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The Macroeconomic Impacts of projected population changes in Greece

by
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Declaration of Author's Rights

This thesis is the result of the author's original research. It has been composed by the author and has not been previously submitted for examination which has led to the award of a degree.

Signed Date

To Elena, Elli and Artemis

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Abstract

The aim of my thesis is to explore the macroeconomic impacts of the projected demographic changes in Greece. Population of Greece is projected to age in the course of the next three decades. The thesis combines demographic projections with a multi-period economic Computable General Equilibrium (CGE) modelling framework to assess the macroeconomic impact of these future demographic trends. The size and age composition of the population in the future depends on current and future values of demographic parameters such as the fertility, mortality rates and the level of annual net migration. I use FIV-FIV demographic software in order to project population changes for 30 years. Total population and working age population changes are introduced as exogenous disturbances to the G-AMOS CGE modelling framework calibrated for the Greek economy for the year 2004. The economic impacts of a very wide range of demographic scenarios are examined. The main finding is that positive net migration is able to cancel the negative impacts of an ageing population that would otherwise occur as a result of the shrinking of the labour force. The very serious policy implication is that a viable, long-lasting migration policy should be implemented, while the importance of policies that could increase fertility should also be considered.

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Chapter 1. Introduction

The impacts of an ageing population upon the economy are attracting considerable attention at the international level and are generally high on the political and economic agenda. A range of issues such as labour market implications, funding of pensions and health care costs are mostly discussed with a particular focus on budgetary impacts.

The economic policy committee of the European commission has stressed that:

"In the coming decades, the size and age-structure of Europe's population will undergo dramatic changes due to low fertility rates, continuous increases in life expectancy and the retirement of the baby-boom generation. There has been a growing recognition at national and European level of the profound economic, budgetary and social consequences of ageing populations" (Economic Policy Committee, European Commision, 2006,p.5)

Greece is among the many countries that face the prospect of an ageing population. Greek fertility rates are low (1.29[1] in 2004). This is the fifth-lowest fertility

[1] The measure of fertility that will be used is the Total Fertility Rate (TFR). This is the average number of children that would be born to a woman over her lifetime if she were to experience the current age-specific fertility rates through her lifetime. It is obtained by summing the age-specific rates for a given time-point. Thus, the TFR is not the observed fertility of any cohort of women, but rather synthesised using the fertility rates at one point in time of each age group. There is no sample of women being monitored through their childbearing years. That would involve a sampling exercise that would last for more than 35 years. Nor is it based on counting up the total number of children actually born over the lifetime, but instead is based on the age-specific fertility rates of women in their "child-bearing years". The convention for the child-bearing years is 15-49. The TFR is measures of the fertility of a hypothetical woman who is subject to *all* the age-specific fertility rates for ages 15-49 that were confirmed for a particular population in a particular year. This rate, then, is the number of children a woman would have if she was subject to prevailing fertility rates at all ages, and survives throughout all her childbearing years.

rate in EU27[2]. Although low fertility rates are the main drivers for the projected age of the population, another demographic phenomenon tends to work in the opposite direction. Greece has traditionally been a country of out-migration. However, in the last two decades the population outflow has reversed. This demographic shock has generated a stock of foreign population, which is estimated to be close to 10% of the national population[3] (Kontis et. al., 2006).

In contrast, the country has experienced a declining fertility rate and a continuously increasing life expectancy. Fertility rates in Greece have been lower than the European average until the end of the 1960's and peaked during the 1970's but never achieved the levels reached in the baby boom period in Europe, making the baby boom in Greece both late and small.

If the assumptions of ESYE (National Statistics Agency) on future trends of demographic variables (fertility, mortality, migration) materialise, then in the course of the next three decades total population is projected to increase slightly by 0.54%. However at the same time working age population is expected to decrease by 6.13%. Under the same assumptions, but without the presence of migration, total population will fall by 11.5% and working age population by 19.76%.

Computable general equilibrium models have been widely used in assessing the impacts of demographic change and in particular population ageing (Auerbach et al. 1989, Fougere et.al., 2004). In the case of Greece there have been studies that focus on the impacts of the changing population structure with the centre of attention being the

[2] At the bottom of the list are Poland, Slovakia, Slovenia and Lithuania, with fertility rates ranging from 1.24 children for the average Polish woman to 1.27 children for the average Lithuanian

[3] Contrary to many countries Greece defines foreigners "by blood" and not "by birth". So, there are people that have been born in the country but have not got citizenship. In contrast, others have not been born and brought up in the country but are granted citizenship. So, when we refer to "foreigners" we may include people that have been born in the country.

impact of migration. Lianos et al. (1995) found that wages of (illegal) immigrants in Northern Greece were 40-60% lower than those of the local population. They also found that the vast majority of immigrants take jobs that the locals would never take. This study is rather descriptive, and thus does not assess the impact of immigration on macroeconomic variables in a quantifiable way. Sarris and Zografakis (1999) use a Computable General Equilibrium model to assess the impact of illegal immigration upon the Greek economy. In their exercise, population stock is only adjusted by a one shot influx of illegal immigrants in the Greek economy. They find that almost a third of the population is adversely affected from illegal immigration. However, the negative impact disappears when they model labour market rigidities. (Fixed nominal wage). This is because wages are not being reduced by the greater supply of labour, and thus incomes of those who would compete with immigrants in the job market are not affected.

The thesis at hand adds to the relevant literature in linking demographic projections with consistent economic modelling. Thus it sheds light on the effect of current and future fertility, mortality and migration trends by interacting a demographic and an economic model.

While demographic changes have many economic implications that are related to public expenditure such as expected increase in demand for health care (Gray, 2004; Wright, 2004), funding of pensions of a growing aged population (World Bank, 1994; Barr, 2000; Orszag and Stiglitz, 2001; Blackburn, 2002, 2006) the focus of this thesis is to assess the impact of future demographic trends upon the economy through the consequent changes in the labour market. The demographic model FIV-FIV originally developed at the Office of Population Research, Princeton University by Frederic C. Shorter, and further developed by Frederic C. Shorter, Robert Sendek, and

Yvette Bayoumy (Shorter et.al., 1995), is combined with a Computable General Equilibrium (CGE) model of the Greek Economy (G-AMOS) calibrated for the year 2004. G-AMOS is a variant of the AMOS model, originally created by Harrigan et al (1991) in Strathclyde University. The projection and simulation horizon is three decades, a span that is long enough to allow for the population changes to be fed into the rest of the economy.

The thesis is organised as follows. Chapter 2 outlines the demographic model and explains the details of the method for performing demographic projections. This is followed by a detailed account of the demographic profile of Greece with particular reference to historical trends of demographic variables as well as the age structure of the "national" and "foreign" population. Next, population projections are generated by using various demographic scenarios, including scenarios with high and low values for life expectancy, high and low values for fertility and high and low values for the amount of net-migration. Scenarios with zero net-migration (natural change only) and scenarios that involve higher net-migration levels are also examined.

Chapter 3 is focused on a discussion of CGE models. It refers to the roots of CGE modelling and critically assesses the strengths and weaknesses of this approach. It presents the arguments against and in favour of CGE modelling and it provides a comparison with other modelling techniques. It also refers to the use of CGE models for the study of the impacts of demographic changes.

Chapter 4 refers to the construction of the necessary economic database for the economic Computable General Equilibrium model. The first steps involve the construction of the necessary Social Accounting Matrix. The procedure involves the estimation of an Input Output table for Greece for the year 2004 starting from 1994 OECD official table. It also requires the construction of a set of income and expenditure accounts for the same year. Data requirements also include sectoral employment. Finally, a set of parameters necessary for the operation of the CGE model is constructed.

Chapter 5 outlines the structure of the economic model. Closures of markets are explained in detail and the required parameterisation is discussed. The multi-level production process is presented.

Chapter 6 presents a set of illustrative "test" simulations that have been performed. This is a necessary step before the core economic-demographic simulations which helps to assure that the model behaves as expected to various shocks. Demand and supply shocks are introduced to the model under various closures of the labour market. The transparency of the model permits an extensive discussion of the results.

Chapter 7 presents the core results of the thesis. It begins with an outline of the theoretical framework within which the simulation exercise is conducted with particular reference to labour market impacts. The overall simulation strategy is analysed next, while supply and demand shocks introduced to the economic model are explained. Next, a detailed discussion of the impacts of the base population scenario is discussed augmented with a set of sensitivity analysis simulations that illuminate the importance of parameterisation and choice of market closures and functional forms. This is followed by the discussion of the macroeconomic impacts of various demographic scenarios outlined in Chapter 2.

Chapter 8 concludes the thesis and discusses future research directions as well as relevant policy implications.

Chapter 2 The Demographic Model FIV-FIV and Population Projections

2.1 Introduction

When performing demographic analysis we primarily refer to three fundamental demographic parameters. These are fertility, life expectancy and net-migration and this section provides their definitions and the way in which they are measured.

The measure of fertility that will be used is the Total Fertility Rate (TFR). This is the average number of children that would be born to a woman over her lifetime if she were to experience the current age-specific fertility rates through her lifetime. It is obtained by summing the age-specific rates for a given time-point. Thus, the TFR is not the observed fertility of any cohort of women, but rather synthesised using the fertility rates at one point in time of each age group. There is no sample of women being monitored through their childbearing years. That would involve a sampling exercise that would last for more than 35 years. Nor is it based on counting up the total number of children actually born over the lifetime, but instead is based on the age-specific fertility rates of women in their "child-bearing years". The convention for the child-bearing years is 15-49. The TFR is a measure of the fertility of a hypothetical woman who is subject to *all* the age-specific fertility rates for ages 15-49 that were confirmed for a particular population in a particular year. This rate, then, is the number of children a woman would have if she was subject to prevailing fertility rates at all ages, and survives throughout all her childbearing years. A value of this measure with particular importance is 2.1 children per woman in childbearing age. This is the fertility rate required in order for the existing population to be replaced. In particular, 2.1 children per woman is enough to replace the two parents and compensate any infant and female mortality. That is to take into account that there are women that do not reach the end of their childbearing years and the children that do not reach the age of 15. In developed countries, the necessary replacement rate is about 2.1. Since replacement cannot occur if a child does not grow to childbearing age, the need for the extra .1 child per woman is due to the possibility of death and those who choose or are unable to have children. In less developed countries, the replacement rate is higher (around 2.3) due to higher childhood and adult death rates.

Life expectancy is a measure of the average length of survival of a living person. It is usually separately calculated for men and women. It is most often interpreted to mean the life expectancy at birth for a given population, which is the same as the expected age at death. It actually is the expected remaining time to live and is often calculated for all ages and not just at birth. In some countries that experience high infant mortality rates it is often the case that the measure reported is not life expectancy at birth but life expectancy at five years of age. This is used in order to isolate the effect of deaths in early childhood. In the twentieth century life expectancy has increased spectacularly. For the U.S. it was 77 years (at birth) at the end of the 20th century, though it was only 47 years in 1900. The trend is similar in most developed countries.

The measure of migration that is used is net migration. This is the difference between immigration and emigration from an area in a period of time. Often net migration is expressed per 1,000 of population and the result is referred to as the net migration rate. When net migration is positive it means that more people are entering the country/region than leaving it, while a negative value means that more people are leaving than entering.

If these demographic parameters are ranked in terms of predictability it could be said that life expectancy is the most predictable, followed by fertility with migration being the most unpredictable. There are in principle two reasons for which analysing fertility is more difficult than analysing mortality (Hinde, 1998). First, people die only once but women may have children more than once. In that sense fertility requires the analyses of a repeated event. The second reason why fertility is more unpredictable is the fact that people usually choose when and how many children to have, whereas they do not choose when to die. Mortality is determined by human action only to a very limited degree. Finally, migration depends on a series of factors such as relative economic conditions, political stability etc and it is therefore very difficult to predict.

Europe's age structure is undergoing a substantial change. Population is ageing meaning that there is an increase in the age of the median citizen which is associated with an increase of the ratio of the retired over the workforce. Researchers and commentators refer to this as a 'demographic time bomb'. This term is used because ageing is supposed to be associated with increased public expenditure on health, social security and pensions, as well as creating shortages in the labour market.

By 2020 in the present territory of the EU 20 million people will be over the age of 85. This represents an increase of 300% since 1960[4]. UN population projections suggest that in the next five decades EU countries will experience an increase of the population aged over 65 years, by 65%. At the same time population of working age, (16-64) will decline by 15%.

The situation in Greece reflects similar demographic trends. Although the population is expected to remain rather stable, with only a 3% fall by 2050 according to

[4] www.europa.eu.int

ESYE[5] it is also expected to age significantly. The number of over 65 year olds is expected to rise by 61% and the number of over 85 year olds by close to 200%. Greece also has a very low fertility rate. The fertility rate that maintains a constant population (assuming net migration is zero) is 2.1 children on average per woman of childbearing age as we have already said. In Greece the figure is at present 1.3 and consequently the country is expected to witness a fall of 13 % in the population age 5-19[6] over the next three decades.

The purpose of this chapter is to give demographic profile of Greece by examining historical and current trends of fertility, mortality and migration. Population projections made by the national statistics agency are presented. This is followed by a detailed explanation of the software FIV-FIV which is used to generate population projections explored in this study. Finally, the projected population under the various scenarios examined will be presented.

[5] National Statistics Agency
[6] National Statistics Agency

2.2. The demographic profile of Greece

In Greece, life expectancy at birth has been increasing during the course of the last century for both males and females. According to the Greek National Statistics Agency (ESYE) life expectancy in 1928 was 44.95 years for males and 47.46 for females. In 2000, the corresponding figures were 75.42 and 80.54. The figures suggest a increasing trend. The projections of ESYE assume that, under all scenarios life expectancy will continue to increase in the future. A graphical representation of the trend of life expectancy at birth as recorded and presented by ESYE is shown below.

Figure 2- 1 Life expectancy at birth

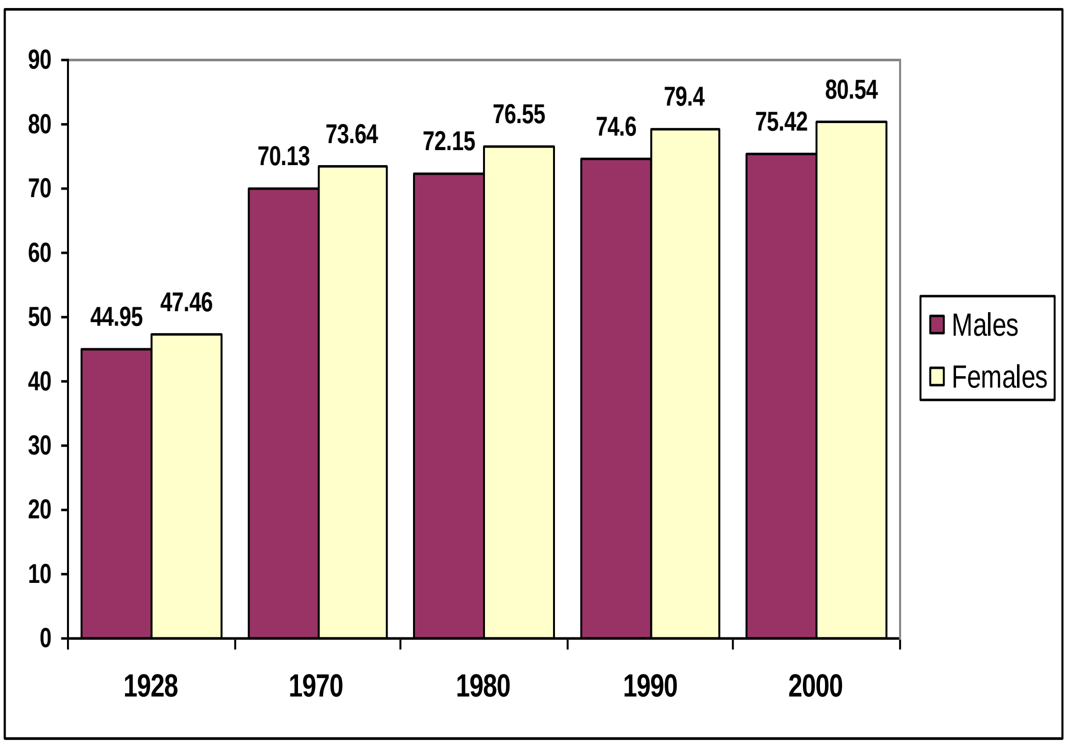
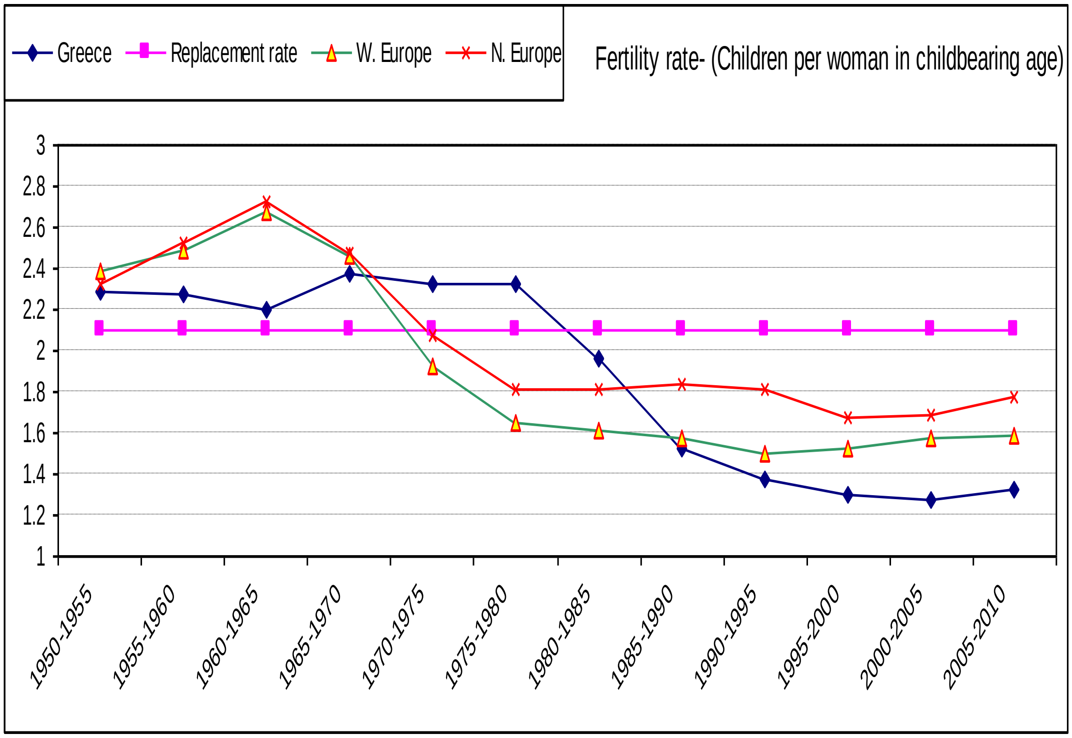


Figure 2.2 shows the trend of fertility in Greece since 1950. The same graph gives the replacement rate as well as the average fertility rate of the countries of Western and Northern Europe[7].

Figure 2 2 Fertility Rates in Greece and EU (source UN)[8]



There are two key points. First fertility rates in Greece were lower than the European average until the end of the 1960s. This is the period of the so called baby boom. Second the fertility rates peak during the 1970s but do not reach the level reached in other European countries during the baby boom period. Thus, one can say that the baby boom in Greece was late and small. It is reasonable to assume that political instability of the post WWII period (civil war) has contributed to that phenomenon.

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[7] Northern Europe Includes, Channel Islands, Denmark Estonia Faeroe Islands, Finland, Iceland, Ireland Isle of Man, Latvia Lithuania Norway, Sweden United Kingdom of Great Britain and Northern Ireland. Western Europe includes Austria, Belgium, France, Germany, Liechtenstein, Luxembourg, Monaco, Netherlands, Switzerland

[8] Source: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, World Population Prospects: The 2006 Revision and World Urbanization Prospects: The 2005 Revision, http://esa.un.org/unpp, Visited March 2008.

Before looking at the data on migration it has to be noted that there is a fundamental issue in relation to the definition of a “migrant”.(Kontis et al, 2006).

In general, there are two ways that someone can acquire citizenship. That is "by birth" (jus soli) or "by blood" (jus sanguinis) (Grieco, 2002, Castles and Davidson, 2000). In a jus soli system, citizenship depends upon the place of birth. People born in these countries are citizens, while people born outside are non-citizens. Thus, in a jus soli context, the term "foreign born" refers to residents of one country who were born in another.

In a jus sanguinis system, descent and heritage play a fundamental role in defining who is, and can become, a citizen. The place of birth is of second importance in relation to if and how they can trace their parentage back to the origin country. Thus, the term "foreigner" refers to someone who cannot trace his heritage back to the host country. In such a case, it is often hard for foreigners to acquire citizenship, even if they have lived in the host country for a long time or even if they have been born there. These differences in definitions not only result in different migration policies but also in difficulties in the comparative analysis of international migration trends.

In the case of Greece we have a “juis sanguinis” policy. As a result, there are people that have been born in the country but have not acquired citizenship. Hence the statistics on migrants include those that due to the juis sanguinis policy cannot be awarded citizenship. An extensive discussion of this issue is outwith the scope of this thesis. However, a convincing critique on the methods used for collection of migration data can be found in Kontis et. al, (2006)

Greece has traditionally been a country of outward migration. Countries such as Germany, Australia and USA have large Greek communities consisting of third or fourth generation migrants. During the period 1890-1914 almost a sixth of the population of Greece emigrated, mostly to the USA and Egypt. The economic crisis that resulted from the fall in the world price of the major exporting product –the currant – was certainly a major cause of this first wave of out-migration. (Cavounidis 2002, 2003, Glytsos, 2005) Emigration was almost encouraged by the Greek authorities as remittances helped to improve the balance of payments (Robolis, 2008, Bagavos et.al, 2006).

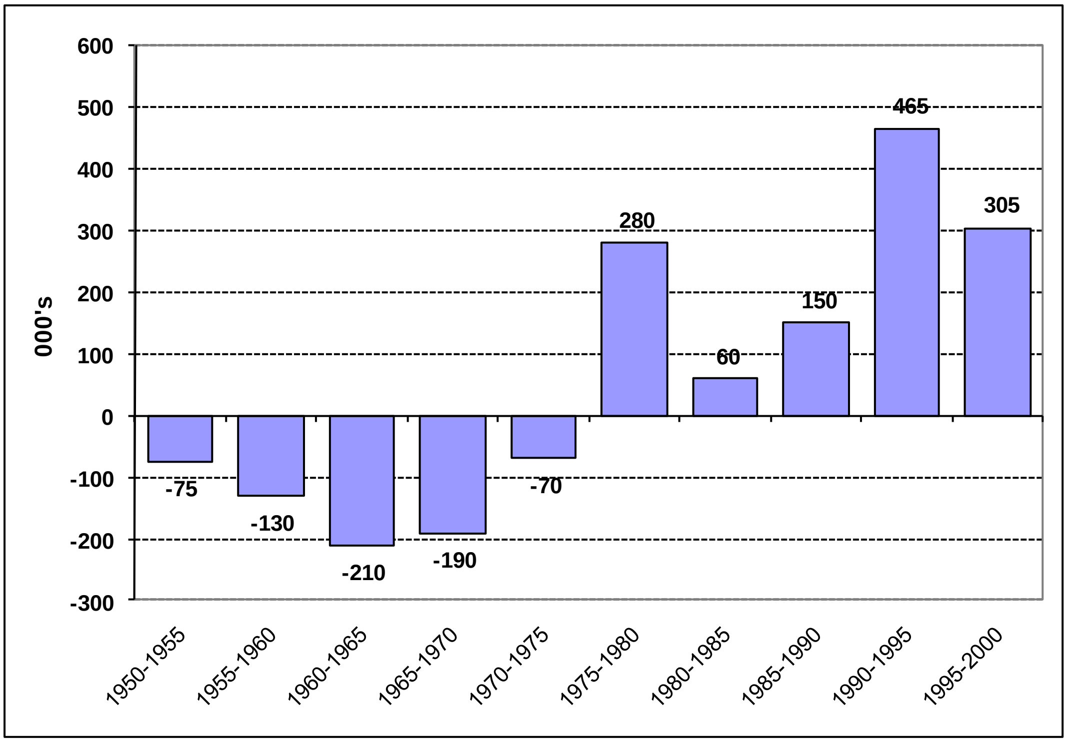
A second wave of out-migration occurred after World War II. The main destinations of emigrants were the countries of the industrialised North Europe and the US, Australia and Canada. More than one million migrants moved out of the country during the period 1955-1973. Subsequently, migration reduced substantially and return migration followed the economic crisis of the 70s and the resultant stricter regulation for immigration in the developed countries of the western world. By the mid eighties almost half of the migrants had returned to the country (Lianos, 1975, 2003).

Over the last three decades and in particular after the collapse of the eastern block Greece has become a recipient of migrants, mainly coming from countries of central and Eastern Europe, with Albania being the primary source. (Sarris and Zografakis, 1999) Recently the number of migrants from India, Pakistan and Iraq has sharply increased with the majority staying in the country illegally (Robolis, 2008). Between 1991 and 2001 the size of foreign population increased more than fourfold from 167,276 to 797,093[9]. Note that during the specific time period total population has been almost constant (10,259,900 and 10,964,020) and thus foreign population rose from 2% to 7% of the total population.

[9] ESYE, www.statistics.gr

The graph below shows the trend of net migration for the second half of the twentieth century. Of course these numbers do not include illegal migrants. Net emigration occurs up to 1975. The spike of positive immigration during the years 1975-1980 is largely explained by the democratisation of the country and consequent political stability.

Figure 2 3 Net migration in thousands by five-year period



Since then, there has been consistent immigration and a further spike in 1990-1995 that coincides with the collapse of the Eastern block (Sarris and Zografakis, 1999).

According to the census of 2001 total population has increased from 10,259,900 to 10,964,020[10] since 1991. Migration is the only possible source for this population increase. Although the registered "foreign population" according to the census was just

[10] National Statistics Agency

above 750,000 it is widely believed that the real number of immigrants is higher and that they comprise 10% of the population (Kasimis and Kasimi, 2004, Kasimis, C., Papadopoulos, A.G 2005). Actually, immigration has not only caused Greece's population to rise but has kept the percentage of working age population to total population constant.

Figure 2 4 percentage changes in working age population and total population. Source ESYE (www.statistics.gr, visited June 2007)

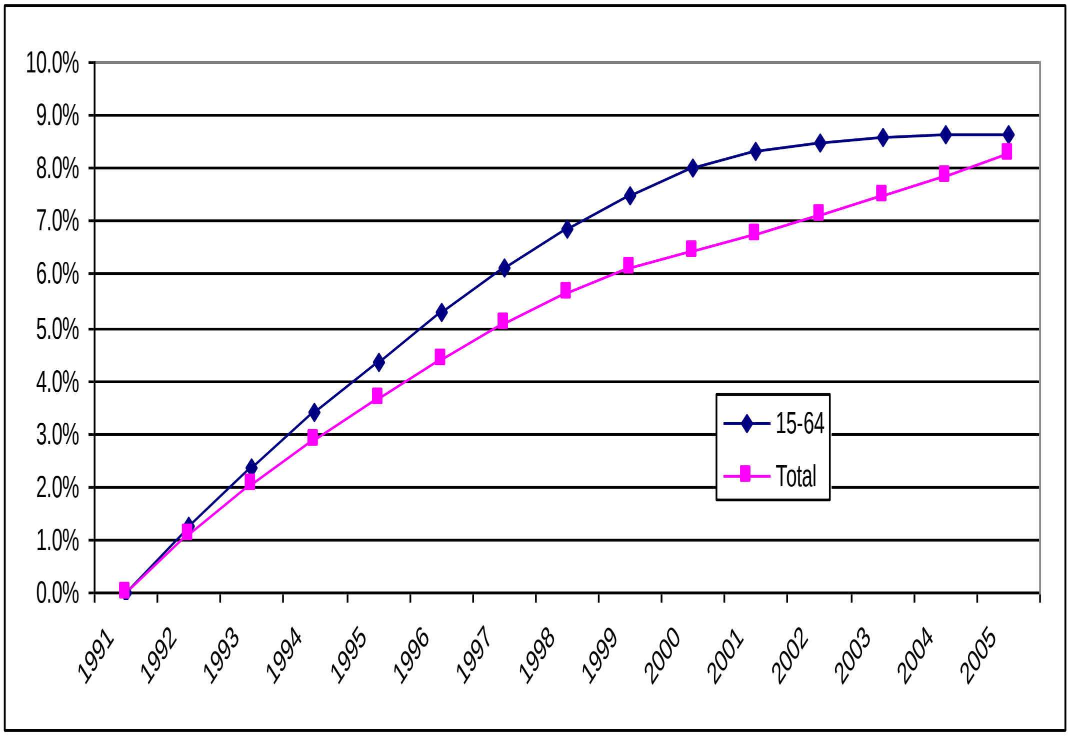


Figure 2.4 shows the percentage changes in the Greek total and working age population for the period 1991 to 2005. The working age population has been rising at a rate slightly higher than that of the total population during this period. As a result the percentage of the working age population in the total population has remained relatively constant, around 67% during the last 15 years. Table 2.1 and figures 2.5 and 2.6 show

the different age distribution of the Greek and foreign total population as recorded during the census of 2001. The difference is striking.

Table 2 1 Age Structure of Greek National and Migrants

	Greeks		Migrants	
	males	females	males	females
Total	**5,006,085**	**5,182,672**	**414,958**	**346,238**
0-4	241,033	229,196	19,853	18,342
05-09	257,878	244,254	22,272	20,463
10-14	279,759	259,447	24,281	21,529
15-19	338,099	313,843	34,088	25,497
20-24	377,646	358,473	56,111	37,268
25-29	374,449	367,277	63,132	44,201
30-34	386,288	384,470	55,231	42,257
35-39	356,500	360,314	41,816	35,817
40-44	354,954	362,262	33,271	31,202
45-49	336,217	338,378	22,280	23,131
50-54	322,796	331,461	14,957	16,051
55-59	275,836	293,153	8,578	8,874
60-64	284,415	325,595	6,798	7,243
65-69	286,263	330,719	4,943	5,014
70-74	244,934	292,236	3,497	4,163
75-79	151,090	193,591	1,981	2,627
80-84	81,229	110,516	1,074	1,435
85+	56,699	87,487	795	1,124

Most migrants are concentrated in the ages of 20-34, while the Greeks have considerable shares in the older age groups. A look at the relevant population pyramids is quite instructive.

Figure 2 5 Population pyramid of foreigners in 2001

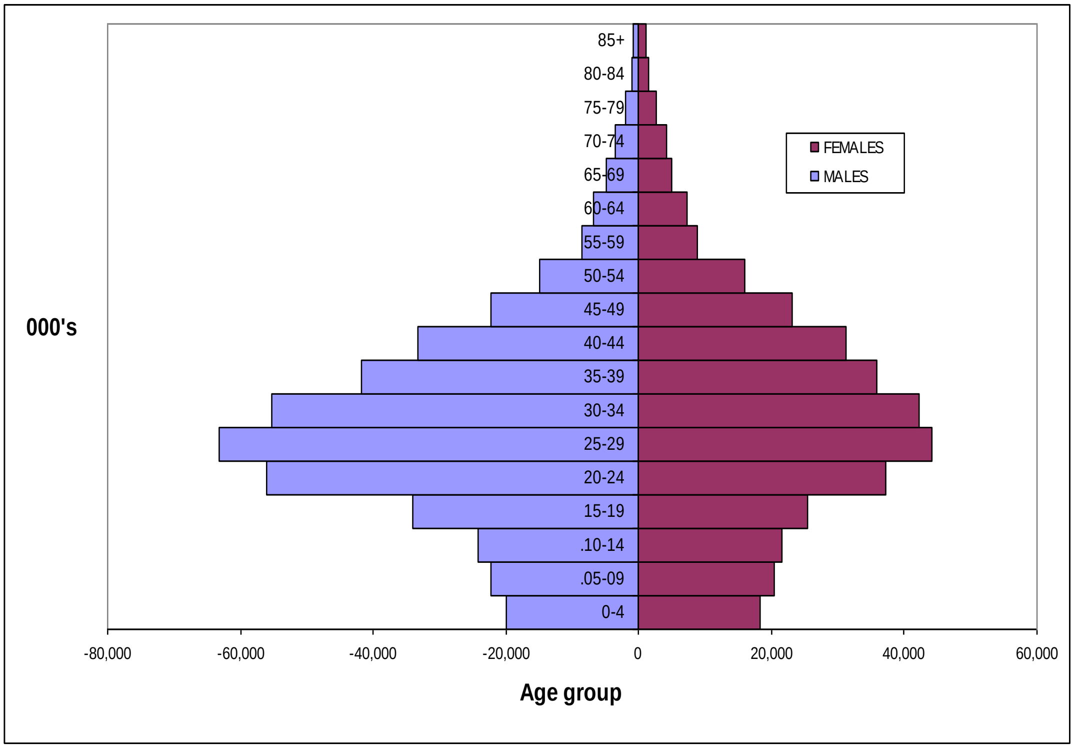
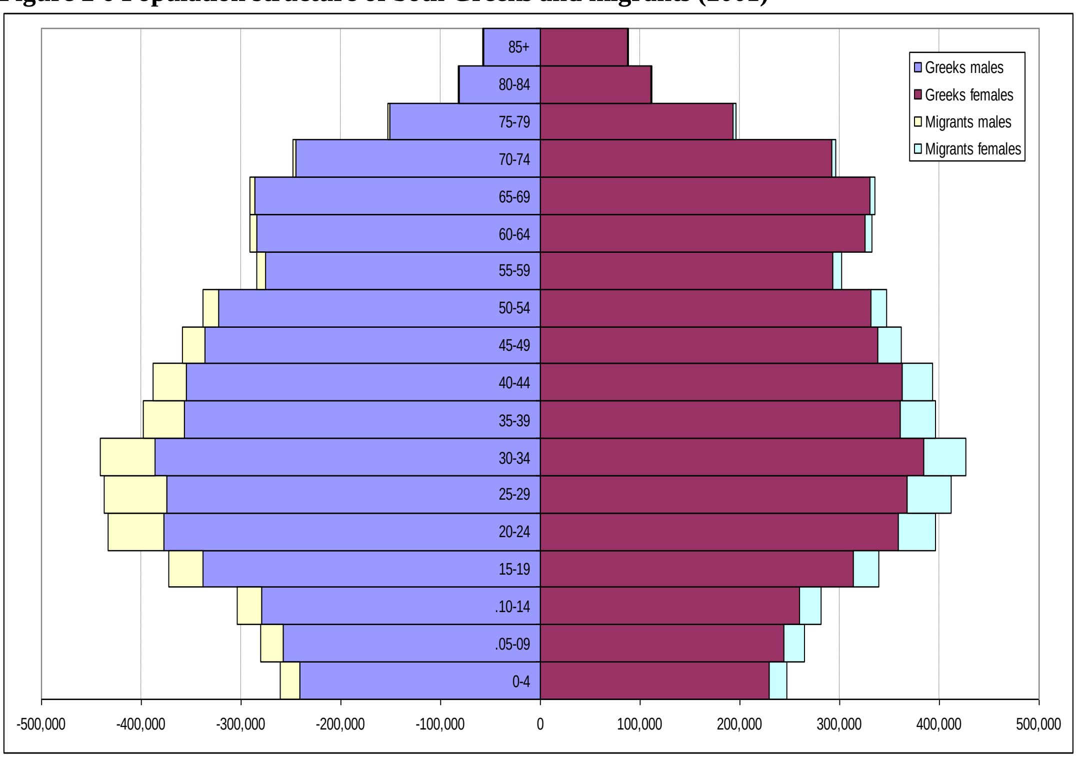


Figure 2 6 Population structure of both Greeks and migrants (2001)



As Figure 2.5 demonstrates migrants are mainly between the ages of 20-34 which is a reasonable age for someone to look for a better future. The assumption that has been used elsewhere about the age distribution of migrants is that 1/3 belongs to the age group 0 – 19 and 2/3 in the age group 20 – 39. Within these age groups, migrants are taken to be distributed equally by age and sex. This age-sex structure can be summarized as "young couples with one child" (Lisenkova et.al., 2008). In particular, this assumption was made in the absence of data for the actual age distribution of the migrant population. It is a great advantage to have actual data as shown in Figure 5, as this is a crucial element of the population projections that are about to follow. In Figure 2.6 total population of Greece is disaggregated by age, sex and between Greeks and migrants. It shows clearly that proportionally migrants add to the younger age groups. The population structure of both Greeks and migrants (2001) is shown in Figure 2.6. Note, that these data do not make a distinction between a "foreigner" and a "migrant". It is likely that the waves of migrants i.e. the flow has a different age structure than the existing foreign population. However, data on the age –sex structure of the flow do not exist[11] (Robolis, 2008, Kritikides, 2002).

[11] Given the data availability, assuming that net- migration flows have the same age-sex structure with the existing foreign population is the best one can do in order to perform population projections.

We can see that migration is an influx that in proportionate terms affects mainly the age groups 20-35. Clearly migration flows have worked towards offsetting the ageing of Greek society considered as a whole.

Having provided a historical analysis of the demographic fundamentals and in order to complete the picture, I now focus on the relative weight of each age group through time. This information is given in Figures 2.7 and 2.8.

Figure 2.7 shows the total Greek population broken down into the age groups 0-14, 15-64, 65+ over the period 1950-2005. These groups reflect children, working age population and retirees. Figure 2.8 gives the sizes of these groups over the same period. Starting from the younger generation, the percentage of children has halved during the last five decades (From 28% in the 1950's, to almost 14% at the turn of the century) reflects a continuously decreasing fertility rate.

Figure 2 7 Total population by age group 1950-2005

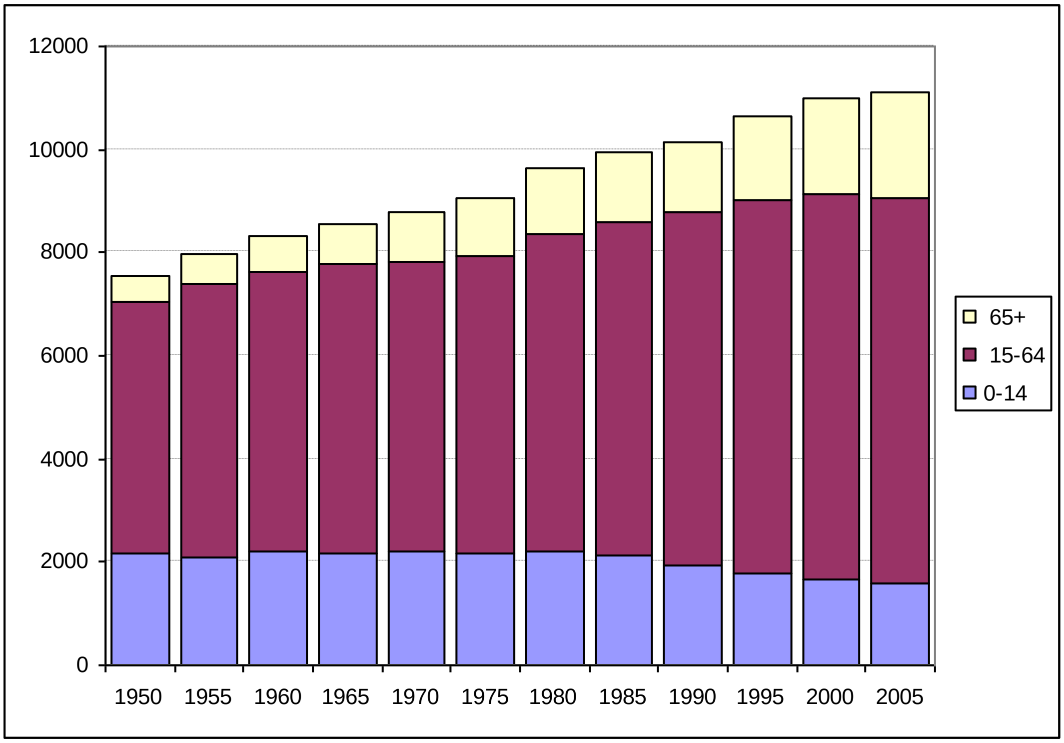


Figure 2 8 Percentages of different age groups 1950-2005-

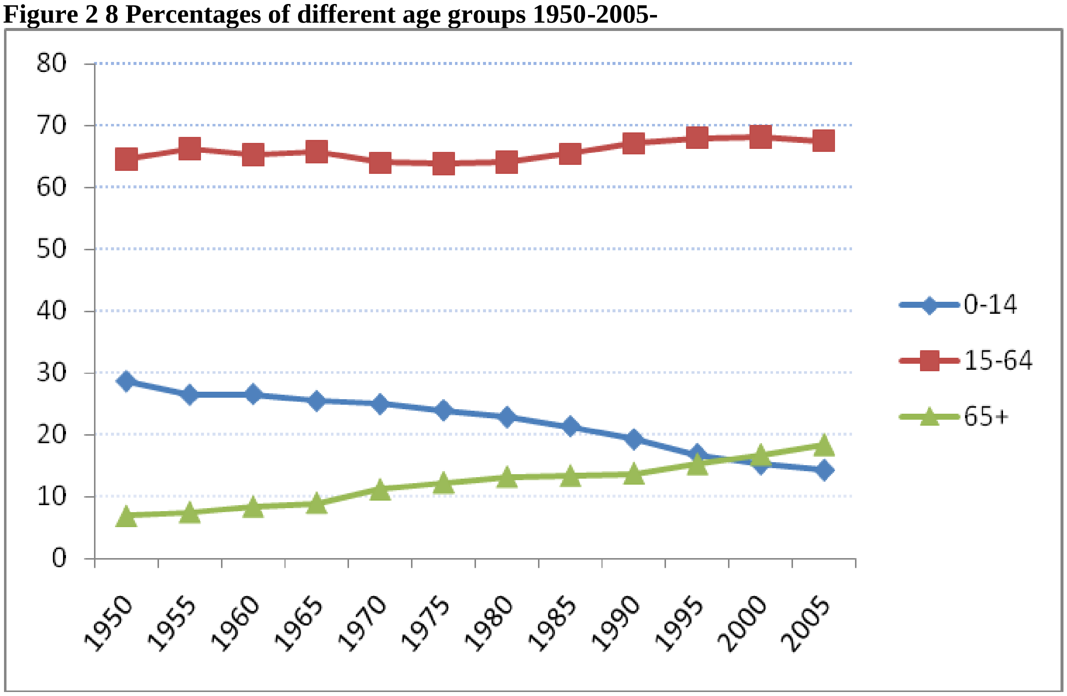
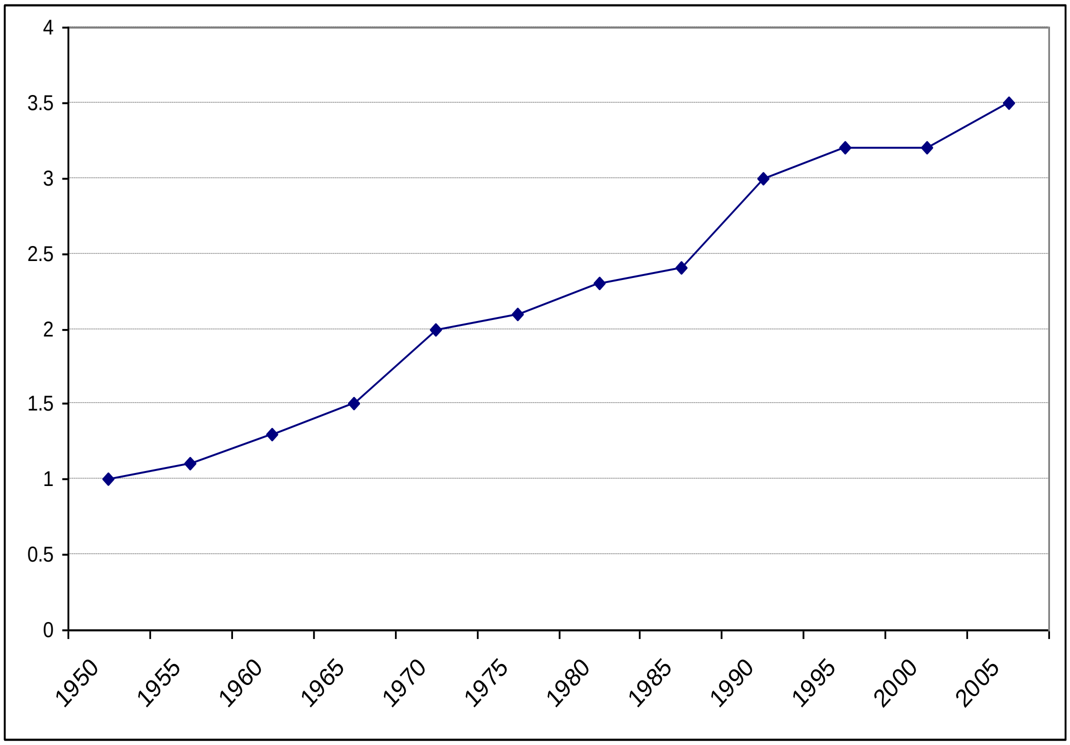


Figure 2.7 shows that the Greek population has been increasing steadily since 1950, although at a lower rate in the recent years.

