Scenarios

The result of simulating the four scenarios is presented below. In Figure 46 is noted the effect of the game-changer projects on the valued added of Retail Trade, Accommodation and Food Services. The effect is a positive one; ergo game-changer projects improve the performance of the evaluated industries by increasing its value added. However, the order of magnitude of that effect is small inasmuch as the largest portion of demand for those industries comes from local consumption; thus it would be necessary enormous increments in tourism exports to generate a large impact.

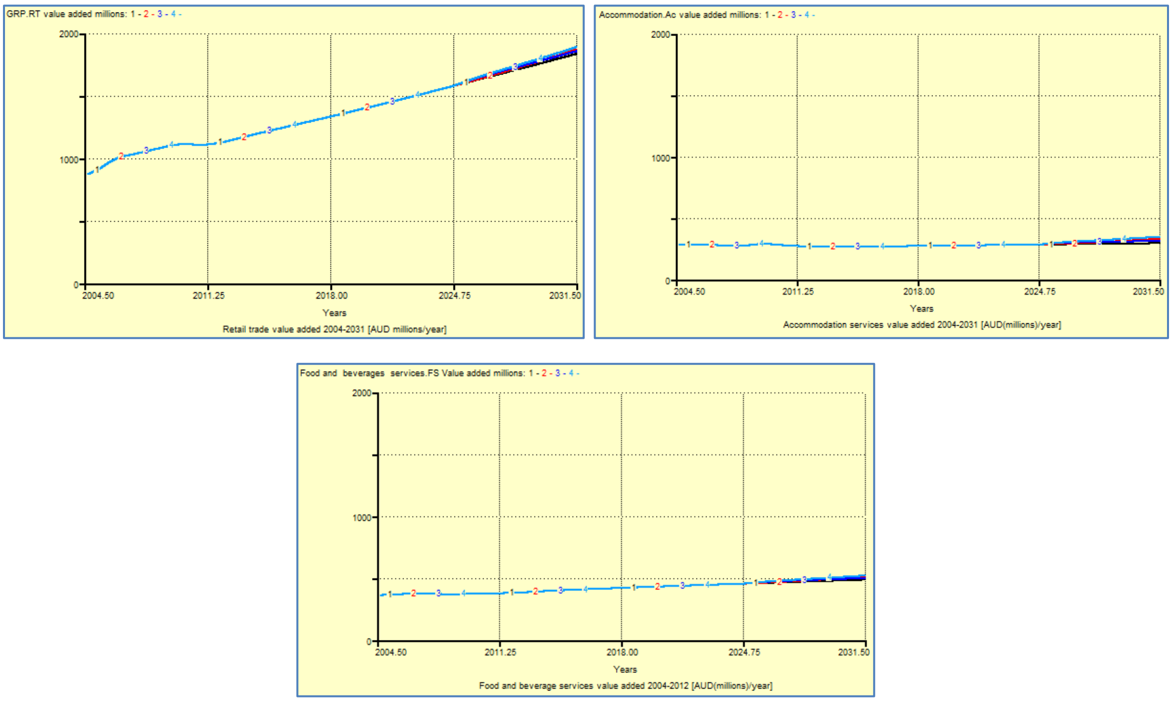


Figure 46 Retail trade, accommodation and food services value added from 2004 to 2031

In Figure 47 is presented the effect of the game changer projects on the economy as a whole. The first insight revealed in this simulation is that disaggregation entails to different results. By comparing base case scenarios from the first (see Figure 24) and the second simulations, it is seen that projections of GRP and GRP per capita to year 2031 differ. In the second simulation the base case scenario is more optimistic than the base case in the first one. This occurs due to productivity has been structured based on the number and size of industries within the Sunshine, giving as result a higher growth rate, unlike in the first prototype, wherein productivity is a single stock. Moreover, this simulation confirms the positive and small effect of the game-changer projects on the economy's performance (GRP) and resident's well-being (GRP per capita). In contrast, the effect of the game-changer projects on the efficiency of the economy is counterintuitive. Given that overall productivity in an economy is the weighted average of each industry's productivity, policies that aim at increasing the size of low-value or low-productivity industries, such as tourism-related ones, result in undermining economy's overall productivity.

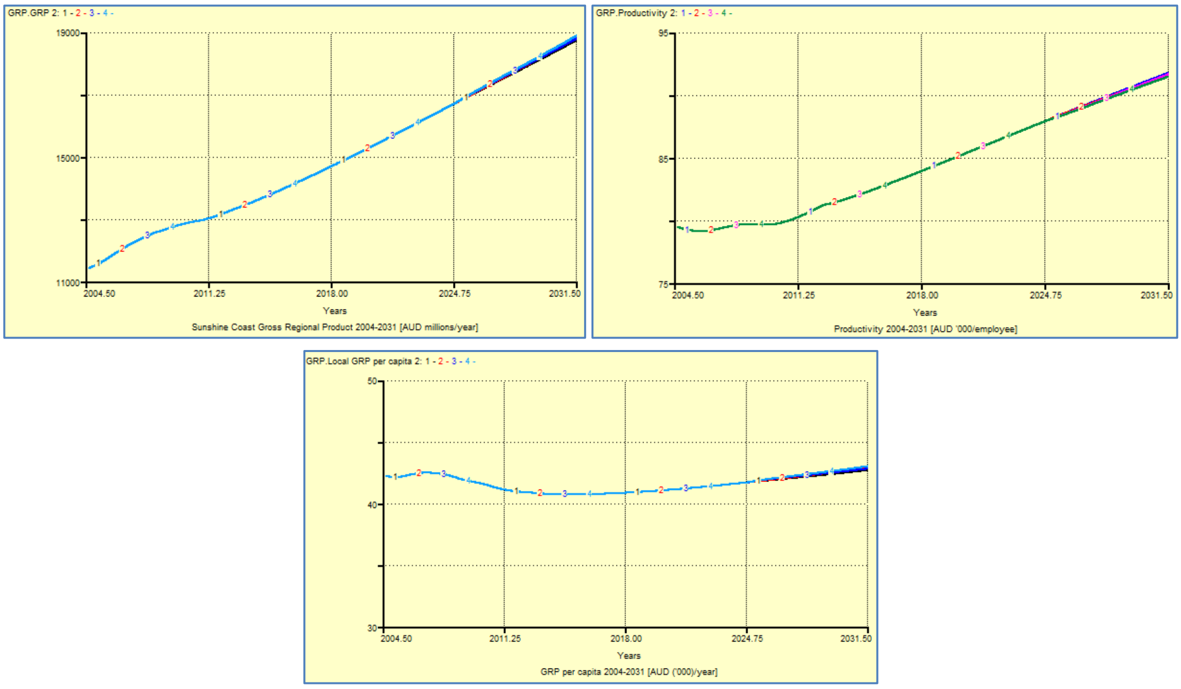


Figure 47 Sunshine Coast GRP and GRP per capita from 2004 to 2031

Ultimately, it is noteworthy to mention again these simulations are not predicting the results of implementation of the game-changer projects; on the contrary the purpose of a simulation model is for evaluating logic and coherence of the assumptions embedded in improvement proposals under a qualitative and quantitative framework. By doing so, stakeholders are able to determine the viability and feasibility of assumptions, and thereby take better decisions.

6. CONCLUSION

The development of this project has revealed the study of regional economies, such as the Sunshine Coast's economy, is a complex subject that requires a thorough analysis, if it is intended to improve its performance. This analysis has been achieved by using System Dynamics as methodology for integrating demographics with macroeconomic theory, tailored to the features of regional economies. The result is a simulation model (comprised of two prototypes) that serves as framework for evaluating regional economies and its improvement proposals, from which valuable insights can be drawn out. These insights are related to the model and its structure, and the modelling process itself.

In regard to model, it is deemed the 3P's (population, participation and productivity) approach works as starting point for developing a structure that accounts for the Sunshine Coast's economy whose performance is gauged by its annual production of goods and services or Gross Regional Product (GRP). The 3P's approach caters two key elements that determine production of goods and services: labour force (population and participation) and industries' productivity. These elements are modelled in detail, which give rise to two prototype models, the first one called "demographics" and the second one called "industries".

With respect to the first prototype, productivity is left exogenous, whereas labour force is deemed endogenous. This implies that the underlying structure of the Sunshine Coast's population is modelled with the purpose of understanding the causes that produces the changes in its behaviour. The result of this modelling process indicates that it is fundamental to disaggregate the structure of population into cohorts in order to represent accurately the phenomenon studied. Due to such a disaggregation level, it is possible to recognise the cause of the deterioration in the Sunshine Coast's economy over the last years. That cause is the decrease in natural increase of population and in net immigration rates.

Accordingly, three scenarios (base case, high and low) are defined to evaluate by the means of quantitative simulation the effect of one of those elements (net migration) on the total population and the GRP. Based on the results obtained, it is concluded that, higher rates of net migration lead to more population, more labour force and more GRP, so that if the performance of the economy is gauged through this variable, it can be said policies that encourage augments in population benefit the economy. On the contrary, simulation indicates higher rates of net migration does not necessary imply an augment in the GRP per capita. Therefore, according to these assumptions, policies that encourage higher levels of population are not effective for improving well-being.

Therefore, the focus is changed to the last of the 3P's: productivity. By simulating productivity in the first prototype under three scenarios it is seen that it has a positive impact on the GRP per capita. Nevertheless, this is achieved by changing an abstract parameter that represents growth in productivity, which does not provide meaningful insights for guiding policy making since this is not a straightforward process. For this reason, in the second prototype productivity is defined as the weighted average of each industry's productivity. These new productivities along with the demand for each industry determine the employment level and in turn the production of goods and services within the economy. Hence, the production side of the economy is disaggregated into 19 industries at division level based on the Australian and New Zealand Standard Industry Classification (ANZAC). Furthermore, some of these industries are broken down at the subdivision level in order to allow the relationship with the industries proposed in "The Sunshine Coast Economic Development Strategy" posited as pillars of the economy in the coming decades.

In addition, tourism is recognised as an activity instead of an industry sector. This activity is deemed as exports that affect certain industries in the Sunshine Coast. Those industries are: Retail Trade, Accommodation and Food Services. Consequently, tourism is incorporated into the prototype model as a special sector outside the 19 industries. As a result, these concepts are coupled with the first prototype giving shape to the second prototype, which contains an enriched structure that permits the analysis of performance and efficiency of the Sunshine Coast's economy at detail and global level.

Subsequently, four scenarios, including the base case, are developed so as to demonstrate the manner improvement proposals can be integrated with a regional economy model. Two of the game-changer projects from the "The Sunshine Coast Economic Development Strategy" are chosen for being simulated and evaluate their impact.

The result of the base case scenario indicates that different levels of disaggregation entail different behaviours. This is critical inasmuch as simulation models used as rationale for policy making ought to be reliable and robust. However, at this stage this statement has been proven. Therefore, more validation tests have to be undertaken before definitive conclusions can be drawn out. In spite of this clarification, the results catered by the prototype model appear to be useful for testing the order of magnitude of the effect of the proposed game-changer projects.

These results indicate the game-changer projects may have a positive effect in the performance of industries and the economy as whole, gauged by industries' value added and GRP respectively. On the contrary, the effect of the game-changer projects on the efficiency of the economy, gauged by productivity, appears to be negative. This is due to these projects are focused on increasing the exports of low-value added industries, giving as a result an augment in their size, and thereby undermining overall productivity. In short, Policy Makers ought to assess thoroughly improvements proposals with the tools and knowledge available before implementing policies that may aggravate problems.

Finally, despite the fact that this prototype model is tailored to the Sunshine Coast's particular issues, it could be modified to the needs of other regions not only in Australia but also in the rest of the world, on account of the generic concepts it draws on. The result obtained intends to be a contribution for future research in the field that prompts good practices in decision making.

7. FURTHER WORK

Notwithstanding this prototype was validated to some extent, a model used as support for decisions that affects thousands of people requires a full set of validations tests that guarantee the reliability in the results. The simulation model built in this project contributes to some extend in the research of regional economies. Nonetheless, it has not been fully developed for being considered a tool for decision making. In order to accomplish so, it is necessary to do much more work given that certain key structures were left out due to the constraint in resources.

The second prototype consists of two big sectors represented by modules: demographics and economy (Figure 48). This structure accounts for the effect of population on the economy. However, the reverse situation, the effect of the economy on the demographics is not addressed; thus in future researches this issue ought to be encompassed. In the Sunshine Coast case, such research should be oriented to investigate the way the economy influences migratory flows, which at this stage are deemed exogenous. Such an answer will provide valuable insights for decision making.