The relative size of the working age population has remained rather stable with a slight increase. From 65% of the total population in 1950 it has increased to 68% in 2005. This implies that the dependency ratio, the ratio of workers to dependants, has not changed dramatically. While the percentage of the old (65+) has increased over the last half century, the percentage of the young has fallen by a larger amount. The diagrams demonstrate this clearly. Figure 2.8 presents the time path of the three main age groups. We can clearly see that the percentage of the young has fallen, the percentage of the working age population has remained rather stable and the percentage of the old has increased.

In addition to changes in the relative size of each age group there are other phenomena that are worth mentioning. First, there has been an increase in the proportion of the population above eighty identified as the "very old". Figure 2.9 gives the percentage of the very old to the total population for the second half of the last century.

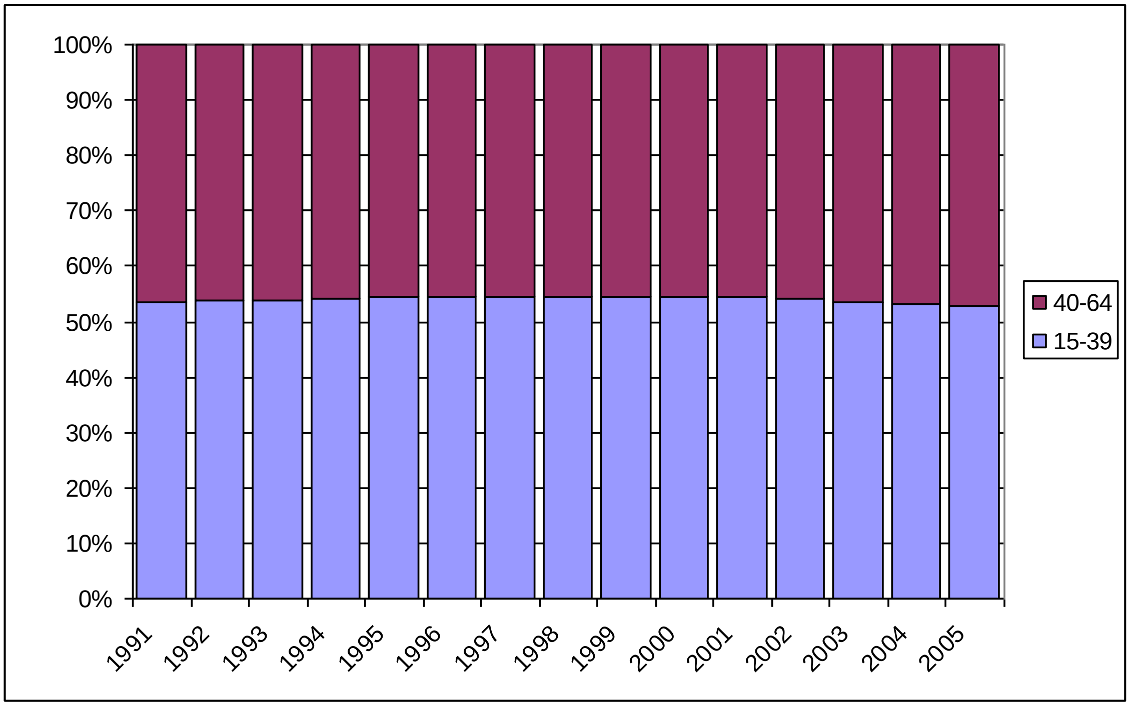
Figure 2 9 Percentage of Population aged 80+



The increased relative size of this age group has been associated with higher demand for health services (Wright, 2002a, 2004a, 2005). Others believe that average age is not a good predictor of health expenditure. Instead they believe that proximity to death is the determining factor (Gray, 2004). Seshamani and Gray (2004) provides a comprehensive literature review.

Second, we have a slight increase in the weight of older workers in relation to younger workers in the workforce. Figure 2.10 below shows the evolution of the composition the working age population over the period 1990-2005.

Figure 2 10 Composition of working age population, older VS younger workers



Researchers have expressed concerns about the relative productivity of these two types of workers and the wider impact of this phenomenon. (Boersch-Supan, 2001; Wright, 2005) A detailed analysis of the economic impact of such developments is outwith the scope of this thesis, but it constitutes a very interesting issue for future research.

2.3. Population Projections made by the ESYE

2.3.1 Introduction

Population projections by ESYE have been performed on the basis of the estimated population on the 1st of January 2004. The agency considered this year a good year to start, as the distance from the last census that took place in 2001 is small and no unpredictable waves of migration that cannot be quantified have occurred in the meantime. The estimation of population in 2004 is done by adding births and net-migration and subtracting deaths that have occurred in the meantime. We now turn to provide a detailed look at the assumptions being made.

2.3.2 Assumptions

ESYE examine three scenarios called low, medium and high depending on the values of the parameters assumed. In the low scenario, the fertility rate decreases slightly, life expectancy increases also slightly and net migration falls during the projection period. In the high scenario there is increased fertility, a bigger increase of life expectancy and a greater inflow of migrants. In the medium scenario there is a moderate (compared to the high scenario) increase in fertility, an increase in life expectancy and net-migration is assumed to remain at the current levels. Table 2.2 below presents the assumptions being made.

Table 2 2 Assumptions of ESYE projections

	Fertility			MALE life expectancy			FEMALE life expectancy			Net In-migration (000's)		
	Low	Medium	High	Low	Medium	High	Low	Medium	High	Low	Medium	High
2004	1.28	1.29	1.3	76.5	76.54	76.58	81.31	81.34	81.37	30	40	50
2005	1.28	1.3	1.32	76.53	76.61	76.69	81.35	81.42	81.48	30	40	50
2006	1.27	1.31	1.34	76.56	76.68	76.8	81.39	81.49	81.59	30	40	50
2007	1.27	1.31	1.36	76.59	76.75	76.91	81.42	81.56	81.7	30	40	50
2008	1.27	1.32	1.37	76.62	76.82	77.02	81.45	81.63	81.82	30	40	50
2009	1.27	1.33	1.39	76.64	76.89	77.14	81.49	81.71	81.93	30	40	50
2010	1.26	1.34	1.41	76.67	76.96	77.25	81.52	81.78	82.04	30	40	50
2011	1.26	1.34	1.43	76.71	77.03	77.36	81.56	81.86	82.16	30	40	50
2012	1.26	1.35	1.44	76.74	77.11	77.48	81.6	81.93	82.28	30	40	50
2013	1.26	1.36	1.46	76.77	77.18	77.6	81.63	82.01	82.39	30	40	50
2014	1.25	1.37	1.48	76.8	77.25	77.72	81.67	82.09	82.51	30	40	50
2015	1.25	1.37	1.49	76.83	77.33	77.83	81.71	82.16	82.63	30	40	50
2016	1.25	1.38	1.51	76.86	77.41	77.96	81.74	82.24	82.76	30	40	50
2017	1.25	1.39	1.52	76.89	77.48	78.08	81.78	82.32	82.88	30	40	50
2018	1.25	1.39	1.54	76.93	77.56	78.21	81.82	82.41	83.00	30	40	50
2019	1.24	1.4	1.55	76.96	77.64	78.33	81.86	82.49	83.13	30	40	50
2020	1.24	1.4	1.57	76.99	77.72	78.45	81.9	82.57	83.25	30	40	50
2021	1.24	1.41	1.58	77.03	77.8	78.58	81.94	82.65	83.39	20	40	60
2022	1.24	1.42	1.59	77.06	77.88	78.71	81.98	82.74	83.52	20	40	60
2023	1.23	1.42	1.61	77.09	77.96	78.84	82.02	82.82	83.65	20	40	60
2024	1.23	1.43	1.62	77.13	78.04	78.97	82.06	82.91	83.78	20	40	60
2025	1.23	1.43	1.63	77.16	78.12	79.1	82.1	82.99	83.91	20	40	60
2026	1.23	1.44	1.65	77.2	78.21	79.24	82.14	83.08	84.05	20	40	60
2027	1.23	1.44	1.66	77.23	78.3	79.37	82.18	83.17	84.19	20	40	60
2028	1.22	1.45	1.67	77.27	78.38	79.51	82.22	83.26	84.32	20	40	60
2029	1.22	1.45	1.68	77.3	78.47	79.65	82.26	83.35	84.46	20	40	60
2030	1.22	1.46	1.7	77.34	78.55	79.78	82.31	83.43	84.6	20	40	60
2031	1.22	1.46	1.71	77.38	78.64	79.93	82.35	83.53	84.74	20	40	60
2032	1.22	1.47	1.72	77.42	78.73	80.07	82.39	83.62	84.88	20	40	60
2033	1.22	1.47	1.73	77.45	78.82	80.21	82.43	83.71	85.03	20	40	60
2034	1.21	1.48	1.74	77.49	78.91	80.36	82.48	83.8	85.17	20	40	60
2035	1.21	1.48	1.75	77.53	79	80.5	82.52	83.89	85.31	20	40	60
2036	1.21	1.48	1.76	77.57	79.1	80.65	82.56	83.99	85.46	20	40	60
2037	1.21	1.49	1.77	77.61	79.19	80.8	82.61	84.08	85.61	20	40	60
2038	1.21	1.49	1.78	77.65	79.29	80.95	82.65	84.17	85.75	20	40	60
2039	1.2	1.5	1.79	77.69	79.38	81.11	82.7	84.27	85.9	20	40	60
2040	1.2	1.5	1.8	77.73	79.48	81.26	82.74	84.36	86.05	20	40	60
2041	1.2	1.5	1.8	77.77	79.57	81.42	82.78	84.46	86.2	20	40	60
2042	1.2	1.51	1.81	77.81	79.67	81.58	82.83	84.55	86.35	20	40	60
2043	1.2	1.51	1.82	77.85	79.77	81.73	82.87	84.65	86.5	20	40	60
2044	1.2	1.51	1.83	77.89	79.87	81.89	82.92	84.74	86.65	20	40	60
2045	1.19	1.52	1.84	77.93	79.97	82.05	82.96	84.84	86.8	20	40	60
2046	1.19	1.52	1.84	77.98	80.08	82.22	83.01	84.94	86.95	20	40	60
2047	1.19	1.52	1.85	78.02	80.18	82.39	83.05	85.03	87.11	20	40	60
2048	1.19	1.52	1.86	78.06	80.29	82.56	83.1	85.13	87.26	20	40	60
2049	1.19	1.53	1.86	78.11	80.39	82.72	83.14	85.23	87.41	20	40	60
2050	1.19	1.53	1.87	78.15	80.49	82.89	83.19	85.32	87.57	20	40	60

Figure 2.11 shows that in the low scenario fertility falls to 1.19 children per woman in 2050. In the medium scenario it rises slightly to 1.53 and in the high scenario it rises to 1.87, from an initial level of 1.28 and 1.3 respectively. Figure 2.12 indicates that life expectancy for men is assumed to rise in a monotonic manner and to reach 78.15 years, 80.49 years, 82.89 years in 2050 for the low medium and high scenarios respectively. The corresponding numbers for women are 83.19, 85.32, 87.57.

Figure 2 11 Assumption for the fertility rate

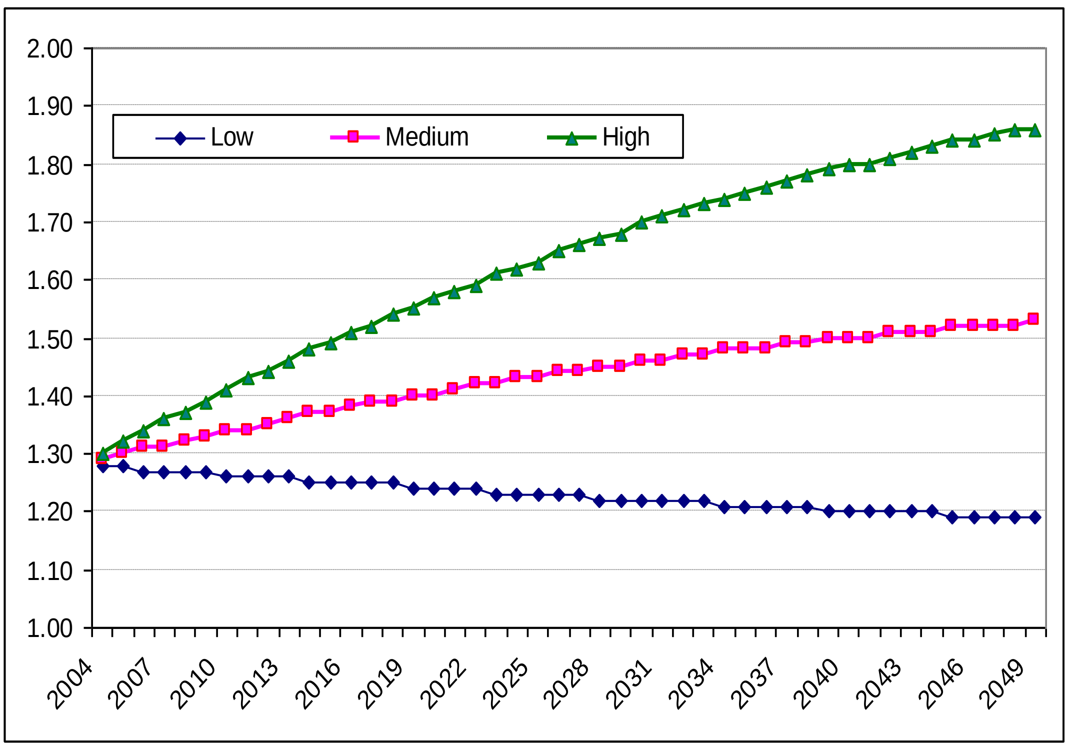


Figure 2 12 Life expectancy assumptions

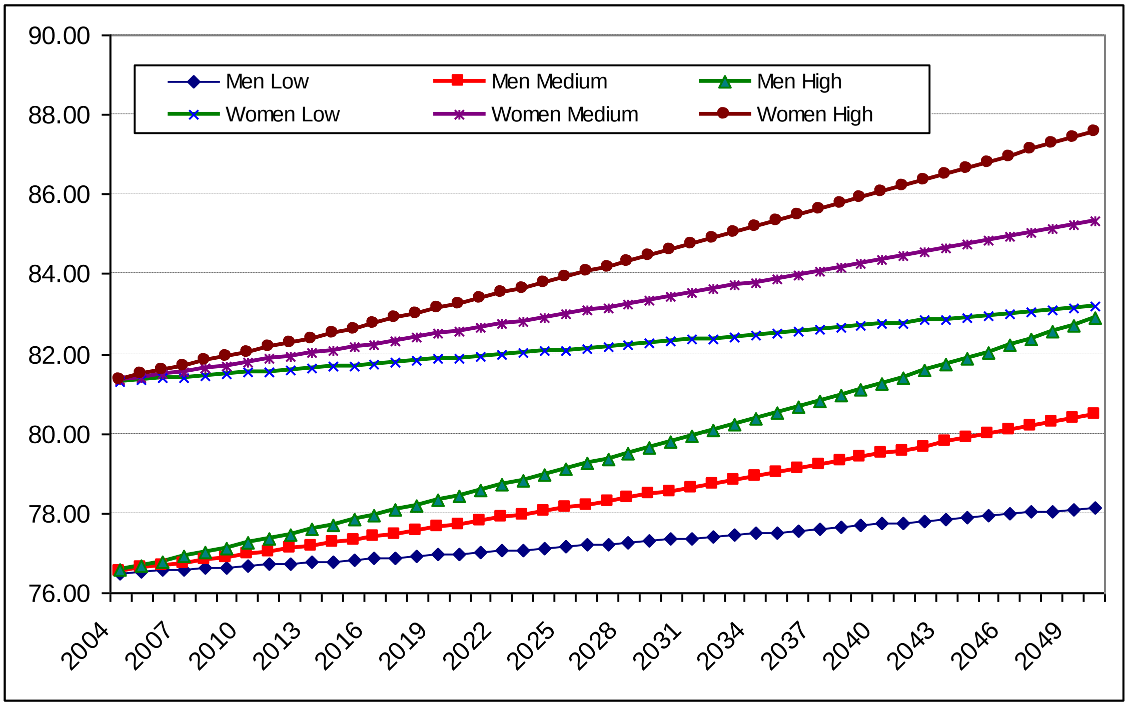
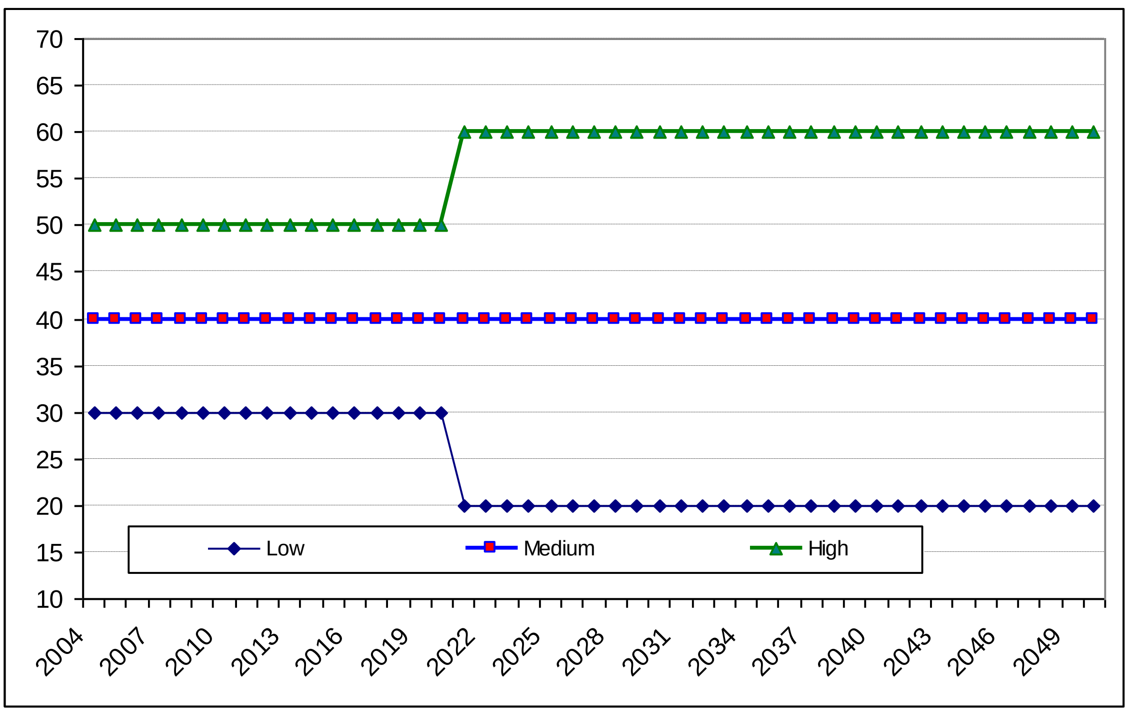


Figure 2 13 Assumptions for net migration



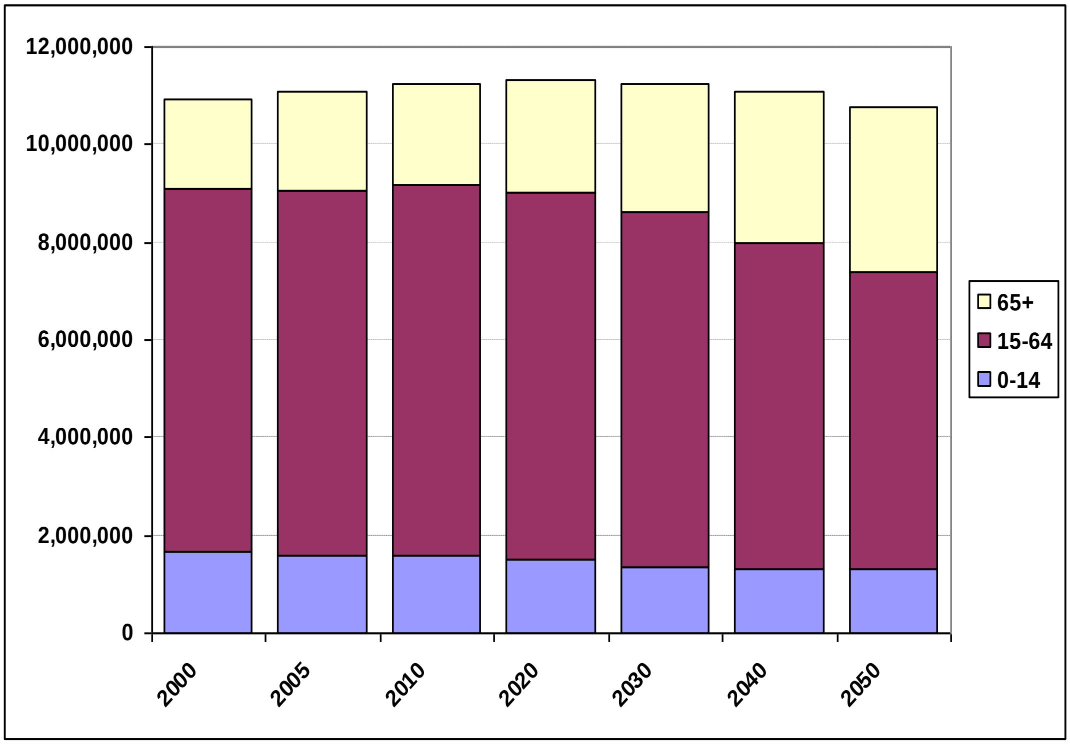
Finally, Figure 2.13shows the assumptions that are being made on the level of migration for each scenario. Under all scenarios, there is positive net-in-migration.

Under the medium scenario it remains stable at 40,000 per annum. Under the high and low scenarios it starts at 50,000 and 30,000 respectively and after 2020 it jumps (surprisingly) to 60,000 and 20,000 respectively.

2.3.3 Projected population

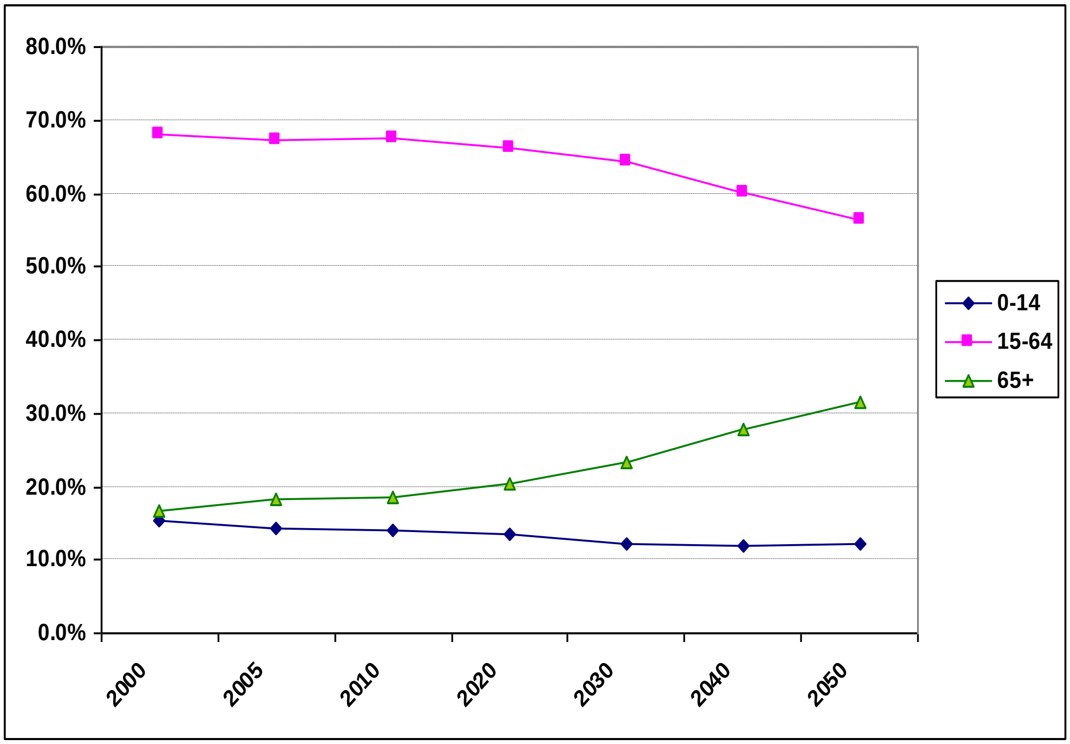
By 2050 and assuming the aforementioned values at each point in time for the demographic parameters, the total population is expected to fall to 10.779 million or 1.27%. However, the group 15-64 falls to 6.08 million which is a fall of 18% from the year 2000. It is reasonable to assume that the shrinking of this age group is one the major, if not the major, characteristics of the future demographic developments. As mentioned before it is the economic impact of the reduction of this group (working age population) that is being examined. Figure 2.14 illustrates both the changes in composition as well as changes in total population. The projected decrease in total population and the shrinking of working age population are both easily observable.

Figure 2 14 Total population by age group 2000-2050



The age group 0-14 falls from 15% in 2000 to 12% in 2050. The group 15-64 drops from 68% of the total population to 56% over the same period, while the aged (65+) increase from 17% to 29%.

Figure 2 15 Percentages of different age groups 2000-2050



The weight of the very old according to the ESYE projection is also going to increase from 3% in 2000 to 10% in 2050. Figure 2.16 below, shows the corresponding changes in the relative size of each age group.

Figure 2 16 Percentage of the very old 1960- 2050

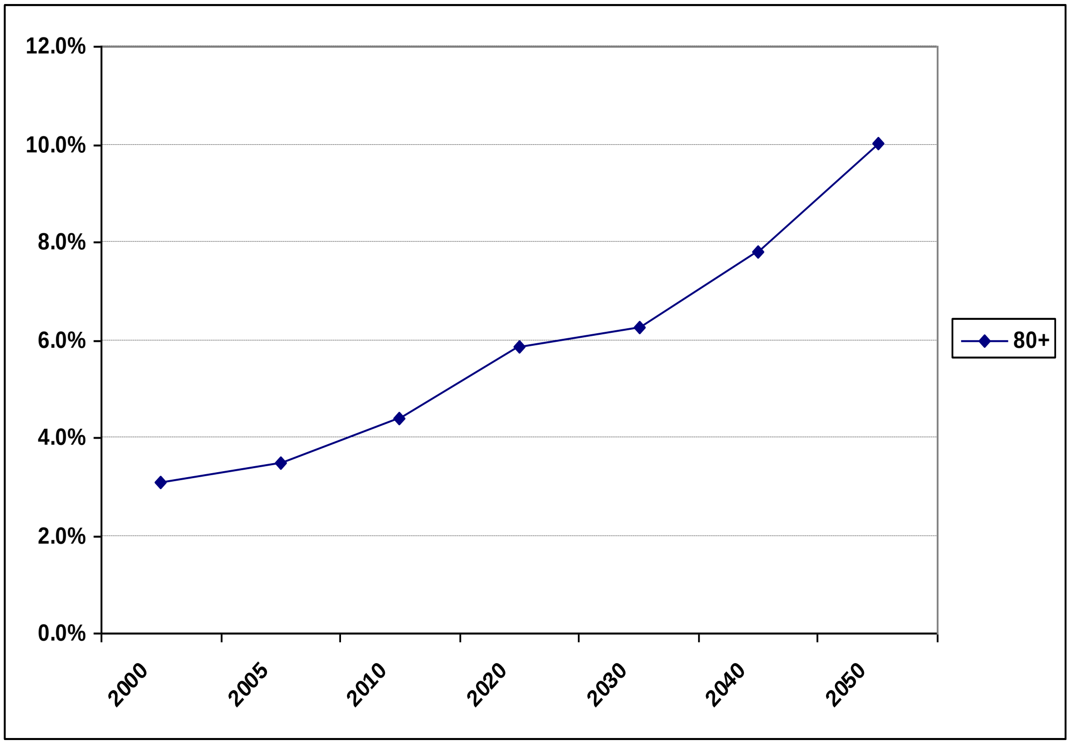


Figure 2.17 indicates that the relation between young and old workers is almost reversed from 2000 to 2050. This is another important projected development as productivity of workers is age related and follows an inverted U-shape while it peaks at around the age of 40 (Boersch –Supan, 2001)

Figure 2 17 Composition of working age population, older VS younger workers

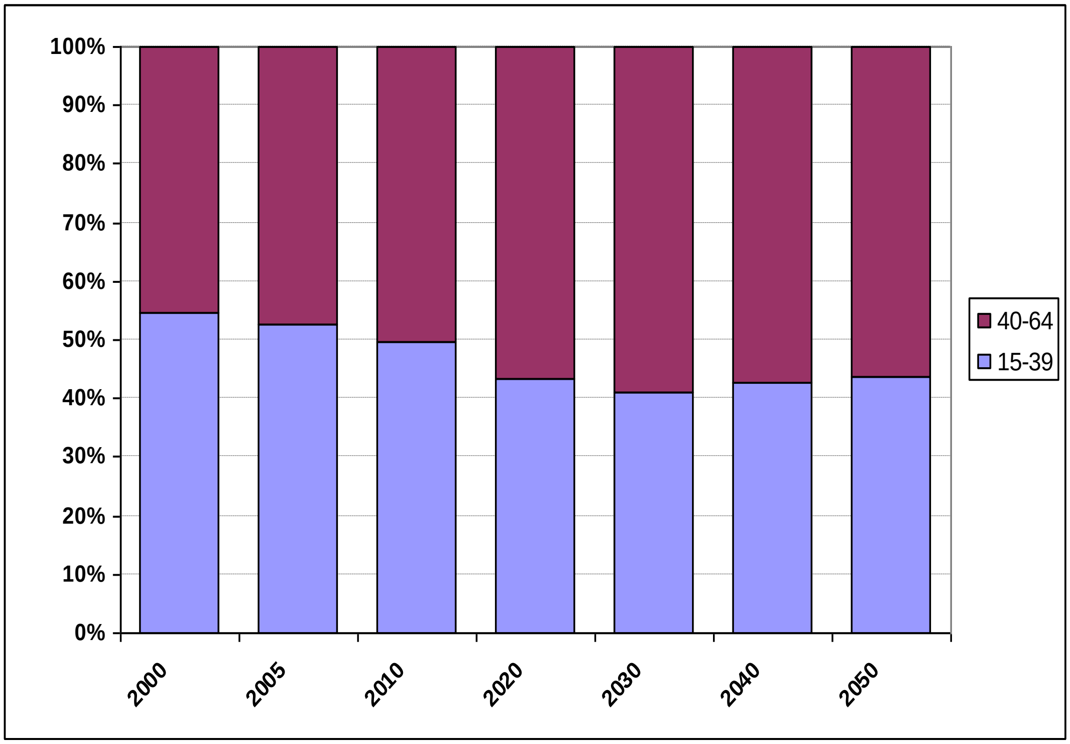
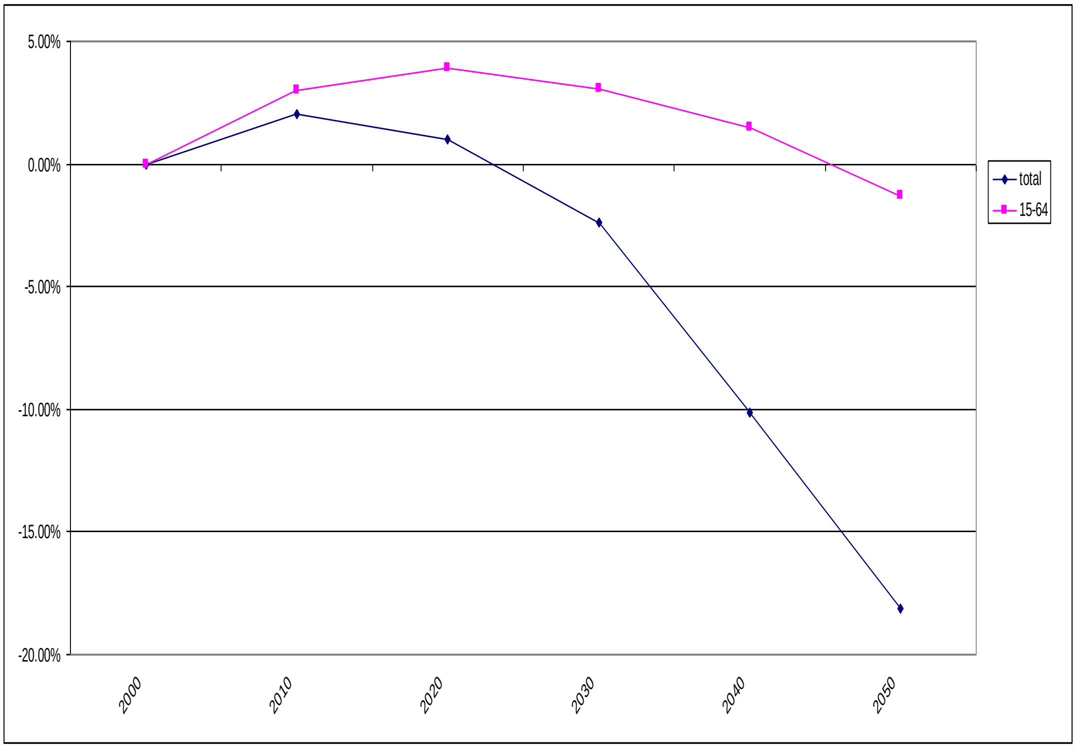


Figure 2.18 presents the percentage changes in the total population and working age population. These two measures are quite relevant to our simulation exercise.

Figure 2 18 Percentage changes of total and working age population



By 2050 the total population is expected to fall by 1.27%. However, the group 15-64, the working age population is expected to witness a drop of 18.21%. I now turn to a detailed explanation of the features of the FIV-FIV software followed by a detailed explanation of the population projections I have performed.

2.4. Population Projections. The demographic software FIV-FIV

2.4.1. Introduction

The purpose of this section is to describe the demographic model that will be used in Section 2.5 to generate demographic projections for Greece. The model that will be used is FIV-FIV, which was developed in 1995 by the Population Council (Shorter et. al, 1995). A short discussion of the usefulness and data requirements of population projections follows. This is followed by an explanation of how the FIV-FIV software works and a detailed account of the calculation methods follows.

2.4.2. How the population projections are performed

For a population to be projected into the future, values of the basic demographic variables (or components of population change) have to be extrapolated. It is, of course, the case that the projected population will depend upon the chosen values of these parameters. A close examination of the current and past demographic trends can be of great assistance in deciding what is "reasonable".

The starting point should always be a precise picture of the structure of the population at the base year.

In addition to a base year population structure we need assumptions for fertility and migration. For both of these parameters, we also need an age structure. That is age specific fertility rates and the age sex structure of migration flows. Values on life expectancy at birth are also necessary. In addition, the values need to be extrapolated for the future. For example, an analysis of past trends in mortality, and a comparison with other countries, may lead us to the assumption that mortality will keep falling (longevity will continue to increase). Extrapolation is usually done in a linear manner but it can also take a form of a curve or even of stepped changes. The assumptions utilise information from every source possible although sometimes they appear to be arbitrary.

Most demographers do not describe population projections as forecasts as they are subject to assumptions that are largely uncertain. So, when presenting population projections one should always state the assumptions made and underline that the projected population is conditioned upon stated assumptions hold. Let us now look at the predictability of each of the demographic components.

The most unpredictable demographic variable is migration (Shorter, 1995). This is not of great importance if migration flows are small relative to the total domestic population. However, if countries face waves of migration that are large relative to the domestic population, projection might be quite unreliable. This is the case for Greece. This fact requires the generation and examination of scenarios involving a wide range of migration assumptions.

The next parameter in terms of variability is the birth rate. Fertility levels often change abruptly. However a change in fertility has no immediate effect. For example, a labour force projection will not be affected for fifteen to twenty years by a current change in fertility. If however we want to project the number of pupils, i.e. people of school age, our assumption is relevant for a much shorter period of time.

The life table, i.e. the table that describes age specific survival rates, is the parameter set that demonstrates the least variability. Mortality levels can, of course, vary between countries and through time and in some populations high infant mortality is a serious issue. In general, however, mortality is extrapolated from previous trends without great concern. The old population already exists in the base year and is subject to existing mortality rates. It is easy to understand why mortality is less variable than fertility. Of course this applies in the absence of unforeseen events like genocide, famines, epidemics etc. For example, the number of people aged over fifty years in twenty years time is easy to predict. The number of children going to primary school in twenty years time is of course subject to greater uncertainty. However, in the previous decades many industrialised countries have revised their mortality assumptions due to the observation that life expectancy increases faster than expected (Ahlburg, 1993)

Given the uncertainty described above, population projections should not be regarded as forecasts. They are, however, very useful as tools for sensitivity analysis. That is, the examination of how projected population changes as a result of changing one of the determinants of demographic change. A comprehensive sensitivity analysis can be a good guide for policy implications and analysis. For example, Lisenkova et. al. (2008) find that the projected population for Scotland is very sensitive to different migration assumptions over the medium term time horizon. Thus, they proceed by examining a wider range of migration scenarios and also comment on current migration policies in Scotland.

Having described what population projections are, and having emphasised the caution with which they should be treated, a detailed mathematical representation of the FIV-FIV software follows.

2.4.3. The FIV-FIV software

This software produces population projections using the cohort component method. This is the most widely used method for population projections. The cohort component method tracks each cohort and its mortality, fertility, and migration over time. Starting with a base population, year-by-year deaths are subtracted, and births and net immigration are added to the population. This program allows us to project future population by sex and age structure, based on the current age-sex structure and additional assumptions about the main demographic variables: mortality, fertility and migration.

Projections are made in five-year cycles and projections can involve five to infinite years. However, the software writes the results in thirty-five year batches and to our view is that this is a sufficient time period within which population projections do not lose meaningfulness[12].

Births create a cohort of the age 0-4 at the end of the first five year cycle. The rest of the cohorts face a probability of mortality and their survivors are five years older in the end of the cycle. Net migration is algebraically added to cohorts during the cycle. The defined cohorts are presented in the following table.

[12] In the projections that are to follow we will be using the time period of three decades. As our base year is 2004 the projection period is up to 2034

Table 2 3 Cohorts identified in FIV-FIV software

Cohort Index	Age at beginning	Age at end	Cohort index	Age at beginning	Age at end
0	Born	0-4	9	40-44	45-49
1	0-4	5-9	10	45-49	50-54
2	5-9	10-14	11	50-54	55-59
3	10-14	14-19	12	55-59	60-64
4	14-19	20-24	13	60-64	65-69
5	20-24	25-29	14	65-69	70-74
6	29-30	30-34	15	70-74	75-79
7	35-39	40-44	16	75+	80+
8	40-44	45-49			

At the end of every cycle, the population of the cohorts 15 and 16 are added together to form the group 75+. One must keep in mind that pooling together all people above the age of 75 in one age group and applying the same survival rate might make the projection less accurate. Projections are separately done for men and women.

The first step in projections is to calculate the population alive in the beginning of the cycle, which comprises of cohorts one to sixteen. The second step is to calculate the population of cohort zero which is remaining and is born during the cycle. The population alive for each cohort with $c \neq 0$, is calculated by taking into account the effect of mortality for each cohort. That is:

(1) $C^5_{s,c} = C^0_{s,c} * S_{s,c}$

C stands for the population of cohort c sex s, at date 0 or five indicated by the superscript. S is the survival rate for each cohort.

Migration enters the calculation in the following way the following way. It is assumed that migrants come in or go out of the country following a uniform distribution during the five year period. So, migrants are exposed to mortality for an average of one half of the cycle. Therefore for migration to be taken into account the equation above is augmented in the following way.

(2) $C^5_{s,c} = C^0_{s,c} * S_{s,c} + M_{s,c} * (1+ S_{s,c})/2$

for cohorts one to sixteen. Note that M can be negative in the case of emigration being higher than immigration. We have now calculated the population alive at the beginning of the cycle.

Next, we have to calculate the number of births. This will depend on the number and age distribution of women of childbearing age, and their age specific fertility rates. Women of the age group 15-49 are the ones considered to be of childbearing age. These include seven cohorts, namely 15-19, 20-24, 25-29, 30-34, 35-39, 40-44, 45-49. The mean number of women with a probability of having a child for each of these cohorts will be:

(3) $W_c= (W^0_c+ W^5_c)/2$

where c is the cohort index and W is the respective number of women.

The number of births is calculated by using age specific fertility rates, F_i, and for the whole cycle the total number of births will be:

(4) $B = 5*\Sigma^{10}_4 (F_c* W_c)$

Births are calculated for males and females separately. Adjusting for the proportion of each gender, and the corresponding survival rate, males and females of the birth cohort are:

(5a) $C^5_{f,0} = g * B_s* + S_{f,0}$

(5b) $C^5_{m,0} = (1- g) * B_s* + S_{m,0}$

where g is the proportion of females born.

Again in order to augment the above equations for migration we need to make assumptions about the age distribution of migrants. The assumption is that migrants come in following a uniform distribution as well as those births is equally distributed between all ages 0 to 5. Therefore, the appropriate survival rate will be:

$(1+S_{s,0})/2$

This is a sufficient approximation if we assume that the probability of dying declines in a linear manner from birth until the age of 5. This is not very precise especially for the newborns. In addition, very few migrants are of the age of some weeks or months. Therefore, the above approximation is almost certainly biased downwards.

The software does not require assumptions to be made related to infant mortality of migrants. Instead it adjusts arbitrarily the above approximation and assumes that the survival rate comes in with a factor of one third instead of a half. Equations 5a and 5b take the form:

(6a) $C^{5}_{f,0} = g * B_s * + S_{f,0} + M_{f,0} * (2/3+1/3 * S_{f,0})$

(6b) $C^{5}_{m,0} = (1- g) * B_s * + S_{m,0} + M_{m,0} * (2/3+1/3 * S_{m,0})$

We have now calculated the new cohort and the projection to the next five-year cycle is complete. The next section presents the population projections generated for Greece under different scenarios.

2.5 Population projections for Greece

2.5.1 Base year population

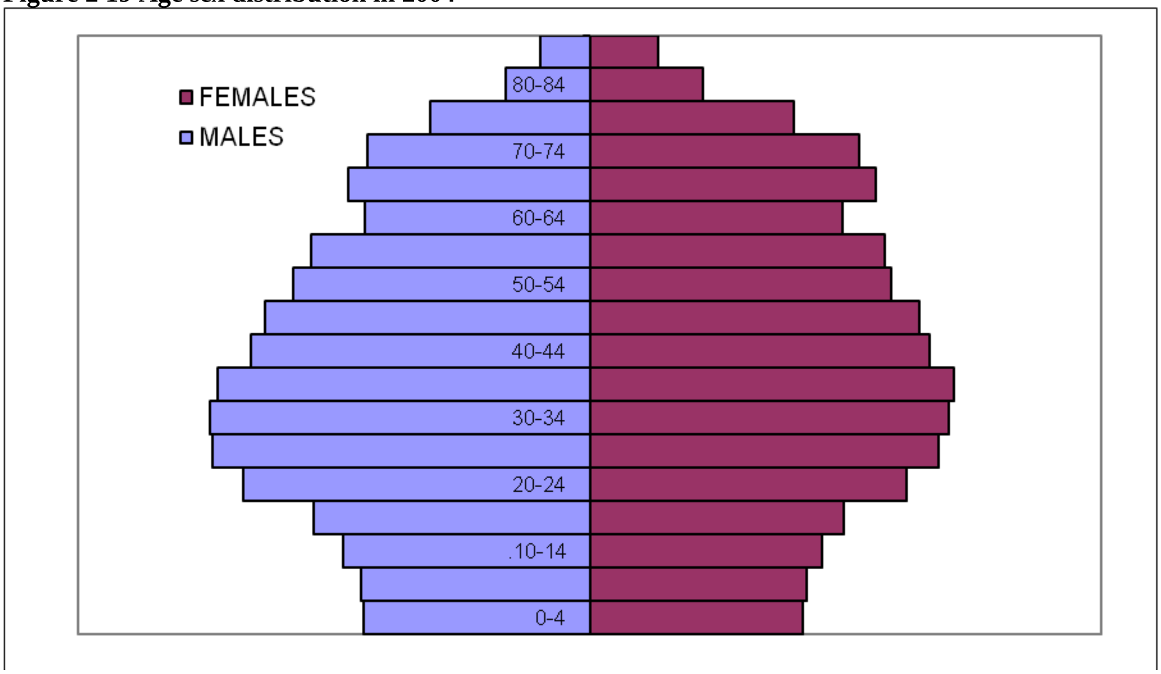
As explained in section 2.4, 2004 is chosen as the base year for population projections performed by the ESYE. The age–sex structure of the population at this point is presented in Table 2.4.

Table 2 4 Age-sex structure of the population for 2004 (source ESYE)

	Male	**Female**	**Total**
	5,475,529	**5,586,206**	**11,061,735**
0-4	265,069	249,376	514,445
05-09	267,886	254,748	522,634
10-14	289,540	272,231	561,771
15-19	323,003	298,416	621,419
20-24	405,619	371,422	777,041
25-29	441,856	408,371	850,227
30-34	444,526	420,595	865,121
35-39	436,345	426,372	862,717
40-44	397,408	398,875	796,283
45-49	380,086	386,578	766,664
50-54	348,088	353,669	701,757
55-59	326,723	346,207	672,930
60-64	263,086	296,861	559,947
65-69	282,875	335,171	618,046
70-74	260,400	315,354	575,754
75-79	187,315	238,763	426,078
80-84	97,701	132,829	230,530
85+	58,003	80,368	138,371

The female population is slightly higher and the most populated groups are the ones in the 20s and 30s. The population pyramid below demonstrates that clearly. The following sections, will present each scenario with its assumptions concerning demographic parameters and the corresponding projected population. For all scenarios, the population is projected for three decades ahead up to 2034. In each case the table with the trajectory for the total population and the working age population will be presented.

Figure 2 19 Age sex distribution in 2004



2.5.2 The base projection. Medium assumptions

The assumptions for the value of the total fertility rate and life expectancy at birth that we used for this projection are given in the medium columns of Table 2.2 in Section 2.3 For both fertility and life expectancy we had to calculate the mean of the five year period in order to input the data into FIV-FIV which requires information for five-year periods. So, for example, for the period 2004-2009, the fertility rate we have input is 1.31 and so on. We believe that averaging these figures does not make a great difference. In order to perform the projection we need age specific fertility rates as well.

The information we get from ESYE for the year 2004 is presented in the second column of Table 2.5. The groups of "under the age of 15" and "over the age of 50" cannot be fed in to the demographic software and therefore we had to pull them together with the groups "15-19" and "45-49" respectively. A useful feature of FIV-FIV is that the user can feed in absolute numbers but the software will calculate percentages and then scale up and down accordingly. The data fed into the model after the adjustment is presented in the third column of Table 2.5. The fourth column presents the corresponding percentages.

Table 2 5 Age specific fertility

Age of the mother	Births (1)	Births (2)	Percentages
Under the age of 15	75	--	--
15-19	3,302	3,377	3.2%
20-24	15,616	15,616	14.8%
25-29	34,019	34,019	32.2%
30-34	33,943	33,943	32.1%
35-39	15,677	15,677	14.8%
40-44	2,745	2,745	2.6%
45-49	237	278	0.3%
Over the age of 50	41	--	--
Total	**105,655**	**105,655**	**100.0%**

The age-pattern of the model varies with the level of total fertility. The assumption is that childbearing starts later and terminates earlier with low fertility.

Another requirement is the age-sex distribution for migrants. Migrants are assumed to have a constant age-sex structure throughout the projection period. There is no data for the year 2004 and therefore the information for 2001 which comes from the census is used. The age-sex composition is as follows.

Table 2 6 Age distribution of foreign population (migrants)

	Males	Females
0-4	4.8%	5.3%
05-09	5.4%	5.9%
10-14	5.9%	6.2%
15-19	8.2%	7.4%
20-24	13.5%	10.8%
25-29	15.2%	12.8%
30-34	13.3%	12.2%
35-39	10.1%	10.3%
40-44	8.0%	9.0%
45-49	5.4%	6.7%
50-54	3.6%	4.6%
55-59	2.1%	2.6%
60-64	1.6%	2.1%
65-69	1.2%	1.4%
70-74	0.8%	1.2%
75-79	0.5%	0.8%
80-84	0.3%	0.4%
85+	0.2%	0.3%

There are two points to make. Again the data of the last three age groups into the group "75+" had to be pooled together. As a unique mortality rate is applied in the whole pooled group, probably "some of them are killed too early" during the projections[13]. The second point is that the information above is related to foreign population residing in Greece already and not to incoming migrant population. So, feeding the above distribution in the projection means that we assume that incoming

[13] I would like to thank Prof Robert Wright for useful comments regarding this issue.

migrants have the same age-sex structure as the existing foreign population. Finally, it is assumed that immigrants and emigrants have the same age-sex structure.

The total number of migrants assumed for the whole period is 40,000 as in the base projection of ESYE. The sex composition in 2004 was 54.5 male against 45.5 female migrants. We assume that the flow of net-migration follows the same sex distribution for the whole period of the projection. That is every year there are 18,200 female and 21,800 male immigrants. It is also assumed that as they arrive, they adopt the fertility and life expectancy profile of the local population.

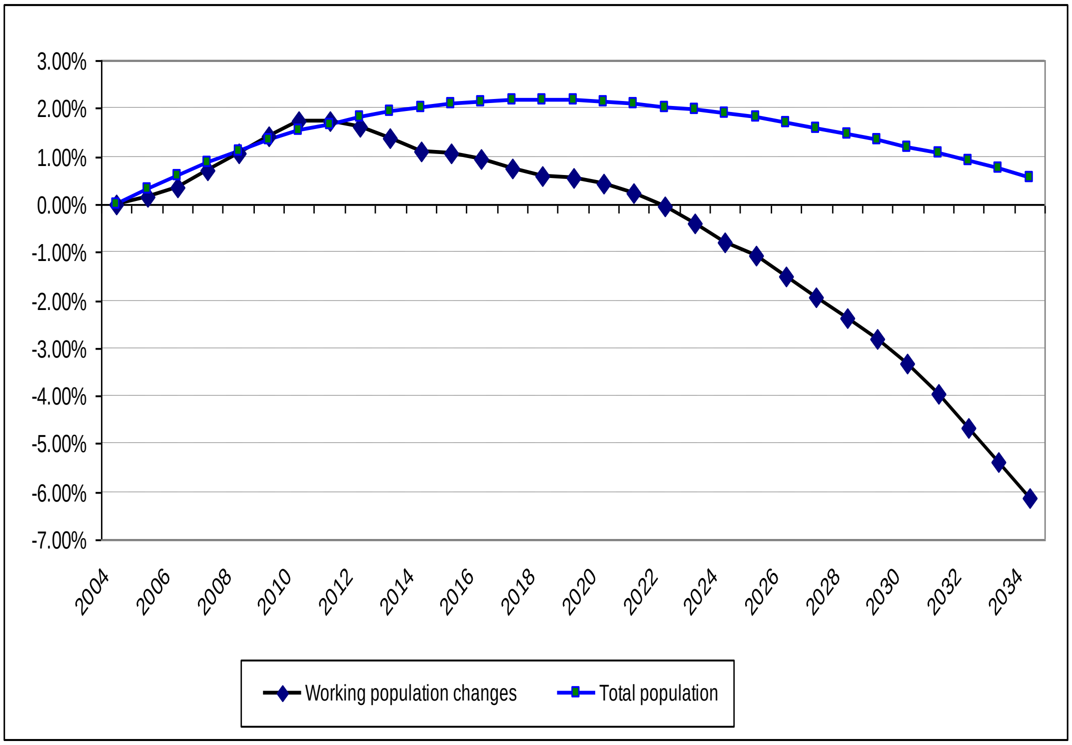
The percentage changes of the working age and total population by the end of the projection period are presented in Table 2.7 and Graph 2.9. Note that in this graph, and any subsequent similar graph the values for working age population and total population for the years 2005 and 2006 are not generated by FIV-FIV but are instead the actual values published by ESYE[14]. A similar strategy has been followed elsewhere[15].

Table 2 7 Working age and total population under the base scenario

BASE	**2004**	**2009**	**2014**	**2019**	**2024**	**2029**	**2034**
16-64 (000s)	7344	7448	7425	7384	7287	7139	6894
% change from base	0.0%	1.4%	1.1%	0.5%	-0.8%	-2.8%	-6.13%
Total (000s)	11041	11188	11263	11279	11250	11187	11101
% change from base	0.0%	1.3%	2.0%	2.2%	1.9%	1.3%	0.5%

[14] As only data for the group 15-64 is published, we had to extrapolate this group and assume that for the first three years, the group15-16 is a fifth of the group 15-19, leaving four fifths for 16-19.
[15] Lisenkova et. Al. (2008)

Figure 2 20 Percentage changes in total and working age population under the base scenario



Total population increases initially and ends up slightly above (0.5%) the 2004 level. It should also be underlined that working age population increases initially, reaches a peak in 2010 and then drops. It crosses the 2004 level in 2022 and by the end of the projection period it has decreased by 6.13%. There is one very important point to notice. Although immigrants have a positive impact on the demographic profile of the population, they cannot prevent it from ageing if they come in at a rate of 40,000 per year. The reduction of the working age population occurs after 2022.

Before going on to other scenarios it would be useful to compare this projection with the projection of ESYE in order to check to what extent it is approximated. A year by year comparison could not be done, as the agency published the projected population for the years 2010, 2020, 2030, 2040, 2050 and only for the base projection. Therefore changes of total and working age population for the year 2030 will be compared between the official projection and the projection generated here. The table below shows the relevant figures.

Table 2 8 Total and working age population by year 2030

	My projection	ESYE	% Difference
16-64	7,101,000	7,145,850	-0.63%
Total	11,173,000	11,249,902	-0.68%

The estimates are quite close. Nevertheless, marginal differences should be attributed to the following reasons.

- The software used applies a unique mortality rate for everyone over the age of seventy five. So, it exhibits a greater number of deaths for the very old. Thus, the lower total population.
- The agency has not published the assumptions it uses for the age distribution of immigrants. The fact that our projection shows a bigger decrease of the working age population indicates that the assumption used by the agency involves slightly younger migrants.
- The fact that the agency does not explicitly state the assumptions for the values of age specific fertility rates means that there is a possibility that these differ from our assumptions.

At the time that the projections were performed the above data were not available. However, differences of the scale of less than one percentage point as those shown in Table 2.8 above, are going to have a small impact upon our results as we shall see later.

2.5.3 Sensitivity of projected population to varying the values of demographic variables

In this section we examine the impact that varying the demographic assumptions has upon the projected population. We conduct projections where the modelled fertility, life expectancy and migration conditions differ from those used in our base projection. We can thus test the sensitivity of the projected population to changes in the forces that are driving demographic change. In particular, we perform projections where two of the three relevant parameters are set to their base values, but here the third takes a high or low value. We start by keeping constant the fertility rate and the net- migration assumptions and explore the impact of varying life expectancy. We then keep life expectancy and net-migration constant and vary the fertility rate. Finally, we keep the fertility rate and life expectancy constant and we vary the level of net migration.

Tables 2.10 and 2.11 and Figures 2.21 and 2.22 report the demographic projections where life expectancy takes high or low values, while fertility rates and net-migration are constant at there “medium” values. The values we give to the demographic parameters are the ones used by ESYE as presented in Table 2.2 of Section 2.3.

In particular for the low life expectancy scenario, life expectancy is assumed to rise gradually and to reach 77.49 years for men and 82.48 years for women in 2034. For the high life expectancy scenario, the corresponding figures are 80.36 and 85.17.

Table 2 9 Working age and total population under the low life expectancy scenario

Low expectancy	2004	2009	2014	2019	2024	2029	2034
16-64	7344	7447	7423	7379	7278	7125	6876
	0.0%	1.4%	1.1%	0.5%	-0.9%	-3.0%	-6.37%
Total	11041	11185	11250	11250	11200	11111	10993
	0.0%	1.3%	1.9%	1.9%	1.4%	0.6%	-0.4%

Figure 2 21 Percentage changes in total and working age population under the low life expectancy scenario

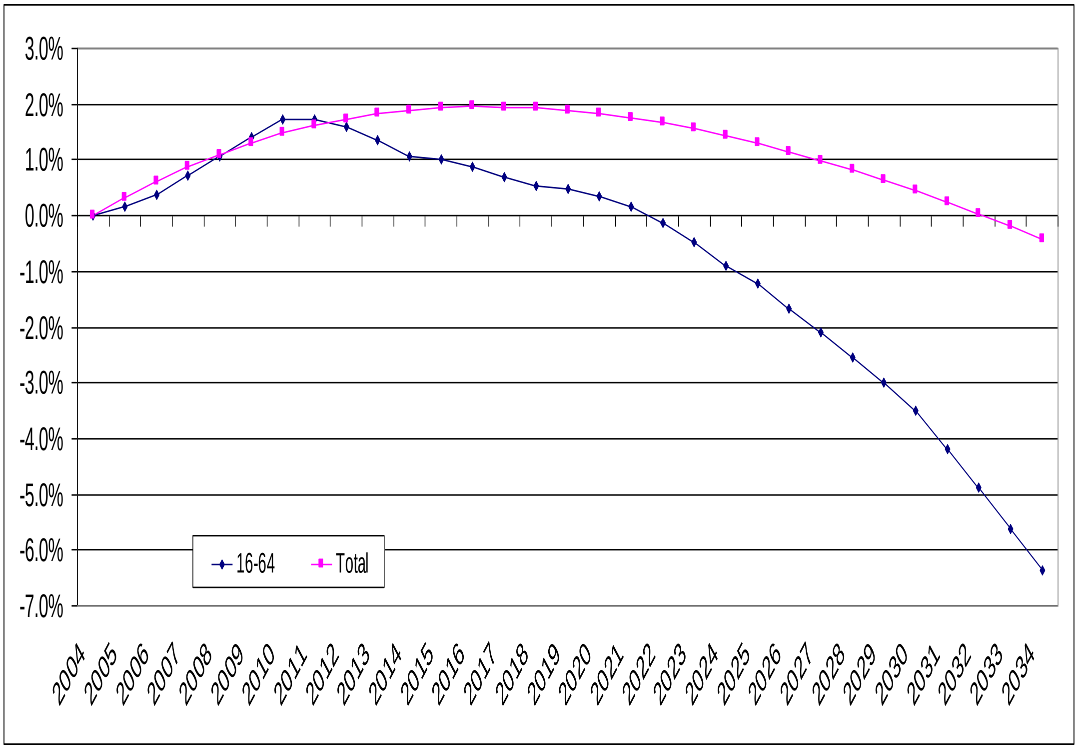
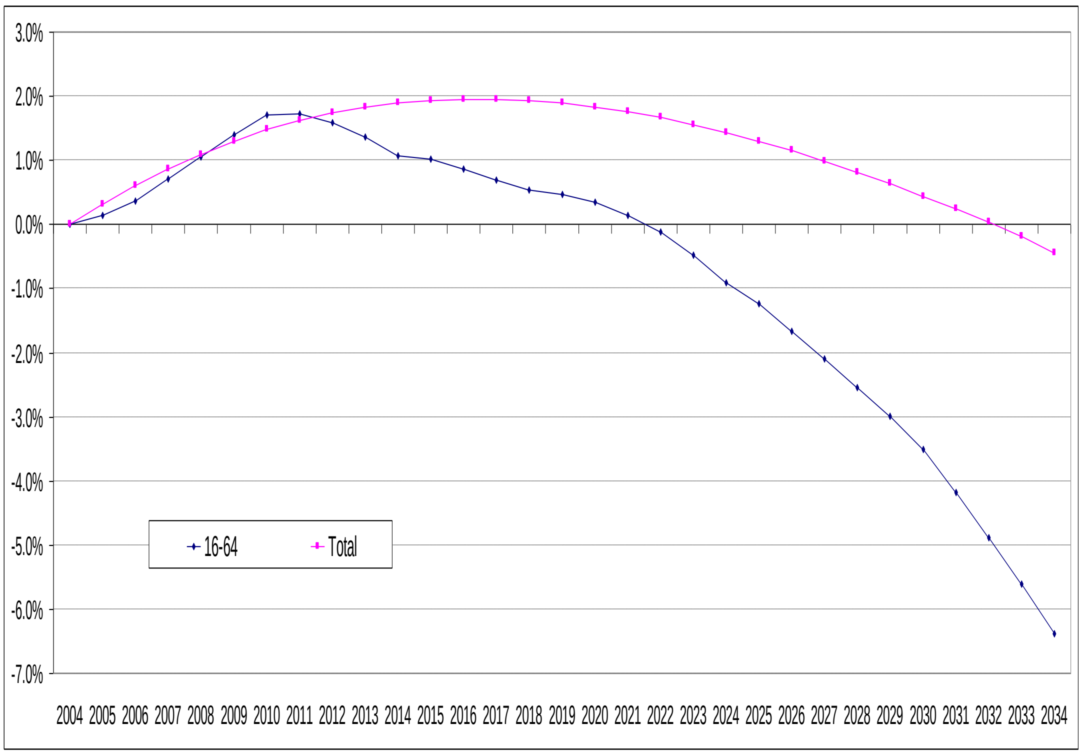


Table 2 10 Working age and total population under the high life expectancy scenario

High expectancy	2004	2009	2014	2019	2024	2029	2034
16-64	7344	7450	7431	7393	7300	7157	6917
	0.0%	1.4%	1.2%	0.7%	-0.6%	-2.5%	-5.81%
Total	11041	11200	11293	11330	11324	11288	11234
	0.0%	1.4%	2.3%	2.6%	2.6%	2.2%	1.8%

Figure 2 22 Percentage changes in total and working age population under the high life expectancy scenario



Varying life expectancy does not change dramatically the projected population. Although, there is an increased total population under high life expectancy, there is only a small change in the working age population, which ranges from -5.81% for high life expectancy to -6.37% for low expectancy. The base scenario generates a change of

-6.13% which, as expected, is in between the high and low expectancy values. The results are quite reasonable as a different life expectancy will mainly alter the increase in the numbers weight of the older age group and have a minimal impact upon other age groups.

Tables 2.11 and 2.12 and Figures 2.23 and 2.24 report the results of projections varying the total fertility rate and allowing it to take high and low values while keeping life expectancy and net-migration constant. The values of the demographic parameters are again the ones used by ESYE as presented in Table 2.2 of Section 2.3.

For the low fertility rate scenario, fertility is assumed to fall in a linear manner and to reach 1.21 children per woman in 2034. For the high fertility rate scenario, we have a rise and the corresponding figure is 1.74. Throughout the projection period life expectancy both for men and women and net migration take the values presented in the corresponding "medium" column of Table 2.2 of Section 2.3.

Table 2 11 Working age and total population under the low fertility rate scenario

Low fertility	2004	2009	2014	2019	2024	2029	2034
16-64	7344	7448	7425	7384	7275	7099	6813
	0.0%	1.4%	1.1%	0.5%	-0.9%	-3.3%	-7.2%
Total	11041	11172	11217	11189	11120	11002	10849
	0.0%	1.2%	1.6%	1.3%	0.7%	-0.4%	-1.7%

Figure 2 23 Percentage changes in total and working age population under the low fertility scenario

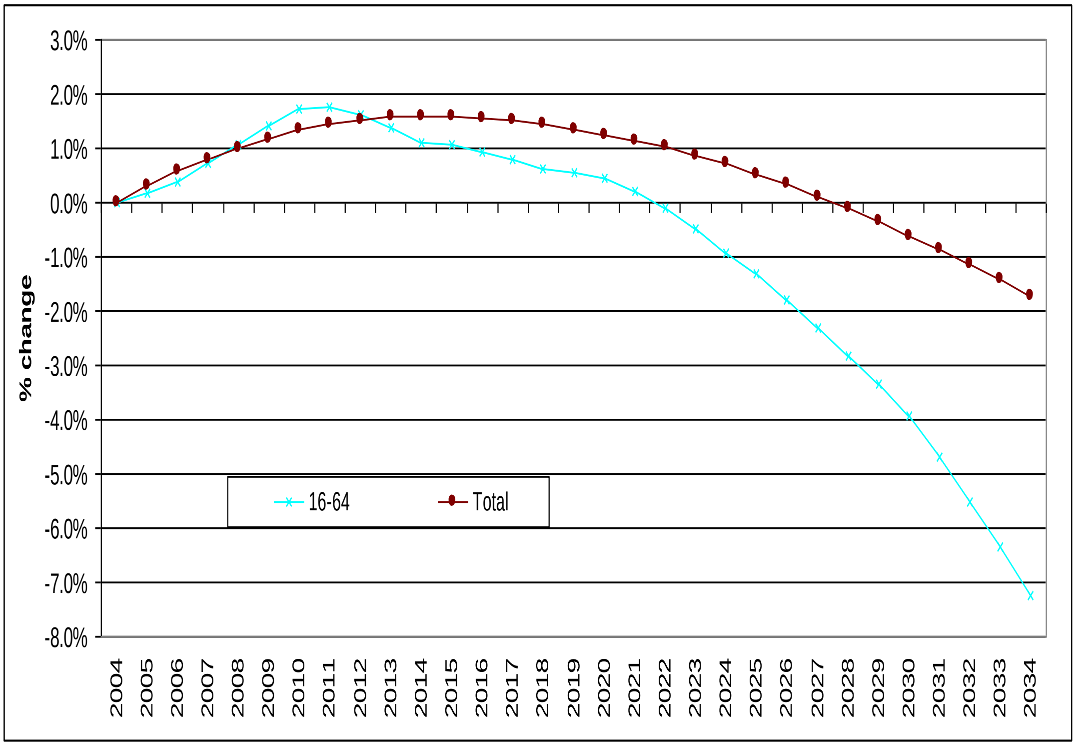
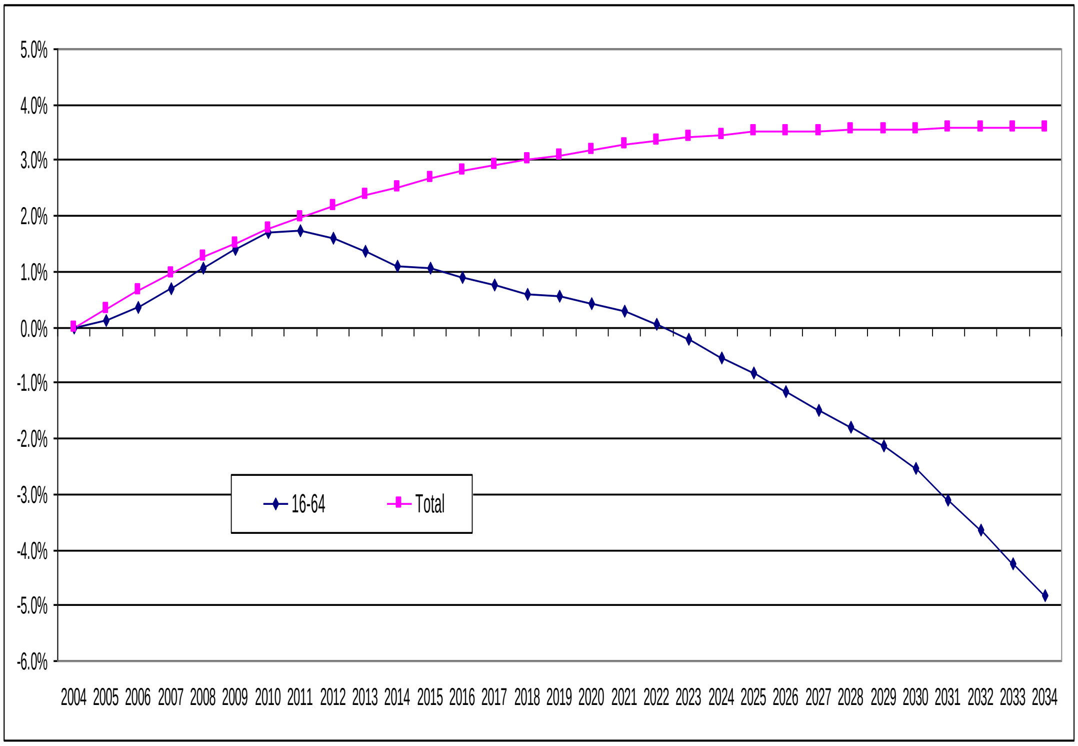


Table 2 12 Working age and total population under the high fertility rate scenario

High fertility	2004	2009	2014	2019	2024	2029	2034
16-64	7344	7448	7425	7384	7303	7188	6989
	0.0%	1.4%	1.1%	0.5%	-0.6%	-2.1%	-4.8%
Total	11041	11208	11320	11383	11424	11433	11436
	0.0%	1.5%	2.5%	3.1%	3.5%	3.6%	3.6%

Figure 2 24 Percentage changes in total and working age population under the high fertility scenario



The impact of choosing a favourable demographic scenario by altering fertility has a significant impact upon the total population, which takes a value above that in the base scenario in the end of the projection period. However, the impact of higher fertility upon the size of the working age population takes time to materialise. The change in the size of this age group is the same up to 2019 as we can see comparing Tables 2.11 and 2.12 to Table 2.8. Again, the "medium" scenario generates changes which are in between the aforementioned values.

Tables 2.13 and 2.14 and Figures 2.25 and 2.26 show the projection results where fertility rates and life expectancy are constant and high and low assumptions of annual net migration. Age distribution and fertility rates of migrants have been discussed before. In this set of projections, for the low migration scenario the assumption is that net annual migration is 20,000 people, while for the high migration scenario we assume 60,000 people. In the ESYE projections the high and low migration scenarios involve a jump in the volume of net-migration in 2020. Here a constant rate of migration is assumed. We believe that this choice serves better our sensitivity analysis exercise and in addition the jump in net migration is arbitrary.

Table 2 13 Working age and total population under the low net migration scenario

twenty	2004	2009	2014	2019	2024	2029	2034
16-64	7344	7367	7261	7135	6952	6720	6394
	0.0%	0.3%	-1.1%	-2.8%	-5.3%	-8.5%	-12.94%
Total	11041	11085	11053	10957	10814	10637	10435
	0.0%	0.4%	0.1%	-0.8%	-2.1%	-3.7%	-5.5%

Figure 2 25 Percentage changes in total and working age population under the low net migration (20,000) scenario

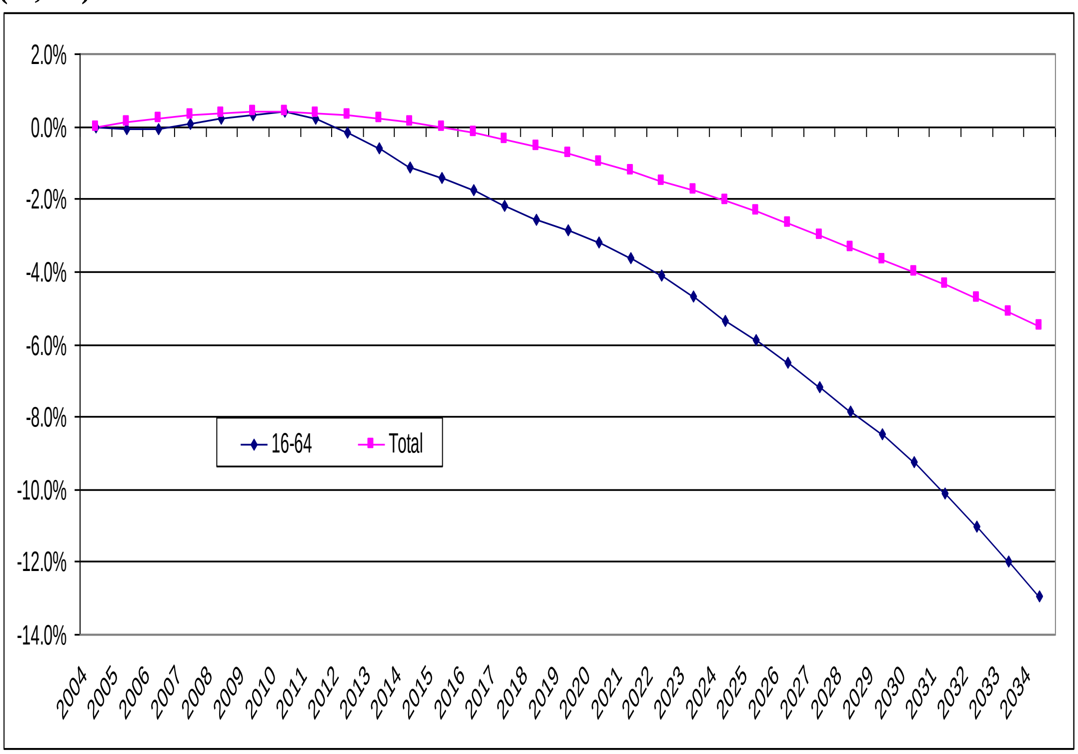
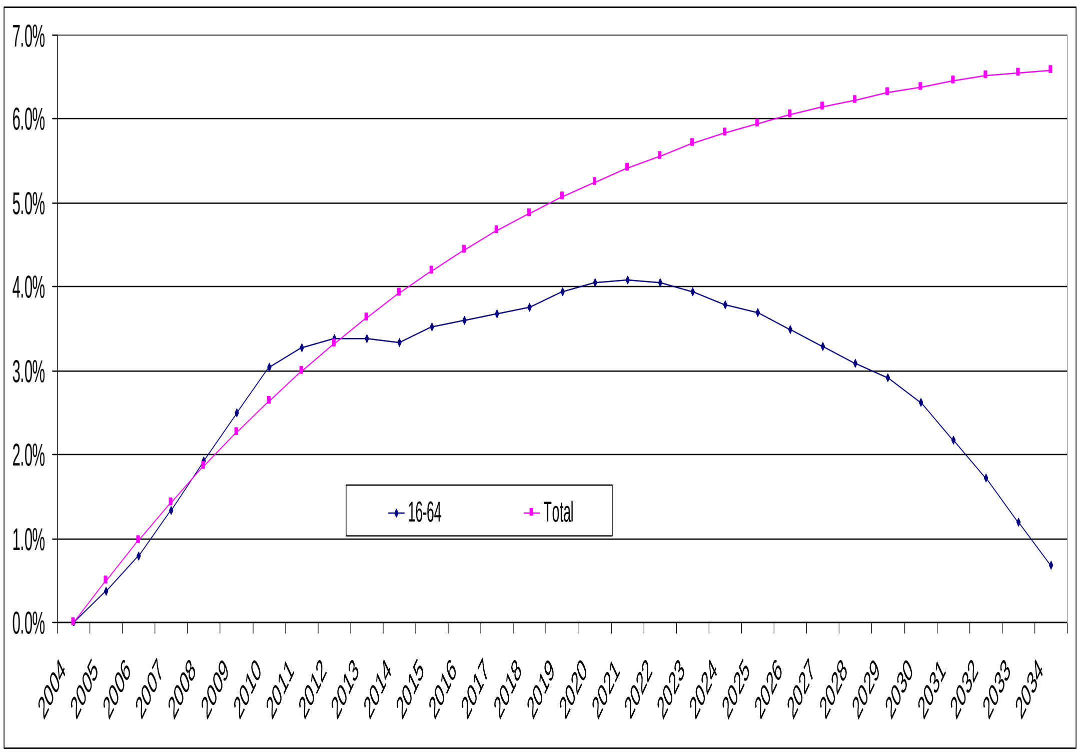


Table 2 14 Working age and total population under the high net-migration scenario

sixty	2004	2009	2014	2019	2024	2029	2034
16-64	7344	7528	7589	7633	7622	7558	7394
	0.0%	2.5%	3.3%	3.9%	3.8%	2.9%	0.68%
Total	11041	11291	11474	11601	11685	11738	11768
	0.0%	2.3%	3.9%	5.1%	5.8%	6.3%	6.6%

Figure 2 26 Percentage changes in total and working age population under the high net-migration scenario



Assuming a high net migration generates not only an increased total population but also a working age population that is still above the base year in 2034. Nevertheless, the working age population peaks in 2022, starts falling and it would fall further had we performed a projection for more years. Again, the base scenario generates changes which are in between the values reported in tables 2.14 and 2.15.

Figures 2.27, 2.28 and 2.29 make it even clearer that varying the migration assumptions make a real difference in the projected population. They present the full trajectories of population changes under different assumptions. In the next section we proceed with a further exploration of alternative migration scenarios.

Figure 2 27 Percentage changes of working age population under different scenarios for life expectancy

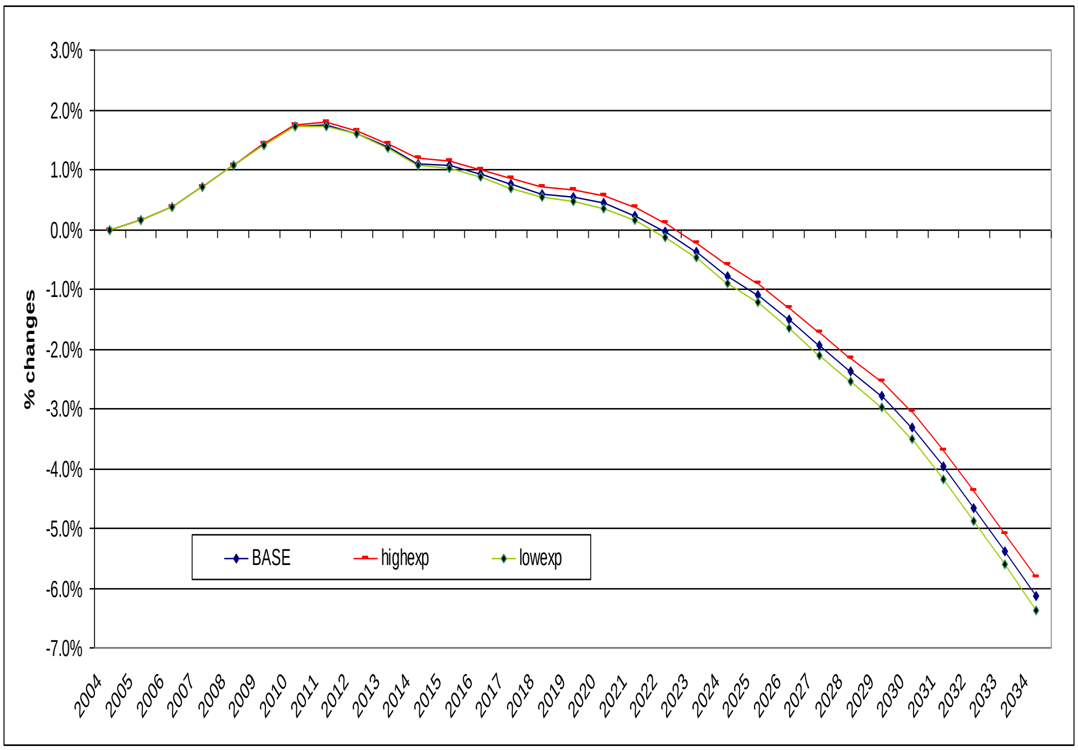


Figure 2 28 Percentage changes of working age population under different scenarios for fertility rate

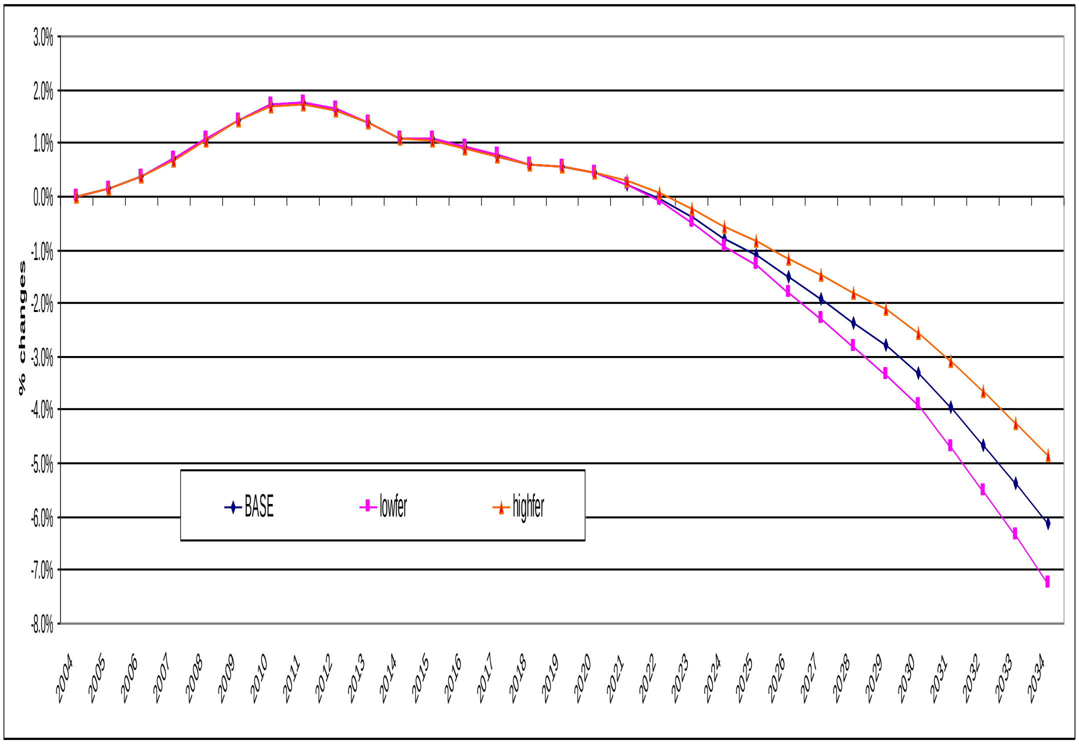
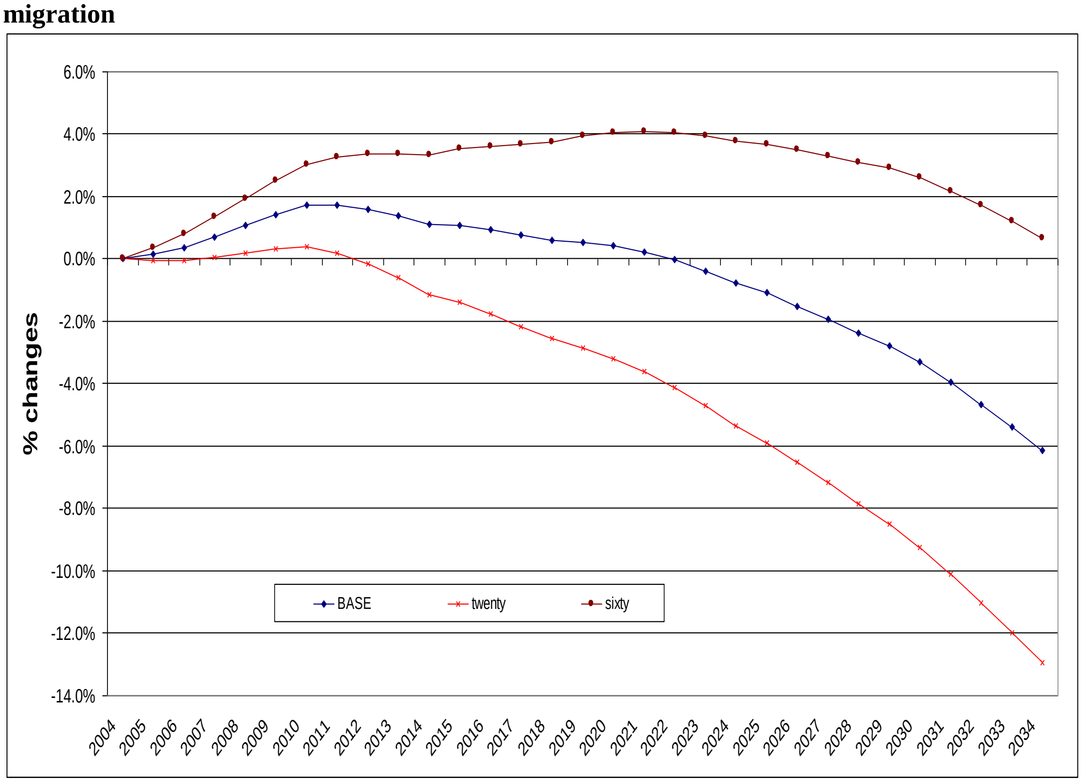


Figure 2 29 Percentage changes of working age population under different scenarios for annual net migration



This section has demonstrated that the projected population is far more sensitive to changes in the assumption concerning the amount of annual net migration than the two other demographic parameters. Migration has the greatest impact as it is a direct injection to the younger age groups, while fertility affects the demographic profile in the long run and life expectancy changes affect the older generations. In Table 2.15 we present the values for working age population and total population by 2034 under different scenarios.