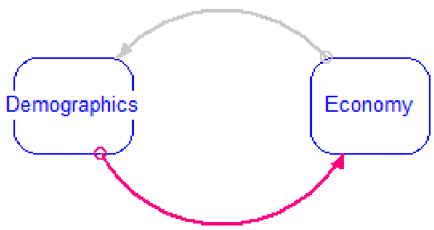


Figure 48 Effect of economy on demographics

In regard to the structure of the economy, it is considered the effect of industries on the economy as a whole, but it is not considered the interaction business to business, which may affect the dynamics of the system. Therefore, this simulation model may either overestimating or underestimating the performance of economy.

On the other hand, this model was developed based on the mainstream macroeconomic theory, which is not exempt of criticism, since it usually takes into account three production factors: capital, labour and productivity. Other fundamental factors such as human capital and natural resources are ignored, which the analysis may be diverted from critical issues for the society. Resident’s well-being does not rely only on the performance or efficiency of the economy; it also relies on the quality of the public services, in the care of the environment and its sustainability, and so on. In a future model version a more eclectic approach should be considered, in which economy and demographics should be sub-sectors of a model a large and holistic model.

At last, a simulation model is not the solution for the region's issues but the decisions taken by all the actors in the society. Therefore, they, including Policy Makers, ought to adopt a change in paradigm, in which decisions are oriented to the general benefit, instead of a particular one, by underpinning them with effective tools such as the ones developed over the last decades, and thereby abandon poor practices that lead to poor results. Until then, it could be considered regions and cities as smart ones.

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9. APPENDIX

9.1 Model equations

First prototype

Pct_employed__within_the_region(t) =

Pct_employed__within_the_region(t - dt) + (Change_in_pct_employed_within_the_region) * dt

INIT Pct_employed__within_the_region = 0.99

INFLOWS:

Change_in_pct_employed_within_the_region =

(Supposed_goal-Pct_employed__within_the_region)/Time_to_reach_goal

Productivity(t) =

Productivity(t - dt) + (Change_in__productivity) * dt

INIT Productivity = 78

INFLOWS:

Change_in__productivity =

Productivity*0.003

Employed_in__local_industries = Residents__employed*Pct_employed__within_the_region

Employment_rate = 0.94

Fraction_of_components = 0.15

GRP = Industries__value_added+Other_components

Industries__value_added = (Employed_in__local_industries*Productivity)/1000

Local_GRP_per_capita = (GRP/Demographics.total_population) * 1000

Other_components = Industries__value_added*Fraction_of_components

Residents__employed = Demographics.Labour_force*Employment_rate

Supposed_goal = 0.9

Time_to_reach_goal = 15

DEMOGRAPHICS (MODULE):

Adults__65plus(t) =

Adults__65plus(t - dt) + (Aging_to_65 + Net_immi_65plus - Deaths_65plus) * dt

INIT Adults__65plus = 43010

INFLOWS:

Aging_to_65 = CONVEYOR OUTFLOW

Net_immi_65plus = Est_net_immi__65_plus

OUTFLOWS:

Deaths_65plus = Adults__65plus/Life_expectancy_plus

Adults_15_to_19(t) =

Adults_15_to_19(t - dt) + (Aging_to_15 + Net_immi_15_to_19 - Aging_to_20 - Deaths_15_to_19) * dt

INIT Adults_15_to_19 = 17567

TRANSIT TIME = 5

INFLOWS:

Aging_to_15 = CONVEYOR OUTFLOW

Net_immi_15_to_19 = Est_net_immi__15_to_19

OUTFLOWS:

Aging_to_20 = CONVEYOR OUTFLOW

Deaths_15_to_19 = LEAKAGE OUTFLOW

LEAKAGE FRACTION = 0.00041095

Adults_20_to_24(t) =

Adults_20_to_24(t - dt) + (Aging_to_20 - Aging_to_25 - Deaths_20_to_24 - Net_immi_20_to_24) * dt

INIT Adults_20_to_24 = 13658

TRANSIT TIME = 5

INFLOWS:

Aging_to_20 = CONVEYOR OUTFLOW

OUTFLOWS:

Aging_to_25 = CONVEYOR OUTFLOW

Deaths_20_to_24 = LEAKAGE OUTFLOW

LEAKAGE FRACTION = 0.00057973

Net_immi_20_to_24 = LEAKAGE OUTFLOW

LEAKAGE FRACTION = Est_net_immi__20_to_24

Adults_25_to_29(t) =

Adults_25_to_29(t - dt) + (Aging_to_25 + Net_immi__25_to_29 - Aging_to_30 - Deaths_25_to_29) * dt

INIT Adults_25_to_29 = 13452

TRANSIT TIME = 5

INFLOWS:

Aging_to_25 = CONVEYOR OUTFLOW

Net_immi__25_to_29 = Est_net__immi__25_to_29

OUTFLOWS:

Aging_to_30 = CONVEYOR OUTFLOW

Deaths_25_to_29 = LEAKAGE OUTFLOW

LEAKAGE FRACTION = 0.00065931

Adults_30_to_34(t) =

Adults_30_to_34(t - dt) + (Aging_to_30 + Net_immi_30_to_34 - Aging_to_35 - Deaths_30_to_34) * dt

INIT Adults_30_to_34 = 17203

TRANSIT TIME = 5

INFLOWS:

Aging_to_30 = CONVEYOR OUTFLOW

Net_immi_30_to_34 = Est_net__immi_30_to_34

OUTFLOWS:

Aging_to_35 = CONVEYOR OUTFLOW

Deaths_30_to_34 = LEAKAGE OUTFLOW

LEAKAGE FRACTION = 0.0007671

Adults_35_to_39(t) =

Adults_35_to_39(t - dt) + (Aging_to_35 + Net_immi_35_to_39 - Aging_to_40 - Deaths_35_to_39) * dt

INIT Adults_35_to_39 = 18154

TRANSIT TIME = 5

INFLOWS:

Aging_to_35 = CONVEYOR OUTFLOW

Net_immi_35_to_39 = Est_net__immi_35_to_39

OUTFLOWS:

Aging_to_40 = CONVEYOR OUTFLOW

Deaths_35_to_39 = LEAKAGE OUTFLOW

LEAKAGE FRACTION = 0.00098082

Adults_40_to_44(t) =

Adults_40_to_44(t - dt) + (Aging_to_40 + Net_immi_40_to_44 - Aging_to_45 - Deaths_40_to_44) * dt

INIT Adults_40_to_44 = 21231

TRANSIT TIME = 5

INFLOWS:

Aging_to_40 = CONVEYOR OUTFLOW

Net_immi_40_to_44 = Est_net_immi__40_to_44

OUTFLOWS:

Aging_to_45 = CONVEYOR OUTFLOW

Deaths_40_to_44 = LEAKAGE OUTFLOW

LEAKAGE FRACTION = 0.0013116

Adults_45_to_49(t) =

Adults_45_to_49(t - dt) + (Aging_to_45 + Net_immi_45_to_49 - Aging_to_50 - Deaths_45_to_49) * dt

INIT Adults_45_to_49 = 20250

TRANSIT TIME = 5

INFLOWS:

Aging_to_45 = CONVEYOR OUTFLOW

Net_immi_45_to_49 = Est_net_immi__45_to_49

OUTFLOWS:

Aging_to_50 = CONVEYOR OUTFLOW

Deaths_45_to_49 = LEAKAGE OUTFLOW

LEAKAGE FRACTION = 0.00197682

Adults_55_to_59(t) =

Adults_55_to_59(t - dt) + (Aging_to_55 + Net_immi__55_to_59 - Aging_to_60 - Deaths_55_to_59) * dt

INIT Adults_55_to_59 = 18475

TRANSIT TIME = 5

INFLOWS:

Aging_to_55 = CONVEYOR OUTFLOW

Net_immi__55_to_59 = Est_net_immi__55_to_59

OUTFLOWS:

Aging_to_60 = CONVEYOR OUTFLOW

Deaths_55_to_59 = LEAKAGE OUTFLOW

LEAKAGE FRACTION = 0.0044072

Adults__50_to_54(t) =

Adults__50_to_54(t - dt) + (Aging_to_50 + Net_immi_50_to_54 - Aging_to_55 - Deaths_50_to_54) * dt

INIT Adults__50_to_54 = 18832

TRANSIT TIME = 5

INFLOWS:

Aging_to_50 = CONVEYOR OUTFLOW

Net_immi_50_to_54 = Est_net_immi__50_to_54

OUTFLOWS:

Aging_to_55 = CONVEYOR OUTFLOW

Deaths_50_to_54 = LEAKAGE OUTFLOW

LEAKAGE FRACTION = 0.0028445

Adults__60_to_64(t) =

Adults__60_to_64(t - dt) + (Aging_to_60 + Net_immi_60_to_64 - Aging_to_65 - Deaths__60_to_64) * dt

INIT Adults__60_to_64 = 15411

TRANSIT TIME = 5

INFLOWS:

Aging_to_60 = CONVEYOR OUTFLOW

Net_immi_60_to_64 = Est_net_immi___60_to_64

OUTFLOWS:

Aging_to_65 = CONVEYOR OUTFLOW

Deaths__60_to_64 = LEAKAGE OUTFLOW

LEAKAGE FRACTION = 0.00715102

Children_0_to_4(t) = Children_0_to_4(t - dt) + (Births + Net_immi_0_to_4 - Aging_to_5 - Deaths_0_to_4) * dt

INIT Children_0_to_4 = 15670

TRANSIT TIME = 5

INFLOWS:

Births = Fertile_age_women*Births_per_woman

Net_immi_0_to_4 = Est_net__immi__0_to_4

OUTFLOWS:

Aging_to_5 = CONVEYOR OUTFLOW

Deaths_0_to_4 = LEAKAGE OUTFLOW

LEAKAGE FRACTION = 0.00124065

Children_10_to_14(t) =

Children_10_to_14(t - dt) + (Aging_to_10 + Net_immi_10_to_14 - Aging_to_15 - Deaths_10_to_14) * dt

INIT Children_10_to_14 = 19573

TRANSIT TIME = 5

INFLOWS:

Aging_to_10 = CONVEYOR OUTFLOW

Net_immi_10_to_14 = Est_net_immi__10_to_14

OUTFLOWS:

Aging_to_15 = CONVEYOR OUTFLOW

Deaths_10_to_14 = LEAKAGE OUTFLOW

LEAKAGE FRACTION = 0.00011821

Children_5_to_9(t) =

Children_5_to_9(t - dt) + (Aging_to_5 + Net_immi_5_to_9 - Aging_to_10 - Deaths_5_to_9) * dt

INIT Children_5_to_9 = 17780

TRANSIT TIME = 5

INFLOWS:

Aging_to_5 = CONVEYOR OUTFLOW

Net_immi_5_to_9 = Est_net_immi__5_to_9

OUTFLOWS:

Aging_to_10 = CONVEYOR OUTFLOW

Deaths_5_to_9 = LEAKAGE OUTFLOW

LEAKAGE FRACTION = 0.00011108

Births_per_woman = 0.05

Est_net_immi__10_to_14 = GRAPH(TIME)

(2002, 705), (2003, 791), (2004, 897), (2005, 723), (2006, 519), (2007, 436), (2008, 639), (2009, 454), (2010, 501), (2011, 405), (2012, 442)

Est_net_immi__15_to_19 = GRAPH(TIME)

(2002, 153), (2003, 224), (2004, 162), (2005, 113), (2006, 189), (2007, 260), (2008, 203), (2009, 215), (2010, -97.0), (2011, -15.0), (2012, 117)

Est_net_immi__20_to_24 = GRAPH(TIME)

(2002, 0.029), (2003, 0.009), (2004, 0.005), (2005, 0.00), (2006, 0.003), (2007, 0.021), (2008, 0.021), (2009, 0.01), (2010, 0.03), (2011, 0.053), (2012, 0.015), (2013, 0.00)

Est_net_immi__40_to_44 = GRAPH(TIME)

(2002, 1028), (2003, 1221), (2004, 1216), (2005, 901), (2006, 600), (2007, 358), (2008, 312), (2009, 331), (2010, 481), (2011, 843), (2012, 1229)

Est_net_immi__45_to_49 = GRAPH(TIME)

(2002, 455), (2003, 616), (2004, 689), (2005, 498), (2006, 579), (2007, 790), (2008, 906), (2009, 934), (2010, 460), (2011, 229), (2012, -49.0)

Est_net_immi__50_to_54 = GRAPH(TIME)
(2002, 423), (2003, 515), (2004, 378), (2005, 174), (2006, 349), (2007, 141), (2008, 296), (2009, 285), (2010, 264), (2011, 305), (2012, 713)

Est_net_immi__55_to_59 = GRAPH(TIME)
(2002, 965), (2003, 1259), (2004, 932), (2005, 756), (2006, 599), (2007, 143), (2008, 352), (2009, 270), (2010, 147), (2011, 326), (2012, 101)