Table 2 15 Sensitivity analysis results. Actual and Percentage change of Total Population and Working Age Population in year 2034

		life expectancy		fertility		net-migration	
	Base	**low**	**high**	**low**	**high**	**low**	**high**
16-64	6894	6876	6917	6813	6989	6394	7394
% change	-6.13%	-6.37%	-5.81%	-7.20%	-4.80%	-12.94%	0.68%
Total	11101	10993	11234	10849	11436	10435	11768
% change	0.50%	-0.40%	1.80%	-1.70%	3.60%	-5.50%	6.60%

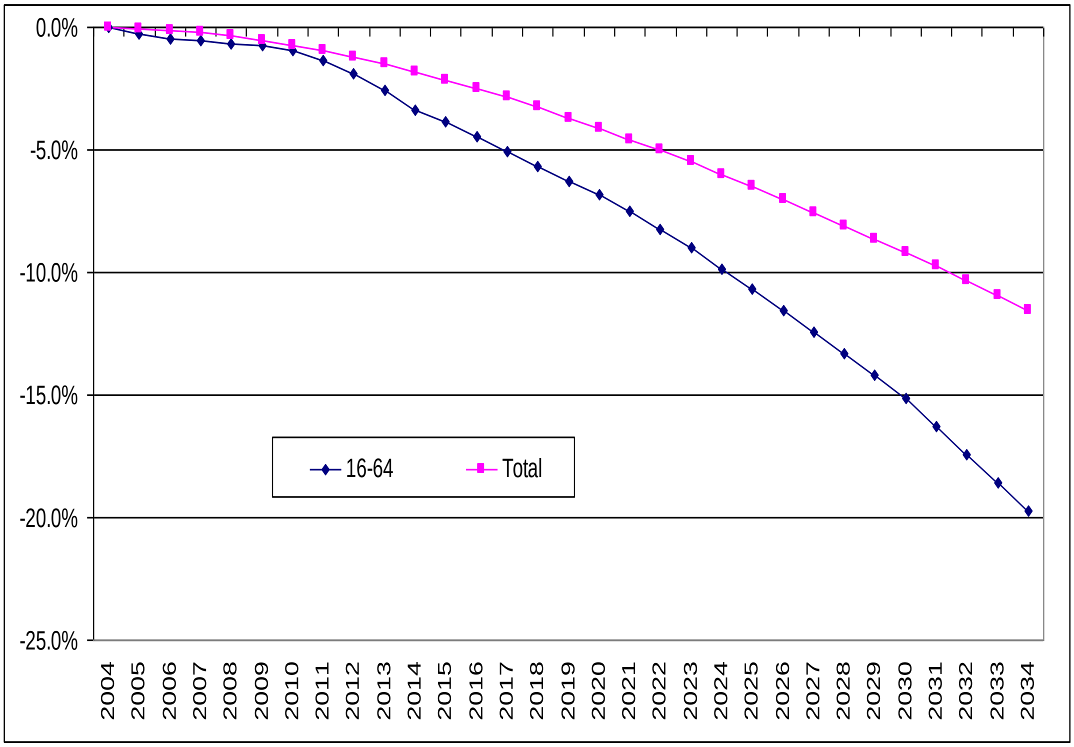
2.5.4 More migration scenarios

Table 2.16 and Figure 2.30 report results from a scenario that assumes zero net migration. That is to say, gross immigration is exactly equal to gross emigration both in numbers and demographic profile. This way we isolate population movement and focus on the impact of natural population change that is driven by the underlying fertility and life expectancy rates, which take the base scenario (medium) values.

Table 2 16 Working age and total population under the zero net-migration scenario

Zero migration	**2004**	**2009**	**2014**	**2019**	**2024**	**2029**	**2034**
16-64	7344	7287	7097	6885	6618	6300	5893
	0.0%	-0.8%	-3.4%	-6.3%	-9.9%	-14.2%	-19.76%
Total	11041	10983	10842	10634	10379	10087	9769
	0.0%	-0.5%	-1.8%	-3.7%	-6.0%	-8.6%	-11.5%

Figure 2 30 Percentage changes in total and working age population under the zero net migration scenario



The working age population is reduced by nearly 20% and total population by more than 11% by 2034. Comparing these figures with the ones in the base scenario (-6.13%, +0.5% respectively) it is clear that migration tends to compensate for the ageing trends by smoothening the prospective reduction of the working age population and completely cancelling natural decline in total population for the next three decades.

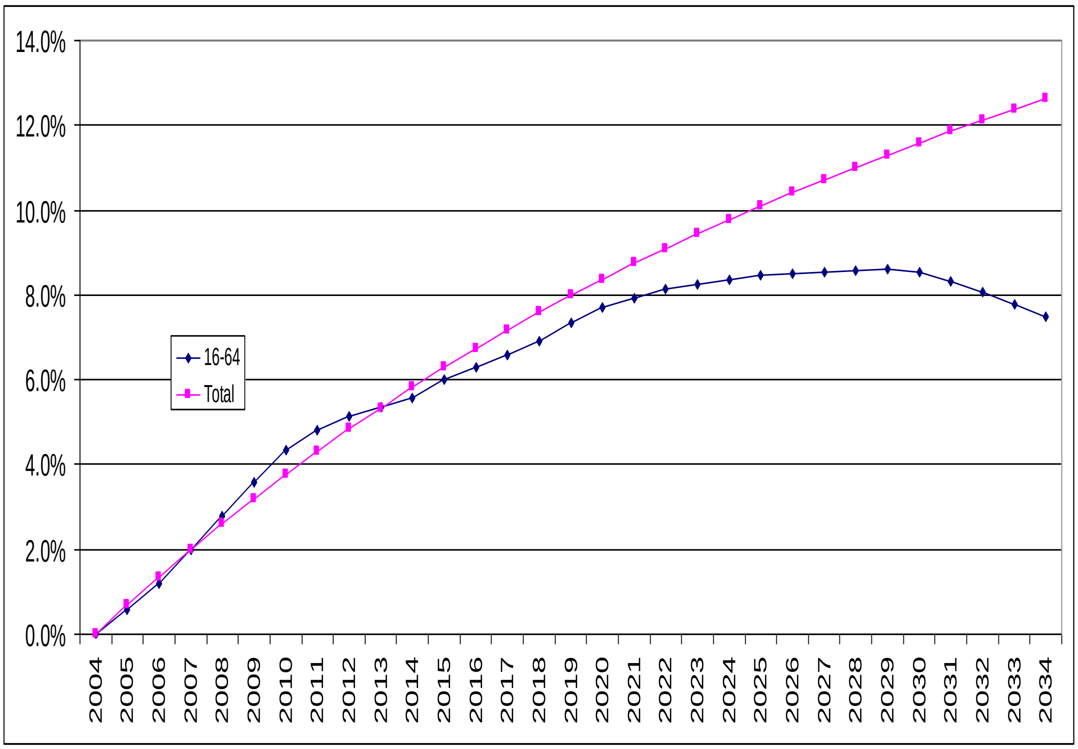
The results reported in Table 2.17 and Figure 2.31 are for a simulation in which the level of annual net-migration is 80,000. If the sex composition of migrants is as before, there are 36,400 females and 43,600 males per year.

Clearly the positive impact of migration is greater than in the scenarios we have examined up to now. In the end of the projection period, working age population has increased by 7.50% while total population has increased by 12.6%. Notice, however, that working age population reaches a peak in 2029 and then starts to decline.

Table 2 17 Working age and total population under the eighty thousand net-migration scenario

Eighty	2004	2009	2014	2019	2024	2029	2034
16-64	7344	7608	7753	7882	7957	7977	7895
	0.0%	3.6%	5.6%	7.3%	8.3%	8.6%	7.50%
Total	11041	11394	11684	11923	12121	12288	12434
	0.0%	3.2%	5.8%	8.0%	9.8%	11.3%	12.6%

Figure 2 31 Percentage changes in total and working age population under the eighty thousand net migration scenario

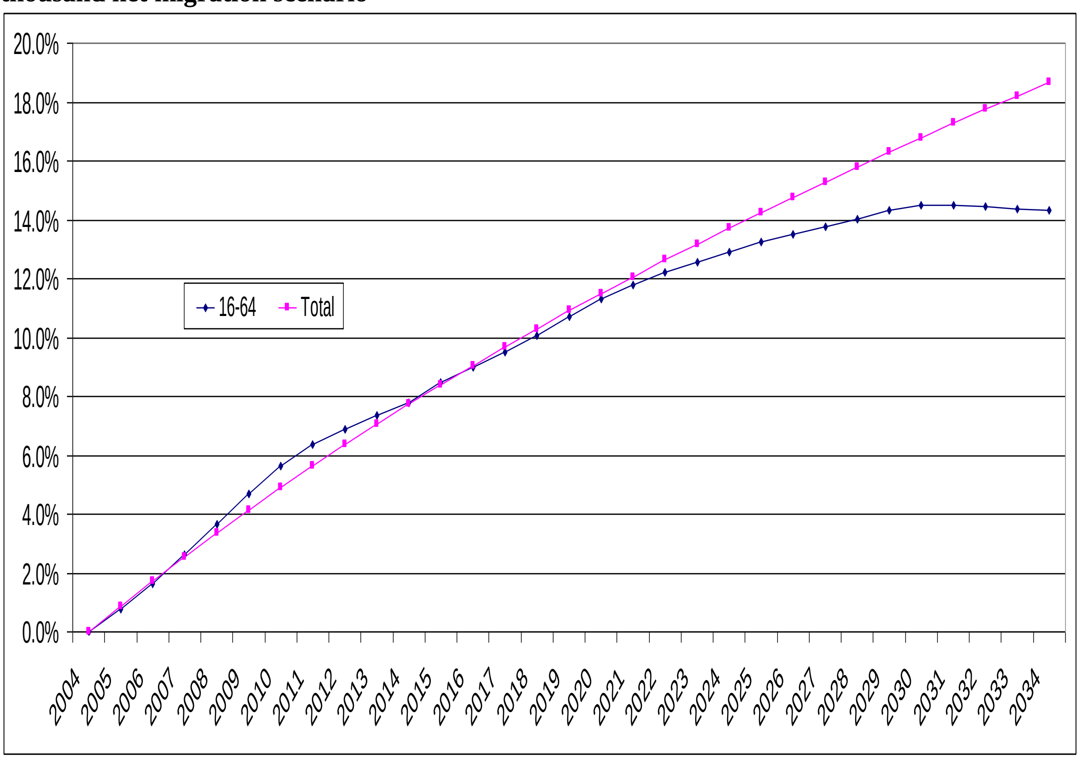


The results given in Table 2.18 and Figure 2.32 are for projections where net-migration takes the value of 100,000 per annum. Assuming the same sex composition as before, there are 45,500 female and 54,500 male migrants with the same age composition as before. Again the ageing of the population process is offset. The positive impact of migration is further increased. By the end of the projection period, working age population has risen by 14.31%, while total population has increased by 18.7%. However, notice that working age population reaches a peak in 2030 and then it starts to gradually decline.

Table 2 18 Working age and total population under the one hundred thousand net-migration scenario

Hundred	2004	2009	2014	2019	2024	2029	2034
16-64	7344	7689	7917	8132	8292	8397	8395
	0.0%	4.7%	7.8%	10.7%	12.9%	14.3%	14.31%
Total	11041	11496	11894	12246	12556	12839	13100
	0.0%	4.1%	7.7%	10.9%	13.7%	16.3%	18.7%

Figure 2 32 Percentage changes in total and working age population under the one hundred thousand net migration scenario



2.6. Conclusions

This chapter has defined the basic demographic parameters and also presented an overview of the population trends in developed countries. A detailed account has also been provided of the demographic history and profile of Greece. The basic observations were the following. Greece's population is ageing as fertility has fallen below the replacement rate and life expectancy is increasing. The country has experienced a "small and late" baby boom. However, in recent years Greece has turned from a country of emigration to a country of immigration and immigrants have largely offset the ageing process during the last two decades in terms of the characteristics of the population as a whole.

Next the population projections prepared by ESYE have been discussed including the assumptions made. The agency's base scenario project a slowly shrinking total population but a more rapidly declining working age population. The operation of the demographic software FIV-FIV was explained and a detailed account of its mathematical representation has been provided. This software has been used in order to make alternative projections. A base projection has been created using FIV-FIV, that is close to the base projection of the ESYE. Why the two projections do not match perfectly has been explained. Potential sources of small discrepancies were identified.

Next, an examination of which the three demographic parameters fertility, life expectancy and net migration, affects most the projected population. The resulting population has been more sensitive to altering the assumption of net migration. In the light of this result, scenarios that involve a wider range of net-migration values have been examined. It can be concluded that migration can largely avert the ageing of the population basically because migrants are younger than the existing population. However, this cannot be the case in the very long run as migrants themselves grow old (Robolis, 2008). This is illustrated in the last two projection where, although high levels of annual net-migration is assumed, working age population reaches a peak around 2030 and then it starts to decline slowly.

Chapter 3 . Computable General Equilibrium Models

3.1 Introduction

Computable General Equilibrium (CGE) Modelling involves the simulation of the general equilibrium structure of the economy. That is, a CGE model solves for a vector of prices and outputs across all the sectors of the economy, in which all markets are simultaneously in equilibrium. This technique has been widely used for assessing the impact of exogenous shocks to the economy and as a result it has proved useful for policy assessment.

CGE models incorporate specific functional forms that typically allow for substitution between inputs in production and outputs in consumption. In most cases such models assume that consumers are utility maximisers, and all employ the assumption of profit maximising and therefore cost minimising firms. In this framework only relative prices matter, and therefore if all prices change by the same proportion the production decisions does not change (Shoven and Whalley, 1984). In these models real values are homogeneous of degree zero in all nominal prices. That is, if all nominal prices increase, relative prices do not change.

Computable General Equilibrium models use a base year Social Accounting Matrix for the chosen economy, such that we have a "comprehensive and disaggregated snapshot of the socioeconomic system for that year" (Thorbecke, 2001, p.4). This year is assumed to represent the equilibrium year and thus results of most simulation exercises are presented as deviations from the base year values. The main sources for the construction of this data set are National Accounts and Input-Output tables.

The fact that most CGEs contain non linear equations and a high degree of complexity makes the use of computational software necessary. While much of the required data is included in the base year data set described above, additional key parameter values require to be, either estimated or chosen by the researcher. For example, parameters values such as trade elasticities, substitution elasticities, etc. It is quite often practically very difficult to estimate the quite large number of parameter values that is necessary. For example the estimation of elasticity values for nested production functions is not straightforward as data may be very limited. Therefore, an investigation of the relevant literature and a careful selection of parameter values is typically required. As an alternative, an additional set of parameters is calibrated in such a way to make the benchmark data set replicate itself. This procedure is known as calibration and assures that the initial data set is in equilibrium. Given this set of exogenous variables the model should replicate the base year data. A simulation involves changing one of the exogenous variables, for example demand for exports, and identifying the impact on endogenous variables such as GDP, employment, wage rate etc.

Once the above procedure is complete the impact of a particular policy or other exogenous shock can be simulated. The researcher has to identify a new value for one or more variables and solve for the equilibrium that is connected with these new values. In this way, the impact of policies such as an increase of taxation, migration waves, subsidies and productivity shocks can be simulated. The final thing to do is compare the new set of prices and output levels and the initial ones in order to assess the impact of the exogenous shock that we have determined. Shocks can be applied on the demand as well as the supply side. The modeller can shock government expenditure, export demands, taxes or change the size of the labour force or a subsidy.

CGEs have been used to assess the impact of for example, trade agreements, (Lloyd and Maclaren, 2004), tax reforms (Jorgensen, 1992, Sarris et.al, 2004). In addition they have been used to assess economic environmental interactions (Turner, 2002, Conrad 1999). Recently, in the light of demographic developments CGE models have been used to assess the impact of an ageing population. For example, Fougere et.al. (2004) examine the case of Canada, while Lisenkova et.al. 2008), assess the macroeconomic impact of the ageing population in Scotland. We must note, that the flexibility of such models and the fact that they incorporate data at the meso level, give the researcher the opportunity to examine very complex scenarios that simultaneously incorporate different types and sizes of shocks.

3.2 What is distinctive about a CGE?

The distinguishing characteristics of a CGE according to Dixon and Parmenter (1996) are the following. They include specification of the behavior of all economic actors and thus they are general. In addition, they describe how demand and supply decisions made by different economic actors determine the prices of at the least some commodities and factors. They include equations ensuring that prices adjust so that demands added across all actors do not exceed total supplies. Finally, they produce numerical results (i.e. they are computable).

The degree of detail is usually large. Of course a CGE could not have the detail of a microeconometric model, which is to solve for the choices of each agent. They do however, in most cases have sectoral disaggregation. While CGEs do not have agent heterogeneity, they do contain details halfway between macro and micro. Neither have they used the generalization of the single good economy met in macroeconometrics. Often, CGEs use sectorally disaggregated data which is generally in the interests of policy makers.

The road from the theoretical model of general equilibrium to a CGE model passes through the measurement of the variables that are involved in the theoretical model. Matching the theoretical with the actual observable variables is not an easy process.

In practice, benchmark equilibria are constructed from national accounts and other government data sources. The information is usually inconsistent (e.g. payments to labour from firms will not equal labour income received by households), and a number of adjustments need to be made to the basic data to ensure that equilibrium conditions hold. Some data are taken as correct and others are adjusted to be consistent in the process of generating a benchmark data set. This is something we had to deal with while constructing the data base for the Greek Version of AMOS.

The modeler must also assign numerical values to a number of parameters that are key, using the method of 'calibration'. The name for this method that had already been used was given by Mansur and Whalley (1984). They claimed that it is preferable to estimation which is practically infeasible. One should first construct a micro consistent equilibrium data set with the use of national accounts before giving numerical values to the parameters. Other parameters are taken from the literature.

3.3 The roots

If we accept that father of Keynesian Economics is Keynes and the father of Input- Output analysis is Leontief, CGE analysis has a clear fountainhead in the works of Walras on general equilibrium theory.

In practice, Computable General Equilibrium (CGE) models have a variety of sources. A comprehensive account of this kind of model can be found in Shoven and Whalley (1992) and in Dixon and Parmenter (1996)

Maurizio Grassini (2005) of the University of Florence uses a very interesting metaphor for the nature of CGEs. He says that every river is generated by a number of springs. In the same manner the formulation of the "river" of CGEs springs from the efforts of theorists who founded General Equilibrium Theory, practical economists used these foundations in order to replicate the real economy and mathematicians (I would say together with programmers) who built the tools that made the complicated calculations possible. The commonly recognised formalization of general equilibrium is the work of Arrow, Debreu (1954) and others in the 1950s, while Johansen (1960) built the first CGE and Scarf (1967) wrote the first algorithm for solving specified general equilibrium models.

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3.4 Strengths and Weaknesses

Advocates of CGEs stress that the models are founded on solid theoretical fundamentals. The behaviour of consumers, producers and the government is explicitly modelled and conclusions for welfare can be derived from the resulting distribution of income. This is quite crucial for policy appraisal.

As mentioned above a bundle of policies can be simultaneously assessed, since most CGEs allow for different types of shocks to be introduced simultaneously. For example in Lisenkova et. al., (2008) we have simultaneous demand shocks which comes in as a change in government expenditure combined with contemporaneous supply shock which are generated by demographic fundamentals and external migration flows. The degree of disaggregation is in most cases sufficient to allow the modeller to shock single sectors or a sub set of sectors. So, one could assess the impact of an oil demand shock, or a shock in demand for manufacturing goods etc.

In most cases CGE studies present their results and follow this up with the explanation of where they stem from. The fact that some studies do not provide an explanation of how their results were generated has provided opponents of CGE with ammunition. They have accused this kind of analysis as being “black box”. As shall be seen later the modelling framework used during the course of this thesis (AMOS) is quite transparent and tractable and resists the “black box” critique.

Theoretically any functional form can be imposed in order to describe the behaviour of consumers and producers, but for reasons that have to do with the parameterisation and the solution method modellers typically choose to use a small number of “well behaved” functional forms. The most commonly used functional form is the Constant Elasticity of Substitution function, which is not only well established in the literature, but also thought to credibly describe actual behaviour. It is important to mention that sensitivity analysis can demonstrate the extent to which results are sensitive to the choice of functional form, but it could not provide an answer to the question “which functional form is appropriate”. The validity in the end lies on the modeller judgement and on whether the results are consistent with prior expectations as well as prior empirical testing.

Having decided upon the functional forms the modeller must decide on the numerical values of the parameters that are associated with the chosen functional forms. As mentioned above a lot of parameter values are chosen so that the model replicates the benchmark data set and thus verifies the equilibrium assumption. The very existence of a unique equilibrium itself has been challenged in the past (Debreu, 1974). However, this is not a critique targeted to CGEs but in general to economic modelling.

Among the strong assumptions of CGE models is that of the existence of a unique and stable equilibrium. The existence of such equilibrium cannot be proved (Debreu, 1974).

Most CGE models, assume that firms minimise costs and consumers maximise utility and consume goods in perfectly competitive markets. However this is not always the case as imperfect competition can also be assumed in product and factor markets. As we shall see later, the AMOS modelling framework allows for different closures in the various markets.

Factors of production exhibit a wide range of degree of mobility. Capital in most cases is fixed in the short run but sectoral mobility makes sure that the rate of return is equalised across the economy. In the long run, capital is in many types of CGE models driven by the level of savings and of course exhibits sectoral mobility. Labour in most cases is mobile across sectors both in the short and in the long run, while it can also change in size through migration.

3.5 Critique of CGEs

Computable general equilibrium models are among the most influential tools in economic policy analysis and not surprisingly they have attracted a great deal of criticism. The focus of the critics has been mainly the choice of parameter values and functional forms.

Critics stress that instead of visiting the data the CGE modeler draws parameter values from data bases that have also been built by selecting parameters from the literature. It has been claimed that the CGE modeler may not be aware of the economic content of the data used in model building primarily for two reasons (Grassini, 2005). First, is the manipulation of national accounts and second, is the calibration procedure as well as the choice of parameters from the literature.

Computable General Equilibrium models incorporate three types of information. First they embody analytical information which is related to their theoretical fundamentals. Second, they contain a functional structure which relates to the algebraic equations which make up the actual models. Third, is the numerical structure that contains signs and magnitudes of coefficients and other parameters in the equations. Many critics do not target the analytical structure of CGEs but it put their functional and numerical structure under the spotlight.

McKittrick (1998) refers to this literature as the "econometric critique". Amongst others, Jorgensen (1984), Lau (1984), Jorgensen et al. (1992), Diewert and Lawrence (1994) are part of this stream of literature. The grounds on which this sort of critique has been based are the following. First, in many occasions modelers use elasticity values that are estimated for commodity and industry classifications that are not consistent with the ones used in the model. Other estimates are quite old while sometimes others are just guessed. Second, the calibration procedure makes parameter values depend on the quality of data available. If a certain economic anomaly occurred in the benchmark year it will be fed into the model and affect the model results. Third, the procedure of calibration tends to limit the researcher to the use of "first order functional forms" and in particular that of Constant Elasticity of Substitution. This functional form is characterised as inflexible and restrictive as it imposes a single non-negative substitution elasticity" across all pairs of goods in the aggregator (Lau, 1984). One could say that it would be preferable to use flexible functional forms. He concludes that the choice of functional forms affects both industry-specific results as well as aggregates, even for small policy shocks.

McKitric (1998) revisited the issue of choice of functional forms. He pointed out three major arguments in the literature against the CGEs. The first is that calibration involves arbitrary choice of value for some parameters, picking values from the literature from others, while others are set such that the model can replicate the base year data. Second that calibration depends upon the quality of the data for the chosen year. Finally, the most popular choice of functional forms is that of constant elasticity of substitution (CES) which is applied universally, while a common non negative value of elasticity is chosen for all industries. The author referred to the literature that stresses the above as the "econometric critique" of CGE models. He also pointed out that the choice of functional forms affects the results of CGE models "at both the industry specific and macroeconomic levels". Grassini (2005) characterises McKitrick's work as an "excellent" contribution in comparative modeling and he claims that CGE modelers should "meditate on the quality of the work".

The above arguments constitute a forceful critique. We next consider the response.

3.6 CGE critique of econometrics

In 1984, Scarf and Shoven edited a book containing a series of papers presented at the Conference on Applied General Equilibrium Analysis held in San Diego in August 1981. The selected papers dealt with a variety of topics. Some of them focussed on methodological issues, others tackled practical problems such as foreign trade, higher energy price effects, taxation impact and its effect on income distributions. Jorgensen's contribution ranks in the methodological group. Shoven described it in the preface as "an ambitious and sophisticated attempt to estimate and report on a large general equilibrium model."

Jorgensen (1984) noted that "the development of econometric methods for estimating the unknown parameters describing technology and preferences in such [CGE] models has been neglected".

Shoven and Whalley (1984) tried to explain why the calibration approach was so widely used; indeed, they underlined

a) that the econometricians require an unrealistically large number of observations,

b) that the simultaneous estimation approach does not have shortcuts capable of fully incorporating all the equilibrium restrictions,

c) That it was not possible to have a sequence of equilibrium observations. So, Jorgensen's econometric approach was rapidly put aside.

Although it is widely said that the calibration is the standard procedure for giving numerical values to the parameters in a CGE model, the so-called econometric critique of computable general equilibrium modelling still appears in many studies. Unfortunately, this critique is multi-faceted and in many cases is based simply on the assumption that some alternative approaches to making the model computable are better than calibration. The critique may have some truth but it requires a better specification of the context. In the 'system-of-equations models', equations are given parameters using time series data. The selection of the parameters of the equations is done in order to give the system of equations (at least) the ability to mimic the corresponding time series data. In this modelling approach, that behavioural equations are the response of groups of individuals or firms to a common economic environment. These responses may well be theoretically founded, but they are also designed on the available statistical information which refer to 'groups of individuals or firms', which, are those also used by any CGE modeller, who observes microeconometric data.

It is useful to remember that macro econometric models went into disarray during the 1970s. The oil shocks, which took place at that time, showed that a one-sector model was inadequate to describe and capture the main features of an economy. Many model builders learnt a lot from the failures of their models. Rethinking – thus stimulating scientific advancement – gave rise to interesting improvements in model design. At that time, some criticism was directed towards the 'foundations' of the 'system-of-equations models' approach. Kydland and Prescott (1991) add a particular critique; they say that '*another reason for the demise of this approach was the general recognition that the policy-invariant behavioural equations are inconsistent with the maximization postulate in dynamic settings',* due to the advances in neoclassical theory that permitted the application of its paradigms.

Mansur and Whalley (1984) declare that they calibrate a model to an equilibrium point combining a data set with a literature search for key parameters, but they practice ‘no test of model’; they simply make sensitivity analysis, namely, they simply investigate how different parameter values generate different outcomes. In this context, the intersection between the ‘system-of-equations models’ and the ‘calibration’ approach turns out to be an empty set. In other words, the values of parameters are not estimated for the specific economy but rather picked up from the literature. With sensitivity analysis the CGE modeller overcomes the critique of that sort.

Dixon and Parmenter (1996) claim that compared to CGE econometrics pay less attention to economic theory and more attention to time series data. And they conclude:

“Is the field past its peak? Is it in danger of going stale? We don’t think so. We think that CGE modeling will generate high profile careers in the years to come. More importantly, it is likely to be increasingly influential in policy making and in business”.

3.7 CGE and other modelling techniques

Analysis of time series tries to form expectations about the future behaviour of an economic variable by taking into account its past behaviour. However, although they can be a useful tool for forecasting they don't provide a theoretically satisfactory description of the whole economy, and so are not suitable for providing a sufficient interpretation of the consequences of economic policies.

In contrast general and partial equilibrium modelling, does provide important insights into the potential effects of economic policy. The principles on which they are based are the same as CGE modelling, and in particular simple general equilibrium modelling adopts a simplified interpretation of the whole economy, while partial equilibrium modelling, models only part of the economy. Simple and partial equilibrium can be characterised as inferior compared to CGE because the first is insufficiently detailed to represent a real economy, and the second does not incorporate interactions and interdependencies which could be essential to policy evaluation.

Fixed price models such as Input-Output models and Social Accounting Matrices offer a rich, and in many cases complete, specification of the economy, similar to CGE modelling. Input– Output models consist of a system of linear equations, each of which describes the distribution of an industry's production throughout the economy, its fundamental purpose is to analyse the interdependence of industries in an economy. Such models allow for scenario analysis, and are computationally straightforward to solve using matrix algebra. They are on the other hand, subject to very strict assumptions. We could not model quantities and prices or supply and demand simultaneously. In most cases the IO modeller assumes a completely passive supply side. Input Output models can be characterised as CGEs with a specification where the supply side is totally passive. In addition within such models, substitution between factors (say because of price changes) is not modelled. These unrealistic assumptions impose key limitations relative to CGE modelling. Since policy makers will be concerned with price changes and their economy-wide effects, I-O modelling provides a less thorough analysis of the effects of economic and policy changes than CGE analysis.

Macroeconometric models offer a more complete account of the economy as a whole. The coefficients on a set of equations are estimated with the use of actual data. They have well-built theoretical fundamentals. One of their drawbacks is the fact that they have data requirements that cannot always be fulfilled. The advantage of such models in relation to CGEs is that they provide a basis for diagnostic testing since the coefficients within the equations are estimated using actual data on the variables and established econometric techniques.

In addition, macroeconometric modelling is superior to CGEs in that it offers the modeller greater ability to deal with the dynamics of the economic system as well in that it incorporates monetary relationships into the system. In CGEs dynamics are usually modelled in simpler ways while the monetary sector is often absent. The main disadvantage of macroeconometric modelling is the fact that it lacks detail relative to CGEs and thus it is less enlightening in relation to impacts of particular policies.

To conclude, a CGE modelling framework such as AMOS, with its transparency, tractability of results and degree of detail, is an appropriate tool for assessing the impacts of a phenomenon such as a demographic change. It successfully defends itself from the ammunition of critiques such as the econometric critique and the "black box" critique.

3.8 CGE and the study of demographic changes

Many studies that focus on the impacts of ageing population use Computable General equilibrium models. Many of them use CGEs with an overlapping Generations structure (OLG).

Auerbach and Kotlikoff (1987) are considered the pioneers of such models with their ground-breaking extensive numerical OLG l with 55 generations, perfect foresight, and labour supply endogenously determined. Auerbach *et al*. (1989), analysed the impacts of demographic changes for the United States, Japan, Germany, and Sweden using this modelling approach. Different scenarios about pension formulas, fiscal policy and openness of the economy were examined. The estimated impact of ageing population on the level of national saving was large and negative. (4% in US, 18% in Japan). They also found that this reduction would vanish if policy measures such as a cut in pensions or an increase in retirement age were to be implemented.

Kotlikoff *et al.* (1997), studied the impacts of privatising Social Security in the United States. The model contains 12 different income groups, imposes a ceiling on earnings subject to Social Security contributions, includes the progressive benefits schedule in US Social Security, and was calibrated on US household income data. Privatisation -- which in the model is equivalent to abolishing public old-age pensions -- was simulated to take place with constant population growth, excluding the effects of population ageing. The pension replacement rate was reduced gradually, starting 11 years after the beginning of the reform in order to ensure that workers aged 45 and above receive their full benefits. They conclude that the capital stock would increase by 37% and output per capita by 11% during an horizon of 60 years.

Hviding and Merette (1998) have studied the impacts of ageing in seven OECD countries. Their model incorporates feed-back effects on capital accumulation from pension reform, as well as "ageing" itself. Agents are rational, with perfect foresight and no borrowing constraints in a life cycle hypothesis manner. Labour supply is fixed and investment is driven by the level of savings. The paper merges pension reforms and ageing populations and the authors claim that it can be considered as an extension of Auerbach *et al.* (1989). They suggest that benefits from pension reforms may not be enough to offset the important macroeconomic impacts of demographic changes.

3.8.1 G- AMOS and OLG models

OLG models have the advantage of disaggregating the population into different age-groups. They can thus employ changes in pension benefits and labour supply. Most of them assume perfect foresight and intertemporal utility maximisation that defines level of savings. The assumption of life cycle hypothesis is to my belief one of their weak points since their results are solely dependent upon this assumption. Many household surveys show old people save more than middle aged workers (Hviding and Merette, 1998), and in addition there is no room for precautionary savings.

Although G-AMOS does not disaggregate age groups at the moment, it encapsulates many of the interdependencies within the Greek economy. Its link with consistent demographic modelling and the examination of various demographic scenarios is among the benefits of the simulation exercise undertaken in this thesis. However, at this stage we focus on the macroeconomic impacts of the declining of the labour force that occurs due to population ageing. Furthermore, the current configuration of G-AMOS allows for age dependant labour supply behaviour to be introduced into the model, so that age specific variations in labour productivity can be embodied. Remember though that the composition of the labour force between young and old workers does not change dramatically during the projection period for Greece. So, we could assume that changes in overall productivity of the labour force that stem from the composition of young and old workers are rather small. Finally, demand changes that would emerge due to population ageing can also be introduced if age specific consumption data allows.

Chapter 4 . The construction of the Economic Database

4.1 Introduction.

Shoven and Whalley (1984) refer to the process of "calibration procedures and model use" in which they define the following distinct stages. These are:

1. Base year data collection
2. Organisation of the benchmark equilibrium data set.
3. Choice of functional form and calibration to benchmark equilibrium. (which in turn comprises three different steps)
    a. Model specification
    b. Identification of exogenous parameter values
    c. Calibration of remaining parameter values to replicate initial equilibrium conditions.
4. Analysis using the model.
    a. In our case and for the purposes of the economic demographic simulations that will take place later on, we need to generate demographic projections that will constitute the set of exogenous disturbances to be introduced to the model.

The aim of this chapter is to focus on the first two stages namely, base year data collection and the organisation of the benchmark data set for Greece.

The fundamental data requirements for the modelling exercise are:

a) An Input–Output Table of the Greek Economy for the base year.

b) A Social Accounting Matrix (SAM) which will consist of the aforementioned IO table and additional information on income flows between the institutional transactors. (A separate set of income-expenditure accounts is constructed for that purpose).

c) Additional data for the Greek economy, such as sectoral employment and investment demands.

An Input Output table is a representation of a country's (or a region's) economy which is conventionally used to predict the effect of changes in the output of one industry on others, and changes by household consumption, government, and export demand on the economy as whole. Wassily Leontief (1941) is the founder of this analysis and he won a Nobel Prize in Economics for his development of this model. Each column of the input-output table reports an industry's inputs and the corresponding row the industry's sales. Intermediate purchases, primary inputs and final demands are recorded. In every IO table, conventional accounting identities must hold: intermediate purchases must equal intermediate sales, primary inputs must equal final demands. In addition, for each sector the sum of its inputs must be equal to outputs.

A Social Accounting Matrix, (SAM) is an extended Input-Output (IO) table. SAM focuses not only to a framework equilibrium in the economy but also to the social framework as it records income flows between economic transactors. In addition to the accounting identities that must hold for the IO table, in the SAM income and expenditure must be equal for all transactors. A SAM, as mentioned in the previous chapter, is the core of the database required for a Computable General Equilibrium model.

The first difficulty that we faced was the non existence of an input output table and SAM for Greece for the chosen base year (2004). The first published Social Accounting Matrix, for the Greek economy was published in 1985 by Skountzos (1988) and the reference year is 1975. This table was based in the work of Pyatt G. et. al. (1977) and it contains 9 different factors of production, with a high degree of disaggregation for labour. It has 35 production sectors with greater disaggregation in manufacturing than services. Another Social Accounting Matrix was constructed by a research team lead by Sarris, et al (1995) with the reference year of 1980. This matrix has a very high degree of disaggregation of institutions and its main purpose was to analyse the economic impact of the integration of the country into the EU. Sarris and Zografakis (2004) constructed a table for 1996 in order to assess the redistributional impact of various scenarios of changes in the tax policy. This has a very high degree of institutional disaggregation. i.e. 15 households categorised by income and occupation of the head of household. The table is based on earlier tables and on data from a variety of sources[16]. The latest comprehensive OECD published input output table for the country was for 1994 which will be our starting point.

The year of 2004 was chosen as, at the time the research was initiated, this was the most recent year for which data on National Accounts were published by the National Statistics Agency. As the latest SAM referred to the year 1996 it was necessary to have a more recent estimate that would capture characteristics in the Greek economy that have evolved in the recent years. For example, the relative importance of different sectors has changed. Telecommunications with development of mobile phones and internet services will be more important for the year we have chosen. Also, the

[16] A major source for the authors mention the Household survey of 1993/94, National Statistics Agency

importance of the construction sector has been changed as the reference year is the year of the Olympic Games, and consequently the year that major construction works were concluded. Thus, the estimated SAM, will be able to capture changes in the composition of the Greek economy that took place since 1994.

4.2 The estimation of the IO table.

Our starting point is the IO table for Greece published by the OECD for the year 1994. The table contains 43 sectors (private and public) which are shown below together with their international Standard Classification Code.

Table 4 1 Sectors identified in the 1994 OECD IO table for Greece[17].

NO	Sector	ISIC Rev.3
1	AGRICULTURE, HUNTING, FORESTRY AND FISHING	01-05
2	MINING AND QUARRYING	10-14
3	FOOD PRODUCTS, BEVERAGES AND TOBACCO	15-16
4	TEXTILES, TEXTILE PRODUCTS, LEATHER AND FOOTWEAR	17-19
5	WOOD AND PRODUCTS OF WOOD AND CORK	20
6	PULP, PAPER, PAPER PRODUCTS, PRINTING AND PUBLISHING	21-22
7	COKE, REFINED PETROLEUM PRODUCTS AND NUCLEAR FUEL	23
8	CHEMICALS EXCLUDING PHARMACEUTICALS	24ex24.23
9	PHARMACEUTICALS	24.23
10	RUBBER AND PLASTICS PRODUCTS	25
11	OTHER NON-METALLIC MINERAL PRODUCTS	26
12	IRON & STEEL	271 273.1
13	NON-FERROUS METALS	272 273.2
14	FABRICATED METAL PRODUCTS, except machinery and equipment	28
15	MACHINERY AND EQUIPMENT, N.E.C.	29
16	OFFICE, ACCOUNTING AND COMPUTING MACHINERY	30
17	ELECTRICAL MACHINERY AND APPARATUS, NEC	31
18	RADIO, TELEVISION AND COMMUNICATION EQUIPMENT	32
19	MEDICAL, PRECISION AND OPTICAL INSTRUMENTS	33
20	MOTOR VEHICLES, TRAILERS AND SEMI-TRAILERS	34
21	BUILDING AND REPAIRING OF SHIPS AND BOATS	35.1
22	AIRCRAFT AND SPACECRAFT	35.3
23	RAILROAD EQUIPMENT AND TRANSPORT EQUIPMENT N.E.C.	35.2, 35.9
24	MANUFACTURING NEC; RECYCLING	36-37
25	ELECTRICITY, GAS AND WATER SUPPLY	40-41
26	CONSTRUCTION	45
27	WHOLESALE AND RETAIL TRADE; REPAIRS	50-52
28	HOTELS AND RESTAURANTS	55
29	TRANSPORT AND STORAGE	60-63
30	POST AND TELECOMMUNICATIONS	64
31	FINANCE, INSURANCE	65-67
32	REAL ESTATE ACTIVITIES	70
33	RENTING OF MACHINERY AND EQUIPMENT	71
34	COMPUTER AND RELATED ACTIVITIES	72
35	RESEARCH AND DEVELOPMENT	73
36	OTHER BUSINESS ACTIVITIES	74
37	PUBLIC ADMIN. AND DEFENCE; COMPULSORY SOCIAL SECURITY	75
38	EDUCATION	80
39	HEALTH AND SOCIAL WORK	85
40	OTHER COMMUNITY, SOCIAL AND PERSONAL SERVICES	90-93
41	PRIVATE HOUSEHOLDS WITH EMPLOYED PERSONS (and extra territorial organisations and bodies)	95-99
42	SBFD including OTHER ADJUSTMENTS	
43	NON COMPETING IMPORTS	

[17] Sectors 42,43 consist of zeros only and have therefore been ignored during the aggregation process which is about to follow

The table also identifies 7 final demand categories.

1. Household consumption
2. Non Profit Institutions
3. Government final consumption.
4. Gross fixed capital formation
5. Change in inventories
6. Valuables
7. Exports

It also identifies the following 5 categories of primary inputs.

1. Net taxes on products
2. Gross Operating Surplus[18] (referring to profits and rents)
3. Compensation of Employees
4. Net taxes on production.
5. Imports

In the figure below we summarise the structure of the table

Table 4 2 The four main components of the 1994 IO table of the OECD

Intermediate block (43x43)	Final Demand on local goods (43x7)
Primary Inputs (5x43)	Final demand of Primary inputs (5x7)

[18] In other tables this category is referred to as Other Value Added.

4.2.1 Making the table compatible with AMOS and the rest of the data sources

This table is in 1994 basic prices in millions of Drachmas. The steps we need to take in order to make the IO compatible with the rest of the required data and the AMOS modelling framework are the following.

1. We need to convert the currency into euros which is the currency of the country since 2002.
2. We aggregate the table to 25 sectors in order to make it compatible with the AMOS modelling framework.
3. We roll forward the table to the year 2004
4. We use the RAS program in order to rebalance the table and make sure that the sum of the columns is equal to the sum of the corresponding rows.

First, the IO table had to be converted in Euros since the drachma has been replaced by the Euro adopted in 2002. This was simply done by dividing each entry by 340.75 which is the exchange rate at which the drachma was locked against the Euro. In the table below we present total sectoral outputs in millions of euros, value added in millions of euros and value added as a share of output. This measure is included because it is going to be used later in order to roll our table forward to the year 2004.

Table 4 3 Value added and Total output by sector (OECD -1994 table)

	Sector	Value Added (€m)	Output (€m)	Value Added / Output
1	AGRICULTURE, HUNTING, FORESTRY AND FISHING	6190.6	9835.2	62.9%
2	MINING AND QUARRYING	428.6	1711.7	25.0%
3	FOOD PRODUCTS, BEVERAGES AND TOBACCO	1867.3	10867.9	17.2%
4	TEXTILES, TEXTILE PRODUCTS, LEATHER AND FOOTWEAR	1970.8	6102.8	32.3%
5	WOOD AND PRODUCTS OF WOOD AND CORK	244.4	769.9	31.7%
6	PULP, PAPER, PAPER PRODUCTS, PRINTING AND PUBLISHING	524.8	1849.0	28.4%
7	COKE, REFINED PETROLEUM PRODUCTS AND NUCLEAR FUEL	288.9	2186.7	13.2%
8	CHEMICALS EXCLUDING PHARMACEUTICALS	561.5	3892.2	14.4%
9	PHARMACEUTICALS	0.0	0.0	0.0
10	RUBBER AND PLASTICS PRODUCTS	235.3	1079.8	21.8%
11	OTHER NON-METALLIC MINERAL PRODUCTS	476.6	1513.3	31.5%
12	IRON & STEEL	305.9	2264.1	13.5%
13	NON-FERROUS METALS	0.0	0.0	0.0
14	FABRICATED METAL PRODUCTS, except machinery and equipment	339.0	1252.7	27.1%
15	MACHINERY AND EQUIPMENT, N.E.C.	285.6	2270.2	12.6%
16	OFFICE, ACCOUNTING AND COMPUTING MACHINERY	3.7	270.5	1.4%
17	ELECTRICAL MACHINERY AND APPARATUS, NEC	133.5	749.8	17.8%
18	RADIO, TELEVISION AND COMMUNICATION EQUIPMENT	98.2	837.2	11.7%
19	MEDICAL, PRECISION AND OPTICAL INSTRUMENTS	27.2	438.8	6.2%
20	MOTOR VEHICLES, TRAILERS AND SEMI-TRAILERS	48.2	1393.0	3.5%
21	BUILDING AND REPAIRING OF SHIPS AND BOATS	343.8	812.8	42.3%
22	AIRCRAFT AND SPACECRAFT	0.0	0.0	0.0
23	RAILROAD EQUIPMENT AND TRANSPORT EQUIPMENT N.E.C.	0.0	0.0	0.0
24	MANUFACTURING NEC; RECYCLING	592.6	1405.3	42.2%
25	ELECTRICITY, GAS AND WATER SUPPLY	1355.4	2143.8	63.2%
26	CONSTRUCTION	4436.2	9307.0	47.7%
27	WHOLESALE AND RETAIL TRADE; REPAIRS	9388.2	14615.1	64.2%
28	HOTELS AND RESTAURANTS	4180.2	7991.3	52.3%
29	TRANSPORT AND STORAGE	2297.3	4196.0	54.7%
30	POST AND TELECOMMUNICATIONS	1428.3	1665.2	85.8%
31	FINANCE, INSURANCE	2376.9	3264.1	72.8%
32	REAL ESTATE ACTIVITIES	8741.8	9842.0	88.8%
33	RENTING OF MACHINERY AND EQUIPMENT	160.1	328.9	48.7%
34	COMPUTER AND RELATED ACTIVITIES	51.7	124.6	41.5%
35	RESEARCH AND DEVELOPMENT	31.4	74.5	42.2%
36	OTHER BUSINESS ACTIVITIES	1413.5	2414.7	58.5%
37	PUBLIC ADMIN. AND DEFENCE; COMPULSORY SOCIAL SECURITY	4177.6	6418.4	65.1%
38	EDUCATION	2924.2	3384.3	86.4%
39	HEALTH AND SOCIAL WORK	3453.7	4625.8	74.7%
40	OTHER COMMUNITY, SOCIAL AND PERSONAL SERVICES	1726.6	2549.6	67.7%
41	PRIVATE HOUSEHOLDS WITH EMPLOYED PERSONS (and extra territorial organisations and bodies)	130.0	130.0	100.0%
42	SBFD including OTHER ADJUSTMENTS	0.0	0.0	0.0
43	NON COMPETING IMPORTS	0.0	0.0	0.0

For reasons of compatibility with the AMOS modelling framework we had to aggregate the 41 sectors to 25. The existing table has a great degree of disaggregation in the manufacturing sector. This degree of detail is not necessary for the analysis at hand. In particular, the following aggregations took place.

Sectors 5 and 6 were combined. That is “wood and products of wood and cork” and “pulp, paper, paper products, printing and publishing” were pulled together in order to form a new sector that was named “wood, paper, printing, publishing products”.

Sectors 8 to 14 were also aggregated. That is, “chemicals excluding pharmaceuticals”, “pharmaceuticals”, “rubber and plastic products”, “other non-metallic mineral products”, “iron and steel”, “non ferrous metals”, “fabricated metal products, except machinery and equipment”, were all aggregate to form “other manufacturing”.

I also combined sectors 15 to 19. So sectors “machinery and equipment, N.E.C”, “office, accounting and computing machinery”, “electrical machinery and apparatus, NEC” , “radio television and communication equipment” and “medical precision and optical instruments” were aggregated pulled together in order to form a new sector entitled, “machinery equipment”.

Sectors 20 to 24 were also aggregated. So, the sectors “motor vehicles, trailers and semi-trailers”, “building and repairing of ships and boats”, “aircraft and spacecraft”, “railroad equipment and transport equipment NEC”, “manufacturing NEC; recycling” formed the new sector “transport equipment etc”.

Sectors 25 to 39 remained as they were initially, whereas sectors 40 and 41, namely “other community, social and personal services”, “private households with employed persons” were pulled together to form “other services”

In the table below we can see the initial OECD IO sectors, with their numbering as well as the newly formed sectors and the number they get in the new 25 sector table.

Table 4 4 Aggregation of the OECD table

1	AGRICULTURE, HUNTING, FORESTRY AND FISHING	1	AGRICULTURE, HUNTING, FORESTRY AND FISHING
2	MINING AND QUARRYING	2	MINING AND QUARRYING
3	FOOD PRODUCTS, BEVERAGES AND TOBACCO	3	FOOD PRODUCTS, BEVERAGES AND TOBACCO
4	TEXTILES, TEXTILE PRODUCTS, LEATHER AND FOOTWEAR	4	TEXTILES, TEXTILE PRODUCTS, LEATHER AND FOOTWEAR
5	WOOD AND PRODUCTS OF WOOD AND CORK	5	WOOD, PAPER, PRINTING, PUBLISHING
6	PULP, PAPER, PAPER PRODUCTS, PRINTING AND PUBLISHING		
7	COKE, REFINED PETROLEUM PRODUCTS AND NUCLEAR FUEL	6	COKE, REFINED PETROLEUM PRODUCTS AND NUCLEAR FUEL
8	CHEMICALS EXCLUDING PHARMACEUTICALS	7	OTHER MANUFACTURING
9	PHARMACEUTICALS		
10	RUBBER AND PLASTICS PRODUCTS		
11	OTHER NON-METALLIC MINERAL PRODUCTS		
12	IRON & STEEL		
13	NON-FERROUS METALS		
14	FABRICATED METAL PRODUCTS, except machinery and equipment		
15	MACHINERY AND EQUIPMENT, N.E.C.	8	MACHINERY, EQUIPMENT
16	OFFICE, ACCOUNTING AND COMPUTING MACHINERY		
17	ELECTRICAL MACHINERY AND APPARATUS, NEC		
18	RADIO, TELEVISION AND COMMUNICATION EQUIPMENT		
19	MEDICAL, PRECISION AND OPTICAL INSTRUMENTS		
20	MOTOR VEHICLES, TRAILERS AND SEMI-TRAILERS	9	TRANSPORT EQUIPMENT ETC.
21	BUILDING AND REPAIRING OF SHIPS AND BOATS		
22	AIRCRAFT AND SPACECRAFT		
23	RAILROAD EQUIPMENT AND TRANSPORT EQUIPMENT N.E.C.		
24	MANUFACTURING NEC; RECYCLING		
25	ELECTRICITY, GAS AND WATER SUPPLY	10	ELECTRICITY, GAS AND WATER SUPPLY
26	CONSTRUCTION	11	CONSTRUCTION
27	WHOLESALE AND RETAIL TRADE; REPAIRS	12	WHOLESALE AND RETAIL TRADE; REPAIRS
28	HOTELS AND RESTAURANTS	13	HOTELS AND RESTAURANTS
29	TRANSPORT AND STORAGE	14	TRANSPORT AND STORAGE
30	POST AND TELECOMMUNICATIONS	15	POST AND TELECOMMUNICATIONS
31	FINANCE, INSURANCE	16	FINANCE, INSURANCE
32	REAL ESTATE ACTIVITIES	17	REAL ESTATE ACTIVITIES
33	RENTING OF MACHINERY AND EQUIPMENT	18	RENTING OF MACHINERY AND EQUIPMENT
34	COMPUTER AND RELATED ACTIVITIES	19	COMPUTER AND RELATED ACTIVITIES
35	RESEARCH AND DEVELOPMENT	20	RESEARCH AND DEVELOPMENT
36	OTHER BUSINESS ACTIVITIES	21	OTHER BUSINESS ACTIVITIES
37	PUBLIC ADMIN. AND DEFENCE; COMPULSORY SOCIAL SECURITY	22	PUBLIC ADMIN. AND DEFENCE; COMPULSORY SOCIAL SECURITY
38	EDUCATION	23	EDUCATION
39	HEALTH AND SOCIAL WORK	24	HEALTH AND SOCIAL WORK
40	OTHER COMMUNITY, SOCIAL AND PERSONAL SERVICES	25	OTHER SERVICES
41	PRIVATE HOUSEHOLDS WITH EMPLOYED PERSONS (and extra territorial organisations and bodies)		

At the end of the above process we have the 25 sector table for the Greek economy and base year 1994. Below we can see the sectoral totals as well as final demands and primary inputs.

Table 4 5 Intermediate demand Final Demand/ Primary inputs in the 1994 OECD table

		Total
Intermediate Demand	AGRICULTURE, HUNTING, FORESTRY AND FISHING	9835.2
	MINING AND QUARRYING	1711.7
	FOOD PRODUCTS, BEVERAGES AND TOBACCO	10867.9
	TEXTILES, TEXTILE PRODUCTS, LEATHER AND FOOTWEAR	6102.8
	WOOD, PAPER, PRINTING, PUBLISHING	2618.9
	COKE, REFINED PETROLEUM PRODUCTS AND NUCLEAR FUEL	2186.7
	OTHER MANUFACTURING	10002.2
	MACHINERY, EQUIPMENT	4566.4
	TRANSPORT EQUIPMENT ETC.	3611.1
	ELECTRICITY, GAS AND WATER SUPPLY	2143.8
	CONSTRUCTION	9307.0
	WHOLESALE AND RETAIL TRADE; REPAIRS	14615.1
	HOTELS AND RESTAURANTS	7991.3
	TRANSPORT AND STORAGE	4196.0
	POST AND TELECOMMUNICATIONS	1665.2
	FINANCE, INSURANCE	3264.1
	REAL ESTATE ACTIVITIES	9842.0
	RENTING OF MACHINERY AND EQUIPMENT	328.9
	COMPUTER AND RELATED ACTIVITIES	124.6
	RESEARCH AND DEVELOPMENT	74.5
	OTHER BUSINESS ACTIVITIES	2414.7
	PUBLIC ADMIN. AND DEFENCE; COMPULSORY SOCIAL SECURITY	6418.4
	EDUCATION	3384.3
	HEALTH AND SOCIAL WORK	4625.8
	OTHER SERVICES	2679.5
	Total Intermediate Inputs	124578.2

Table 4.5 –(continued)

Primary Inputs	Imports	16012.8
	Taxes less subsidies on products	7011.1
	Taxes less subsidies on production	473.6
	Compensation of employees	22145.7
	Gross Operating Surplus	40620.0
	Gross Value added	62765.8
	Total Primary Inputs	86263.3
Final Demands	HHs and NPISHs	55167.3
	GGFC	9817.7
	Gross fixed capital formation	13069.6
	Valuables and Change in Inventories	75.8
	Exports	8132.9
	Total Final demands	86263.3
	Gross Inputs/Outputs	210841.5

4.2.2 Rolling forward the IO table

Having prepared an IO table for 1994 the next task is to roll it forward in order to reflect 2004 prices. In order to do this we have used data available from the web-site of the national statistics agency[19]. (www.statistics.gr). In order to calculate new column totals I used information on gross value added per sector for the year 2004, as well as the output totals for both 1994 and 2004. In 1994 according to the national accounts the ratio of output to value added was 1.56. The ratio in 2004 was 1.48. This constitutes a

[19] Data from the national statistics was retrieved during the spring of 2006. The Greek accounts have been updated in autumn 2006, however at that point the construction of the data set was completed.

reduction of 5.2%. In order to proceed and calculate the sectoral outputs we assume that the ratio of output to gross value added has decreased by 5.2% during this decade. So the first step was to take for every sector the initial output to gross value added ratio, reduce it by 5.2% and apply the new reduced ratio to the value for gross value added that comes from the national accounts for 2004. That is:

$$output_{2004} = \frac{output_{1994}}{GVA_{1994}} \times 0.948 \times GVA_{2004}$$

In the above formula the value of output and value of the year 1994 come from the 1994 IO table, while value added for 2004 comes from the national accounts.

Take for example, the sector mining and quarrying. In 1994 the value added for this sector was €428.6m and total output €1711.7m which makes the ratio of output to gross value added 4.02. If we reduce 4.02 by 5.2% i.e. (multiply it by 0.948) we get 3.81. Applying this factor to the reported Gross Value Added for this sector which is €873m we get €3330m as the total output of the sector. This figure was augmented by €41m because we had to reallocate €6506m of FISIM (Financial Intermediation Services Indirectly Measure) value added to the rest of the sectors. In the *System of National Accounts*, refers to the total property income receivable by financial intermediaries minus their total interest payable, excluding the value of any property income receivable from the investment of their own funds, as such income does not arise from financial intermediation. FISIM is not identified as a separate sector in our IO. However the value added has to be taken into account so that total value added matches national accounts. Due to the nature of FISIM the appropriate allocation to the rest of the sectors is done on the basis of the share of the sales of “finance and insurance” to other sectors. So, for our sector we have 0.63% of total sales of finance and insurance, of value added to total value added. The sector in question purchased 0.63% of total sales of “finance and insurance”. Therefore it was allocated 0.63% of the €6506m of value added by FISIM which is €41m. This extra amount added to the estimate of €3330m gives us the estimate of total output for the sector mining and quarrying being €3371m. The available data on gross value added is shown in table 4.6.

The above method has allowed the compositional changes of the Greek economy to be taken into account. For example, the estimated table captures the reduced importance of primary production and the increased importance of construction and telecommunications, while primary sectors accounted for 10% of the economy’s value added in 1994, they accounted for 5.5% in 2004. Construction sector had a share of 7% in 1994 and 8.32% in 2004. For post and telecommunication the corresponding figures are 2.26% and 3.6%.

Table 4 6 Gross value by sector.

Gross Value added by industry source:www.statistics.gr	€m
agriculture hunting forestry	7,720
Fishing	872
mining and quarring	873
Manufacturing	16,699
electricity, gas, water supply	2,697
Construction	12,774
Wholesale retail repair of of vehicles and household goods	20,328
hotels and restaurants	12,139
Transport storage and communication	14,456
financial intermediation	8,643
real estate, renting and business activities	22,623
public adm, defence, compulsory social security	11,422
Education	7,799
health and social work	8,154
other community etc. services	5,736
private households	767
extra territorial	0
Fisim	6,506

We can see that data on value added which was available did not have exactly the same disaggregation as the table we have calculated. Therefore we had to aggregate or split the figures available in order to match the desired disaggregation. So, in order to calculate the new total for the sector "agriculture, hunting, forestry and fishing" we had to sum up the entries of the first two rows of the table above and repeat the aforementioned procedure. A counterexample is the fact that the gross value added that appears under the title "manufacturing" in table 4.6 above had to be split among the manufacturing sectors of the table. In particular the above figure of €16,699m was split among the following sectors:

- Food products, beverages and tobacco (19.5%)
- Textiles, textile products, leather and footwear (8.4%)
- Wood, paper printing and publishing (7.0%)
- Coke refined petroleum products and nuclear fuel (32.0%)
- Other manufacturing (14.6%)
- Machinery and equipment (11.6%)
- Transport equipment etc. (6.9%)

In parentheses we see that the shares of value added allocated to the above sectors were the ones that existed in 1994. In the table below, we present the new totals that correspond to the 25 sectors of intermediate demand.

Table 4 7 Estimated totals of sectors for the year 2004

	Total
AGRICULTURE, HUNTING, FORESTRY AND FISHING	13146.9
MINING AND QUARRYING	3371.4
FOOD PRODUCTS, BEVERAGES AND TOBACCO	18570.3
TEXTILES, TEXTILE PRODUCTS, LEATHER AND FOOTWEAR	4243.7
WOOD, PAPER, PRINTING, PUBLISHING	3903.5
COKE, REFINED PETROLEUM PRODUCTS AND NUCLEAR FUEL	40190.8
OTHER MANUFACTURING	12501.4
MACHINERY, EQUIPMENT	15678.9
TRANSPORT EQUIPMENT ETC.	4073.6
ELECTRICITY, GAS AND WATER SUPPLY	4207.7
CONSTRUCTION	26226.5
WHOLESALE AND RETAIL TRADE; REPAIRS	31092.0
HOTELS AND RESTAURANTS	22611.8
TRANSPORT AND STORAGE	16105.3
POST AND TELECOMMUNICATIONS	6394.3
FINANCE, INSURANCE	11906.7
REAL ESTATE ACTIVITIES	20906.4
RENTING OF MACHINERY AND EQUIPMENT	694.7
COMPUTER AND RELATED ACTIVITIES	262.0
RESEARCH AND DEVELOPMENT	156.3
OTHER BUSINESS ACTIVITIES	5094.7
PUBLIC ADMIN. AND DEFENCE; COMPULSORY SOCIAL SECURITY	17074.2
EDUCATION	8785.2
HEALTH AND SOCIAL WORK	10635.5
OTHER SERVICES	9152.6
Total Intermediate Inputs	306986

To calculate the entries of the intermediate block we use 1994 column coefficients and apply them to the estimated 2004 sectoral totals. In order to complete the I-O table I had to collect data from national statistics referring to the totals for primary inputs and final demands. In the following table we see the data that have been used.

Table 4 8 Final demands and Primary Inputs

Primary Inputs	**€m**
Imports	50,012
Taxes less subsidies on products	1,546
Taxes less subsidies on production	17,398[20]
Compensation of employees	57,325
Gross Operating Surplus	92,149
Gross Value added	149,474
Total Primary Inputs	**218,429**
Final Demands	**€m**
HHs and NPISHs	113,004
GGFC	27,891
Gross fixed capital formation	42,396
Valuables and Change in Inventories	32
Exports	35,106
Total Final demands	**218,429**

4.2.3 Rebalancing the table using the RAS procedure

At this point, the table has to be rebalanced and for that purpose I used the RAS procedure. The procedure was developed by the department of Applied Economics outwith the survey years. However the method has also been used for constructing a wider range of tables. A brief description of how the program works is the following. The procedure uses iterations and does the minimum necessary changes to ensure that the column totals equal the row totals. It starts with the given row and column totals and

[20] This is allocated between the two types of subsidies according to the shares of the unbalanced table. The total amount of taxes less subsidies reported in the national statistics is €18,943m

with the set of final demands and primary inputs. It assumes constant column coefficients in the first iteration and multiplies the entries with a scalar. It assumes constant row coefficients in the second iteration and multiplies them with a scalar, constant column coefficients in the third and so on, so forth. Although the two assumptions are not compatible, this procedure secures maximum consistency between known sectoral total and the coefficient matrix (Sarris, et. al. 2004). The procedure, the authors claim, does not guarantee the best results but it gives an optimal mathematical solution using the assumption of constant coefficients.

Below we can see the finalised table after the above described procedure has been completed.

Table 4 9 Intermediate flows

		1	2	3	4	5	6	7	8	9	10	11	12
1	AGRICULTURE, HUNTING, FORESTRY AND FISHING	1492.7	0.1	5223.1	226.2	43.2	0.7	18.9	0.1	3.5	0.0	1.7	10.9
2	MINING AND QUARRYING	0.4	0.5	0.9	0.1	0.1	3143.2	36.0	0.3	0.1	58.3	44.7	0.2
3	FOOD PRODUCTS, BEVERAGES AND TOBACCO	221.7	4.5	1543.4	16.5	5.1	37.5	13.8	3.5	1.0	1.0	98.3	11.7
4	TEXTILES, TEXTILE PRODUCTS, LEATHER AND FOOTWEAR	14.7	1.3	3.9	257.1	5.9	18.2	9.8	4.0	9.3	0.5	4.4	44.7
5	WOOD, PAPER, PRINTING, PUBLISHING	6.8	2.4	195.2	27.7	399.0	28.9	82.4	32.2	51.0	0.7	1015.1	275.3
6	COKE, REFINED PETROLEUM PRODUCTS AND NUCLEAR FUEL	726.9	156.4	349.9	84.7	163.7	7747.2	614.2	120.7	27.9	1352.2	1474.1	815.9
7	OTHER MANUFACTURING	235.7	23.3	180.2	63.8	117.2	390.2	1128.9	377.7	64.8	13.5	3774.7	459.9
8	MACHINERY, EQUIPMENT	33.5	38.2	8.1	6.8	6.3	158.2	61.5	827.0	18.8	79.0	1029.3	64.9
9	TRANSPORT EQUIPMENT ETC.	3.5	4.0	5.7	4.8	7.3	20.6	41.5	89.7	77.9	1.5	29.8	223.1
10	ELECTRICITY, GAS AND WATER SUPPLY	100.9	37.7	89.7	60.2	65.4	556.5	383.2	59.3	19.0	29.3	31.2	156.5
11	CONSTRUCTION	16.0	4.1	1.0	0.4	2.0	37.7	4.4	2.0	1.0	24.5	130.3	118.8
12	WHOLESALE AND RETAIL TRADE; REPAIRS	184.9	29.7	690.3	123.8	130.1	2274.8	386.1	238.7	52.8	135.7	1480.6	1094.3
13	HOTELS AND RESTAURANTS	0.0	0.5	0.2	0.2	4.7	155.3	9.1	2.4	0.1	3.6	2.3	40.9
14	TRANSPORT AND STORAGE	50.4	22.9	65.0	21.9	20.1	210.4	57.7	46.4	6.8	11.5	66.8	2454.3
15	POST AND TELECOMMUNICATIONS	2.9	3.7	54.0	35.1	32.6	121.4	65.0	54.4	13.6	18.3	35.4	1558.6
16	FINANCE, INSURANCE	386.2	50.2	333.8	142.9	126.0	1460.0	360.6	284.6	74.3	168.7	994.1	1338.8
17	REAL ESTATE ACTIVITIES	0.8	14.1	37.7	8.8	7.4	137.0	31.4	18.2	2.7	29.1	124.9	2016.1
18	RENTING OF MACHINERY AND EQUIPMENT	0.0	24.6	0.0	0.0	0.0	0.2	0.0	0.0	0.0	13.9	74.4	0.0
19	COMPUTER AND RELATED ACTIVITIES	0.0	4.6	0.1	0.0	0.0	3.0	0.4	0.5	0.1	0.1	0.0	0.0
20	RESEARCH AND DEVELOPMENT	0.5	4.7	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
21	OTHER BUSINESS ACTIVITIES	12.1	12.1	396.1	151.8	110.1	473.4	277.8	150.3	35.1	6.1	572.2	667.0
22	PUBLIC ADMIN. AND DEFENCE; COMPULSORY SOCIAL SECURITY	6.6	0.1	27.4	1.6	4.1	1.4	1.5	0.5	0.1	0.2	1.1	16.0
23	EDUCATION	0.1	0.5	2.1	3.6	0.8	11.1	3.2	7.2	1.1	0.0	0.3	1.3
24	HEALTH AND SOCIAL WORK	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
25	OTHER SERVICES	0.1	1.5	3.6	0.8	18.8	66.6	12.5	3.2	0.8	6.6	1.7	468.2
	Total Intermediate Inputs	**3500.0**	**441.9**	**9211.4**	**1238.7**	**1270.2**	**17053.4**	**3599.8**	**2322.9**	**461.9**	**1954.5**	**10987.2**	**11838.0**

Table 4.9- Intermediate flows (continued)

	13	14	15	16	17	18	19	20	21	22	23	24	25	Total intermediate Demand
1	1125.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	111.0	0.4	23.0	12.6	8294.3
2	1.5	0.3	0.0	0.1	0.2	0.0	0.0	0.0	0.0	0.2	0.0	0.1	0.1	3287.3
3	3342.1	50.8	0.3	2.9	0.9	1.8	0.1	0.1	5.9	162.5	1.9	104.2	9.5	5640.8
4	21.9	2.6	0.0	1.3	0.1	0.2	0.0	0.0	0.1	46.6	0.2	15.8	3.6	466.5
5	153.2	28.4	1.6	73.9	52.2	15.2	7.9	36.6	11.1	43.8	15.4	17.0	52.1	2625.1
6	576.0	4132.0	38.0	267.7	4.2	19.3	0.2	2.4	66.8	547.8	118.6	329.5	201.6	19937.9
7	66.5	131.5	0.8	13.8	62.5	2.4	0.2	1.3	9.3	131.3	21.4	367.1	49.1	7686.9
8	20.1	61.2	6.0	24.2	3.5	0.5	6.4	8.9	26.4	604.3	8.6	172.3	7.6	3281.6
9	11.3	163.6	0.9	9.4	0.3	8.3	0.9	1.1	15.9	133.5	10.5	11.7	18.7	895.5
10	521.8	105.0	26.9	69.5	9.5	2.5	6.4	3.6	5.7	134.7	39.7	67.3	88.9	2670.3
11	90.9	22.8	4.7	33.4	822.8	0.4	0.0	2.3	5.2	250.9	30.5	58.0	25.9	1690.0
12	791.9	813.0	30.8	437.4	118.0	124.8	9.2	6.8	117.8	352.3	65.9	183.6	180.2	10053.5
13	0.1	288.4	55.6	32.7	0.7	1.1	0.0	0.2	41.6	119.4	8.5	27.2	173.4	968.0
14	165.3	892.7	42.0	133.1	2.0	3.9	2.1	0.0	36.6	327.4	64.8	23.9	189.4	4917.5
15	409.6	249.2	45.9	315.1	6.0	17.7	23.7	0.5	66.0	309.3	37.0	80.2	143.0	3698.3
16	584.5	418.5	211.4	740.5	813.8	19.2	5.0	3.0	119.3	642.9	309.7	376.6	285.9	10250.5
17	889.5	234.6	28.8	148.4	30.9	27.6	22.1	4.3	172.4	442.3	284.0	275.8	404.7	5393.7
18	4.5	243.9	9.1	27.2	1.6	0.6	0.0	2.0	4.4	10.7	8.9	4.6	26.2	456.9
19	0.0	19.5	0.7	16.8	0.0	0.0	0.0	0.0	0.0	40.4	4.6	47.1	0.0	137.9
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	53.7	3.0	0.3	0.0	63.5
21	253.0	121.6	5.7	295.3	228.7	6.7	15.2	0.4	104.4	314.6	95.4	94.5	44.8	4444.3
22	11.9	2.1	0.2	2.5	1.0	0.4	0.3	0.6	1.2	4.0	1.8	2.0	3.2	92.0
23	0.1	2.5	0.3	29.8	0.0	0.0	0.0	0.0	20.0	21.1	11.8	0.2	0.1	117.4
24	0.2	3.1	0.0	1.8	0.0	0.0	0.0	0.0	0.0	317.9	1.2	44.6	0.1	372.5
25	730.1	509.0	26.4	105.1	2.8	0.8	4.3	1.8	1210.1	57.1	35.0	54.9	1030.1	4351.8
	9770.9	**8497.2**	**536.3**	**2782.0**	**2161.8**	**253.3**	**104.0**	**76.9**	**2040.7**	**5179.8**	**1178.9**	**2381.5**	**2950.8**	**101793.9**

Table 4 10 Primary inputs by sector

Sector number →	1	2	3	4	5	6	7	8	9	10	11	12
Imports	1076.2	2232.1	5476.6	1472.9	1468.9	15711.6	6404.3	11609.6	2603.0	26.9	0.0	0.0
Taxes less subsidies on products	310.5	5.8	170.6	25.9	19.9	400.3	61.8	35.6	8.2	25.3	1135.0	134.5
Taxes less subsidies on production	-25.9	5.7	84.7	19.0	14.3	195.6	38.2	23.7	9.0	18.6	164.0	169.2
Compensation of employees	701.0	400.2	1798.7	680.8	636.6	2283.3	1462.3	1017.0	572.2	1085.2	4468.5	2945.4
Gross Operating Surplus	7585.2	285.7	1828.2	806.6	493.6	4546.6	935.0	670.1	419.3	1097.2	9471.8	16004.9
Total primary inputs	9646.9	2929.5	9358.9	3005.1	2633.3	23137.4	8901.6	13355.9	3611.7	2253.2	15239.3	19254.1
Total inputs	**13146.9**	**3371.4**	**18570.3**	**4243.7**	**3903.5**	**40190.8**	**12501.4**	**15678.9**	**4073.6**	**4207.7**	**26226.5**	**31092.0**

Table 4 10 (continued) - Primary inputs by sector (continued)

Sector number →	13	14	15	16	17	18	19	20	21	22	23	24	25	Totals
Imports	177.1	502.8	612.0	79.8	0.0	109.0	55.9	0.0	311.8	0.0	0.0	0.0	81.5	50012.0
Taxes less subsidies on products	150.9	67.3	8.3	604.8	146.2	3.6	1.2	1.3	49.1	427.0	69.5	188.6	110.0	4161.0
Taxes less subsidies on production	182.9	233.4	31.1	128.9	125.4	3.4	1.2	1.0	24.3	0.0	15.2	37.9	44.7	1545.4
Compensation of employees	2065.0	4473.0	2635.2	4523.4	29.4	42.8	28.1	67.2	1102.2	11055.6	6324.0	3768.1	3159.7	57325.0
Gross Operating Surplus	10265.0	2331.6	2571.3	3787.8	18443.5	282.6	71.6	9.9	1566.6	411.8	1197.6	4259.4	2806.0	92149.0
Total primary inputs	12840.9	7608.1	5858.0	9124.7	18744.6	441.4	158.0	79.4	3054.0	11894.3	7606.4	8254.0	6201.8	205192.4
Total inputs	**22611.8**	**16105.3**	**6394.3**	**11906.7**	**20906.4**	**694.7**	**262.0**	**156.3**	**5094.7**	**17074.2**	**8785.2**	**10635.5**	**9152.6**	**306986.3**

Table 4 11 Final demand on local goods

		Households	Government	GDFCF	Inventories	Exports	**Total final demand**
1	AGRICULTURE, HUNTING, FORESTRY AND FISHING	2660.0	0.0	53.1	12.6	2126.8	**4852.5**
2	MINING AND QUARRYING	3.1	0.0	10.0	0.5	70.5	**84.1**
3	FOOD PRODUCTS, BEVERAGES AND TOBACCO	8683.5	0.0	18.2	8.5	4219.2	**12929.4**
4	TEXTILES, TEXTILE PRODUCTS, LEATHER AND FOOTWEAR	2300.6	0.0	2.9	-6.2	1479.9	**3777.3**
5	WOOD, PAPER, PRINTING, PUBLISHING	1000.7	0.0	52.7	-1.8	226.7	**1278.4**
6	COKE, REFINED PETROLEUM PRODUCTS AND NUCLEAR FUEL	5221.4	0.0	38.2	39.9	14953.5	**20252.9**
7	OTHER MANUFACTURING	1989.6	0.0	165.0	-12.9	2672.8	**4814.5**
8	MACHINERY, EQUIPMENT	1030.9	0.0	10058.5	-9.0	1316.9	**12397.3**
9	TRANSPORT EQUIPMENT ETC.	1156.3	0.0	1315.7	-0.8	706.9	**3178.1**
10	ELECTRICITY, GAS AND WATER SUPPLY	1537.4	0.0	0.0	0.0	0.0	**1537.4**
11	CONSTRUCTION	506.8	0.0	24029.6	0.0	0.0	**24536.4**
12	WHOLESALE AND RETAIL TRADE; REPAIRS	15331.0	0.0	2471.4	0.4	3235.7	**21038.6**
13	HOTELS AND RESTAURANTS	21575.4	0.0	0.0	0.0	68.3	**21643.7**
14	TRANSPORT AND STORAGE	5711.5	1.7	35.0	0.0	5439.7	**11187.8**
15	POST AND TELECOMMUNICATIONS	1905.4	0.0	2.0	0.0	788.6	**2696.0**
16	FINANCE, INSURANCE	1523.7	0.0	18.7	0.0	113.8	**1656.2**
17	REAL ESTATE ACTIVITIES	15294.0	0.0	218.7	0.0	0.0	**15512.7**
18	RENTING OF MACHINERY AND EQUIPMENT	237.8	0.0	0.0	0.0	0.0	**237.8**
19	COMPUTER AND RELATED ACTIVITIES	0.0	0.0	117.8	0.0	6.2	**124.0**
20	RESEARCH AND DEVELOPMENT	0.2	92.6	0.0	0.0	0.0	**92.9**
21	OTHER BUSINESS ACTIVITIES	145.9	0.0	367.4	0.0	137.1	**650.4**
22	PUBLIC ADMIN. AND DEFENCE; COMPULSORY SOCIAL SECURITY	824.2	16141.7	1.3	0.1	14.9	**16982.1**
23	EDUCATION	2031.8	6635.9	0.0	0.0	0.1	**8667.9**
24	HEALTH AND SOCIAL WORK	5517.6	4745.4	0.0	0.0	0.0	**10263.0**
25	OTHER SERVICES	4148.0	273.6	347.7	0.0	31.6	**4800.8**
	Total	**100336.9**	**27891.0**	**39324.1**	**31.2**	**37609.2**	**205192.4**

Table 4 12 Primary Inputs into final demand

	Households	Government	GDFCF	Inventories	Exports	Total final demand
Imports	0.0	0.0	0.0	0.0	0.0	0.0
Taxes less subsidies on products	11177.0	0.0	2240.7	-1.7	-2535.8	10880.3
Taxes less subsidies on production	0.0	0.0	0.0	0.0	0.0	0.0
Compensation of employees	0.0	0.0	0.0	0.0	0.0	0.0
Gross Operating Surplus	0.0	0.0	0.0	0.0	0.0	0.0
Gross Value Added	0.0	0.0	0.0	0.0	0.0	0.0
Total Primary Inputs	11177.0	0.0	2240.7	-1.7	-2535.8	10880.3
Gross Inputs/Outputs after fisim	**113004.0**	**27891.0**	**42396.0**	**32.0**	**35106.0**	**218429.0**

4.2.4 Interpretation of the table

We have constructed an Input-Output table for Greece for the year 2004. The schematic representation of the table is shown below. Along the rows each cell shows where the output of every sector is directed i.e. the sales of the sector. Reading down a column, each cell represents a purchase by the sector on top from the sector on the left. At the bottom of the column we have the entries of value added, imports and subsidies associated with the particular sector. Total Gross Output must equal Total Gross Inputs for every sector.

Table 4 13 Schematic representation of the estimated IO table

Intermediate block (25x25)	Final Demand on local goods (25x7)
Primary Inputs (5x25)	Final Demands for Primary Inputs (5x7)

4.3 The construction of Social Accounting Matrix

4.3.1 Income expenditure accounts

The constructed IO table shows how income was generated in Greece for the year 2004. It does not answer the following question. How has this income been distributed between economic transactors? From the IO alone, for example, we cannot see how much of the income generated in the local economy is actually allocated to residents of the country and how much is accrued by people living abroad. Or, how much of the income is saved and invested? Questions like the ones mentioned above can be answered in the framework of a Social Accounting Matrix.

The Social Accounting framework is similar to the IO in the sense that row entries record incomes and column entries record expenditure. The basic difference is that not only income from expenditure on a good or service is recorded. The SAM records also transfers of income to and from the operators to the owners of capital and other property, taxes etc.

The institutions/transactors that will be recorded in the SAM will be 5. Namely:

a) Households (H)
b) Corporate (all private firms) (C)
c) Government (G)
d) Capital Formation (CF)
e) External sector. (E) – The external sector in our case will consist of Rest of the EU (REU) and the Rest of the World (ROW)

Turner (2002) provides a schematic structure of the Social Accounting Matrix.

Table 4 14 Schematic representation of the SAM

Expenditure by / Income to	Production activities (25 production sectors)	Institutions H, C,G, CF, E	Factors of Production Labour (L) Capital (C)
Production Activities	T	U	
Institutions H, C,G, CF, E	V	W	X
Factors of Production Labour (L) Capital (C)	Y		

The capital letters in the table above represent sub-matrices which we explain below.

- T is the 25x25 matrix of intermediate flows and is identical to the upper left quadrant of the IO table represented in table 4.14.
- U is a 25x7 matrix of final demand expenditures by institutions. The entries of this matrix are given by the corresponding entries of the upper right quadrant of the table in table 4.14.
- V is a 5x25 matrix of income flows from the 25 production sectors to the 5 institutions. Here all entries are zero apart from the ones that record net commodity taxes paid to government and payments from production sectors to the external sectors in the form of purchasing imported goods. These entries are taken from the lower left quadrant

of the IO. However in the IO table imports are not separated between REU and ROW. Therefore for each production sector the corresponding entry should be divided. This was done on the basis of information retrieved from national statistics on the composition of imports. We had no sectoral breakdown, i.e. how much each sector is importing from REU and how much from ROW, so the allocation was done on the basis of the shares of the totals[21].

- Y is a 2x25 matrix of payments to value added by each the 25 production sectors. These entries are identical to the two corresponding rows of the IO table.
- X is 5x2 matrix which shows the factor income payments to each of the transactors/Institutions. The total factor income payments are the totals of "Other Value Added" and "income from employment".
- W is a 5x5 matrix which reflects income transfers between institutions. For the construction of this sub-matrix we have used data from the IO table as well as data from the National Accounts. A detailed explanation of its construction follows now.

4.3.2 The set of income- expenditure accounts.

As mentioned above, the main data requirements have to do with the income flows between the institutions of the economy. That is sub-matrix W of in table 4.14. We will also need the shares of other value added that go to government, private

[21] For example, from the national accounts we retrieve the following information. For 2004 total imports were €50,012m. According to the national statistics the proportion of those imports coming from EU was in the was 54.8% (www.statistics.gr). Therefore imports from the EU are calculated to be €27,407.

firms, and households (self-employed). These are elements of sub-matrix X. Note here, that all the remaining required entries are the ones in the rows and columns of the institutions. Therefore, a full set of income expenditure accounts for the institutions contained in the Social Accounting would fill in the gaps. If the set of income expenditure accounts is balanced, it means that the SAM will be balanced as its two components are themselves balanced. The main source for constructing the accounts is the national accounts as published by the National Statistics Agency in Spring, 2006 (www.statistics.gr) There are however, elements that are difficult to estimate and alternative sources will be used. That is the SAM constructed by Sarris and Zografakis for the year 1996 and the one by Kontis et. al. (2006)[22]. Finally, other elements will be used as balancing items, in order to make sure that we fulfil the conditions described above.

In constructing the income-expenditure accounts we begin with the three local transactors – households, government and corporate – for which data are more readily available from existing published sources. Table 4.15 shows the outline of the format used for these three accounts.

[22] Kontis et. al. (2006) constructed a SAM for 2004. However at the time of publication (December 2006) extensive work had already been done and a complete change of the database was unfeasible. The SAM of Kontis et.al.(2006) has been utilised in a very limited way. It has been consulted for the entry of transfers of households to the external sector entry reflects remittances paid abroad (usually by migrant population). The SAM by Sarris & Zografakis (1996) is constructed to analyse impacts of different tax policies. The SAM by Kontis et.al (2006) is constructed for an analysis of impacts of migration. In that sense the latter provides a better estimate for the particular figure.

Table 4 15 Template for constructing income-expenditure accounts for the three local transactors (Households, government and corporations)

Income	*Expenditure*
Income from employment (Households only)*	IO final demand expenditure (including expenditure taxes)*
Net commodity taxes (Government only)*	
Income from Other Value Added (OVA)*	
Payments from corporations**	Payments to corporations**
Payments from government**	Payments to government**
Payments from households**	Payments to households**
Transfers from REU**	Transfers to REU**
Transfers from ROW**	Transfers to ROW**
	Payments to capital (savings)***

Notes:

1. Items marked * are taken from the balanced IO table.

2. Items marked ** are constrained only by the corresponding entry in another account – e.g. payments to corporations in the household account must correspond to payments from households in the corporate account.

3. Items marked *** are entries which ensure that income equal expenditure, and thus balance the income-expenditure account. Everything balances through adjusting savings)

Household Account

The Household account is constructed first as this account is traditionally the one for which information is most readily available. As will become clear, this was not true in this case. The entries in the household income-expenditure account that can come directly from the Greek IO table for 2004 are:

- household income from employment, €57,325m
    - the sum of the compensation of employment row
- final demand expenditure by households -€113,004m
    - the column total for expenditure by Greek households

Household income from government will equal the sum of property income (this includes interest income from government debt) and is equal to €9,545m, social benefits (€30,862m) and other transfers (€16,668m). Therefore we obtain a sum of €57,095m.

In order to estimate profit income we use information from the SAM constructed by Sarris and Zografakis (2004). In this table income of households from corporations is €12,647m and income from government is €7,228m. This means that income from corporations is 75% higher than income from government. Using the assumption that these two figures have grown proportionately between 1996 and 2004 we estimate income from corporations being €99,916m (€57,095m x 1.75). In the absence of relevant information, the assumption applied here is that government expenditure and Other Value Added have increased by the same percentage.

In the same manner income of households from the external sector was estimated as follows. In Sarris and Zografakis, income from the external sector was €842m.

That is 12% of income of government income from households. Using the same assumption as above the estimated value is €6,650m. This figure had to be split between transfers from REU and transfers from ROW. In the absence of any other information we allocated this figure using the share of exports to EU countries, to total exports. Total exports according to the national accounts were €35,106m and exports to the rest of the EU accounted for 47.7% of the total which is €16,746m. This would make the estimated figure for transfers from the REU €3,172m, leaving €3,478m for transfers from the ROW.

Payments by Greek households to government are calculated from a variety of taxes, specifically income tax, capital gains tax, inheritance tax, stamp duties, insurance premium tax, council tax and social security contributions. Given the information published in national statistics the sum of the above taxes is €38,025m.

Payments of households to capital will equal the amount of savings and are estimated on data from Sarris & Zografakis. For 1996, they report a savings rate equal to 12.1% of total income. Using the assumption that the savings rate is the same for 2004, we estimate payments to capital being €26,518m

The entry of transfers of households to the external sector has been taken from Kontis et. al. (2006). The entry reflects rent and remittances paid abroad (usually by migrant population). The SAM by Sarris & Zografakis (2006) is constructed to analyse the impacts of different tax policies. The SAM by Kontis et.al (2006) is constructed for an analysis of impacts of migration. In that sense the latter provides a better estimate for this particular figure. The transfers are estimated €454m and were split using the same assumptions that have been used to disaggregate transfers from the external sector. The estimated figures are €217m to the REU and €237m to ROW.

Payments of households to corporations are very difficult to estimate due to data constraints and are therefore treated as the balancing item in the household account. This figure is estimated as €42,985m.

Government Account

. Government income consists of the following components.

Profit income is taken directly from the IO table as the sum of OVA for the IO sectors that are regarded to be the public sector. This amounts to €5,869m.

Net commodity taxes are also taken from the IO table and are equal to the total of the Net Commodity Taxes row. This is €18,943m.

Income from households is equal with payments of households to government which has been calculated above and is equal to €38,026m

Income from corporations is estimated €29,026m. In the next paragraph where we analyse the income expenditure accounts for corporations we will explain how we estimated this figure.

Income from the external sector will be the balancing item in this case and is calculated to be €12,170m. This is split between the REU and ROW according to the composition of exports. The calculated corresponding figures are, €5,805 and €6,365m.

For government expenditure we have the following:

IO expenditure is equal to €27,891m, taken to be the total of the government column in the IO table.

Payments to households are equivalent to income of households from government and are calculated in the previous paragraph to be €57,095m.

Payments to capital are taken from the national statistics and are equal to negative €9,942m. This represents government savings for the year 2004 and the negative sign implies there was a budget deficit.

Payments to corporations are the balancing item in this account and are calculated to be €28,990m.

Corporate Account

Income from other value added in the corporate account is equal to total OVA for all sectors from the 2004 estimated IO table, minus OVA in the government and household income accounts. In the relevant section above we have discussed the way in which we have calculated OVA in each of these accounts. This provides us with a figure for OVA in the corporate account of €66,297m.

Income from households is the balancing item in the household account (payments of households to corporations). This is calculated above and equal to €42,985m.

Income from government is the balancing item in the government account (payments of government to corporations). This is again calculated above and equal to €28,990m.

Income from the external sector is recorded to be zero in the Sarris and Zografakis table and we retain this figure.

Payments of corporations to government in Sarris and Zografakis are 1.31 times greater than payments of households to government. Assuming that these two quantities have the same relation we estimate payments from corporations to government to be €29,026m.

Payments to households (€79,933m) and government ((€29,026m) have been explained above, while transfers will be assumed to be zero as this is the figure recorded by Sarris and Zografakis. This leaves us with payments to capital (or savings) which will be the balancing item and is calculated to be equal to €29,767.