Est_net_immi__5_to_9 = GRAPH(TIME)
(2002, 676), (2003, 936), (2004, 733), (2005, 683), (2006, 688), (2007, 531), (2008, 605), (2009, 631), (2010, 435), (2011, 691), (2012, 766)

Est_net_immi__65_plus = GRAPH(TIME)
(2002, 392), (2003, 536), (2004, 542), (2005, 322), (2006, 57.0), (2007, 208), (2008, 11.0), (2009, 323), (2010, 504), (2011, 847), (2012, 769)

Est_net_immi___60_to_64 = GRAPH(TIME)
(2002, 554), (2003, 484), (2004, 470), (2005, 353), (2006, 329), (2007, 846), (2008, 902), (2009, 674), (2010, 662), (2011, 976), (2012, 108)

Est_net__immi_30_to_34 = GRAPH(TIME)
(2002, 964), (2003, 1456), (2004, 1225), (2005, 935), (2006, 495), (2007, 433), (2008, 398), (2009, 372), (2010, 184), (2011, 1.00), (2012, 500)

Est_net__immi_35_to_39 = GRAPH(TIME)
(2002, 597), (2003, 651), (2004, 549), (2005, 557), (2006, 761), (2007, 1251), (2008, 1688), (2009, 1368), (2010, 946), (2011, 180), (2012, 360)

Est_net__immi__0_to_4 = GRAPH(TIME)
(2002, 424), (2003, 505), (2004, 469), (2005, 366), (2006, 347), (2007, 485), (2008, 552), (2009, 494), (2010, 184), (2011, -165), (2012, 269)

Est_net__immi__25_to_29 = GRAPH(TIME)
(2005, 248), (2005, 220), (2006, 158), (2007, 96.0), (2007, 339), (2008, 294), (2009, 543), (2009, 398), (2010, 97.0), (2011, -136), (2012, 180)

Female_fraction = 0.51

Fertile_age_women =
(Adults_15_to_19+Adults_20_to_24+Adults_25_to_29+Adults_30_to_34+Adults_35_to_39+Adults_40_to_44+ Adults_45_to_49)*Female_fraction

Labour_force =
(Adults_15_to_19* 0.65)+ (Adults_20_to_24* 0.82)+ (Adults_25_to_29* 0.81)+ (Adults_30_to_34* 0.81)+ (Adults_35_to_39* 0.82)+ (Adults_40_to_44* 0.84)+ (Adults_45_to_49* 0.84)+ (Adults__50_to_54* 0.80)+ (Adults_55_to_59* 0.67)+ (Adults__60_to_64*0.47)+ (Adults__65plus* 0.09)

Life_expectancy_plus = 25

Participation_rate = (Labour_force/(Population_15_to_64+Adults__65plus)) * 100

Population_15_to_64 = Adults_15_to_19 + Adults_20_to_24 + Adults_25_to_29 + Adults_35_to_39 + Adults_40_to_44 + Adults_30_to_34 + Adults_45_to_49 + Adults_55_to_59 + Adults__50_to_54 + Adults__60_to_64

total_population = Adults__65plus + Children_0_to_4 + Children_10_to_14 + Children_5_to_9 + Population_15_to_64

Second prototype

Since the modelling process in this project is guided by an incremental and iterative approach, equations of module demographics apply to the second prototype. The remaining equations are presented below.

GRP (module)

AdSS_value_added_millions =
Administrative_and_Support_Services.Professional_scientific_and_technical_services__value_added/1000

AFF_value_added_millions =
Agriculture__forestry_and_fishing.Agriculture_forestry_and_fishing_value_added/1000

AFS_value_added_millions =
Accommodation_and__food_services.Accommodation_and_food_services_value_added/1000

ARS_value_added_millions =
Art_and_Recreation__Services.Art_and_Recreation_Services__value_added/1000

Change_in_GRP = TREND(GRP_2,1)

Construction_value_added_millions =
Construction.Construction_value_added/1000

EGWWS_value_added_millions =
Electricity_Gas_Water_and_Waste_Services.Electricity_Gas_Water_and_Waste_Services__value_added/1000

ET_value_added_millions =
Education_and_training.Education_and_training_value_added/1000

FIS_value_added_millions =
Financial_Insurances__services.Financial_Insurances_services__value_added/1000

Fraction_of_components = 0.15

GRP = Industries_value_added + Other_components

HCSA_value_added_millions =
Health_care_and_social_assistance.Health_care_and_social_assistance__value_added/1000

IMT_value_added_millions =
Information_Media_and_telecommunications.Information_media_and_telecommunications__value_added/1000

Local_GRP_per_capita = (GRP/Demographics.Total___Population) * 1000

Manufacturing__value_added_millions = Manufacturing.Manufacturing_value_added/1000

Mining_value_added_millions = Mining.Mining__value_added/1000

OS_value_added_millions = Other__Services.Other_Services__value_added/1000

Other_components = Industries_value_added * Fraction_of_components

PAS_value_added_millions =
Public_Administration__and_Safety.Public_Administration_and_Safety__value_added/1000

Productivity = (Industries_value_added/Employed_in_local_industries) * 1000

PSTS_value_added_millions =
Professional_scientific_and_technical_services.Professional_scientific_and_technical_services__value_added/1000

RHRSS_value_added_millions =
Rental_Hiring_and_Real_State_Services.Rental_Hiring_and_Real_State_Services__value_added/1000

RT_value_added_millions = Retail_trade.Retail_trade__value_added/1000

TPW_value_added_millions =
Transport_Postal__and_Warehousing.Transport_postal_and_warehousing_value_added/1000

WT_value_added_millions = Wholesale_trade.Wholesale_trade__value_added/1000

Employed_in_local_industries = Accommodation_and__food_services.Employed_AFS + Administrative_and_Support_Services.Employed_AdSS + Agriculture.Employed__agriculture + Art_and_Recreation__Services.Employed__ARS + Construction.Employed_construction + Education_and_training.Employees_education_and_training + Electricity_Gas_Water_and_Waste_Services.Employed__EGWWS + Financial_Insurances__services.Employed__FIS + Health_care_and_social_assistance.Employed__HCSA + Information_Media_and_telecommunications.Employed__IMT + Manufacturing.Employed_manufacturing + Mining.Employed__mining + Other__Services.Employed__OS + Professional_scientific_and_technical_services.Employed_PSTS + Public_Administration__and_Safety.Employed_PAS + Rental_Hiring_and_Real_State_Services.Employed__RHRSS + Retail_trade.Employed__RT + Transport_Postal__and_Warehousing.Employed__TPW + Wholesale_trade.Employed__WT

Industries_value_added = AFF_value_added_millions + Mining_value_added_millions + Manufacturing__value_added_millions + EGWWS_value_added_millions + Construction_value_added_millions + WT_value_added_millions + RT_value_added_millions + AFS_value_added_millions + TPW_value_added_millions + IMT_value_added_millions + FIS_value_added_millions + RHRSS_value_added_millions + PSTS_value_added_millions + AdSS_value_added_millions + PAS_value_added_millions + ET_value_added_millions + HCSA_value_added_millions + ARS_value_added_millions + OS_value_added_millions

Agriculture, forestry and fishing (module)

Agriculture_forestry_and_fishing_value_added = Agriculture.Agriculture__value_added + Other_agriculture_forestry_and_fishing.Other_agriculture_forestry_and_fishing__value_added

Employed_AFF =
Agriculture.Employed__agriculture+Other_agriculture_forestry_and_fishing.Employed__OAFF

Agriculture (module)

Earnings(t) = Earnings(t - dt) + (Change_in_employees__earnings) * dt

INIT Earnings = 47

INFLOWS:

Change_in_employees__earnings = Earnings*Yearly_growth__in_earnings

Employed__agriculture(t) = Employed__agriculture(t - dt) + (Change_in__employment_Ag) * dt

INIT Employed__agriculture = 4278

INFLOWS:

Change_in__employment_Ag =

(Desired__employment_Ag-Employed__agriculture)/Time_to_adjust__employment_Ag

Local_expenditure__per_capita_Ag(t) =

Local_expenditure__per_capita_Ag(t - dt) + (Change_in_local_expenditure) * dt

INIT Local_expenditure__per_capita_Ag = 1.15

INFLOWS:

Change_in_local_expenditure =

(Indicated_Local_expenditure_per_capita-Local_expenditure__per_capita_Ag)/Time_to_adjust_LE

Productivity__Ag(t) = Productivity__Ag(t - dt) + (Change_in__productivity) * dt

INIT Productivity__Ag = 52

INFLOWS:

Change_in__productivity = (Productivity__Ag*Yearly_growth_in__productivity)

Agriculture__value_added = Employed__agriculture*Productivity__Ag

Ag__value_added_demand = Revenue_Ag-Non_staff_expenses_and_costs

Capital__gains = Capital__share*Agriculture__value_added

Capital__share = 1- MIN(1,Labour__share)

Cost_fraction = 0.56

Desired__employment_Ag =

IF(Labour__share>1) THEN Ag__value_added_demand/(Productivity__Ag*Labour__share) ELSE

Ag__value_added_demand/Productivity__Ag

Exports_ag = GRAPH(TIME)
(2001, 180974), (2002, 129166), (2003, 136726), (2004, 105978), (2005, 154172), (2006, 104175), (2007, 107653), (2008, 81892), (2009, 90325), (2010, 97806), (2011, 127011), (2012, 147905)

Indicated_Local_expenditure_per_capita =

Local_expenditure__per_capita_Ag* (1+GRP.Change_in_GRP)

Labour__share = Earnings/Productivity__Ag

Local_sales__Ag = Demographics.Total___Population*Local_expenditure__per_capita_Ag

Non_staff_expenses_and_costs = Revenue_Ag*Cost_fraction

Revenue_Ag = Local_sales__Ag+Exports_ag

Time_to_adjust_LE = 1

Time_to_adjust__employment_Ag = 1

Yearly_growth_in__productivity = 0.11 + STEP(-0.11,2012.5)

Yearly_growth__in_earnings = 0.11 + STEP(-0.11,2012.5)

Other agriculture forestry and fishing (module)

Earnings(t) = Earnings(t - dt) + (Change_in_employees__earnings) * dt
INIT Earnings = 40
INFLOWS:
Change_in_employees__earnings = Earnings*Yearly_growth__in_earnings

Employed__OAFF(t) = Employed__OAFF(t - dt) + (Change_in__employment_OAFF) * dt
INIT Employed__OAFF = 653
INFLOWS:
Change_in__employment_OAFF =
(Desired__employment_OAFF-Employed__OAFF)/Time_to_adjust__employment_OAFF

Local_expenditure__per_capita_OAFF(t) =
Local_expenditure__per_capita_OAFF(t - dt) + (Change_in_local_expenditure) * dt
INIT Local_expenditure__per_capita_OAFF = 0.15
INFLOWS:

Change_in_local_expenditure =

(Indicated_Local_expenditure_per_capita-Local_expenditure__per_capita_OAFF)/Time_to_adjust_LE

Productivity__OAFF(t) = Productivity__OAFF(t - dt) + (Change_in__productivity) * dt

INIT Productivity__OAFF = 44

INFLOWS:

Change_in__productivity = (Productivity__OAFF*Yearly_growth_in__productivity)

Capital__gains = Capital__share*Other_agriculture_forestry_and_fishing__value_added

Capital__share = 1- MIN(1,Labour__share)

Cost_fraction = 0.5

Desired__employment_OAFF = IF(Labour__share>1) THEN

OAFF__value_added_demand/(Productivity__OAFF*Labour__share) ELSE

OAFF__value_added_demand/Productivity__OAFF

Exports_OAFF = GRAPH(TIME)

(2001, 18003), (2002, 20584), (2003, 19314), (2004, 17188), (2005, 20150), (2006, 15155), (2007, 17599), (2008, 15656), (2009, 17730), (2010, 21697), (2011, 39736), (2012, 58861)

Indicated_Local_expenditure_per_capita = Local_expenditure__per_capita_OAFF* (1+GRP.Change_in_GRP)

Labour__share = Earnings/Productivity__OAFF

Local_sales__OAFF = Demographics.Total___Population*Local_expenditure__per_capita_OAFF

Non_staff_expenses_and_costs = Revenue_OAFF*Cost_fraction

OAFF__value_added_demand = Revenue_OAFF-Non_staff_expenses_and_costs

Other_agriculture_forestry_and_fishing__value_added = Employed__OAFF*Productivity__OAFF

Revenue_OAFF = Local_sales__OAFF+Exports_OAFF

Time_to_adjust_LE = 10

Time_to_adjust__employment_OAFF = 1

Yearly_growth_in__productivity = 0.10+ STEP(-0.10,2012.5)

Yearly_growth__in_earnings = 0.1 - STEP(-0.1,2012.5)

Mining (module)

Earnings(t) = Earnings(t - dt) + (Change_in_employees__earnings) * dt

INIT Earnings = 115

INFLOWS:

Change_in_employees__earnings = Earnings*Yearly_growth__in_earnings

Employed__mining(t) = Employed__mining(t - dt) + (Change_in__employment_mining) * dt

INIT Employed__mining = 187

INFLOWS:

Change_in__employment_mining =

(Desired__employment_mining-Employed__mining)/Time_to_adjust__employment_mining

Local_expenditure__per_capita_mining(t) =

Local_expenditure__per_capita_mining(t - dt) + (Change_in_local_expenditure) * dt

INIT Local_expenditure__per_capita_mining = 0.75

INFLOWS:

Change_in_local_expenditure =

(Indicated_Local_expenditure_per_capita-Local_expenditure__per_capita_mining)/Time_to_adjust_LE

Productivity(t) = Productivity(t - dt) + (Change_in__productivity) * dt

INIT Productivity = 363

INFLOWS:

Change_in__productivity = (Mining*Yearly_growth_in__productivity)

Capital__gains = Capital__share*Mining__value_added

Capital__share = 1- MIN(1,Labour__share)

Cost_fraction = 0.62

Desired__employment_mining = IF(Labour__share>1) THEN

Mining_value_added_demand/(Mining*Labour__share) ELSE Mining_value_added_demand/Mining

Exports_mining = GRAPH(TIME)

(2001, 36413), (2002, 37602), (2003, 41898), (2004, 40906), (2005, 46302), (2006, 55615), (2007, 66974),

(2008, 78429), (2009, 82953), (2010, 77111), (2011, 60194), (2012, 58045)

Indicated_Local_expenditure_per_capita = Local_expenditure__per_capita_mining* (1+GRP.Change_in_GRP)

Labour__share = Earnings/Productivity

Local_sales__mining = Demographics.Total___Population*Local_expenditure__per_capita_mining

Mining_value_added_demand = Revenue_mining-Non_staff_expenses_and_costs

Mining__value_added = Employed__mining*Mining

Non_staff_expenses_and_costs = Revenue_mining*Cost_fraction

Revenue_mining = Local_sales__mining+Exports_mining

Time_to_adjust_LE = 1

Time_to_adjust__employment_mining = 1

Yearly_growth_in__productivity = -0.035

Yearly_growth__in_earnings = -0.035

Manufacturing (module)

Employed_manufacturing =
Food_and_product__manufacturing.Employed__FPM+Rest_of__manufacturing.Employed__RM

Manufacturing_value_added =
Food_and_product__manufacturing.Food_and_product_manufacturing__value_added+Rest_of__manufacturi
ng.Rest_of_manufacturing__value_added

Food and product manufacturing (module)

Earnings(t) = Earnings(t - dt) + (Change_in_employees__earnings) * dt
INIT Earnings = 93
INFLOWS:
Change_in_employees__earnings = (Indicated__earnings-Earnings)/Earnings_AT

Employed__FPM(t) = Employed__FPM(t - dt) + (Change_in__employment_FPM) * dt
INIT Employed__FPM = 1633
INFLOWS:
Change_in__employment_FPM =
(Desired__employment_FPM-Employed__FPM)/Time_to_adjust__employment_FPM

Local_expenditure__per_capita_FPM(t) =
Local_expenditure__per_capita_FPM(t - dt) + (Change_in_local_expenditure) * dt
INIT Local_expenditure__per_capita_FPM = 1.5

INFLOWS:

Change_in_local_expenditure =

(Indicated_Local_expenditure_per_capita-Local_expenditure__per_capita_FPM)/Time_to_adjust_LE

Productivity__FPM(t) = Productivity__FPM(t - dt) + (Change_in__productivity) * dt

INIT Productivity__FPM = 98

INFLOWS:

Change_in__productivity = (Indicated_productivity-Productivity__FPM)/Producitivy_AT

Capital__gains = Capital__share*Food_and_product_manufacturing__value_added

Capital__share = 1- MIN(1,Labour__share)

Cost_fraction = 0.75

Desired__employment_FPM = IF(Labour__share>1) THEN

FPM__value_added_demand/(Productivity__FPM*Labour__share) ELSE

FPM__value_added_demand/Productivity__FPM

Earnings_AT = 1

Exports_FPM = GRAPH(TIME)

(2002, 128521), (2002, 125574), (2003, 127904), (2004, 136240), (2005, 129907), (2006, 125138), (2007, 125352), (2008, 130680), (2009, 125991), (2010, 134960), (2011, 140726), (2012, 142775)

Food_and_product_manufacturing__value_added = Employed__FPM*Productivity__FPM

FPM__value_added_demand = Revenue_FPM-Non_staff_expenses_and_costs

Indicated_Local_expenditure_per_capita = Local_expenditure__per_capita_FPM* (1+GRP.Change_in_GRP)

Indicated_productivity = 87

Indicated__earnings =

(((Productivity__FPM/Earnings_AT)+Change_in__productivity)/Productivity__FPM)*Earnings

Labour__share = Earnings/Productivity__FPM

Local_sales__FPM = Demographics.Total___Population*Local_expenditure__per_capita_FPM

Non_staff_expenses_and_costs = Revenue_FPM*Cost_fraction

Producitivy_AT = 1

Revenue_FPM = Local_sales__FPM+Exports_FPM

Time_to_adjust_LE = 10

Time_to_adjust__employment_FPM = 1

Rest of manufacturing (module)

Earnings(t) = Earnings(t - dt) + (Change_in_employees__earnings) * dt

INIT Earnings = 108

INFLOWS:

Change_in_employees__earnings = Earnings*Yearly_growth_in_earnings

Employed__RM(t) = Employed__RM(t - dt) + (Change_in__employment_RM) * dt

INIT Employed__RM = 7456

INFLOWS:

Change_in__employment_RM =

(Desired__employment_RM-Employed__RM)/Time_to_adjust__employment_RM

Productivity__RM(t) = Productivity__RM(t - dt) + (Change_in__productivity) * dt

INIT Productivity__RM = 117

INFLOWS:

Change_in__productivity = Productivity__RM*Yearly_growth_in_productivity

Capital__gains = Capital__share*Rest_of_manufacturing__value_added

Capital__share = 1- MIN(1,Labour__share)

Cost_fraction = 0.65

Desired__employment_RM = IF(Labour__share>1) THEN

RM__value_added_demand/(Productivity__RM*Labour__share) ELSE

RM__value_added_demand/Productivity__RM

Exports_RM = GRAPH(TIME)

(2002, 645008), (2002, 773440), (2003, 725200), (2004, 725967), (2005, 826148), (2006, 917326), (2007, 936245), (2008, 955645), (2009, 816672), (2010, 731476), (2011, 607139), (2012, 652311)

Labour__share = Earnings/Productivity__RM

Local_expenditure_per_capita_RM = GRAPH(TIME)

(2002, 4.80), (2003, 5.16), (2004, 5.51), (2005, 5.48), (2006, 5.48), (2007, 5.52), (2008, 4.65), (2009, 3.91), (2010, 3.34), (2011, 3.38), (2012, 3.47)

Local_sales__RM = Demographics.Total___Population*Local_expenditure_per_capita_RM

Non_staff_expenses_and_costs = Revenue_RM*Cost_fraction

Rest_of_manufacturing__value_added = Employed__RM*Productivity__RM

Revenue_RM = Local_sales__RM+Exports_RM

RM__value_added_demand = Revenue_RM-Non_staff_expenses_and_costs

Time_to_adjust__employment_RM = 3

Yearly_growth_in_earnings = 0

Yearly_growth_in_productivity = 0

Electricity, gas, water and waste services (module)

Earnings(t) = Earnings(t - dt) + (Change_in_employees__earnings) * dt

INIT Earnings = 179

INFLOWS:

Change_in_employees__earnings = Earnings*Yearly_growth__in_earnings

Employed__EGWWS(t) = Employed__EGWWS(t - dt) + (Change_in__employment_EGWWS) * dt

INIT Employed__EGWWS = 678

INFLOWS:

Change_in__employment_EGWWS =

(Desired__employment_EGWWS-Employed__EGWWS)/Time_to_adjust__employment_EGWWS

Local_expenditure__per_capita_EGWWS(t) =

Local_expenditure__per_capita_EGWWS(t - dt) + (Change_in_local_expenditure) * dt

INIT Local_expenditure__per_capita_EGWWS = 1.02

INFLOWS:

Change_in_local_expenditure =

(Indicated_Local_expenditure_per_capita-Local_expenditure__per_capita_EGWWS)/Time_to_adjust_LE

Productivity__EGWWS(t) = Productivity__EGWWS(t - dt) + (Change_in__productivity) * dt

INIT Productivity__EGWWS = 275

INFLOWS:

Change_in__productivity = (Productivity__EGWWS*Yearly_growth_in__productivity)

Capital__gains = Capital__share*Electricity_Gas_Water_and_Waste_Services__value_added

Capital__share = 1- MIN(1,Labour__share)

Cost_fraction = 0.47

Desired__employment_EGWWS = IF(Labour__share>1) THEN
EGWWS__value_added_demand/(Productivity__EGWWS*Labour__share)

ELSE EGWWS__value_added_demand/Productivity__EGWWS

EGWWS__value_added_demand = Revenue_EGWWS-Non_staff_expenses_and_costs

Electricity_Gas_Water_and_Waste_Services__value_added = Employed__EGWWS*Productivity__EGWWS

Exports_EGWWS = GRAPH(TIME)
(2002, 12670), (2002, 13493), (2003, 13477), (2004, 13495), (2005, 13793), (2006, 13828), (2007, 14281), (2008, 15279), (2009, 16169), (2010, 16327), (2011, 15919), (2012, 15124)

Indicated_Local_expenditure_per_capita =
Local_expenditure__per_capita_EGWWS* (1+GRP.Change_in_GRP)

Labour__share = Earnings/Productivity__EGWWS

Local_sales__EGWWS = Demographics.Total___Population*Local_expenditure__per_capita_EGWWS

Non_staff_expenses_and_costs = Revenue_EGWWS*Cost_fraction

Revenue_EGWWS = Local_sales__EGWWS+Exports_EGWWS

Time_to_adjust_LE = 1

Time_to_adjust__employment_EGWWS = 1

Yearly_growth_in__productivity = -0.015

Yearly_growth__in_earnings = -0.015

Construction (module)

Construction_value_added =
Building__construction.Building_Construction__value_added+Heavy_and_Civil_Engineering_Construction.Heavy_and_Civil_Engineering_Construction__value_added+Construction_services.Construction_services__value_added

Employed_construction =
Building__construction.Employed__BC+Heavy_and_Civil_Engineering_Construction.Employed__HCE+Construction_services.Employed__CS

Building construction (module)

Earnings(t) = Earnings(t - dt) + (Change_in_employees__earnings) * dt

INIT Earnings = 146

INFLOWS:

Change_in_employees__earnings = (Indicated__earnings-Earnings)/Earnings_AT

Employed__BC(t) = Employed__BC(t - dt) + (Change_in__employment_BC) * dt

INIT Employed__BC = 4294

INFLOWS:

Change_in__employment_BC =

(Desired__employment_BC-Employed__BC)/Time_to_adjust__employment_BC

Productivity__BC(t) = Productivity__BC(t - dt) + (Change_in__productivity) * dt

INIT Productivity__BC = 197

INFLOWS:

Change_in__productivity = (Indicated__productivity-Productivity__BC)/Productivity_AT

BC_value_added_demand = Revenue_BC-Non_staff_expenses_and_costs

Building_Construction__value_added = Employed__BC*Productivity__BC

Capital__gains = Capital__share*Building_Construction__value_added

Capital__share = 1- MIN(1,Labour__share)

Cost_fraction = 0.6

Desired__employment_BC = IF(Labour__share>1) THEN

BC_value_added_demand/(Productivity__BC*Labour__share) ELSE

BC_value_added_demand/Productivity__BC

Earnings_AT = 1

Indicated__earnings =

(((Productivity__BC/Earnings_AT)+Change_in__productivity)/Productivity__BC)*Earnings

Indicated__productivity = 130

Labour__share = Earnings/Productivity__BC

Local_expenditure_per_capita = GRAPH(TIME)

(2002, 7.69), (2003, 8.83), (2004, 8.96), (2005, 8.32), (2006, 8.12), (2007, 7.98), (2008, 7.81), (2009, 6.61), (2010, 5.92), (2011, 4.98), (2012, 4.69)

Local_sales__BC = Demographics.Total___Population*Local_expenditure_per_capita

Non_staff_expenses_and_costs = Revenue_BC*Cost_fraction

Productivity_AT = 3

Revenue_BC = Local_sales__BC

Time_to_adjust__employment_BC = 1

Construction services (module)