External Account

The income of the external sector will result from the purchases of imports and any transfers. The total figure of imports will be the sum of the corresponding row of the IO table which is €50,012m. This will be split as mentioned above, between REU (€27,407m) and ROW (€22,605m). Transfers to the external sector have been analysed above and are equal to zero for both REU and ROW.

Similarly the export column total is €35,106m which is split in the same manner between REU (€16,746m) and ROW (€18,360m). Transfers of the external sector to other transactors will be the sum of the corresponding figures that have been explained above. From REU the figure is 3,172m to households and 5,805m to government. This makes a total of 8,905. Respectively for ROW the figures are €3,478m, €6,365m and €9,843m.

The remaining item is savings by the external transactors in Greece. Since the expenditure that we have estimated for the external sector is greater than its income (€53,927m and €50,012m with the difference being €3,915m) the sector is in deficit. This means that it is borrowing from the local economy or runs a trade deficit.

Capital Account

Income of the capital account will be the sum of payments to capital or savings from all other transactors. We have already analysed these figures. They are the sum of income from households, Government and Corporations and equal €46,363.

Expenditure of the capital account is already fixed from the IO column totals of Gross Domestic Fixed Capital Formation and Changes in inventories. This is €4,2428m. This is equal to €3,915 surplus which is effectively borrowed by the Greek Economy in order for the trade deficit to be financed.

The table below is a comprehensive representation of the data collection-estimation that is described above. All the new entries required for completing the SAM for Greece in 2004 can be taken directly from the balanced set of income-expenditure accounts. Our method thus ensures that no further balancing is necessary.

Table 4 16 Income –Expenditure Accounts Greece 2004

Households			
Income	**220,987**	**Expenditure**	**220,987**
Income from employment	57,325	IO expenditure	113,004
Profit income (OVA)	19,983	Payments to corporations	42,985
Income from corporations	79,933	Payments to government	38,026
Income from government	57,095	Payments to capital	26,518
Transfers from REU	3,172	Transfers to REU	217
Transfers from ROW	3,478	Transfers to ROW	237
Government			
Income	**104,034**	**Expenditure**	**104,034**
Profit income (OVA)	5,869	IO expenditure	27,891
Net commodity taxes	18,943	Payments to corporations	28,990
Income from households	38,026	Payments to households	57,095
Income from corporations	29,026	Transfers to REU	0
Income from REU	5,805	Payments to capital (savings)	-9,942
Income from ROW	6,365		
Corporations			
Income	**138,726**	**Expenditure**	**138,726**
Profit income (OVA)	66,297	Payments to households	79,933
Income from households	42,985	Payments to government	29,026
Income from government	28,990	Transfers to REU	0
Income from REU	0	Transfers to ROW	0
Income from ROW	0	Payments to capital (savings)	29,767
Capital			
Income	**42,428**	**Expenditure**	**42,428**
Households	26,518	GDFCF	42,396
Corporate	29,767	Change in Inventories	32
Government	-9,942		
REU and ROW	-3,915		
External			
EU income from Greece	27,407	EU expenditure in Greece	25,723
Goods & Services	27,158	Goods & Services	16,746
Transfers	249	Transfers	8,978
ROW income from Greece	22,605	ROW expenditure in Greece	28,204
Goods & Services	22400	Goods & Services	18,360
Transfers	205	Transfers	9,843
Total income	**50,012**	**Total expenditure**	**53,927**
		Surplus/deficit	-3,915

4.3.3 Additional data required for Computable General Equilibrium modelling – Investment demands, and Labour supply data

The Input- Output Table and the Social Accounting Matrix provide information on the supply of capital formation. However, no information is given in relation to the demand for capital formation i.e. investment goods. We will estimate sectoral investment demands by assuming that investment is equal to long-run depreciation in the base year (where all markets are taken to be in long-run equilibrium). Thus, the base year capital stock in each sector is estimated by grossing up investment demands using the depreciation rate for capital – i.e. dividing each sectors investment demand by the depreciation rate, which is assumed, in the absence of econometric estimates, to be equal to 0.15 in each sector. The table below presents, the shares of sectoral investment demand that are calculated using the method outlined above.

Table 4 17 Shares of investment demand by sector

Agriculture	0.082
Fishing	0.003
Mining and Quarrying	0.020
Food Manufacture	0.009
Textiles	0.005
Leather Products	0.049
Wood Products	0.010
Paper, Printing and Publishing	0.007
Coke and Petroleum Products	0.005
Chemicals Rubber and Plastic	0.012
Metal and Non Metal products	0.103
Transportation and Machinery and Equipment	0.174
Electrical Equipment	0.111
Other Manufacture	0.025
Electricity, Gas and Water Supply	0.028
Construction	0.041
Trade	0.200
Hotels and Catering	0.003
Transportation and Communications	0.001
Financial Intermediation	0.000
Real Estate, Renting and Business Activities	0.017
Public Administration and Defense	0.004
Education Services	0.013
Health and Social Services	0.046
Other Services	0.030
Total	1

We also require information on basic population and labour market statistics and sectoral employment for the year 2004. The data are retrieved from the web-site of National Statistics Agency and is shown in the tables below.

Table 4 18 Basic Labour Market Statistics

Employment (FTE) – SES	4,313,150
Working age pop	7,474,000
Unemployed	493,000
Total labour force	4,806,150
Non-participants	4,798,676
Total population	11,061,735
Unemployment rate (as % of labour force)	10.26%

Table 4 19 Sectoral employment

Agriculture, livestock, hunting, forestry	530950
Fishing	13025
Mining and Quarrying	14925
Manufacturing	563300
Electricity, GAS, Water supply	38650
Construction	350325
Wholesale ,retail vehicle repair and home equipment	755125
Hotels and restaurants	274225
Transport and telecommunication	269350
Financial services	113125
Real estate	280500
Public Admin, Defense and compulsory NI	353375
Education	310950
Health and Social services	220375
Other services	156150
Private households	67600
Other organisations	1250

The disaggregation of the table above provided by the national statistics agency is not the same as the disaggregation that we have used in our table. Extra calculations were required in order to match the two. So, for example we had to allocate the employment of the "manufacturing" sector above to the seven manufacturing sectors we have identified. This was done on the basis of the assumption that all manufacturing sectors face the same average cost of labour. Therefore, we calculated shares of wages paid by each of the seven manufacturing sectors and allocated labour accordingly. In the table below we report the implied sectoral employment estimates.

Table 4 20 Sectoral employment of waged labour

AGRICULTURE, HUNTING, FORESTRY AND FISHING	543925
MINING AND QUARRYING	14925
FOOD PRODUCTS, BEVERAGES AND TOBACCO	112403
TEXTILES, TEXTILE PRODUCTS, LEATHER AND FOOTWEAR	40041
WOOD, PAPER, PRINTING, PUBLISHING	45463
COKE, REFINED PETROLEUM PRODUCTS AND NUCLEAR FUEL	134293
OTHER MANUFACTURING	97472
MACHINERY, EQUIPMENT	59813
TRANSPORT EQUIPMENT ETC.	40863
ELECTRICITY, GAS AND WATER SUPPLY	38650
CONSTRUCTION	350325
WHOLESALE AND RETAIL TRADE; REPAIRS	755125
HOTELS AND RESTAURANTS	274225
TRANSPORT AND STORAGE	163307
POST AND TELECOMMUNICATIONS	99855
FINANCE, INSURANCE	113125
REAL ESTATE ACTIVITIES	280500
RENTING OF MACHINERY AND EQUIPMENT	2081
COMPUTER AND RELATED ACTIVITIES	1304
RESEARCH AND DEVELOPMENT	3620
OTHER BUSINESS ACTIVITIES	56362
PUBLIC ADMIN. AND DEFENCE; COMPULSORY SOCIAL SECURITY	353375
EDUCATION	310950
HEALTH AND SOCIAL WORK	220375
OTHER SERVICES	200772
Total	**4313150**

The above numbers represent sectoral employment including waged labour, self employed and family members. The economic model requires that we use as an input only wage labour. The reason is that the Input-Output table records “compensation of employees” which refers to waged labour. On the basis of that entry and sectoral employment the nominal price of labour is calculated by the model. Hence including self employed and family members would result in a nominal price of labour which is very low and misleading. Repeating the above process of sectoral allocation of employment but this time for the numbers of waged labour only we get sectoral employment numbers as shown below.

Table 4 21 Sectoral employment of waged labour

AGRICULTURE, HUNTING, FORESTRY AND FISHING	362724
MINING AND QUARRYING	14112
FOOD PRODUCTS, BEVERAGES AND TOBACCO	103014
TEXTILES, TEXTILE PRODUCTS, LEATHER AND FOOTWEAR	38990
WOOD, PAPER, PRINTING, PUBLISHING	36458
COKE, REFINED PETROLEUM PRODUCTS AND NUCLEAR FUEL	130767
OTHER MANUFACTURING	83748
MACHINERY, EQUIPMENT	58242
TRANSPORT EQUIPMENT ETC.	32769
ELECTRICITY, GAS AND WATER SUPPLY	38560
CONSTRUCTION	295911
WHOLESALE AND RETAIL TRADE; REPAIRS	602181
HOTELS AND RESTAURANTS	206692
TRANSPORT AND STORAGE	159807
POST AND TELECOMMUNICATIONS	94148
FINANCE, INSURANCE	111620
REAL ESTATE ACTIVITIES	240611
RENTING OF MACHINERY AND EQUIPMENT	2083
COMPUTER AND RELATED ACTIVITIES	1610
RESEARCH AND DEVELOPMENT	3271
OTHER BUSINESS ACTIVITIES	53669
PUBLIC ADMIN. AND DEFENCE; COMPULSORY SOCIAL SECURITY	353189
EDUCATION	298959
HEALTH AND SOCIAL WORK	214185
OTHER SERVICES	153856
Total	**3691176**

4.4 Chapter Summary Conclusion

In this chapter we have gone through the first stages of constructing a database for a CGE model for the Greek Economy for the year 2004. Our starting point was the 1994 IO table for Greece published by the OECD. This table has been aggregated and rolled forward to the year 2004. An additional set of income – expenditure accounts has been constructed using data from the national statistics agency. We have also utilized the accounts that have been constructed by Sarris & Zografakis for the year 1996. The constructed Input–Output table and Social Accounting Matrix are sufficient to allow us perform a modelling exercise of the most straightforward type of general equilibrium model, an Input –Output model. We need to keep in mind that such a model does not incorporate price or substitution effects.

However, if we want to proceed with more sophisticated simulations where substitution and prices are consistently modelled, the constructed data base will need to be augmented and combined with a set of parameters and decisions the functional forms that connect the elements of the base year data set. In other words we need to specify how the variables of our data set are related to each other in terms of parameter values and functional forms. This is going to be the objective of the next chapter.

Chapter 5 . The economic model G-AMOS

G-AMOS stands for Greek-AMOS while AMOS is an acronym for *A M*acro-Micro Model *O*f *S*cotland. It has been developed by a team of researchers in the University of Strathclyde. It is referred to as a Computable General Equilibrium modelling framework *"*… because it encompasses a range of behavioural assumptions, reflected in equations which can be activated and configured in many different ways" (Harrigan *et al*, 1991, p. 424). A wide range of model closures as well as parameter values are offered to the user, as appropriate for particular applications. A good general description of CGE modelling is given in Greenaway *et al* (1992) and an extensive review of regional CGE models can be found in Partridge and Rickman (1998).

AMOS has been used for simulating the impacts of various policies such as at the regional and interregional level such as Scottish Fiscal autonomy (McGregor et. al., 2004b), Regional Development Agencies (Gillespie et. al. 2002), Foreign Direct Investment (Gillespie et.al, 2001). A series of papers examines the interregional impacts of regional policies (McGregor et. al., 1999, Ferguson et.al.2004, Gilmartin et.al, 2007). Extensive research in economic-environmental modelling with the use of AMOS has been done by Allan et.al (2006b), Hanley et.al (2006), Turner (2002).

The similarities between Greece and Scotland make AMOS an "appropriate" tool for simulating the behaviour of the Greek economy. Note that Scotland is a small open economy within the common currency area of Great Britain. In the same manner, Greece is a small open economy in the common currency area of the eurozone[23]. The G-AMOS modelling framework has been calibrated to data on the Greek economy given in the form of a Social Accounting Matrix (SAM) for the year 2004. The model has 3 transactor groups - households, firms and government - and 2 exogenous external transactors – the rest of the EU (REU) and the rest of the world (ROW). The model has 25 activities/commodities and these are listed in Table A1.1 in Appendix 1. A condensed account of the model structure is given in Table A2.1.

In the version of AMOS used here, production takes place in perfectly competitive industries using multi-level production functions. This means that in every time period all commodity markets are in equilibrium, with price equal to the marginal cost of production. Value-added is produced using capital and labour via standard production function formulations so that, in general, factor substitution occurs in response to relative factor-price changes. Typically, constant elasticity of substitution (CES) technology is adopted, which is the case in simulations reported in chapters 6 and 7[24]. In each industry intermediate purchases are modelled as the demand for a composite commodity with fixed (Leontief) coefficients. These are substitutable for imported commodities via an Armington link. The composite input then combines with value-added (capital and labour) in the production of each sector's gross output. Cost minimisation drives the industry cost functions (equation 1 in Table A2.1) and the factor demand functions (equations 7 and 8 in Table A2.1). A graphical representation of the production function is given in Appendix 3.

Whilst the G-AMOS framework offers a wide choice of labour market closures, in the simulations reported in chapters 6 and 7 the labour market is

[23] In 2004 that is the reference year, eurozone and eu practically coincided. There were 14 full members of EU out of which 12 used the euro as their currency. Remember 2004 is the year the enlargement took place and by January 2005 10 more countries started having the euro as their currency. The two exceptions were Britain (pound sterling) and Denmark (krone).
[24] Leontief and Cobb-Douglas options are available as special cases.

characterised by a bargaining function (also expressed as a wage curve) represented as equation 5 in Table A2.1[25]. This establishes a negative relationship between the real wage and the unemployment rate (Minford *et al*, 1994). Empirical support for this wage curve specification is now widespread, (Blanchflower and Oswald, 1994, 1998). The bargaining function is parameterised using the econometric work reported in Layard *et al.* (1991):

$$\ln rw_{n,t} = a - 0.113 \ln u_t + 0.40 \ln rw_{n,t-1}$$

where r_w is the Greek real wage, u is the Greek unemployment rate, *t* is the time subscript and a is a calibrated parameter.[26] To transform the real wage to the nominal wage, we multiply by the consumer price index (equation 2 in Table A2.1). Nevertheless, sensitivity analysis has been performed in section 6 where we examine extreme cases for the closure of the labour market.

Perfect labour mobility is assumed between sectors, generating a unified labour market. Therefore, although wage rates vary between sectors in the base-year data set, in the simulations wages in all sectors change by the same proportionate amount in response to exogenous shocks. The nominal wage in each time period is then derived through the interaction of the resulting wage curve and the general equilibrium labour demand curve (equation 9 in Table A2.1). In the derivation of the general equilibrium labour demand curve, it is important to note that all prices and incomes are taken to be endogenous.

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[25] In one set of simulations the bargaining function results are compared with those generated by a fixed labour supply and a fixed real wage closure.

[26] The calibration is made so that the model, together with the set of exogenous variables, will recreate the base year data set. This calibrated parameter does not influence simulation outputs, but the assumption of initial equilibrium is, of course, important.

The four main components of commodity final demand (represented by equation 12 in Table A2.1) are consumption, investment, government expenditure and exports. Household consumption is a linear homogenous function of real disposable income and relative prices (equations 2, 11 and 13 in Table A2.1). Real government expenditure per head is assumed to be constant (equation 17, Table A2.1) and in these simulations the population is typically determined exogenously using the demographic model. Exports are determined by exogenous external demand via an Armington link, making exports relative price sensitive (equation 18, Table A2.1).

The modelling of investment demand is a little more complex. In the multi-period variant of the model, capital stock adjustment at the sectoral level, which ultimately determines aggregate investment demand, is dealt with in the following way. Within each time period, both the total capital stock and its sectoral composition are fixed. The interaction between this fixed capital supply and capital demand at the sectoral level determines each sector's capital rental rate (equations 8 and 10, Table A2.1). The capital stock in each sector is then updated between periods via a simple capital stock adjustment procedure, according to which investment equals depreciation plus some fraction of the gap between the desired and actual level of the capital stock (equations 6, 14 and 15 in Table A2.1).[27] Desired capital stocks are determined on cost-minimisation criteria, using the user cost of capital as the relevant price of capital (equations 3 and 4 in Table A2.1). In the base period the economy is assumed to be in long-run equilibrium, where desired and actual capital stocks are equal, with investment simply equal to depreciation. Investment as a

[27] This process of capital accumulation is compatible with a simple theory of optimal firm behaviour given the assumption of quadratic adjustment costs. The whole process is analogous to Tobin's q.

source of product demand is then determined by running the demand for increased capital stock by sector through the capital matrix (equation 16, Table A2.1).

The conceptual time periods of the model are interpreted as years: annual data are used for the calibration and, where applicable, the estimation of parameter values.

As stated earlier in this section, the structural characteristics of the AMOS model are parameterised on a Social Accounting Matrix (SAM) for Greece for 2004. In all sectors, the elasticity of substitution between capital and labour in the production of value added is 0.3 although sensitivity analysis is conducted. Intermediate composite goods are assumed to be produced by a Leontief type production procedure with fixed coefficients. This is required because of the large number of zero entries. The default Armington trade elasticities for imports and exports are 8.0[28]. This is to reflect the fact that the country is considered to be a "price taker" in international markets. Sarris and Zografakis (1999) also applied a high value of Armington elasticity[29] while Ioakimoglou (1999) econometrically estimated that 80% of variation of prices in Greece is attributable to international price changes. Nevertheless sensitivity analysis using alternative values of 2, 5 and 8 is performed in chapter 7. The speed of adjustment parameter for the adjustment of actual to desired capital stock is 0.3.

Before discussing the simulation results it is important to clarify a key characteristic of the G-AMOS model. G-AMOS is not a forecasting model. When it is parameterised on the base year data set, it is assumed that the economy is in long-

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[28] The value that has been used in most cases where results for AMOS are reported is 2.0. A value of 8.0 is chosen in this exercise.

[29] The authors do not explicitly state the value they choose, they refer to it as "high but not infinity"

run equilibrium. If there are no changes to the exogenous variables and the model is run in period-by-period mode, then the model will simply report an unchanging economy that replicates the base year data set from period to period.

Chapter 6 . Illustrative Simulations Using G-AMOS

6.1 Introduction

Chapter 4 has explained how the economic database for the Greek version of the AMOS Modeling framework (hereafter G-AMOS) has been constructed. This chapter reports on the results of some initial simulations. The response of the model to a series of shocks is examined. In particular:

- A permanent increase in export demand for the sectors "Food products beverages and Tobacco", "Textiles, Leather, Footwear", "Coke, Refined Petroleum Products" and "Other Manufacturing". These sectors were chosen because they have a relatively large propensity to export and thus are expected to have a considerable impact on the rest of the economy.
- An increase in labour efficiency for the sectors, "Agriculture" and "Other Manufacturing". These sectors were chosen because they are relatively large employers and thus sizeable and interpretable results are again expected.

The demand and supply shocks described above are introduced into the model under a combination of different closures. The assumption on the labour market closure and the migration assumptions is varied. A detailed account on the different sets of assumptions that govern this set of simulations is provided in the next section.

6.2 Alternative closures

The first labour market closure that we use is one where the wages are determined by a bargaining process. In this closure real wages and the unemployment rate are inversely related. In particular I am going to be using the ecometrically – parameterised wage equation identified by Layard, Nickell, Jackman (1991) which is of the following form:

Equation 1- wage bargain equation

$$\ln rw_{n,t} = a - 0.113 \ln u_t + 0.40 \ln rw_{n,t-1}$$

Where

- w is the nominal wage rate
- cpi is the consumer price index
- u is the unemployment rate and
- α is a parameter calibrated so that the model replicates the benchmark data set.

The alternative labour market closure that we will be using is a Keynesian closure where nominal wages are fixed. Having a fixed nominal wage in a small open economy like Greece is of course counter intuitive. However, testing the model under this restriction can help us verify that it is doing what it is expected to do.

In addition, the assumption on migration is going to vary. Initially, migration is allowed to take place between the Greece and the "Rest of EU"[30]. When this assumption is employed, population adjusts through migration. The rate of immigration is positively related to the ratio of real consumption wage between

[30] It is indeed the case that EU citizens can freely move within EU countries. The AMOS modeling framework initially built for Scotland offers the option of allowing for migration between Scotland and the Rest of UK.

Greece and the Rest of EU and negatively related to the respective ratio of unemployment rates (Treyz et.al, 1993). The equation used is econometrically parameterised by Layard et al (1991) and is the following:

Equation 2- Migration Flow

$$\ln\left[\frac{m^G}{L^G}\right] = \delta - 0.08\left[\ln u^G - \ln u^{EU}\right] + 0.06\left[\ln\left[\frac{w^G}{cpi^G}\right] - \ln\left[\frac{w^{EU}}{cpi^{EU}}\right]\right]$$

where:

- m is net migration
- L is population
- δ is a calibrated parameter that ensures zero net migration (the equilibrium condition) for the base year data, and
- G and EU indicate Greece and Rest of European Union respectively

The intuition behind the above equation is that higher wages attract workers and higher unemployment pushes workers out of the country. Hence migration between Greece and countries of the rest of the EU works as an adjustment mechanism in the labour market.

In summary, we are going to interchange between a bargaining and a Keynesian closure in the labour market and between migration flow and zero migration. The table below shows the combination of set ups that will be used for each simulation and a simple classification that I will be using hereafter.

Table 6 1 Set of simulations

	Demand Shock	Supply Shock
Bargaining, Migration on	1a	2a
Bargaining, Migration off	1b	2b
Keynesian, Migration on	1c	2c
Keynesian, Migration off	1d	2d

The shocks introduced are the following. For the demand shock the impact of an export demand increase of 50% for the sectors “Food Products Beverages and Tobacco”, “Textiles, Leather, Footwear”, “Coke, Refined Petroleum Products” and “Other Manufacturing” is simulated. This demand shock is compatible with an increase in exports of manufactured goods that could occur from the integration of the Greek economy in international markets and in particular the euro area. For the supply shock the scenario involves an increase in labour efficiency of 10% for the sectors “Agriculture” and “Other Manufacturing”. Such a shock could occur from the sectoral policies such as labour subsidies, that make labour cheaper. The simulation horizon is chosen to be 80 periods in order to allow enough time for the shocks to feed in the whole economy and also allow for adjustment process.

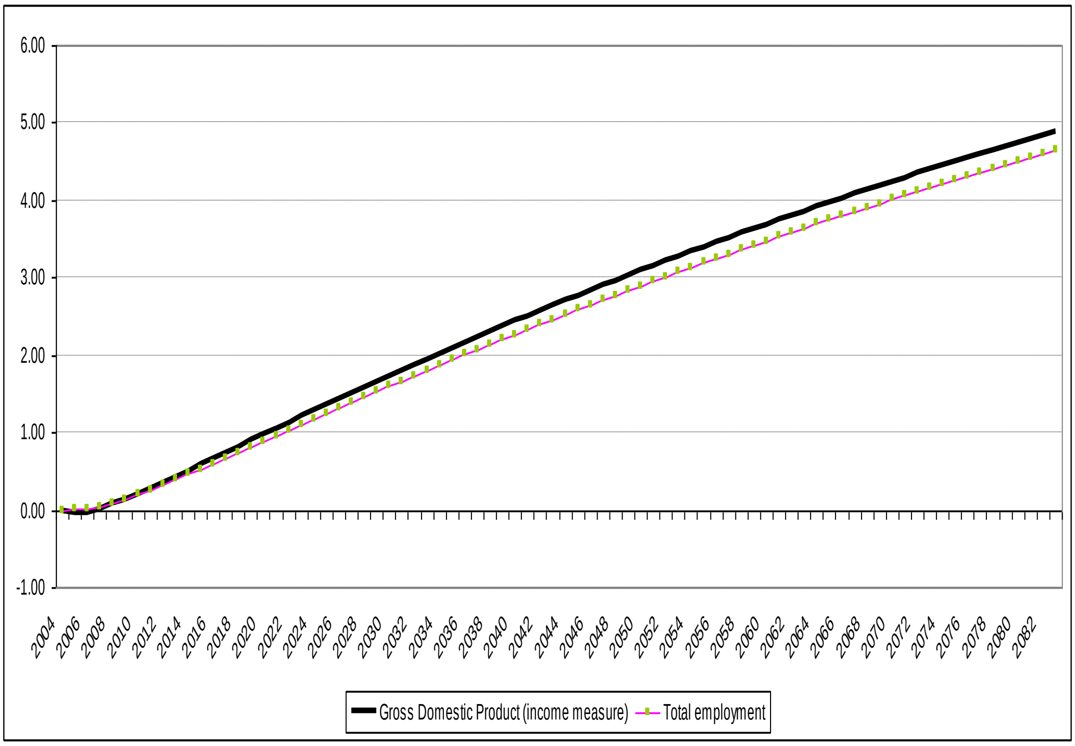
6.3 Results – Demand Shock

6.3.1 Demand Shock under the Bargaining closure of the labour market and flow migration (1a)

In this simulation the impact of a permanent demand shock described above when the labour market closure is set to the Bargaining option and migration is on, is identified. Note that, in all cases the shock is introduced in period 2.

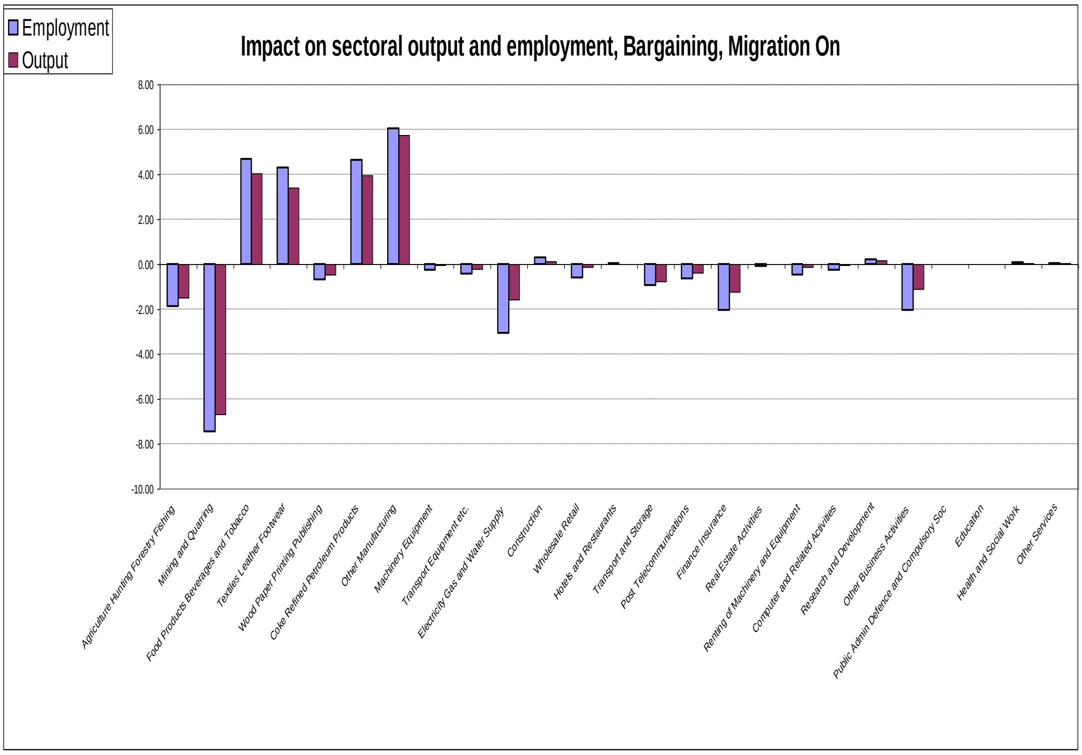
The impact in terms of GDP and employment is positive. After 80 periods GDP has increased by 4.89% and employment by 4.64%. Figure 1 presents the trajectory of GDP and Employment after the initial shock. The fact that GDP is at first reduced (-0.05 in period 2) after the shock is attributed to the fact that employment shifts towards sectors that undergo the demand shock and also shifts away from sectors that have high GDP/employee ratio. However, the positive demand shock materialises in the next period and GDP jumps up.

Figure 6 1 GDP and Employment % changes after a demand shock, Bargaining Migration On



The above becomes apparent by looking at sectoral Value Added and employment immediately after the shock. Sectors that are directly affected by the shock have an increased value added while most of other sectors have decreased value added due to the fact that labour moves to the sectors with the increased demand.

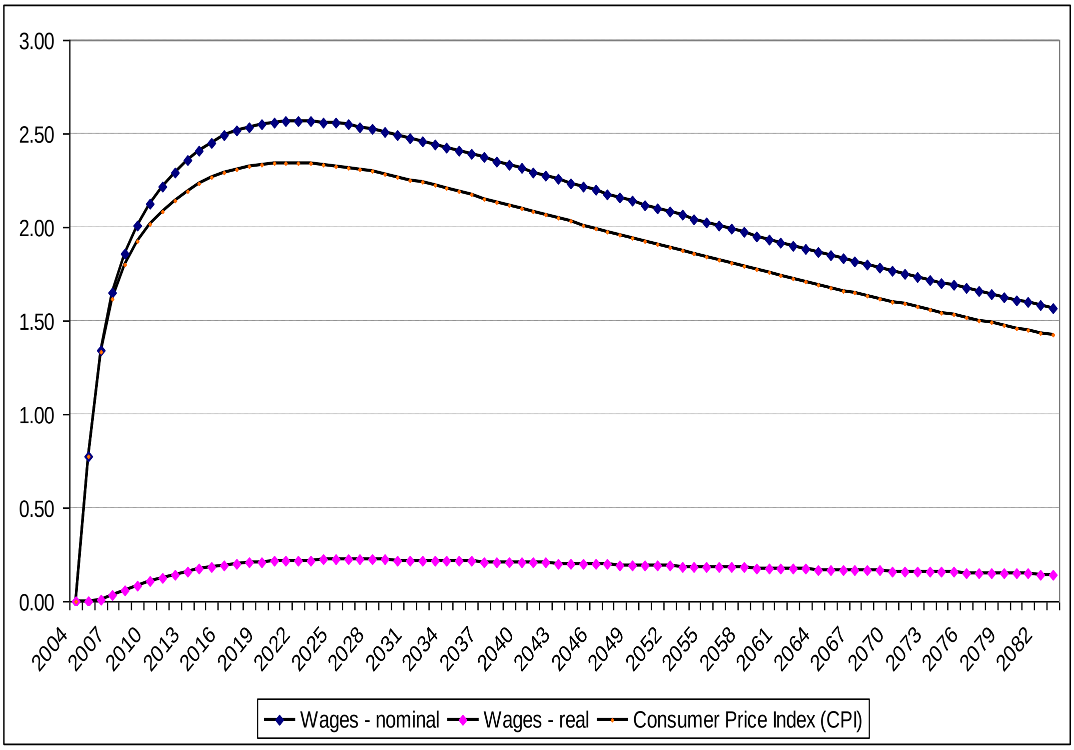
Figure 6 2 Value Added and Employment % change by sector, Bargaining, Migration On (period 2)



However by the end of the simulation period the positive effect of the increased demand is fed through the rest of the economy and employment and GDP has increased across all sectors.

Looking at prices one can observe the following. Nominal wages and CPI jump up and then start converging to the initial level after 20 periods. CPI and nominal wages follow a very similar pattern and hence the real wage does not really deviate from zero. Note that that by definition at each point the difference between real and nominal wages is equal to the deviation of CPI from zero. Figure 6.3 illustrates the above.

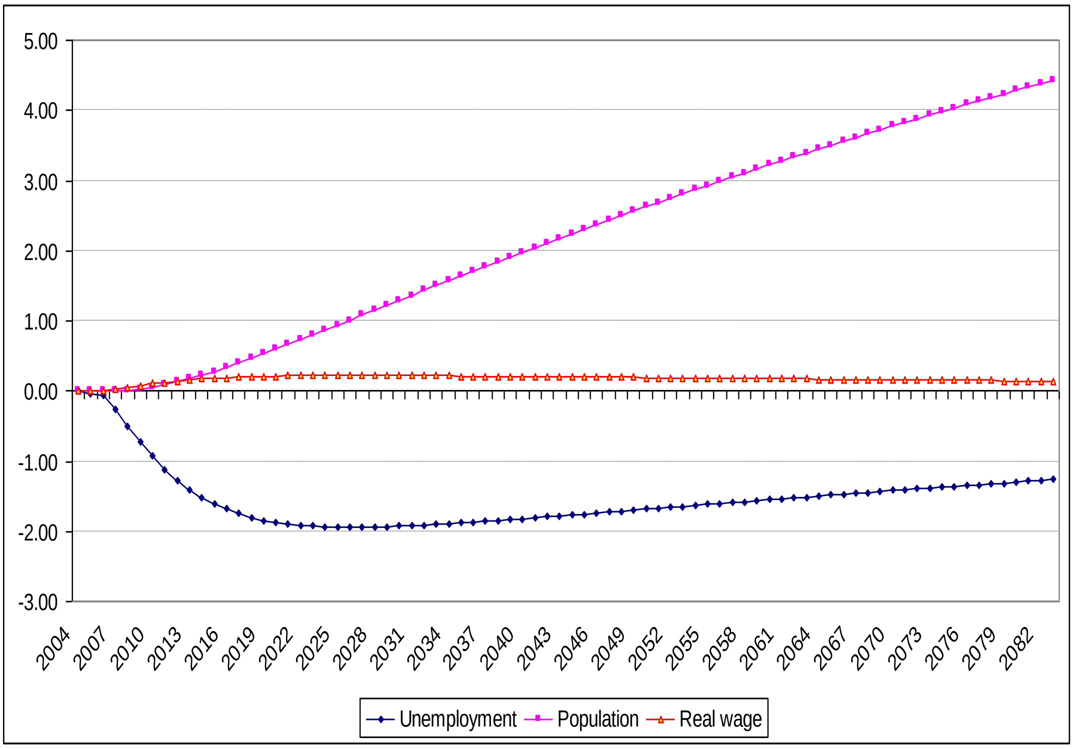
Figure 6 3 CPI, real and nominal wage Bargaining, Migration On



One more thing to observe is the effect of choosing to allow for migration. The demand shock results in lower unemployment and higher wages, and therefore to an inflow if immigrants. Recall that the migration is dictated by equation 1. In Figure 6.4 we see the course of unemployment, real wage and population.

Note that unemployment and real wage in the Rest of EU remains constant and that population in the host country (Greece) is assumed to change through migration only, while natural change is not present.

Figure 6 4 Population, Real Wage and Unemployment Bargaining, Migration On



6.3.2 Demand Shock under the Bargaining closure of the labour market and zero migration (1b)

I now turn to the impact of the same demand shock with the labour market closure being set again to the Bargaining option but migration being restricted to zero. Under this closure, one channel of adjustment of the labour market is closed.

The impact in terms of GDP is maximised after 80 periods when it deviates from base by 1.94%. Employment reaches a peak after 80 periods as well with the maximum deviation being 1.56%. Figure 6.5 presents the path of GDP and Employment. Again, the fact that GDP is initially reduced should be explained by the reallocation of employment and the respective GDP/employee ratio that differs between sectors.

Figure 6 5 GDP and Employment % changes after a demand shock, Bargaining Migration Off

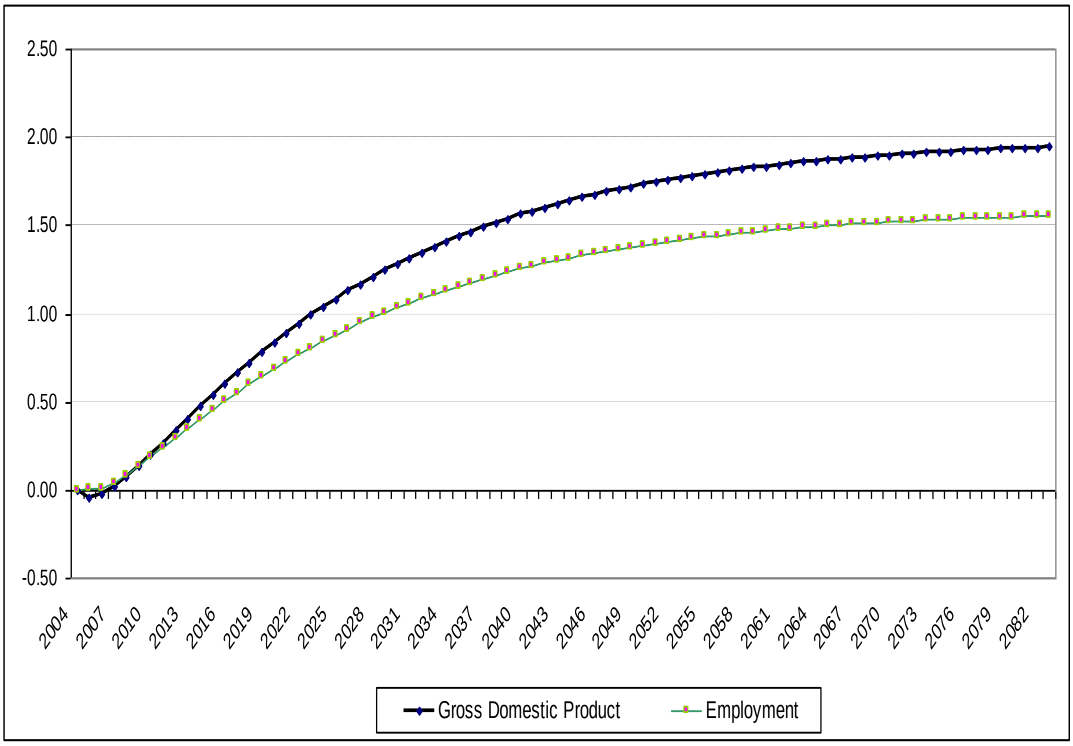
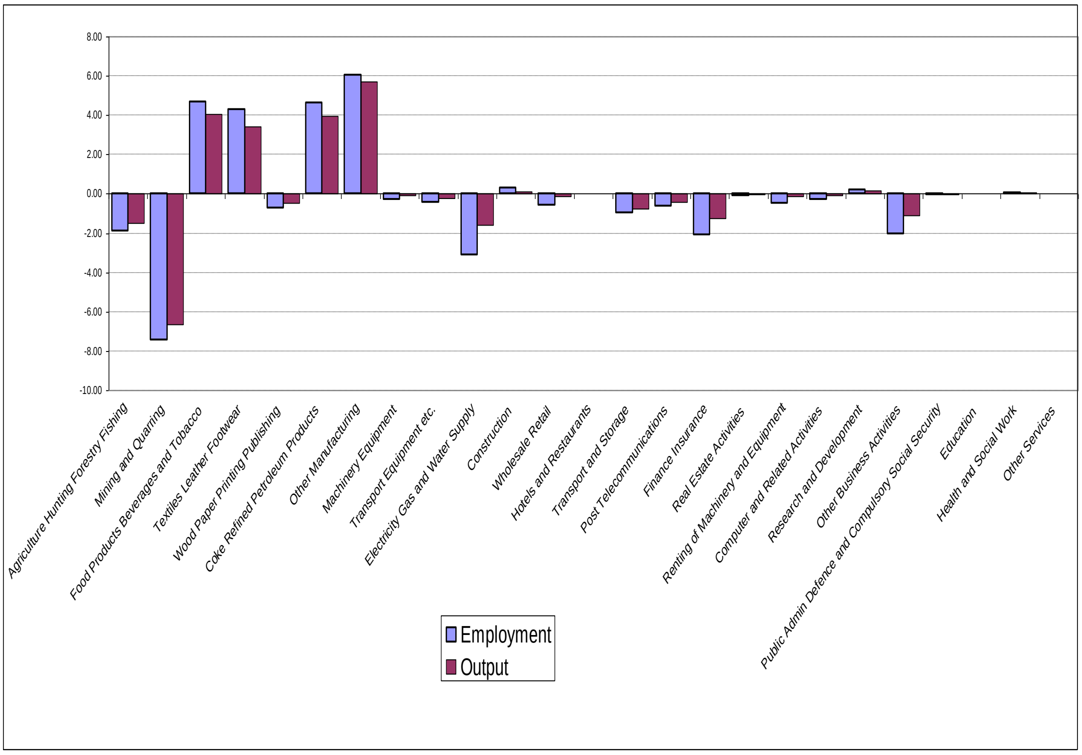


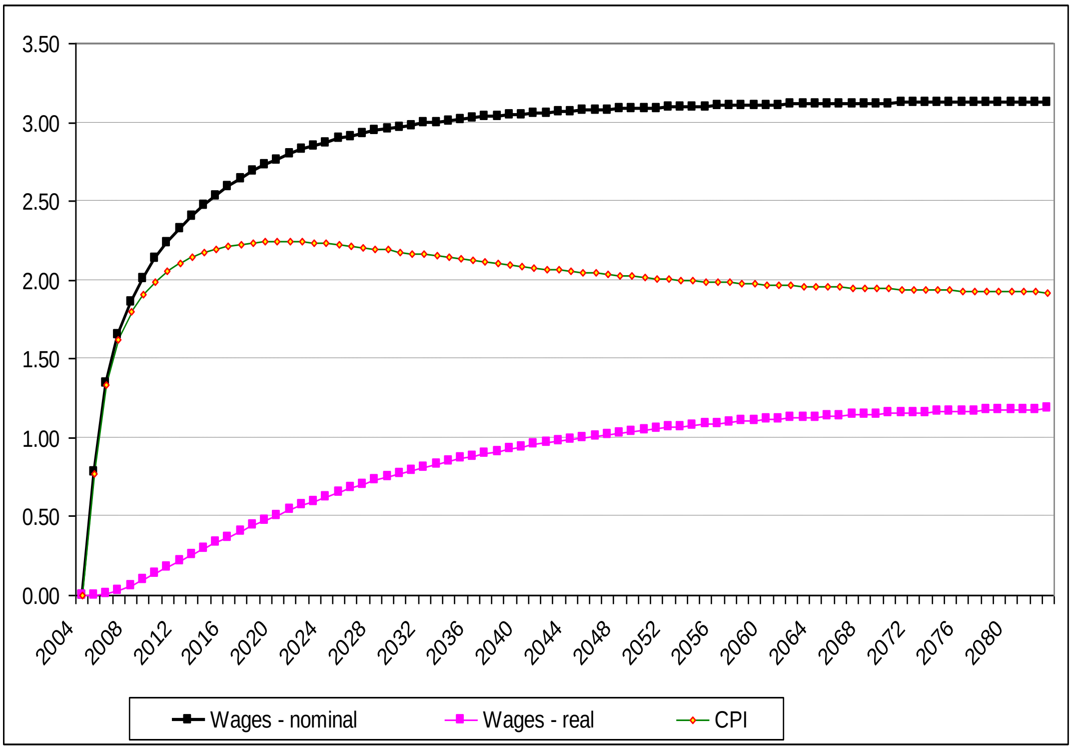
Figure 6.6 tells a very similar story to the respective one above. The shocked sectors moving to the positive while others move to the negative. Extra investment in the shocked sectors increases employment, while no investment takes place in the rest of the sectors and the less employment.

Figure 6 6 Value Added and Employment % change by sector - Bargaining Migration Off (period 2)



The picture of prices is also similar to the one above with an initial jump and convergence. I present CPI, real and nominal wage in Figure 6.7.

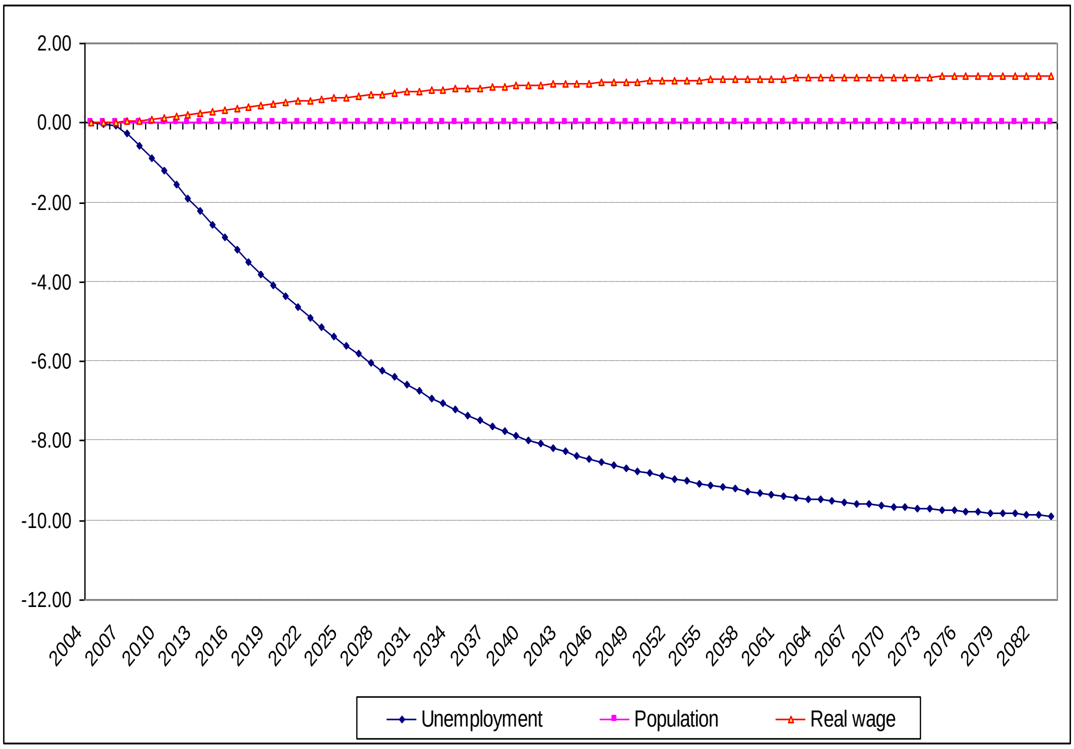
Figure 6 7 CPI, real and nominal wage, Bargaining, Migration Off



In this case the demand shock does not alter the population as migration is "switched off". The demand shock again results in lower unemployment and higher wages, but there is no inflow of migrants to ease the tightening of labour market.

Figure 6.8 reflects the course of unemployment, real wage and population. Population of course coincides with the x-axis as there is no migration and no natural change. Unemployment and real wage move in opposite directions as they should.

Figure 6 8 Population, Real Wage and Unemployment Bargaining Migration Off

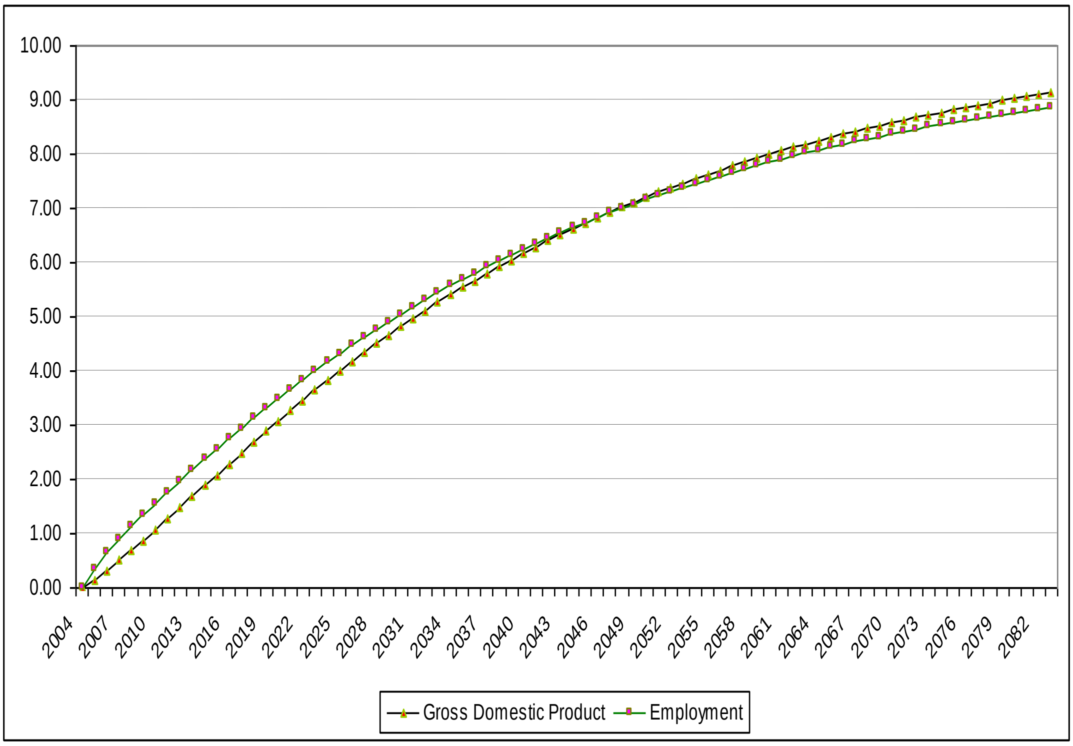


6.3.3 Demand Shock under the Keynesian closure of the labour market and flow migration (1c)

Now I will examine the impacts of the same demand shock when the labour market closure is set to the Keynesian option and migration is on. As I have mentioned above the Keynesian option implies a fixed nominal wage.

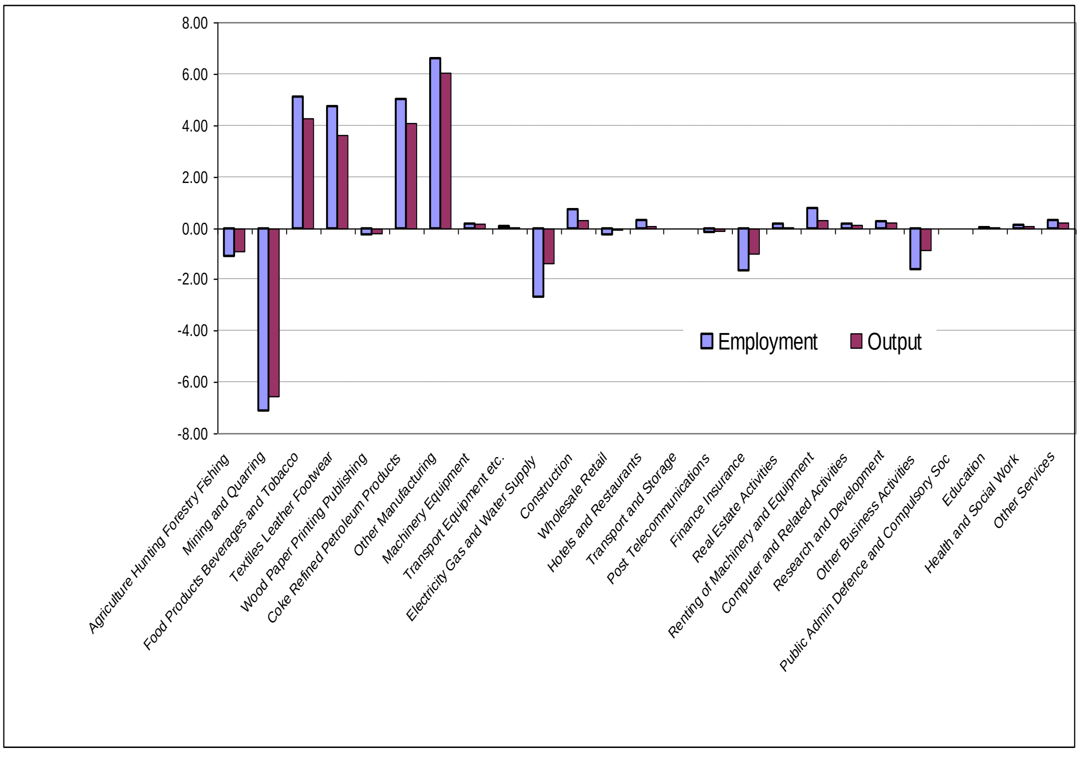
In this case the impact on GDP and Employment increase for the whole of the simulation period After 80 periods, GDP reaches a point which is roughly 9.13% higher than base while Employment has deviated by 8.86%. Figure 6.9 shows the rate of GDP and Employment after the initial shock. Note that in this case GDP moves up immediately after the shock. The reason is that nominal wage is fixed and therefore increased demand increases employment. There is no wage increase to crowd out demand for labour.

Figure 6 9 GDP and Employment % changes after a demand shock, Keynesian Migration On



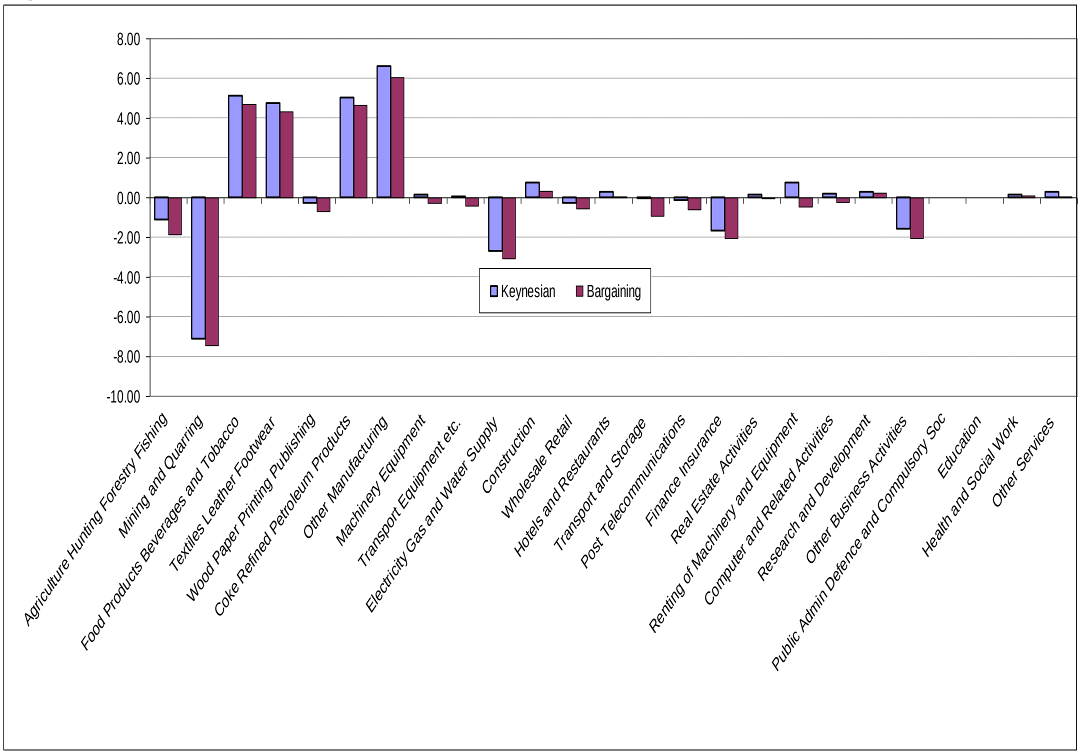
Below we can see the histogram of Value Added and Employment percentage changes by sector one period after the shock. Sectors that are shocked have an increased value added while most of other sectors have decreased value added. However, in this case positive impacts are higher while negative impacts are lower and therefore the overall impact is positive without delay after the shock.

Figure 6 10 Value Added and Employment % change by sector, Keynesian, Migration On (period 2)



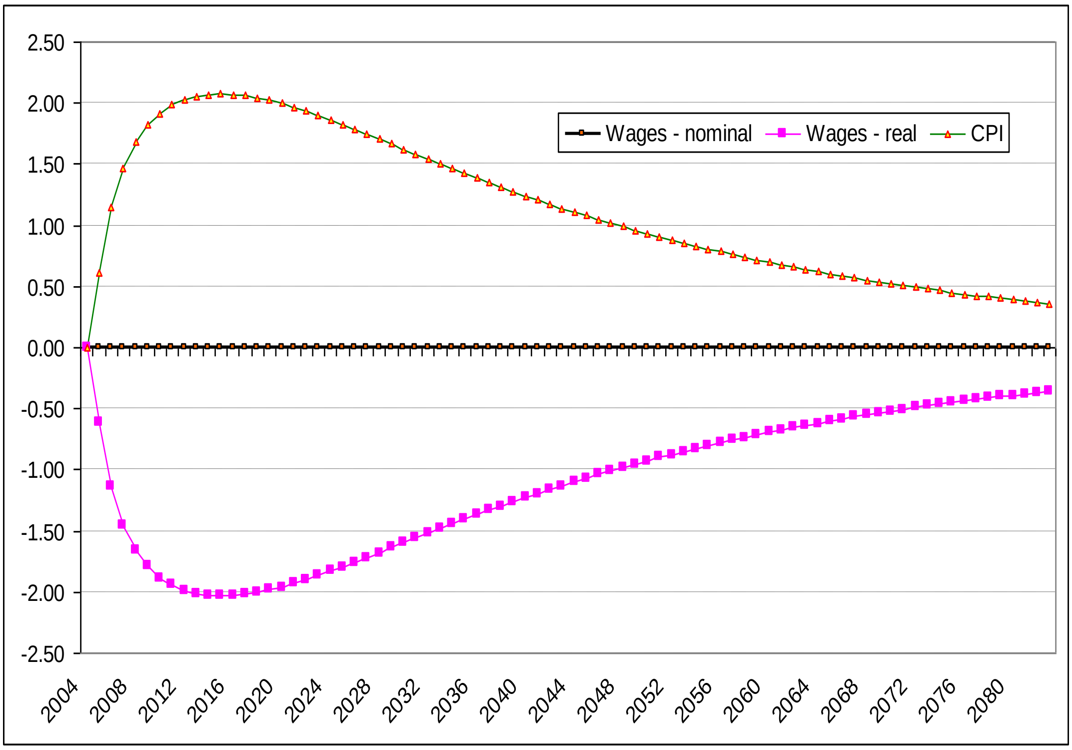
I present value added one period after the shock for the case of Bargaining-Migration on (1a) and Keynesian –Migration on (1c). The fact that in 1a scenario wage can increase crowds out the potential increase in value added compared to scenario 1c. In the same way the wage increase makes the impact on value added even more negative for the sectors that shrink.

Figure 6 11 Value added one period after the shock (1a VS 1c)



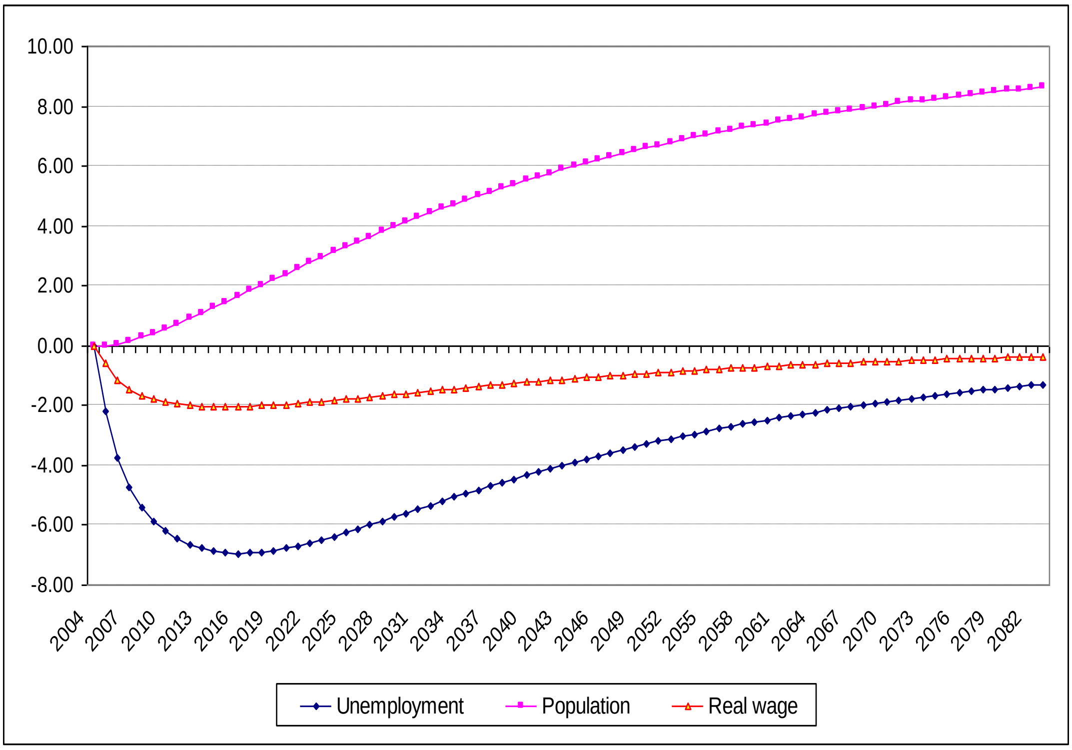
Prices behave as expected in the sense that nominal wage changes are restricted to zero as we have assumed, and CPI is the mirror image of the real wage. This should be such by definition. Figure 12 is quite explicatory.

Figure 6 12 CPI, real and nominal wage Keynesian, Migration On



Unemployment, real wage and migration are related in accordance to equation 1. Figure 6.13 is quite similar to figure 6.4 as expected.

Figure 6 13 Population, Real Wage and Unemployment Bargaining, Migration On



6.3.4 Demand Shock under the Keynesian closure of the labour market and zero migration (1d)

Finally, I present the impact of the same demand shock with the labour market closure being set to the Keynesian option but migration being restricted to zero.

The impact in terms of GDP is 6.70% above base after 80 periods while the employment impact is 6.55%.

Figure 6 14 GDP and Employment % changes after a demand shock, Keynesian Migration Off

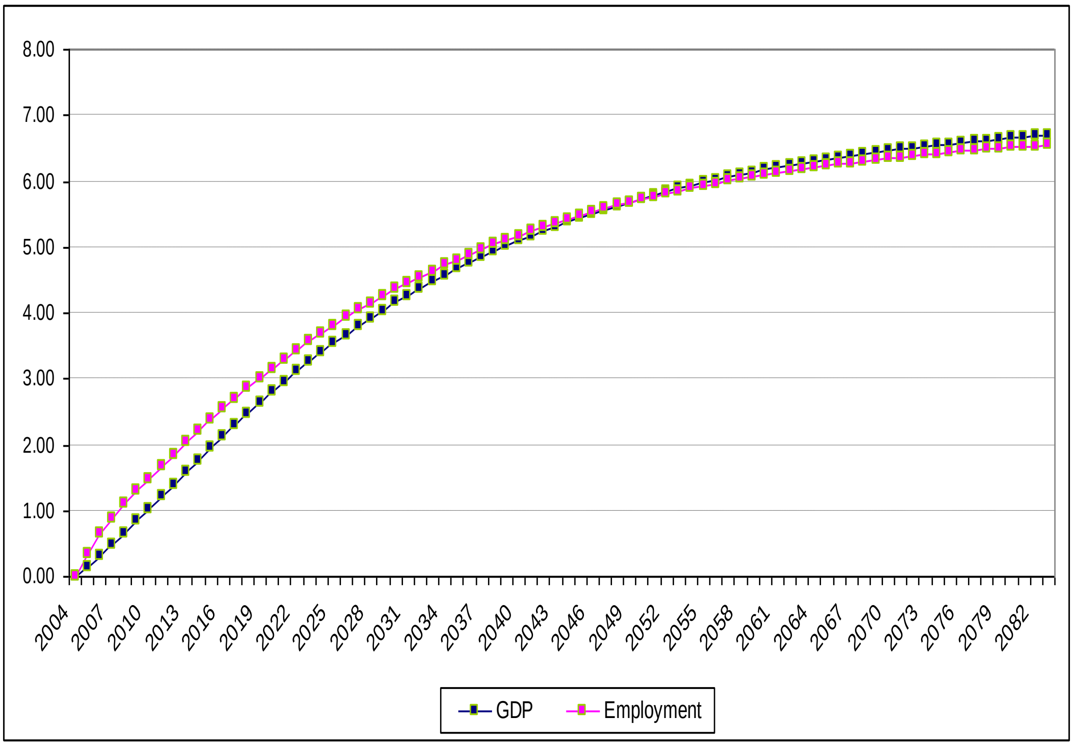
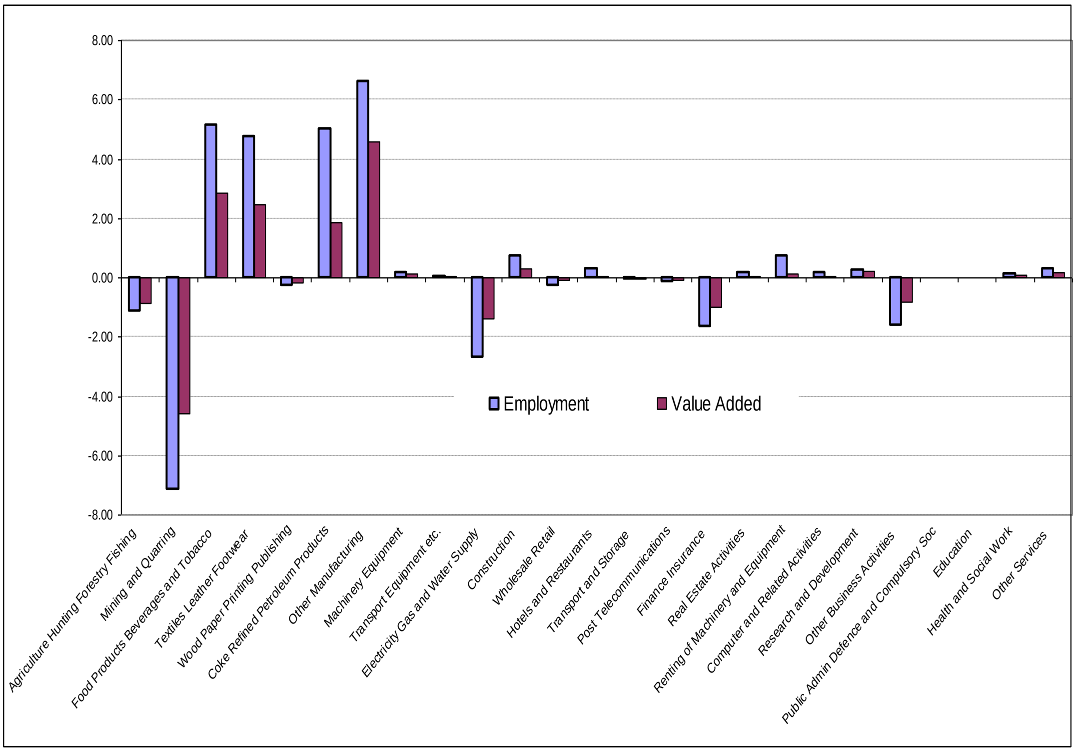


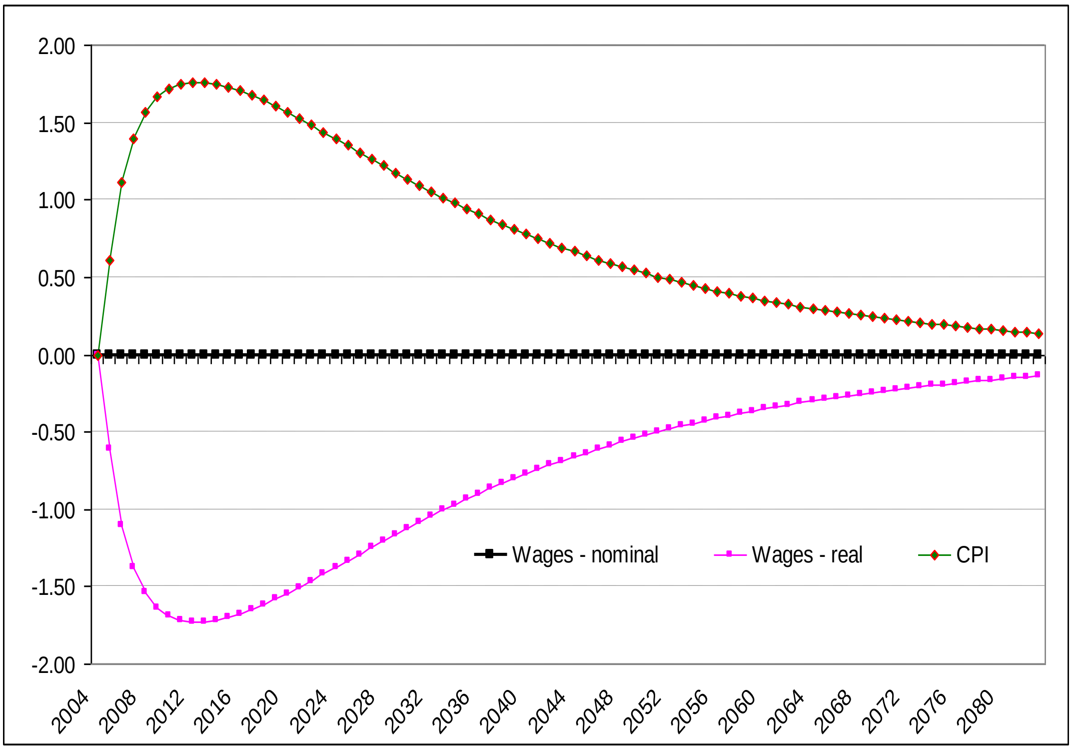
Figure 6.15 below shows the impact on individual sectors one period after the shock. The results once again are the ones expected. There is a large percentage decrease in Mining and Quarrying but the sector is relatively small and so is its overall impact.

Figure 6 15 Value Added and Employment % change by sector - Keynesian Migration off (period 2)



The behaviour of prices is exactly like the one above, with the inverse relation of real wage and CPI being obvious and a convergence to equilibrium after 9 periods. Figure 6.16 below is quite illustrative.

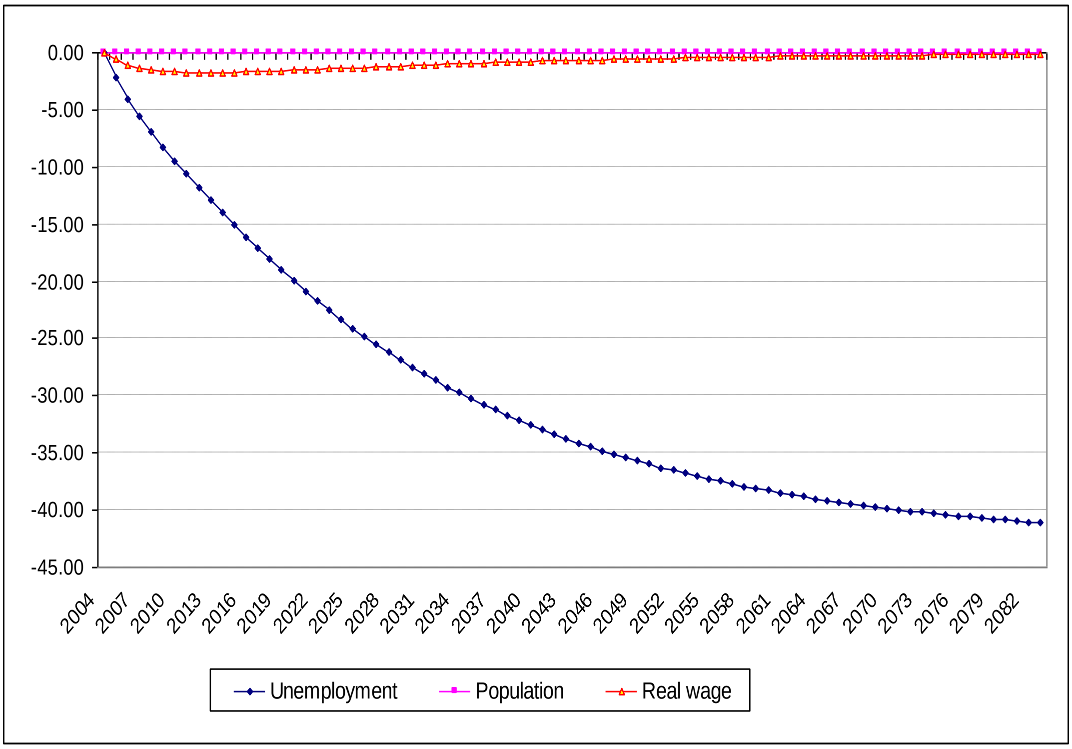
Figure 6 16 CPI, real and nominal wage, Keynesian, Migration Off



In this case the demand shock does not alter the population as migration is "switched off".

In figure 6.17 we see that population is fixed while real wages and unemployment (note that we record percentage changes in the unemployment rate) fall initially due to the demand shock and its combination with a fixed nominal wage.

Figure 6 17 Population, Real Wage and Unemployment Keynesian Migration Off

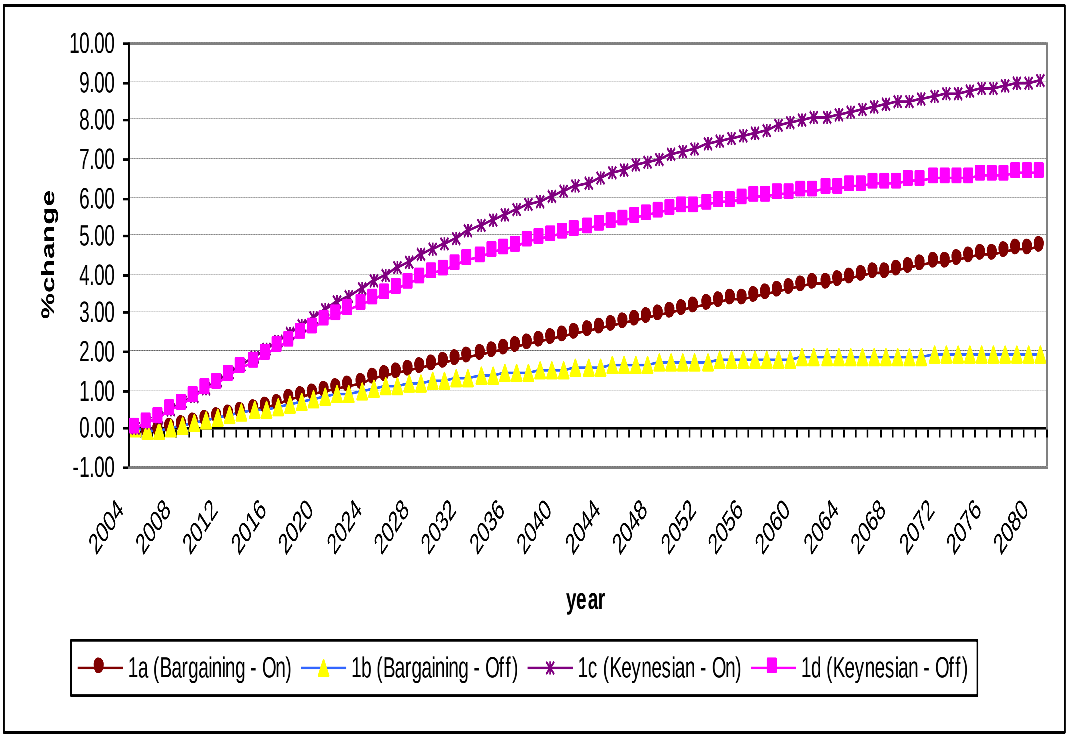


Comparisons between the scenarios described above are to follow. This can give more insights into the workings of the AMOS modeling framework. Differences generated by the various assumptions will be highlighted.

6.3.5 Comparisons of demand shock simulations

The demand shock has positive effects on GDP. Figure 6.18 demonstrates the route of GDP for each simulation. We can see that the impact is greater under the two scenarios that involve a fixed nominal wage. This is due to the fact that despite the demand shock the nominal wage does not respond and real wage falls as prices have risen due to the higher demand. Consequently, employment rises by more under this closure. Under the bargaining closure there is an increase in the real wage which crowds out higher labour demand. This can also be seen above in Figures 6.4 and 6.8.

Figure 6 18 % change in GDP under different closures



We can see here that under the Keynesian closures the real wage decreases initially while under the bargaining closure we have a slight increase of the real wage. As expected we have an inverted picture when we look at changes in employment. This is illustrated below in Figure 6.20.

Figure 6 19 % Change of Real Wage under different closures

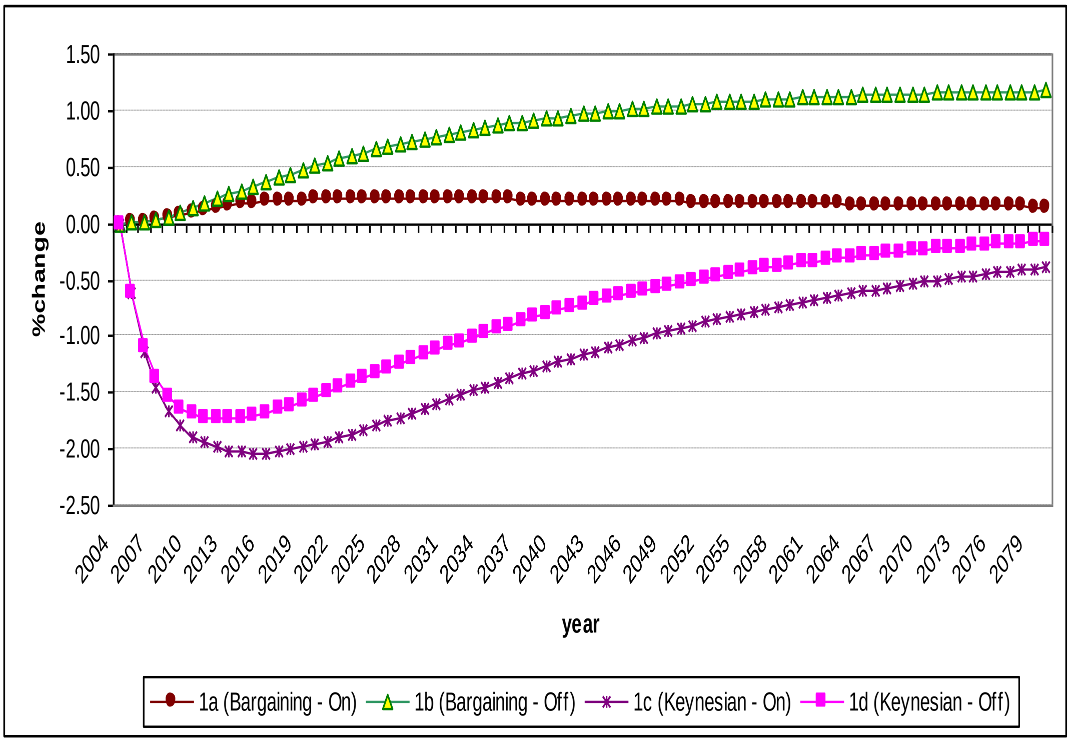
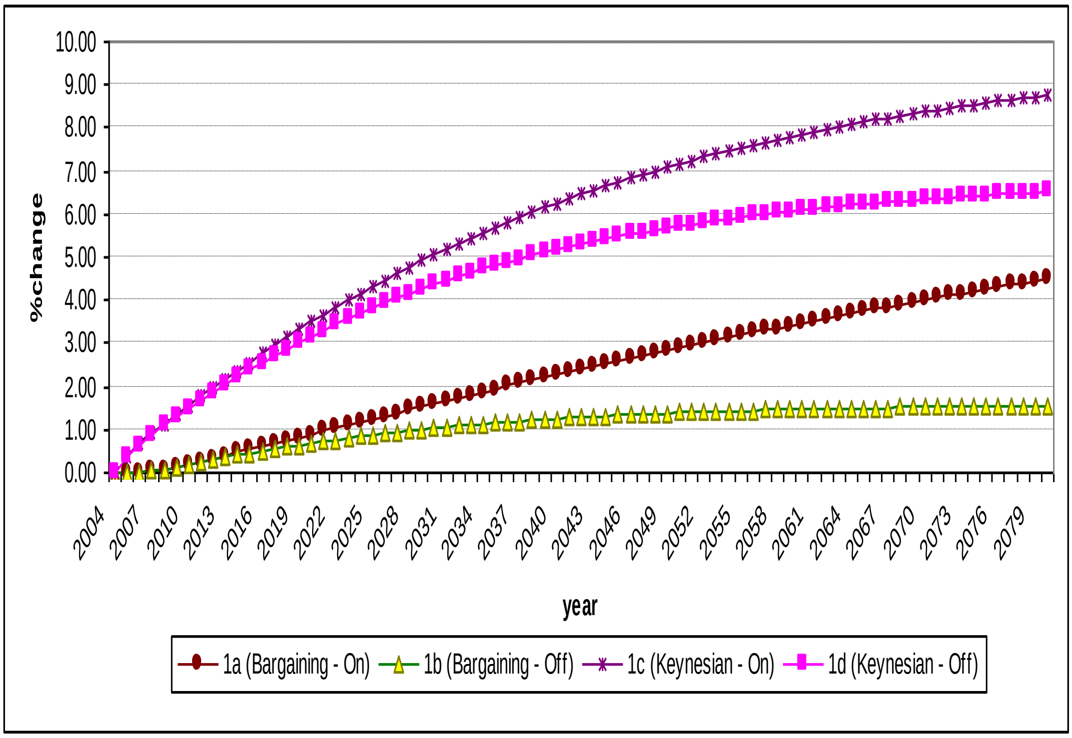
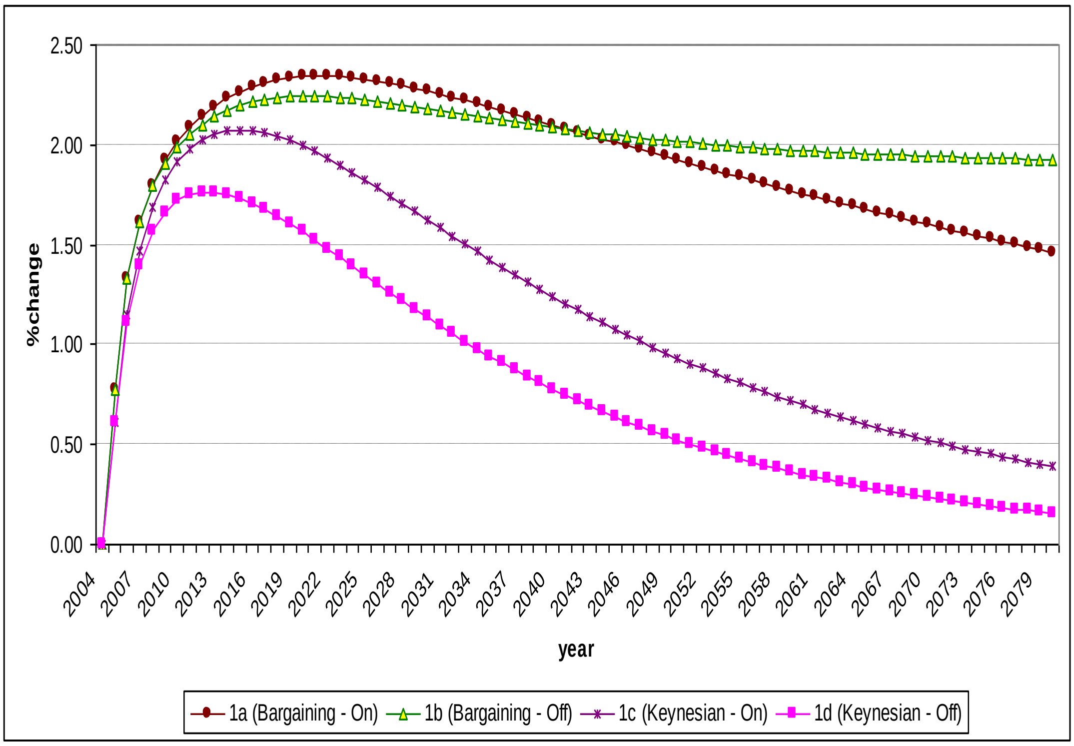


Figure 6 20 % Change of Employment under different Closures



Finally, looking at the trajectory of CPI (Figure 21) we can see that with the bargaining closure CPI increases by more than what it does with the Keynesian closure. This is because increased wages push prices further up.

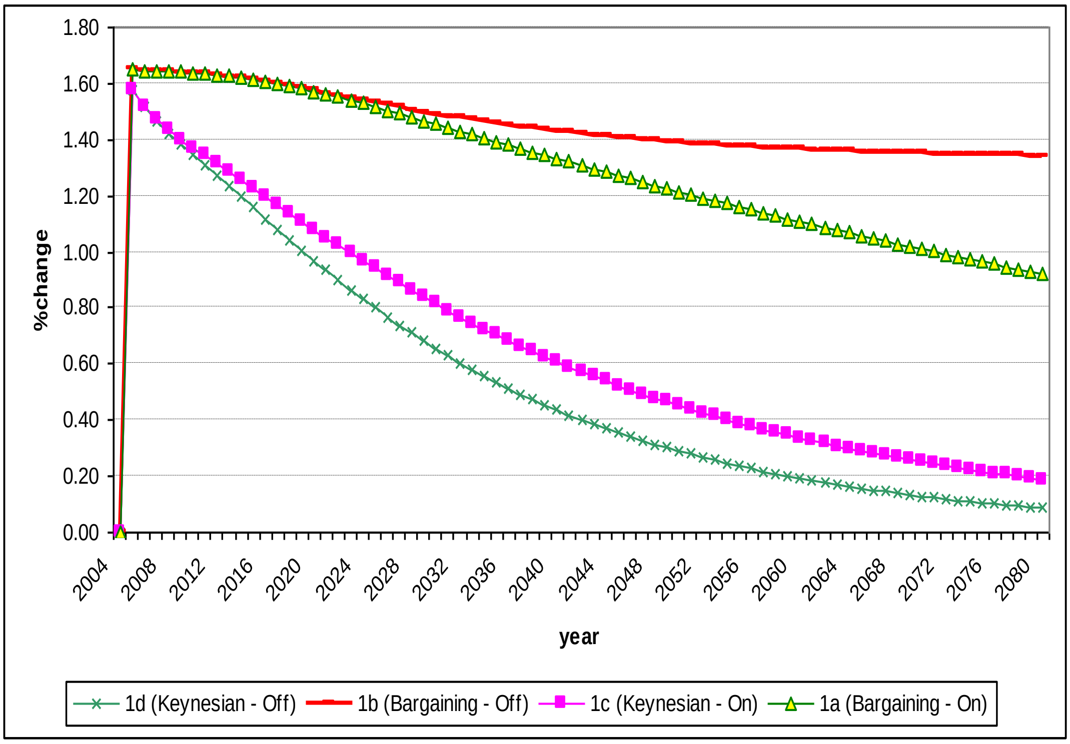
Figure 6 21 % Change of CPI under different closures



The adjustment should be largely attributed to the assumed high values of Armington elasticities. This assumption is consistent with the fact that Greece is a price taker at the international level.