Earnings(t) = Earnings(t - dt) + (Change_in_employees__earnings) * dt
INIT Earnings = 52
INFLOWS:
Change_in_employees__earnings = Earnings*Yearly_growth_in_earnings

Employed__CS(t) = Employed__CS(t - dt) + (Change_in__employment_CS) * dt
INIT Employed__CS = 11991
INFLOWS:
Change_in__employment_CS = (Desired__employment_CS-Employed__CS)/Time_to_adjust__employment_CS

Productivity__CS(t) = Productivity__CS(t - dt) + (Change_in__productivity) * dt
INIT Productivity__CS = 62
INFLOWS:
Change_in__productivity = Yearly_growth__in_productivity*Productivity__CS

Capital__gains = Capital__share*Construction_services__value_added

Capital__share = 1- MIN(1,Labour__share)

Construction_services__value_added = Employed__CS*Productivity__CS

Cost_fraction = 0.57

CS_value_added_demand = Revenue_CS-Non_staff_expenses_and_costs

Desired__employment_CS = IF(Labour__share>1) THEN
CS_value_added_demand/(Productivity__CS*Labour__share) ELSE
CS_value_added_demand/Productivity__CS

Labour__share = Earnings/Productivity__CS

Local_expenditure_per_capita = GRAPH(TIME)
(2002, 4.70), (2003, 5.59), (2004, 5.91), (2005, 5.48), (2006, 5.60), (2007, 6.32), (2008, 6.74), (2009, 6.09), (2010, 7.11), (2011, 6.49), (2012, 5.33)

Local_sales__CS = Demographics.Total___Population*Local_expenditure_per_capita

Non_staff_expenses_and_costs = Revenue_CS*Cost_fraction

Revenue_CS = Local_sales__CS

Time_to_adjust__employment_CS = 3

Yearly_growth_in_earnings = -0.001

Yearly_growth__in_productivity = -0.001

Heavy and Civil Engineering Construction (module)

Earnings(t) = Earnings(t - dt) + (Change_in_employees__earnings) * dt
INIT Earnings = 54
INFLOWS:
Change_in_employees__earnings = Earnings*Yearly_growth_earnings

Employed__HCE(t) = Employed__HCE(t - dt) + (Change_in__employment_HCE) * dt
INIT Employed__HCE = 787
INFLOWS:
Change_in__employment_HCE =
(Desired__employment_HCE-Employed__HCE)/Time_to_adjust__employment_HCE

Productivity__HCE(t) = Productivity__HCE(t - dt) + (Change_in__productivity) * dt
INIT Productivity__HCE = 57
INFLOWS:
Change_in__productivity = Productivity__HCE*Yearly_growth_productivity

Capital__gains = Capital__share*Heavy_and_Civil_Engineering_Construction__value_added

Capital__share = 1- MIN(1,Labour__share)

Cost_fraction = 0.92

Desired__employment_HCE = IF(Labour__share>1) THEN HCE_value_added_demand/(Productivity__HCE*Labour__share) ELSE HCE_value_added_demand/Productivity__HCE

HCE_value_added_demand = Revenue_HCE-Non_staff_expenses_and_costs

Heavy_and_Civil_Engineering_Construction__value_added = Employed__HCE*Productivity__HCE

Labour__share = Earnings/Productivity__HCE

Local_expenditure_per_capita = GRAPH(TIME)
(2002, 1.83), (2003, 1.78), (2004, 2.08), (2005, 2.35), (2006, 2.79), (2007, 3.50), (2008, 3.89), (2009, 3.22), (2010, 4.41), (2011, 5.69), (2012, 5.16)

Local_sales__CS = Demographics.Total___Population*Local_expenditure_per_capita

Non_staff_expenses_and_costs = Revenue_HCE*Cost_fraction

Revenue_HCE = Local_sales__CS

Time_to_adjust__employment_HCE = 3

Yearly_growth_earnings = 0.14 + STEP(-0.14, 2012.5)

Yearly_growth_productivity = 0.14 + STEP(-0.14, 2012.5)

Wholesale trade (module)

Earnings(t) = Earnings(t - dt) + (Change_in_employees__earnings) * dt
INIT Earnings = 119
INFLOWS:
Change_in_employees__earnings = Earnings*Yearly_growth__in_earnings

Employed__WT(t) = Employed__WT(t - dt) + (Change_in__employment_WT) * dt
INIT Employed__WT = 3880
INFLOWS:
Change_in__employment_WT =
(Desired__employment_WT-Employed__WT)/Time_to_adjust__employment_WT

Local_expenditure__per_capita_WT(t) =
Local_expenditure__per_capita_WT(t - dt) + (Change_in_local_expenditure) * dt
INIT Local_expenditure__per_capita_WT = 4.5
INFLOWS:
Change_in_local_expenditure =

(Indicated_Local_expenditure_per_capita-Local_expenditure__per_capita_WT)/Time_to_adjust_LE

Productivity__WT(t) = Productivity__WT(t - dt) + (Change_in__productivity) * dt

INIT Productivity__WT = 158

INFLOWS:

Change_in__productivity = (Productivity__WT*Yearly_growth_in__productivity)

Capital__gains = Capital__share*Wholesale_trade__value_added

Capital__share = 1- MIN(1,Labour__share)

Cost_fraction = 0.55

Desired__employment_WT = IF(Labour__share>1) THEN
WT__value_added_demand/(Productivity__WT*Labour__share) ELSE
WT__value_added_demand/Productivity__WT

Exports_WT = GRAPH(TIME)
(2002, 260433), (2003, 201970), (2004, 144853), (2005, 180341), (2006, 224652), (2007, 224900), (2008, 165048), (2009, 118687), (2010, 101608), (2011, 47821), (2012, 67304)

Fraction_non_employees__expenses = 0.55

Indicated_Local_expenditure_per_capita = Local_expenditure__per_capita_WT* (1+GRP.Change_in_GRP)

Labour__share = Earnings/Productivity__WT

Local_sales__WT = Demographics.Total___Population*Local_expenditure__per_capita_WT

Non_staff_expenses_and_costs = Revenue_WT*Cost_fraction_1

Revenue_WT = Local_sales__WT+Exports_WT

Time_to_adjust_LE = 10

Time_to_adjust__employment_WT = 1

Wholesale_trade__value_added = Employed__WT*Productivity__WT

WT__value_added_demand = Revenue_WT-Non_staff_expenses_and_costs

Yearly_growth_in__productivity = 0.03

Yearly_growth__in_earnings = 0.03

Retail trade (module)

Earnings(t) = Earnings(t - dt) + (Change_in_employees__earnings) * dt

INIT Earnings = 45

INFLOWS:

Change_in_employees__earnings = Earnings*Yearly_growth__in_earnings

Employed__RT(t) = Employed__RT(t - dt) + (Change_in__employment_RT) * dt

INIT Employed__RT = 19059

INFLOWS:

Change_in__employment_RT =

(Desired__employment_RT-Employed__RT)/Time_to_adjust__employment_RT

Local_expenditure__per_capita_RT(t) =

Local_expenditure__per_capita_RT(t - dt) + (Change_in_local_expenditure) * dt

INIT Local_expenditure__per_capita_RT = 4

INFLOWS:

Change_in_local_expenditure =

(Indicated__Local_Expenditure-Local_expenditure__per_capita_RT)/Time_to_adjust_LE

Productivity__RT(t) = Productivity__RT(t - dt) + (Change_in__productivity) * dt

INIT Productivity__RT = 46

INFLOWS:

Change_in__productivity = (Productivity__RT*Yearly_growth_in__productivity)

Capital__gains = Capital__share*Retail_trade__value_added

Capital__share = 1- MIN(1,Labour__share)

Cost_fraction = 0.4

Day_trip_tourists_expenditure_on_RT =

Tourism__exports.DT_Total_days*Day_trip_tourist_expenditure_per_day_on_RT

Day_trip_tourist_expenditure_per_day_on_RT = GRAPH(time)

(2002, 0.027), (2003, 0.025), (2004, 0.019), (2005, 0.026), (2006, 0.034), (2007, 0.033), (2008, 0.032), (2009, 0.029), (2010, 0.029), (2011, 0.025), (2012, 0.028)

Desired__employment_RT = IF(Labour__share>1)

THEN Retail_trade__value_added_demand/(Productivity__RT*Labour__share)

ELSE Retail_trade__value_added_demand/Productivity__RT

Domestic_Overnight_expenditure_on_RT =
Tourism__exports.DO_Total_days*Domestic_overnight_tourist_expenditure_per_day_on_RT

Domestic_overnight_tourist_expenditure_per_day_on_RT = GRAPH(TIME)
(2002, 0.027), (2003, 0.025), (2004, 0.019), (2005, 0.026), (2006, 0.034), (2007, 0.033), (2008, 0.032), (2009, 0.029), (2010, 0.029), (2011, 0.025), (2012, 0.028)

Exports_RT =
Day_trip_tourists_expenditure_on_RT+Domestic_Overnight_expenditure_on_RT+International_tourists_expenditure_on_RT

Indicated__Local_Expenditure = Local_expenditure__per_capita_RT * (1 + GRP.Change_in_GRP)

International_tourists_expenditure_on_RT =
Tourism__exports.IO_Total_days*International_tourist_expenditure_per_day_on_RT

International_tourist_expenditure_per_day_on_RT = GRAPH(TIME)
(2002, 0.027), (2003, 0.025), (2004, 0.019), (2005, 0.026), (2006, 0.034), (2007, 0.033), (2008, 0.032), (2009, 0.029), (2010, 0.029), (2011, 0.025), (2012, 0.028)

Labour__share = Earnings/Productivity__RT

Local_sales__RT = Demographics.Total___Population*Local_expenditure__per_capita_RT

Non_staff_expenses_and_costs = Revenue_RT*Cost_fraction

Retail_trade__value_added = Employed__RT*Productivity__RT

Retail_trade__value_added_demand = Revenue_RT-Non_staff_expenses_and_costs

Revenue_RT = Local_sales__RT+Exports_RT

Time_to_adjust_LE = 1

Time_to_adjust__employment_RT = 1

Yearly_growth_in__productivity = 0.025

Yearly_growth__in_earnings = 0.025

Accommodation and food services (module)

Accommodation_and_food_services_value_added =
Food_and__beverages__services.Food_and_beverages_services__value_added+Accommodation.Accommodation__value_added

Employed_AFS = Food_and__beverages__services.Employed__FS+Accommodation.Employed__Ac

Accommodation (module)

Earnings(t) = Earnings(t - dt) + (Change_in_employees__earnings) * dt

INIT Earnings = 65

INFLOWS:

Change_in_employees__earnings = Earnings*Yearly_growth__in_earnings

Employed__Ac(t) = Employed__Ac(t - dt) + (Change_in__employment_Ac) * dt

INIT Employed__Ac = 3810

INFLOWS:

Change_in__employment_Ac =

(Desired__employment_Ac-Employed__Ac)/Time_to_adjust__employment_Ac

Local_expenditure__per_capita_Ac(t) =

Local_expenditure__per_capita_Ac(t - dt) + (Change_in_local_expenditure) * dt

INIT Local_expenditure__per_capita_Ac = 0.55

INFLOWS:

Change_in_local_expenditure =

(Indicated_Local_expenditure_per_capita-Local_expenditure__per_capita_Ac)/Time_to_adjust_LE

Productivity__Ac(t) = Productivity__Ac(t - dt) + (Change_in__productivity) * dt

INIT Productivity__Ac = 75

INFLOWS:

Change_in__productivity = (Productivity__Ac*Yearly_growth_in__productivity)

Accommodation__value_added = Employed__Ac*Productivity__Ac

Ac__value_added_demand = Revenue_Ac-Non_staff_expenses_and_costs

Capital__gains = Capital__share*Accommodation__value_added

Capital__share = 1- MIN(1,Labour__share)

Cost_fraction = 0.54

Desired__employment_Ac = IF(Labour__share>1) THEN

Ac__value_added_demand/(Productivity__Ac*Labour__share) ELSE

Ac__value_added_demand/Productivity__Ac

Exports_Ac = Tourism__exports.Demand_for_accommodation*Tourist_expenditure_per_day_on_FS

Indicated_Local_expenditure_per_capita = Local_expenditure__per_capita_Ac* (1+GRP.Change_in_GRP)

Labour__share = Earnings/Productivity__Ac

Local_sales__Ac = Demographics.Total___Population*Local_expenditure__per_capita_Ac

Non_staff_expenses_and_costs = Revenue_Ac*Cost_fraction_1

Revenue_Ac = Local_sales__Ac+Exports_Ac

Time_to_adjust_LE = 10

Time_to_adjust__employment_Ac = 1

Tourist_expenditure_per_day_on_FS = 0.05

Yearly_growth_in__productivity = 0.01

Yearly_growth__in_earnings = 0.01

Food and beverages services (module)

Earnings(t) = Earnings(t - dt) + (Change_in_employees__earnings) * dt
INIT Earnings = 42
INFLOWS:
Change_in_employees__earnings = (Indicated__earnings-Earnings)/Earnings_AT

Employed__FS(t) = Employed__FS(t - dt) + (Change_in__employment_FS) * dt
INIT Employed__FS = 8070
INFLOWS:
Change_in__employment_FS = (Desired__employment_FS-Employed__FS)/Time_to_adjust__employment_FS

Local_expenditure__per_capita_FS(t) =
Local_expenditure__per_capita_FS(t - dt) + (Change_in_local_expenditure) * dt
INIT Local_expenditure__per_capita_FS = 2
INFLOWS:
Change_in_local_expenditure = (Indicated_Local_expenditure_per_capita-
Local_expenditure__per_capita_FS)/Time_to_adjust_LE

Productivity__FS(t) = Productivity__FS(t - dt) + (Change_in__productivity) * dt
INIT Productivity__FS = 45
INFLOWS:

Change_in__productivity = (Indicated_productivity-Productivity__FS)/Productivity_AT

Capital__gains = Capital__share*Food_and_beverages_services__value_added

Capital__share = 1- MIN(1,Labour__share)

Cost_fraction = 0.63

Day_trip_tourist_expenditure_per_day_on_FS = GRAPH(TIME)
(2002, 0.03), (2003, 0.03), (2004, 0.029), (2005, 0.032), (2006, 0.03), (2007, 0.031), (2008, 0.025), (2009, 0.021), (2010, 0.025), (2011, 0.025), (2012, 0.026)

Day_trip_turists_expenditure_on_FS =
Tourism__exports.DT_Total_days*Day_trip_tourist_expenditure_per_day_on_FS
Desired__employment_FS = IF(Labour__share>1) THEN
FS__value_added_demand/(Productivity__FS*Labour__share) ELSE
FS__value_added_demand/Productivity__FS

Domestic_Overnight_expenditure_on_FS =
Domestic_overnight_tourist_expenditure_per_day_on_FS*Tourism__exports.DO_Total_days

Domestic_overnight_tourist_expenditure_per_day_on_FS = GRAPH(time)
(2002, 0.03), (2003, 0.03), (2004, 0.029), (2005, 0.032), (2006, 0.03), (2007, 0.031), (2008, 0.025), (2009, 0.021), (2010, 0.025), (2011, 0.025), (2012, 0.026)

Earnings_AT = 1

Exports_FS =
Day_trip_turists_expenditure_on_FS+Domestic_Overnight_expenditure_on_FS+International_turists_expenditure_on_FS

Food_and_beverages_services__value_added = Employed__FS*Productivity__FS

FS__value_added_demand = Revenue_FS-Non_staff_expenses_and_costs

Indicated_Local_expenditure_per_capita = Local_expenditure__per_capita_FS* (1+GRP.Change_in_GRP)

Indicated_productivity = 34

Indicated__earnings =
(((Productivity__FS/Earnings_AT)+Change_in__productivity)/Productivity__FS)*Earnings

International_tourist_expenditure_per_day_on_FS = 0.029

International_turists_expenditure_on_FS =
Tourism__exports.IO_Total_days*International_tourist_expenditure_per_day_on_FS

Labour__share = Earnings/Productivity__FS

Local_sales__FS = Demographics.Total___Population*Local_expenditure__per_capita_FS

Non_staff_expenses_and_costs = Revenue_FS*Cost_fraction

Productivity_AT = 3

Revenue_FS = Local_sales__FS+Exports_FS

Time_to_adjust_LE = 10

Time_to_adjust__employment_FS = 1

TRANSPORT, POSTAL AND WAREHOUSING (MODULE)

Earnings(t) = Earnings(t - dt) + (Change_in_employees__earnings) * dt
INIT Earnings = 79
INFLOWS:
Change_in_employees__earnings = Earnings*Yearly_growth__in_earnings

Employed__TPW(t) = Employed__TPW(t - dt) + (Change_in__employment_TPW) * dt
INIT Employed__TPW = 3997
INFLOWS:
Change_in__employment_TPW =
(Desired__employment_TPW-Employed__TPW)/Time_to_adjust__employment_TPW

Local_expenditure__per_capita_TPW(t) =
Local_expenditure__per_capita_TPW(t - dt) + (Change_in_local_expenditure) * dt
INIT Local_expenditure__per_capita_TPW = 2.6
INFLOWS:
Change_in_local_expenditure =
(Indicated_Local_Expenditure-Local_expenditure__per_capita_TPW)/Time_to_adjust_LE

Productivity__TPW(t) = Productivity__TPW(t - dt) + (Change_in__productivity) * dt
INIT Productivity__TPW = 87
INFLOWS:
Change_in__productivity = (Productivity__TPW*Yearly_growth_in__productivity)

Capital__gains = Capital__share*Transport_postal_and_warehousing_value_added

Capital__share = 1- MIN(1,Labour__share)

Cost_fraction = 0.58

Desired__employment_TPW = IF(Labour__share>1) THEN
TPW__value_added_demand/(Productivity__TPW*Labour__share) ELSE
TPW__value_added_demand/Productivity__TPW

Expenditure_fraction__on_local_TPW = 2.3

Exports_TPW = GRAPH(TIME)
(2001, 158027), (2002, 150561), (2003, 102545), (2004, 101407), (2005, 128912), (2006, 176689), (2007, 178159), (2008, 194864), (2009, 168594), (2010, 154708), (2011, 223658), (2012, 216150)

Indicated_Local_Expenditure = Local_expenditure__per_capita_TPW*(1+GRP.Change_in_GRP)

Labour__share = Earnings/Productivity__TPW

Local_sales__TPW = Demographics.Total___Population*Local_expenditure__per_capita_TPW

Non_staff_expenses_and_costs = Revenue_TPW*Cost_fraction

Revenue_TPW = Local_sales__TPW+Exports_TPW

Time_to_adjust_LE = 1

Time_to_adjust__employment_TPW = 1

TPW__value_added_demand = Revenue_TPW-Non_staff_expenses_and_costs

Transport_postal_and_warehousing_value_added = Employed__TPW*Productivity__TPW

Yearly_growth_in__productivity = 0.01

Yearly_growth__in_earnings = 0.01

INFORMATION, MEDIA AND TELECOMMUNICATIONS (MODULE)

Earnings(t) = Earnings(t - dt) + (Change_in_employees__earnings) * dt
INIT Earnings = 122
INFLOWS:
Change_in_employees__earnings = Earnings*Yearly_growth__in_earnings

Employed__IMT(t) = Employed__IMT(t - dt) + (Change_in__employment_IMT) * dt
INIT Employed__IMT = 1556

INFLOWS:

Change_in__employment_IMT =

(Desired__employment_IMT-Employed__IMT)/Time_to_adjust__employment_IMT

Local_expenditure__per_capita_TPW(t) =

Local_expenditure__per_capita_TPW(t - dt) + (Change_in_local_expenditure) * dt

INIT Local_expenditure__per_capita_TPW = 1.35

INFLOWS:

Change_in_local_expenditure =

(Indicated_Local_expenditure_per_capita-Local_expenditure__per_capita_TPW)/Time_to_adjust_LE

Productivity__IMT(t) = Productivity__IMT(t - dt) + (Change_in__productivity) * dt

INIT Productivity__IMT = 140

INFLOWS:

Change_in__productivity = (Productivity__IMT*Yearly_growth_in__productivity)

Capital__gains = Capital__share*Information_Media_and_telecommunications__value_added

Capital__share = 1- MIN(1,Labour__share)

Cost_fraction = 0.5

Desired__employment_IMT = IF(Labour__share>1) THEN

IMT__value_added_demand/(Productivity__IMT*Labour__share) ELSE

IMT__value_added_demand/Productivity__IMT

Exports_IMT = GRAPH(TIME)

(2002, 72900), (2002, 80297), (2003, 73962), (2004, 73632), (2005, 90765), (2006, 118080), (2007, 124504), (2008, 122377), (2009, 89364), (2010, 75748), (2011, 109442), (2012, 108384)

IMT__value_added_demand = Revenue_IMT-Non_staff_expenses_and_costs

Indicated_Local_expenditure_per_capita = Local_expenditure__per_capita_TPW* (1+ GRP.Change_in_GRP)

Information_media_and_telecommunications__value_added = Employed__IMT*Productivity__IMT

Labour__share = Earnings/Productivity__IMT

Local_sales__IMT = Demographics.Total___Population*Local_expenditure__per_capita_TPW

Non_staff_expenses_and_costs = Revenue_IMT*Cost_fraction

Revenue_IMT = Local_sales__IMT+Exports_IMT

Time_to_adjust_LE = 10

Time_to_adjust__employment_IMT = 1

Yearly_growth_in__productivity = 0.001

Yearly_growth__in_earnings = 0.001

FINANCIAL AND INSURANCE SERVICES (MODULES)

Earnings(t) = Earnings(t - dt) + (Change_in_employees__earnings) * dt

INIT Earnings = 103

INFLOWS:

Change_in_employees__earnings = Earnings*Yearly_growth__in_earnings

Employed__FIS(t) = Employed__FIS(t - dt) + (Change_in__employment_FIS) * dt

INIT Employed__FIS = 3046

INFLOWS:

Change_in__employment_FIS =

(Desired__employment_FIS-Employed__FIS)/Time_to_adjust__employment_FIS

Local_expenditure__per_capita_FIS(t) =

Local_expenditure__per_capita_FIS(t - dt) + (Change_in_local_expenditure) * dt

INIT Local_expenditure__per_capita_FIS = 3.2

INFLOWS:

Change_in_local_expenditure =

(Indicated_Local_expenditure_per_capita-Local_expenditure__per_capita_FIS)/Time_to_adjust_LE

Productivity__FIS(t) = Productivity__FIS(t - dt) + (Change_in__productivity) * dt

INIT Productivity__FIS = 181

INFLOWS:

Change_in__productivity = (Productivity__FIS*Yearly_growth_in__productivity)

Capital__gains = Capital__share*Financial_Insurances_services__value_added

Capital__share = 1- MIN(1,Labour__share)

Cost_fraction = 0.32

Desired__employment_FIS = IF(Labour__share>1) THEN

FIS__value_added_demand/(Productivity__FIS*Labour__share) ELSE

FIS__value_added_demand/Productivity__FIS

Exports_FIS = GRAPH(TIME)

(2002, 39640), (2003, 43529), (2004, 47406), (2005, 55952), (2006, 65822), (2007, 73014), (2008, 88284), (2009, 97573), (2010, 98467), (2011, 99137), (2012, 102675), (2013, 109626)

Financial_Insurances_services__value_added = Employed__FIS*Productivity__FIS

FIS__value_added_demand = Revenue_FIS-Non_staff_expenses_and_costs

Indicated_Local_expenditure_per_capita = Local_expenditure__per_capita_FIS* (1+GRP.Change_in_GRP)

Labour__share = Earnings/Productivity__FIS

Local_sales__FIS = Demographics.Total___Population*Local_expenditure__per_capita_FIS

Non_staff_expenses_and_costs = Revenue_FIS*Cost_fraction

Revenue_FIS = Local_sales__FIS+Exports_FIS

Time_to_adjust_LE = 1

Time_to_adjust__employment_FIS = 3

Yearly_growth_in__productivity = 0.04

Yearly_growth__in_earnings = 0.04

RENTAL HIRING AND REAL ESTATE SERVICES (module)

Earnings(t) = Earnings(t - dt) + (Change_in_employees__earnings) * dt
INIT Earnings = 87
INFLOWS:
Change_in_employees__earnings = Earnings*Yearly_growth__in_earnings

Employed__RHRSS(t) = Employed__RHRSS(t - dt) + (Change_in__employment_RHRSS) * dt
INIT Employed__RHRSS = 4079
INFLOWS:
Change_in__employment_RHRSS =
(Desired__employment_RHRSS-Employed__RHRSS)/Time_to_adjust__employment_RHRSS

Local_expenditure__per_capita_RHRSS(t) =
Local_expenditure__per_capita_RHRSS(t - dt) + (Change_in_local_expenditure) * dt
INIT Local_expenditure__per_capita_RHRSS = 0.5
INFLOWS:
Change_in_local_expenditure =
(Indicated_Local_expenditure_per_capita-Local_expenditure__per_capita_RHRSS)/Time_to_adjust_LE

Productivity__RHRSS(t) = Productivity__RHRSS(t - dt) + (Change_in__productivity) * dt

INIT Productivity__RHRSS = 122

INFLOWS:

Change_in__productivity = (Productivity__RHRSS*Yearly_growth_in__productivity)

Capital__gains = Capital__share*Rental_Hiring_and_Real_Estate_Services__value_added

Capital__share = 1- MIN(1,Labour__share)

Cost_fraction = 0.4

Desired__employment_RHRSS = IF(Labour__share>1) THEN RHRSS__value_added_demand/(Productivity__RHRSS*Labour__share) ELSE RHRSS__value_added_demand/Productivity__RHRSS

Exports_RHRSS = GRAPH(TIME)
(2001, 433601), (2002, 492187), (2003, 632995), (2004, 738195), (2005, 836842), (2006, 923937), (2007, 915766), (2008, 798054), (2009, 728331), (2010, 684114), (2011, 684262), (2012, 726133)

Indicated_Local_expenditure_per_capita = Local_expenditure__per_capita_RHRSS* (1+GRP.Change_in_GRP)

Labour__share = Earnings/Productivity__RHRSS

Local_sales__RHRSS = Demographics.Total___Population*Local_expenditure__per_capita_RHRSS

Non_staff_expenses_and_costs = Revenue_RHRSS*Cost_fraction

Rental_Hiring_and_Real_Estate_Services__value_added = Employed__RHRSS*Productivity__RHRSS

Revenue_RHRSS = Local_sales__RHRSS+Exports_RHRSS

RHRSS__value_added_demand = Revenue_RHRSS-Non_staff_expenses_and_costs

Time_to_adjust_LE = 10

Time_to_adjust__employment_RHRSS = 1

Yearly_growth_in__productivity = -0.015

Yearly_growth__in_earnings = -0.015

PROFESSIONAL, SCIENTIFIC AND TECHNICAL SERVICES (module)

Earnings(t) = Earnings(t - dt) + (Change_in_employees__earnings) * dt

INIT Earnings = 98

INFLOWS:

Change_in_employees__earnings =

(Indicated__earnings-Earnings)/Earnings_AT

Employed_PSTS(t) = Employed_PSTS(t - dt) + (Change_in__employment_PSTS) * dt

INIT Employed_PSTS = 4936

INFLOWS:

Change_in__employment_PSTS =

(Desired__employment_PSTS-Employed_PSTS)/Time_to_adjust__employment_PSTS

Local_expenditure__per_capita_PSTS(t) =

Local_expenditure__per_capita_PSTS(t - dt) + (Change_in_local_expenditure) * dt

INIT Local_expenditure__per_capita_PSTS = 5.5

INFLOWS:

Change_in_local_expenditure =

(Indicated_Local_expenditure_per_capita-Local_expenditure__per_capita_PSTS)/Time_to_adjust_LE

Productivity__PSTS(t) = Productivity__PSTS(t - dt) + (Change_in__productivity) * dt

INIT Productivity__PSTS = 119

INFLOWS:

Change_in__productivity = (Indicated__productivity-Productivity__PSTS)/Productivity_AT

Capital__gains = Capital__share*Professional_scientific_and_technical_services__value_added

Capital__share = 1- MIN(1,Labour__share)

Cost_fraction = 0.55

Desired__employment_PSTS = IF(Labour__share>1) THEN

PSTS__value_added_demand/(Productivity__PSTS*Labour__share) ELSE

PSTS__value_added_demand/Productivity__PSTS

Earnings_AT = 1

Exports_PSTS = GRAPH(TIME)

(2002, 8127), (2003, 9250), (2004, 10183), (2005, 11512), (2006, 12356), (2007, 13218), (2008, 29004), (2009, 26574), (2010, 28681), (2011, 15475), (2012, 15647), (2013, 16214)

Indicated_Local_expenditure_per_capita = Local_expenditure__per_capita_PSTS* (1+GRP.Change_in_GRP)

Indicated__earnings =

(((Productivity__PSTS/Earnings_AT)+Change_in__productivity)/Productivity__PSTS)*Earnings

Indicated__productivity = 80

Labour__share = Earnings/Productivity__PSTS

Local_sales__PSTS = Demographics.Total___Population*Local_expenditure__per_capita_PSTS

Non_staff_expenses_and_costs = Revenue_PSTS*Cost_fraction

Productivity_AT = 4

Professional_scientific_and_technical_services__value_added = Employed_PSTS*Productivity__PSTS

PSTS__value_added_demand = Revenue_PSTS-Non_staff_expenses_and_costs

Revenue_PSTS = Local_sales__PSTS+Exports_PSTS

Time_to_adjust_LE = 1.5

Time_to_adjust__employment_PSTS = 1

ADMINISTRATIVE AND SUPPORT SERVICES (MODULE)

Earnings(t) = Earnings(t - dt) + (Change_in_employees__earnings) * dt
INIT Earnings = 53
INFLOWS:
Change_in_employees__earnings = Earnings*Yearly_growth__in_earnings

Employed_AdSS(t) = Employed_AdSS(t - dt) + (Change_in__employment_AdSS) * dt
INIT Employed_AdSS = 4496
INFLOWS:
Change_in__employment_AdSS =
(Desired__employment_AdSS-Employed_AdSS)/Time_to_adjust__employment_AdSS

Local_expenditure__per_capita_AdSS(t) =
Local_expenditure__per_capita_AdSS(t - dt) + (Change_in_local_expenditure) * dt
INIT Local_expenditure__per_capita_AdSS = 2.1
INFLOWS:
Change_in_local_expenditure =
(Indicated_Local_expenditure_per_capita-Local_expenditure__per_capita_AdSS)/Time_to_adjust_LE

Productivity__AdSS(t) = Productivity__AdSS(t - dt) + (Change_in__productivity) * dt
INIT Productivity__AdSS = 58
INFLOWS:
Change_in__productivity = (Productivity__AdSS*Yearly_growth_in__productivity)

Administrative_and_Support_Services_value_added = Employed_AdSS*Productivity__AdSS

AdSS__value_added_demand = Revenue_AdSS-Non_staff_expenses_and_costs

Capital__gains = Capital__share*Administrative_and_Support_Services_services__value_added

Capital__share = 1- MIN(1,Labour__share)

Cost_fraction = 0.52

Desired__employment_AdSS = IF(Labour__share>1) THEN
AdSS__value_added_demand/(Productivity__AdSS*Labour__share) ELSE
AdSS__value_added_demand/Productivity__AdSS

Exports_AdSS = GRAPH(TIME)
(2001, 4288), (2002, 4784), (2003, 5309), (2004, 5557), (2005, 5785), (2006, 5903), (2007, 6316), (2008, 6665), (2009, 6175), (2010, 5761), (2011, 6141), (2012, 6002)

Indicated_Local_expenditure_per_capita = Local_expenditure__per_capita_AdSS* (1+GRP.Change_in_GRP)

Labour__share = Earnings/Productivity__AdSS

Local_sales__AdSS = Demographics.Total___Population*Local_expenditure__per_capita_AdSS

Non_staff_expenses_and_costs = Revenue_AdSS*Cost_fraction

Revenue_AdSS = Local_sales__AdSS+Exports_AdSS

Time_to_adjust_LE = 10

Time_to_adjust__employment_AdSS = 2

Yearly_growth_in__productivity = 0.001

Yearly_growth__in_earnings = 0.001

PUBLIC AND ADMINISTRATION SERVICES (MODULE)

Earnings(t) = Earnings(t - dt) + (Change_in_employees__earnings) * dt
INIT Earnings = 74
INFLOWS:
Change_in_employees__earnings = Earnings*Yearly_growth__in_earnings

Employed_PAS(t) = Employed_PAS(t - dt) + (Change_in__employment_PAS) * dt
INIT Employed_PAS = 5122
INFLOWS:
Change_in__employment_PAS =

(Desired__employment_PAS-Employed_PAS)/Time_to_adjust__employment_PAS

Local_expenditure__per_capita_PAS(t) =
Local_expenditure__per_capita_PAS(t - dt) + (Change_in_local_expenditure) * dt
INIT Local_expenditure__per_capita_PAS = 2.6
INFLOWS:
Change_in_local_expenditure =
(Indicated_Local_expenditure_per_capita-Local_expenditure__per_capita_PAS)/Time_to_adjust_LE

Productivity__PAS(t) = Productivity__PAS(t - dt) + (Change_in__productivity) * dt
INIT Productivity__PAS = 83
INFLOWS:
Change_in__productivity = (Productivity__PAS*Yearly_growth_in__productivity)

Capital__gains = Capital__share*Public_Administration_and_Safety__value_added

Capital__share = 1- MIN(1,Labour__share)

Cost_fraction = 0.43

Desired__employment_PAS = IF(Labour__share>1) THEN
PAS__value_added_demand/(Productivity__PAS*Labour__share) ELSE
PAS__value_added_demand/Productivity__PAS

Exports_PAS = GRAPH(TIME)
(2001, 7576), (2002, 8312), (2003, 9122), (2004, 9522), (2005, 9680), (2006, 9361), (2007, 9702), (2008, 9821),
(2009, 10111), (2010, 10109), (2011, 10391), (2012, 10487)

Indicated_Local_expenditure_per_capita = Local_expenditure__per_capita_PAS* (1+GRP.Change_in_GRP)

Labour__share = Earnings/Productivity__PAS

Local_sales__PAS = Demographics.Total___Population*Local_expenditure__per_capita_PAS

Non_staff_expenses_and_costs = Revenue_PAS*Cost_fraction

PAS__value_added_demand = Revenue_PAS-Non_staff_expenses_and_costs

Public_Administration_and_Safety__value_added = Employed_PAS*Productivity__PAS

Revenue_PAS = Local_sales__PAS+Exports_PAS

Time_to_adjust_LE = 10

Time_to_adjust__employment_PAS = 1

Yearly_growth_in__productivity = 0.03

Yearly_growth__in_earnings = 0.03

EDUCATION AND TRAINING (MODULE)

Education_and_training_value_added = Preschool_and_school__education.Preschool_and_school_education__value_added+Tertiary__education.Tertiary_education__value_added+Adult_community_and_other_education.Adult_Community_and_other_education__value_added

Employees_education_and_training = Preschool_and_school__education.Employed__PS+Tertiary__education.Employed__TE+Adult_community_and_other_education.Employed__ACO

ADULT COMMUNITY AND OTHER EDUCATION (MODULE)

Earnings(t) = Earnings(t - dt) + (Change_in_employees__earnings) * dt
INIT Earnings = 30
INFLOWS:
Change_in_employees__earnings = (Indicated__earnings-Earnings)/Earnings_AT

Employed__ACO(t) = Employed__ACO(t - dt) + (Change_in__employment_ACO) * dt
INIT Employed__ACO = 1038
INFLOWS:
Change_in__employment_ACO =
(Desired__employment_ACO-Employed__ACO)/Time_to_adjust__employment_ACO

Local_expenditure__per_capita_ACO(t) =
Local_expenditure__per_capita_ACO(t - dt) + (Change_in_local_expenditure) * dt
INIT Local_expenditure__per_capita_ACO = 0.22
INFLOWS:
Change_in_local_expenditure =
(Indicated_Local_expenditure_per_capita-Local_expenditure__per_capita_ACO)/Time_to_adjust_LE

Productivity__ACO(t) = Productivity__ACO(t - dt) + (Change_in__productivity) * dt
INIT Productivity__ACO = 33
INFLOWS:
Change_in__productivity =
(Indicated_productivity-Productivity__ACO)/Productivity_AT

ACO_value_added_demand = Revenue_ACO-Non_staff_expenses_and_costs

Adult_Community_and_other_education__value_added = Employed__ACO*Productivity__ACO

Capital__gains = Capital__share*Adult_Community_and_other_education__value_added

Capital__share = 1- MIN(1,Labour__share)

Cost_fraction = 0.22

Desired__employment_ACO = IF(Labour__share>1) THEN
ACO_value_added_demand/(Productivity__ACO*Labour__share) ELSE
ACO_value_added_demand/Productivity__ACO

Earnings_AT = 1

Exports_ACO = GRAPH(TIME)
(2001, 7785), (2002, 7713), (2003, 8335), (2004, 8818), (2005, 8981), (2006, 9210), (2007, 8778), (2008, 9286), (2009, 10119), (2010, 11576), (2011, 12011), (2012, 10251)

Indicated_Local_expenditure_per_capita = Local_expenditure__per_capita_ACO* (1+GRP.Change_in_GRP)

Indicated_productivity = 29

Indicated__earnings =
(((Productivity__ACO/Earnings_AT)+Change_in__productivity)/Productivity__ACO)*Earnings

Labour__share = Earnings/Productivity__ACO

Local_sales__ACO = Demographics.Total___Population*Local_expenditure__per_capita_ACO

Non_staff_expenses_and_costs = Revenue_ACO*Cost_fraction

Productivity_AT = 1

Revenue_ACO = Local_sales__ACO+Exports_ACO

Time_to_adjust_LE = 1

Time_to_adjust__employment_ACO = 3

PRESCHOOL AND SCHOOL EDUCATION (MODULE)

Earnings(t) = Earnings(t - dt) + (Change_in_employees__earnings) * dt
INIT Earnings = 57
INFLOWS:

Change_in_employees__earnings = Earnings*Yearly_growth__in_earnings

Employed__PS(t) = Employed__PS(t - dt) + (Change_in__employment_PS) * dt

INIT Employed__PS = 6447

INFLOWS:

Change_in__employment_PS =

(Desired__employment_PS-Employed__PS)/Time_to_adjust__employment_WT

Local_expenditure__per_student(t) =

Local_expenditure__per_student(t - dt) + (Change_in_local_expenditure) * dt

INIT Local_expenditure__per_student = 10

INFLOWS:

Change_in_local_expenditure =

(Indicated_Local_expenditure_per_capita-Local_expenditure__per_student)/Time_to_adjust_LE

Productivity__PS(t) = Productivity__PS(t - dt) + (Change_in__productivity) * dt

INIT Productivity__PS = 65

INFLOWS:

Change_in__productivity = (Productivity__PS*Yearly_growth_in__productivity)

Capital__gains = Capital__share*Preschool_and_school_education__value_added

Capital__share = 1- MIN(1,Labour__share)

Cost_fraction = 0.25

Desired__employment_PS =

IF(Labour__share>1) THEN PS_value_added_demand/(Productivity__PS*Labour__share) ELSE

PS_value_added_demand/Productivity__PS

Exports_PS = GRAPH(TIME)

(2002, 36939), (2002, 45865), (2003, 40222), (2004, 28531), (2005, 38790), (2006, 33849), (2007, 45526), (2008, 44221), (2009, 41109), (2010, 64876), (2011, 33325), (2012, 32338)

Indicated_Local_expenditure_per_capita = Local_expenditure__per_student* (1+GRP.Change_in_GRP)

Labour__share = Earnings/Productivity__PS

Local_sales__PS = Students*Local_expenditure__per_student

Non_staff_expenses_and_costs = Revenue_PS*Cost_fraction

Preschool_and_school_education__value_added = Employed__PS*Productivity__PS

PS_value_added_demand = Revenue_PS-Non_staff_expenses_and_costs

Revenue_PS = Local_sales__PS+Exports_PS

Students =
(Demographics.Children_0_to_4 * 0.2 * 0.86)+Demographics.Children_5_to_9+Demographics.Children_10_to_14 + (Demographics.Adults_15_to_19 * 0.5)

Time_to_adjust_LE = 1

Time_to_adjust__employment_WT = 5

Yearly_growth_in__productivity = 0.015

Yearly_growth__in_earnings = 0.015

TERTIARY EDUCATION (MODULE)

Earnings(t) = Earnings(t - dt) + (Change_in_employees__earnings) * dt
INIT Earnings = 58
INFLOWS:
Change_in_employees__earnings = (Indicated__earnings-Earnings)/Earnings_AT

Employed__TE(t) = Employed__TE(t - dt) + (Change_in__employment_TE) * dt
INIT Employed__TE = 1557
INFLOWS:
Change_in__employment_TE =
(Desired__employment_TE-Employed__TE)/Time_to_adjust__employment_TE

Local_expenditure__per_capita_TE(t) =
Local_expenditure__per_capita_TE(t - dt) + (Change_in_local_expenditure) * dt
INIT Local_expenditure__per_capita_TE = 0.47
INFLOWS:
Change_in_local_expenditure =
(Indicated_Local_expenditure_per_capita-Local_expenditure__per_capita_TE)/Time_to_adjust_LE

Productivity__TE(t) = Productivity__TE(t - dt) + (Change_in__productivity) * dt
INIT Productivity__TE = 65
INFLOWS:
Change_in__productivity =

(Indicated_productivity-Productivity__TE)/Productivity_AT

Capital__gains = Capital__share*Tertiary_education__value_added

Capital__share = 1- MIN(1,Labour__share)

Cost_fraction = 0.26

Desired__employment_TE =
IF(Labour__share>1) THEN TE__value_added_demand/(Productivity__TE*Labour__share) ELSE
TE__value_added_demand/Productivity__TE

Earnings_AT = 1

Exports_TE = GRAPH(TIME)
(2002, 10590), (2002, 11039), (2003, 18450), (2004, 22249), (2005, 24063), (2006, 16418), (2007, 16651), (2008, 16278), (2009, 17007), (2010, 14316), (2011, 14174), (2012, 14833)

Indicated_Local_expenditure_per_capita = Local_expenditure__per_capita_TE* (1+GRP.Change_in_GRP)

Indicated_productivity = 62

Indicated__earnings =
(((Productivity__TE/Earnings_AT)+Change_in__productivity)/Productivity__TE)*Earnings

Labour__share = Earnings/Productivity__TE

Local_sales__TE = Demographics.Total___Population*Local_expenditure__per_capita_TE

Non_staff_expenses_and_costs = Revenue_TE*Cost_fraction

Productivity_AT = 5

Revenue_TE = Local_sales__TE+Exports_TE

Tertiary_education__value_added = Employed__TE*Productivity__TE

TE__value_added_demand = Revenue_TE-Non_staff_expenses_and_costs

Time_to_adjust_LE = 10

Time_to_adjust__employment_TE = 1

HEALTH CARE AND SOCIAL ASSISTANCE (MODULE)

Earnings(t) = Earnings(t - dt) + (Change_in_employees__earnings) * dt

INIT Earnings = 60

INFLOWS:

Change_in_employees__earnings = Earnings*Yearly_growth__in_earnings

Employed__HCSA(t) = Employed__HCSA(t - dt) + (Change_in__employment_HCSA) * dt

INIT Employed__HCSA = 14037

INFLOWS:

Change_in__employment_HCSA =

(Desired__employment_HCSA-Employed__HCSA)/Time_to_adjust__employment_HCSA

Local_expenditure__per_capita_HCSA(t) =

Local_expenditure__per_capita_HCSA(t - dt) + (Change_in_local_expenditure) * dt

INIT Local_expenditure__per_capita_HCSA = 3.5

INFLOWS:

Change_in_local_expenditure =

(Indicated_Local_expenditure_per_capita-Local_expenditure__per_capita_HCSA)/Time_to_adjust_LE

Productivity__HCSA(t) = Productivity__HCSA(t - dt) + (Change_in__productivity) * dt

INIT Productivity__HCSA = 61

INFLOWS:

Change_in__productivity = (Productivity__HCSA*Yearly_growth_in__productivity)

Capital__gains = Capital__share*Health_care_and_social_assistance__value_added

Capital__share = 1- MIN(1,Labour__share)

Cost_fraction = 0.2

Desired__employment_HCSA =

IF(Labour__share>1) THEN HCSA__value_added_demand/(Productivity__HCSA*Labour__share) ELSE HCSA__value_added_demand/Productivity__HCSA

Exports_HCSA = GRAPH(TIME)

(2002, 133675), (2002, 138664), (2003, 145727), (2004, 145052), (2005, 158859), (2006, 152268), (2007, 162825), (2008, 171109), (2009, 176348), (2010, 183484), (2011, 176720), (2012, 201671)

HCSA__value_added_demand = Revenue_HCSA-Non_staff_expenses_and_costs

Health_care_and_social_assistance__value_added = Employed__HCSA*Productivity__HCSA

Indicated_Local_expenditure_per_capita = Local_expenditure__per_capita_HCSA* (1+GRP.Change_in_GRP)

Labour__share = Earnings/Productivity__HCSA

Local_sales__HCSA = Demographics.Total___Population*Local_expenditure__per_capita_HCSA

Non_staff_expenses_and_costs = Revenue_HCSA*Cost_fraction

Revenue_HCSA = Local_sales__HCSA+Exports_HCSA

Time_to_adjust_LE = 2

Time_to_adjust__employment_HCSA = 1

Yearly_growth_in__productivity = -0.001

Yearly_growth__in_earnings = -0.001

ART AND RECREATION SERVICES (MODULE)

Earnings(t) = Earnings(t - dt) + (Change_in_employees__earnings) * dt

INIT Earnings = 27

INFLOWS:

Change_in_employees__earnings = Earnings*Yearly_growth__in_earnings

Employed__ARS(t) = Employed__ARS(t - dt) + (Change_in__employment_ARS) * dt

INIT Employed__ARS = 2571

INFLOWS:

Change_in__employment_ARS =

(Desired__employment_ARS-Employed__ARS)/Time_to_adjust__employment_ARS

Local_expenditure__per_capita_ARS(t) =

Local_expenditure__per_capita_ARS(t - dt) + (Change_in_local_expenditure) * dt

INIT Local_expenditure__per_capita_ARS = 1

INFLOWS:

Change_in_local_expenditure =

(Indicated_Local_expenditure_per_capita-Local_expenditure__per_capita_ARS)/Time_to_adjust_LE

Productivity__ARS(t) = Productivity__ARS(t - dt) + (Change_in__productivity) * dt

INIT Productivity__ARS = 31

INFLOWS:

Change_in__productivity = (Productivity__ARS*Yearly_growth_in__productivity)

ARS__value_added_demand = Revenue_ARS-Non_staff_expenses_and_costs

Art_and_Recreation_Services__value_added = Employed__ARS*Productivity__ARS

Capital__gains = Capital__share*Art_and_Recreation_services__value_added

Capital__share = 1- MIN(1,Labour__share)

Cost_fraction = 0.64

Desired__employment_ARS = IF(Labour__share>1) THEN
ARS__value_added_demand/(Productivity__ARS*Labour__share) ELSE
ARS__value_added_demand/Productivity__ARS

Exports_ARS = GRAPH(TIME)
(2001, 7811), (2002, 7444), (2003, 29741), (2004, 31842), (2005, 21212), (2006, 10808), (2007, 20685), (2008, 16490), (2009, 14816), (2010, 13585), (2011, 7256), (2012, 8707)

Indicated_Local_expenditure_per_capita = Local_expenditure__per_capita_ARS* (1+GRP.Change_in_GRP)

Labour__share = Earnings/Productivity__ARS

Local_sales__ARS = Demographics.Total___Population*Local_expenditure__per_capita_ARS

Non_staff_expenses_and_costs = Revenue_ARS*Cost_fraction

Revenue_ARS = Local_sales__ARS+Exports_ARS

Time_to_adjust_LE = 10

Time_to_adjust__employment_ARS = 1

Yearly_growth_in__productivity = 0.02

Yearly_growth__in_earnings = 0.02

OTHER SERVICES (MODULE)

Earnings(t) = Earnings(t - dt) + (Change_in_employees__earnings) * dt
INIT Earnings = 41
INFLOWS:
Change_in_employees__earnings = Earnings*Yearly_growth__in_earnings

Employed__OS(t) = Employed__OS(t - dt) + (Change_in__employment_OS) * dt
INIT Employed__OS = 5494
INFLOWS:
Change_in__employment_OS =
(Desired__employment_OS-Employed__OS)/Time_to_adjust__employment_OS

Local_expenditure__per_capita_OS(t) =
Local_expenditure__per_capita_OS(t - dt) + (Change_in_local_expenditure) * dt
INIT Local_expenditure__per_capita_OS = 2.5
INFLOWS:
Change_in_local_expenditure =
(Indicated_Local_expenditure_per_capita-Local_expenditure__per_capita_OS)/Time_to_adjust_LE

Productivity__OS(t) = Productivity__OS(t - dt) + (Change_in__productivity) * dt
INIT Productivity__OS = 47
INFLOWS:
Change_in__productivity = (Productivity__OS*Yearly_growth_in__productivity)

Capital__gains = Capital__share*Other_Services__value_added

Capital__share = 1- MIN(1,Labour__share)

Cost_fraction = 0.62

Desired__employment_OS =
IF(Labour__share>1) THEN OS__value_added_demand/(Productivity__OS*Labour__share) ELSE
OS__value_added_demand/Productivity__OS

Exports_OS = GRAPH(TIME)
(2002, 7168), (2002, 7450), (2003, 8235), (2004, 8793), (2005, 9429), (2006, 9718), (2007, 10503), (2008, 10740), (2009, 52810), (2010, 61872), (2011, 13965), (2012, 15250)

Indicated_Local_expenditure_per_capita = Local_expenditure__per_capita_OS* (1+GRP.Change_in_GRP)

Labour__share = Earnings/Productivity__OS

Local_sales__OS = Demographics.Total___Population*Local_expenditure__per_capita_OS

Non_staff_expenses_and_costs = Revenue_OS*Cost_fraction

OS__value_added_demand = Revenue_OS-Non_staff_expenses_and_costs

Other_Services__value_added = Employed__OS*Productivity__OS

Revenue_OS = Local_sales__OS+Exports_OS

Time_to_adjust_LE = 10

Time_to_adjust__employment_OS = 1

Yearly_growth_in__productivity = 0.005

Yearly_growth__in_earnings = 0.005