Indeed if we look at Figure 22, we can see that the trajectory of the price of exported goods, i.e. a measure of competitiveness, follows a very similar pattern. When nominal wage is fixed, we have an increase of prices of the goods that are exported as the shock takes place but then they swift convergence to the price that is dictated by international markets (equilibrium price)

Figure 6 22 % Change in Prices of Exported Goods



In all above diagrams we can also notice the impact of allowing migration to be a channel of adjustment to the shocks. When migration is allowed to respond to changes in unemployment and wages, the convergence of prices to the initial level is slower. It is the case that inward migration mitigates the pressure on wages that springs up from increased labour demand. Below we present a table with the summary of results for this set of simulations.

Table 6 2 Summary of results for the demand shock

	2004	*2020*	*2030*	*2040*	*2050*	*2060*	*2070*	*2080*
1a (Bargaining - On)								
GDP	*0.00*	*0.98*	*1.74*	*2.44*	*3.09*	*3.69*	*4.24*	*4.75*
Real wage	*0.00*	*0.21*	*0.22*	*0.21*	*0.19*	*0.18*	*0.16*	*0.15*
unemployment	*0.00*	*-1.87*	*-1.93*	*-1.82*	*-1.69*	*-1.55*	*-1.42*	*-1.30*
Unemployment actual.	*9.12*	*8,95*	*8,94*	*8,95*	*8,97*	*8,98*	*8,99*	*9,00*
Total employment	*0.00*	*0.89*	*1.60*	*2.27*	*2.90*	*3.48*	*4.01*	*4.50*
Price of exports	*0.00*	*1.57*	*1.46*	*1.33*	*1.22*	*1.11*	*1.01*	*0.92*
CPI	*0.00*	*2.34*	*2.27*	*2.10*	*1.92*	*1.76*	*1.60*	*1.46*
1b (Bargaining - Off)								
GDP	*0.00*	*0.84*	*1.28*	*1.56*	*1.73*	*1.84*	*1.90*	*1.94*
Real wage	*0.00*	*0.51*	*0.77*	*0.94*	*1.05*	*1.11*	*1.15*	*1.18*
unemployment	*0.00*	*-4.38*	*-6.58*	*-7.97*	*-8.82*	*-9.34*	*-9.65*	*-9.84*
Unemployment actual.	*9.12*	*8.72*	*8.52*	*8.39*	*8.32*	*8.27*	*8.24*	*8.22*
Total employment	*0.00*	*0.69*	*1.04*	*1.26*	*1.39*	*1.47*	*1.52*	*1.55*
Price of exports	*0.00*	*1.57*	*1.49*	*1.43*	*1.39*	*1.37*	*1.35*	*1.34*
CPI	*0.00*	*2.25*	*2.18*	*2.09*	*2.02*	*1.97*	*1.94*	*1.93*
1c (Keynesian - On)								
GDP	*0.00*	*3.08*	*4.82*	*6.17*	*7.21*	*7.99*	*8.58*	*9.02*
Real wage	*0.00*	*-1.96*	*-1.60*	*-1.23*	*-0.93*	*-0.69*	*-0.52*	*-0.39*
unemployment	*0.00*	*-6.78*	*-5.60*	*-4.33*	*-3.29*	*-2.49*	*-1.87*	*-1.41*
Unemployment actual.	*9.12*	*8.50*	*8.61*	*8.73*	*8.82*	*8.89*	*8.95*	*8.99*
Total employment	*0.00*	*3.49*	*5.05*	*6.25*	*7.16*	*7.85*	*8.37*	*8.76*
Price of exports	*0.00*	*1.08*	*0.82*	*0.61*	*0.45*	*0.34*	*0.25*	*0.19*
CPI	*0.00*	*2.00*	*1.63*	*1.24*	*0.93*	*0.70*	*0.52*	*0.39*
1d (Keynesian - Off)								
GDP	*0.00*	*2.80*	*4.16*	*5.10*	*5.74*	*6.17*	*6.46*	*6.65*
Real wage	*0.00*	*-1.54*	*-1.12*	*-0.77*	*-0.52*	*-0.35*	*-0.23*	*-0.16*
unemployment	*0.00*	*-19.95*	*-27.47*	*-32.56*	*-35.99*	*-38.28*	*-39.82*	*-40.86*
Unemployment actual.	*9.12*	*7.30*	*6.61*	*6.15*	*5.84*	*5.63*	*5.49*	*5.39*
Total employment	*0.00*	*3.16*	*4.36*	*5.18*	*5.73*	*6.10*	*6.35*	*6.51*
Price of exports	*0.00*	*0.97*	*0.66*	*0.44*	*0.29*	*0.19*	*0.13*	*0.09*
CPI	*0.00*	*1.57*	*1.14*	*0.78*	*0.52*	*0.35*	*0.24*	*0.16*

6.4 Results – Supply Shock

6.4.1 Supply Shock under the Bargaining closure of the labour market and flow migration (2a)

This section analyses the impacts of a positive supply shock which will be examined under the same set of labour market closures as used for the demand shock of the previous section. In all simulations the impact of a 10% increase in labour efficiency is identified for the sectors, "Agriculture" and "Other Manufacturing". Different closures are expected to generate different paths to new long run equilibria and it is these paths that are examined here. This kind of shock simulates a fall in the cost of labour per unit of output, i.e. an increase in productivity which is compatible with an targeted influx of skilled workers that increases labour productivity in those particular sectors.

The first of this set of simulations is one with the labour market closure set to the bargaining option and migration is on. A positive Harrod Neutral- Labour Augmenting efficiency shock increases output per unit of labour which pushes downwards wages per efficiency unit of labour. Efficiency units are defined as "output per worker per hour." It is a measure of the amount produced for a constant production technology by a worker in some time period. As labour efficiency increases, output per worker in the unit of time increases and less labour is required to produce the same amount of output. Hence prices of value added and commodity outputs fall in the sectors that undergo the shock. The impact in terms of GDP does not reach a maximum and it keeps increasing at a steady pace. Employment initially falls below the equilibrium level by 0.22% and then it starts increasing steadily. The reactions of the economy are illustrated in figure 6.23. The steady increase should be attributed to continuous in migration as we shall see later. The initial decrease of employment stems from the fact that labour becomes cheaper for the sectors that face the positive supply shock so they lay workers off. However, lower production costs improve competitiveness and export demand. Demand for labour starts increasing again and migrants are attracting in by increased real wage. Unemployment starts decreasing falls below zero and remains in the negative for the whole of the simulation period constantly attracting migrants. Essentially, a factor of production (labour) has been made cheaper and at the same time abundant. In migration will continue up to the point that unemployment rate reaches the initial equilibrium. No tightening of the labour market occurs as extra labour demand can be covered by extra migration.

Figure 6 23 GDP and Employment % changes after a supply shock, Bargaining Migration On

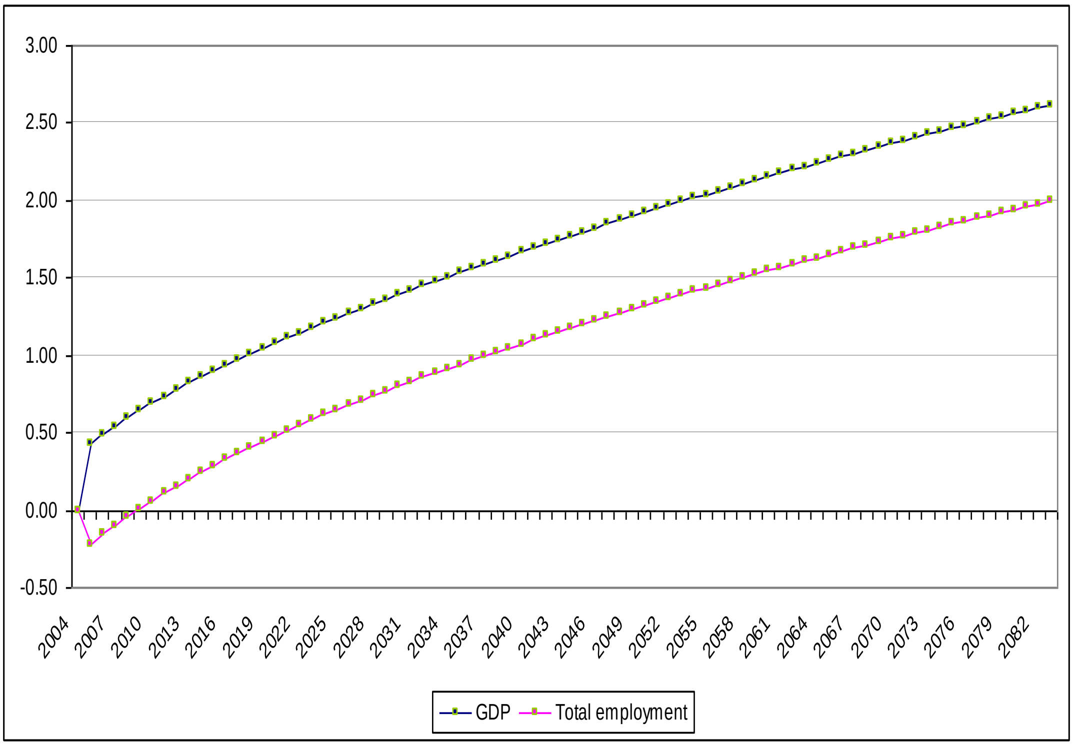


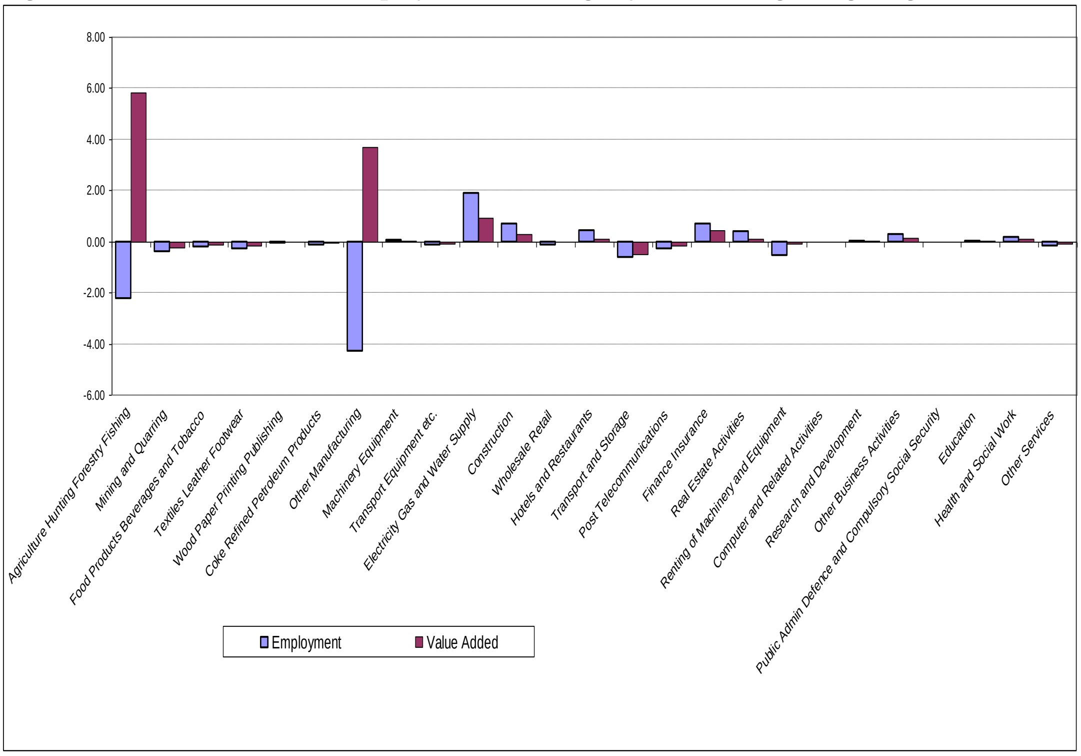
Table 6 3 Comparison between impacts on agriculture and other manufacturing

	Output	FTEs per million of output	Export/ Total Output	Value added %change	Price % change
Agriculture	13,146.9	30.7	16.2%	15.8%	-7.1%
Manufacturing	12,501.4	5.4	21.4%	8.2%	-6.4%

The table above shows that that although the two sectors are comparable in size, the sectors that is more labour intensive (Agriculture) benefits more by the positive efficiency shock. Also, the higher the export propensity the smaller the impact upon prices.

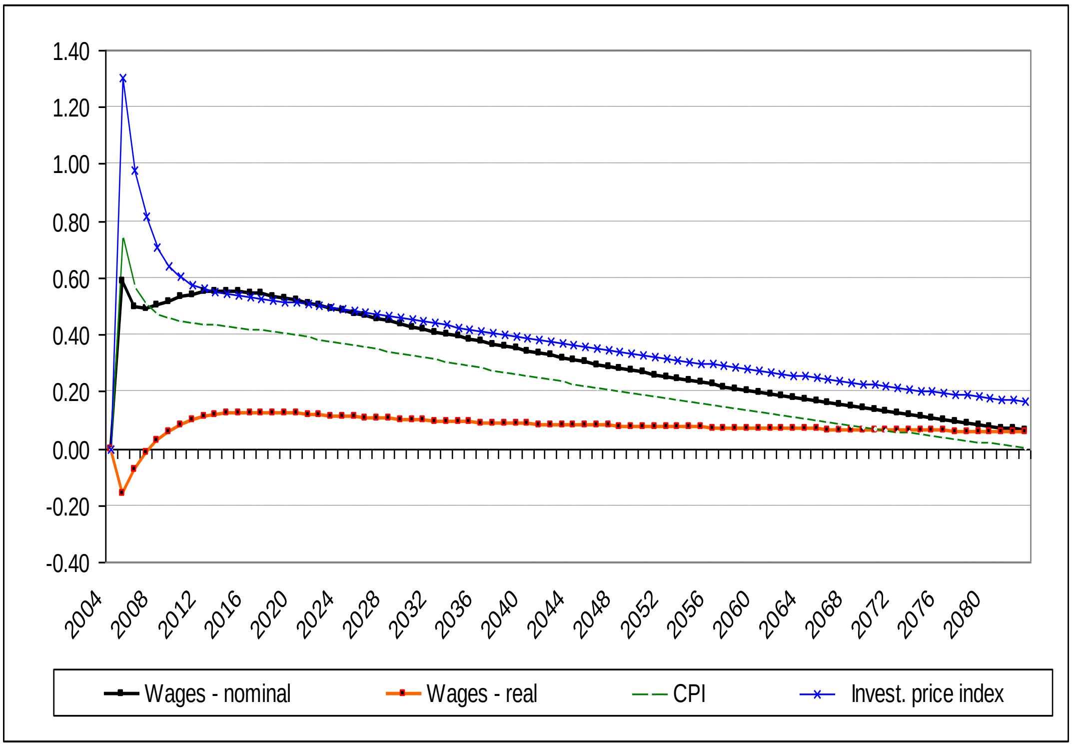
In Figure 6.24 shows the impact on sectoral Employment and Value added immediately after the shock. Employment is reduced significantly in the sectors that undergo the shock. Remember, both of the sectors I have decided to shock are big employers. Although they reduce employment value added increases as labour has become more efficient. The shocked sectors are obviously driving the positive GDP shock exemplified above.

Figure 6 24 Value Added and Employment % change by sector, Bargaining, Migration On



On the price front we see Nominal wages and CPI jump up and then start converging back to their initial values. Nominal wages increase by more than what CPI increases and thus real wage falls. Figure 6.25 shows real and nominal wage as well as CPI and Investment Price Index. A major influence on the CPI is the investment price index. In the diagram below one can see that they follow a quite similar pattern.

Figure 6 25 CPI, real and Nominal Wage and Investment Price Index Bargaining, Migration On

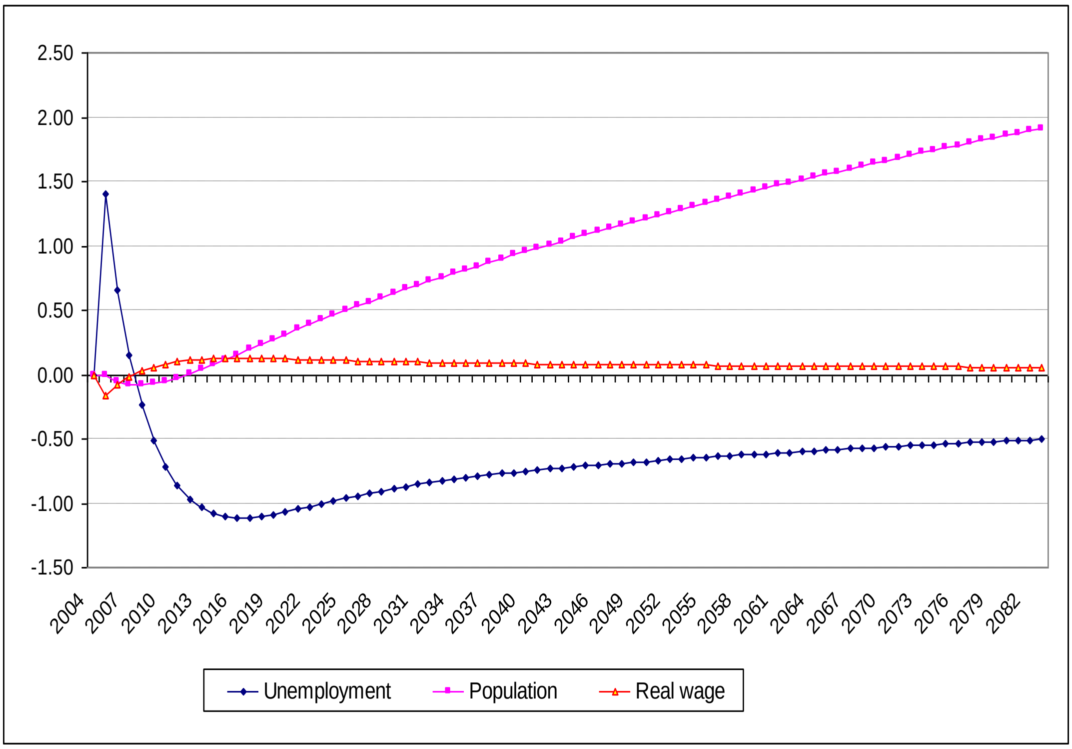


Capital rental rates increase in the sectors that undergone the shock. In these sectors while labour efficiency has increased by 10 % employment falls only by 2.21% in agriculture and 4.26% in "other manufacturing". Gillmartin et.al. (2007) using a two region version of AMOS (AMOSRUK) report CPI falling below zero during a similar efficiency shock. The authors impose an efficiency shock into one of the three identified sectors of the economy. Therefore the weight of output that becomes cheaper is much higher than that is in this case. However, in both cases the price fall of the shocked sectors feeds in –although slowly- the rest of the economy through cheaper intermediate purchases. In this case although prices decrease gradually they don't fall below zero.

Note that I have assumed high substitutability of local and foreign goods as Greece is considered to be a price taker (Sarris & Zografakis, 1999). Output in the sectors that are subject to the shock becomes cheaper as I have mentioned earlier. Falling prices in conjunction with high international substitutability, result in significantly lower imports and significantly higher exports and higher of course output. Increased investment demand pushes capital rental rates up as capital is fixed within period. Capital rental rates are influencing CPI as it is apparent in the above figure.

The effect of choosing to allow for migration is obvious in the following figure. We see that population keeps increasing for the whole of the simulation period as unemployment remains below equilibrium.

Figure 6 26 Population, Real Wage and Unemployment Bargaining, Migration On



It is evident that real wage adjusts back to the equilibrium value and unemployment is lower than the base value for the whole of the simulation period. Hence the continuous population increases due to immigration.

6.4.2 Supply Shock under the Bargaining closure of the labour market and zero migration (2b)

I now examine the same supply shock with the labour market closure being set to the Bargaining option but migration being restricted to zero. This way I effectively close one channel of adjustment of the labour market.

The impact in terms of GDP is stabilised roughly after 70 periods at 1.3% above base. It does not keep increasing steadily as in the previous section. Employment initially moves to the negative for the same reasons that have been mentioned above. It is stabilised again after 70 periods at roughly 0.65%.

Figure 6 27 GDP and Employment % changes after an efficiency shock, Bargaining Migration Off

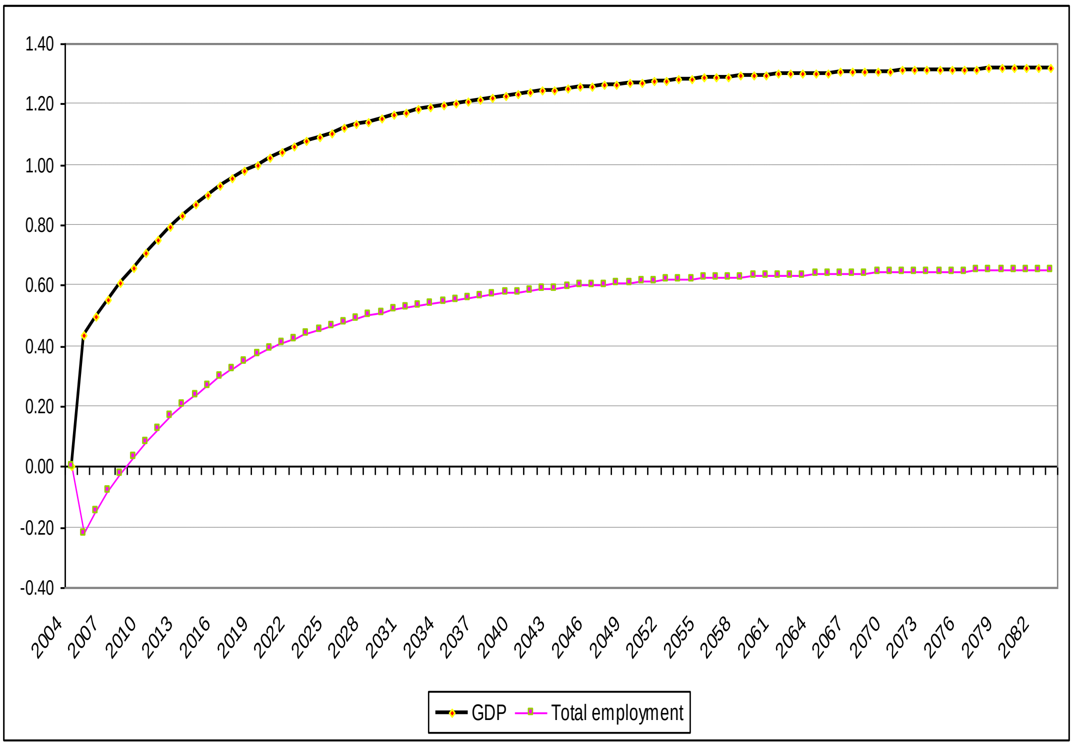
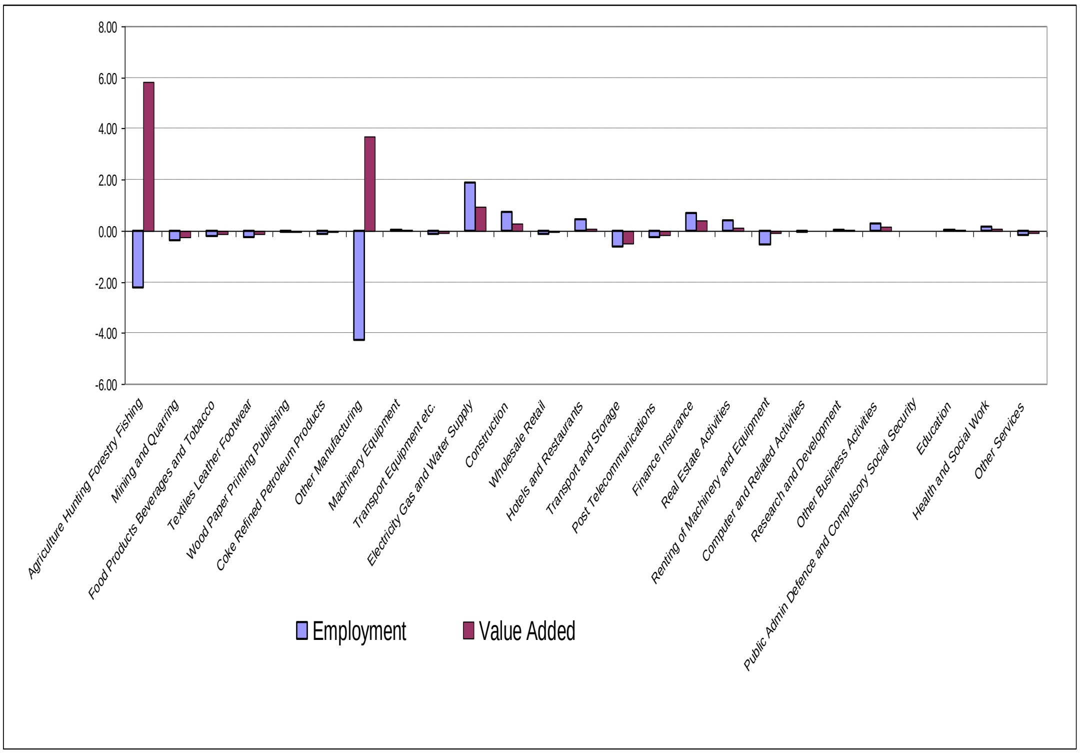


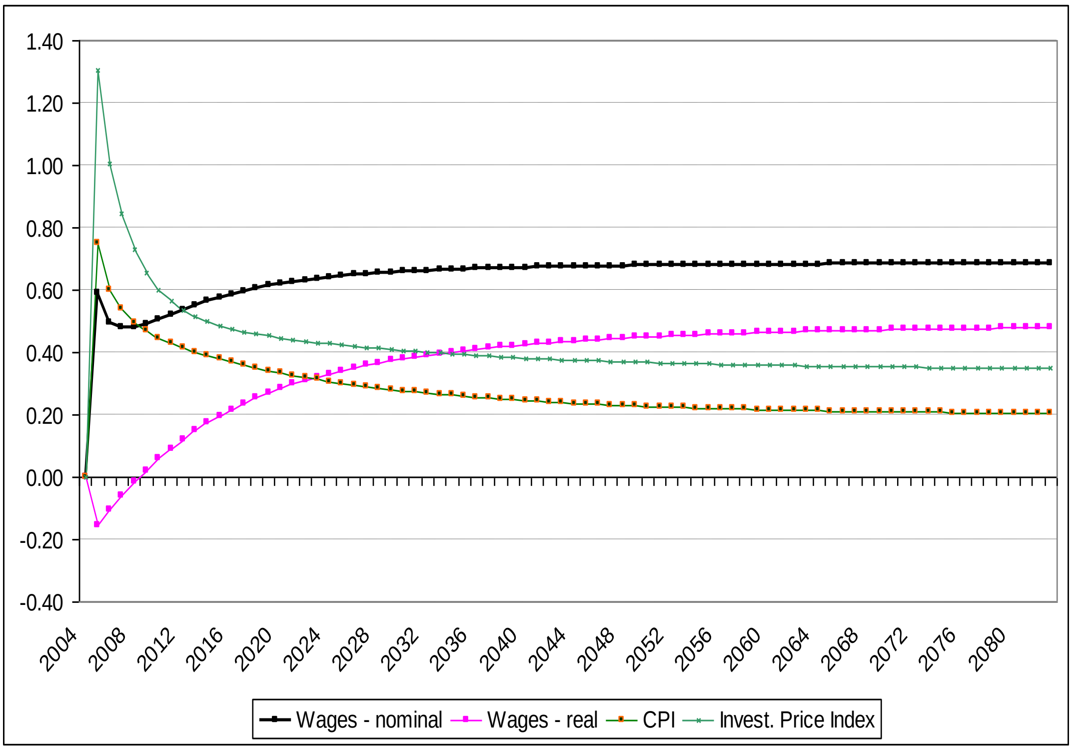
Figure 6.28 tells a very analogous story to the one above with the shocked sectors increasing their value added and at the same time reducing employment one period after the shock.

Figure 6 28 Value Added and Employment % change by sector - Bargaining Migration Off



The picture of prices is also comparable to the previous one. Increased prices are attributable to increased capital rental rates. Prices start falling gradually thereafter. The thing to observe is the difference in the behaviour of real wage that does not converge back to zero but instead it is stabilised at 0.48% above equilibrium. This is due to the fact that migration has not been allowed for and therefore increased labour demand keeps pushing wages up. Increased wages are at the root of a converging and not continuously expanding GDP, as it happened above in simulation Bargaining- Migration On (2a).

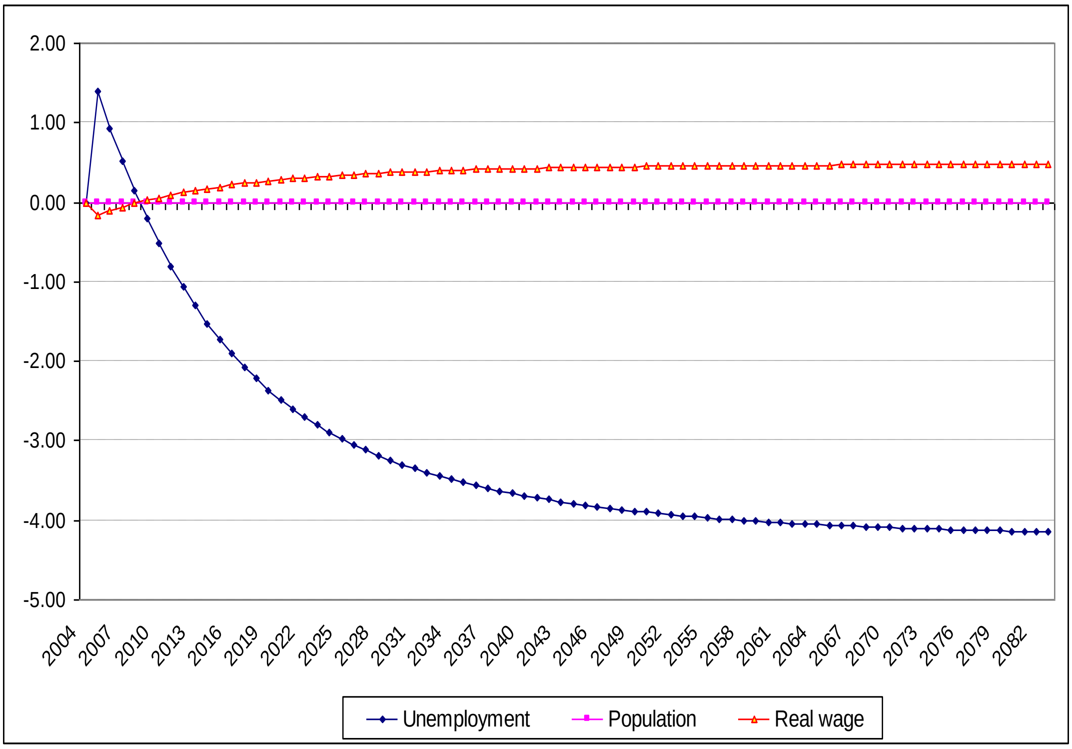
Figure 6 29 CPI, real and nominal wage, Bargaining, Migration Off



Now, the efficiency shock does not change the population as migration is set to zero. The supply shock results in lower unemployment and higher wages, but there is no inflow of migrants to ease the tightening of labour market.

Figure 30 mirrors the course of unemployment, real wage and population. Population is unchanging in this case.

Figure 6 30 Population, Real Wage and Unemployment Bargaining Migration Off



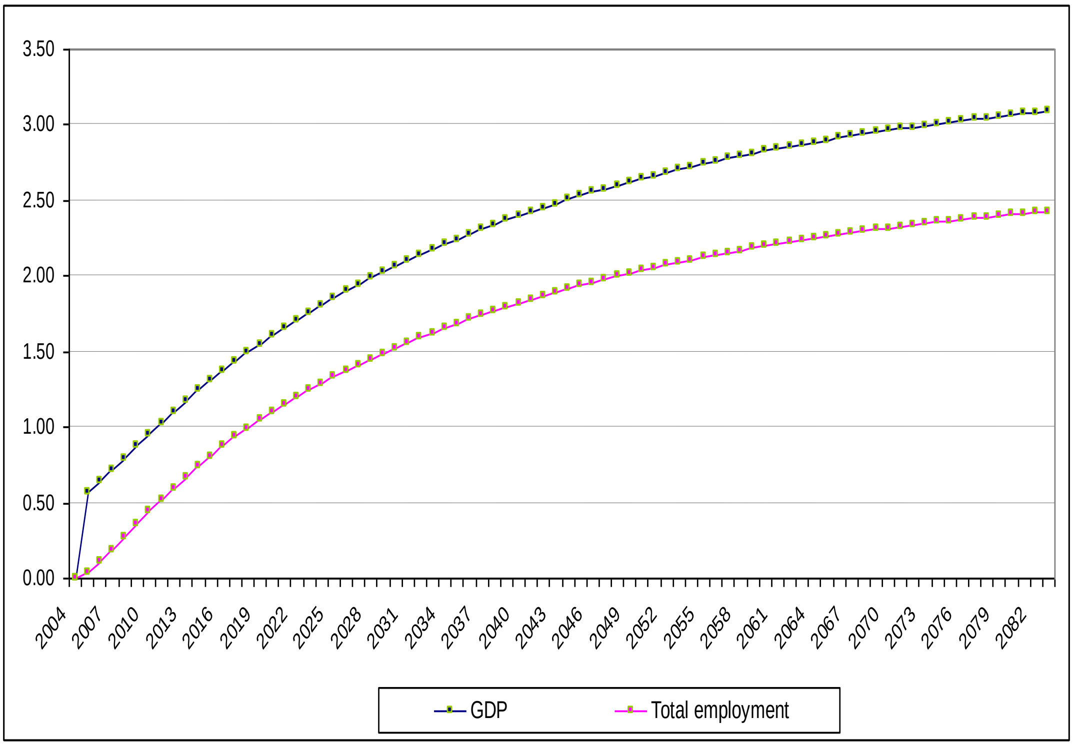
6.4.3 Supply Shock under the Keynesian closure of the labour market and flow migration (2c)

Now, the impacts of the same shock when the labour market closure is set to the Keynesian option i.e. with a fixed nominal wage and migration is on is examined.

GDP and Employment increase for the whole of the simulation period but with an ever decreasing rate.

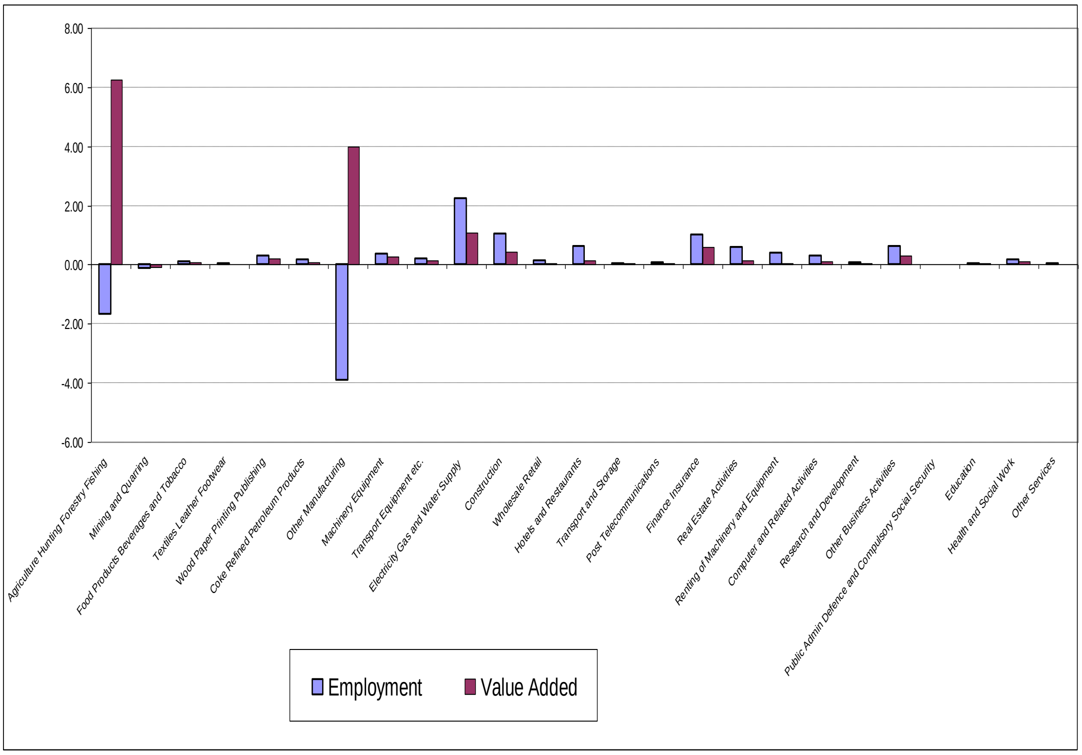
In Figure 6.31 I show the course of GDP and Employment after the initial shock. In this case GDP moves up instantly after the shock. The explanation is that nominal wage is fixed and therefore increased efficiency increases employment. Nominal wage does not respond and does not crowd out demand for labour.

Figure 6 31 GDP and Employment % changes after a supply shock, Keynesian Migration On



The following histogram of Value Added and Employment percentage changes by sector one period after the shock. Sectors that are shocked have an increased value added while most of other sectors have decreased value added.

Figure 6 32 Value Added and Employment % change by sector, Keynesian, Migration On

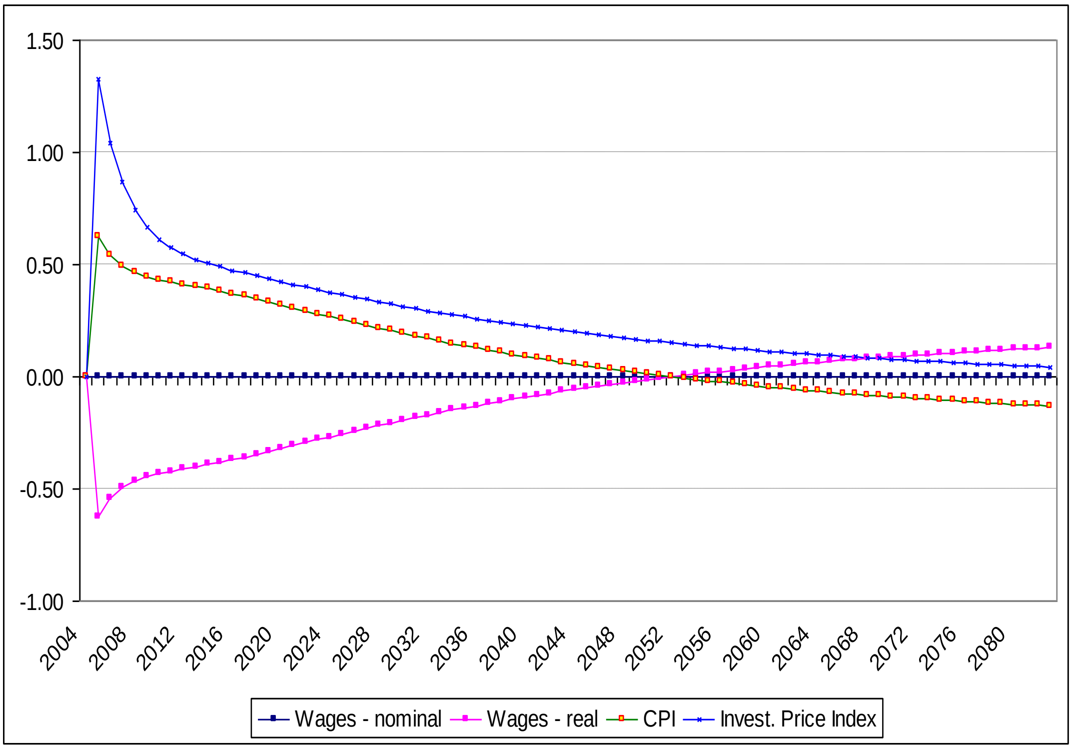


Looking at sectoral changes in Employment right after the shock (Figure 6.33) it is obvious (as in the case of demand shock) that sectors that are negatively affected are worse under bargaining and the ones that are positively affected are better off under the Keynesian closure.

Figure 6 33 % changes in Employment one period after the shock (Bargaining VS Keynesian)

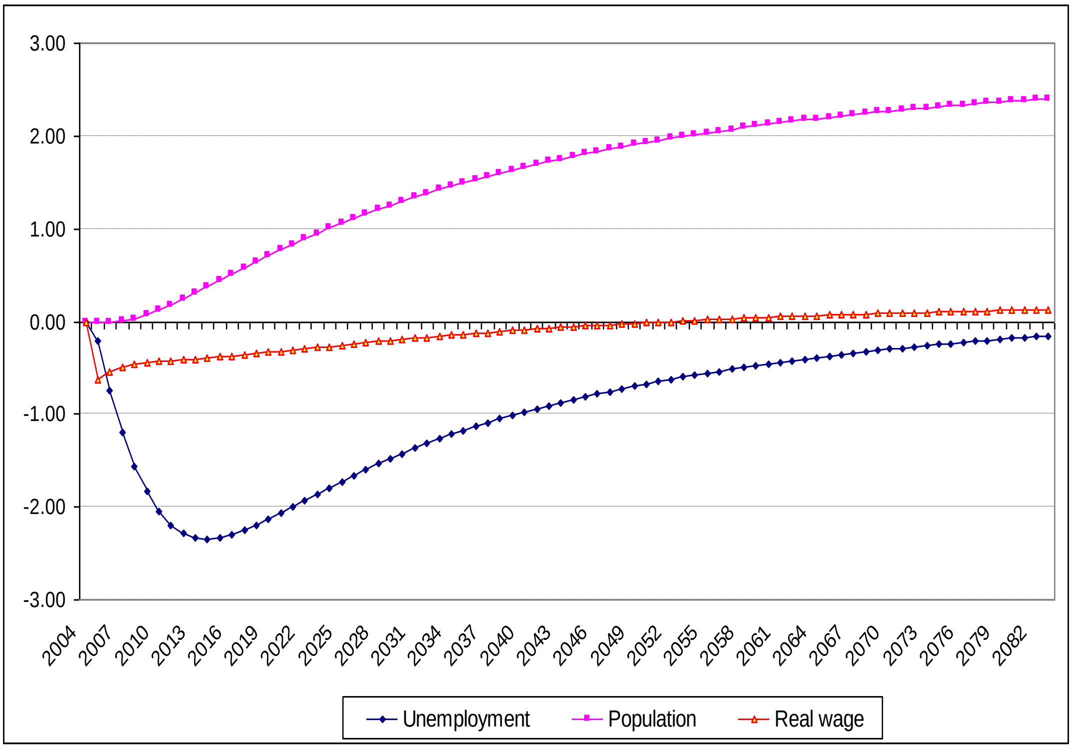
CPI is again the mirror image of real wage as in the simulation with the demand shock and the same set of closures. Prices behave as anticipated in the sense that nominal wage changes are zero as we have assumed, and CPI is the mirror image of the real wage. This should be such by definition. CPI falls below zero after 50 periods.

Figure 6 34 CPI, real and nominal wage Keynesian, Migration On



In the figure below one can see both the root and the consequence of immigration. That is real wage falls but unemployment falls by more so overall labour market conditions attract migrants. Towards the end of the simulation period both real wage and unemployment have almost returned to initial values and therefore population exhibits a concave trajectory which is almost flattened towards the end.

Figure 6 35 Population, Real Wage and Unemployment Bargaining, Migration On

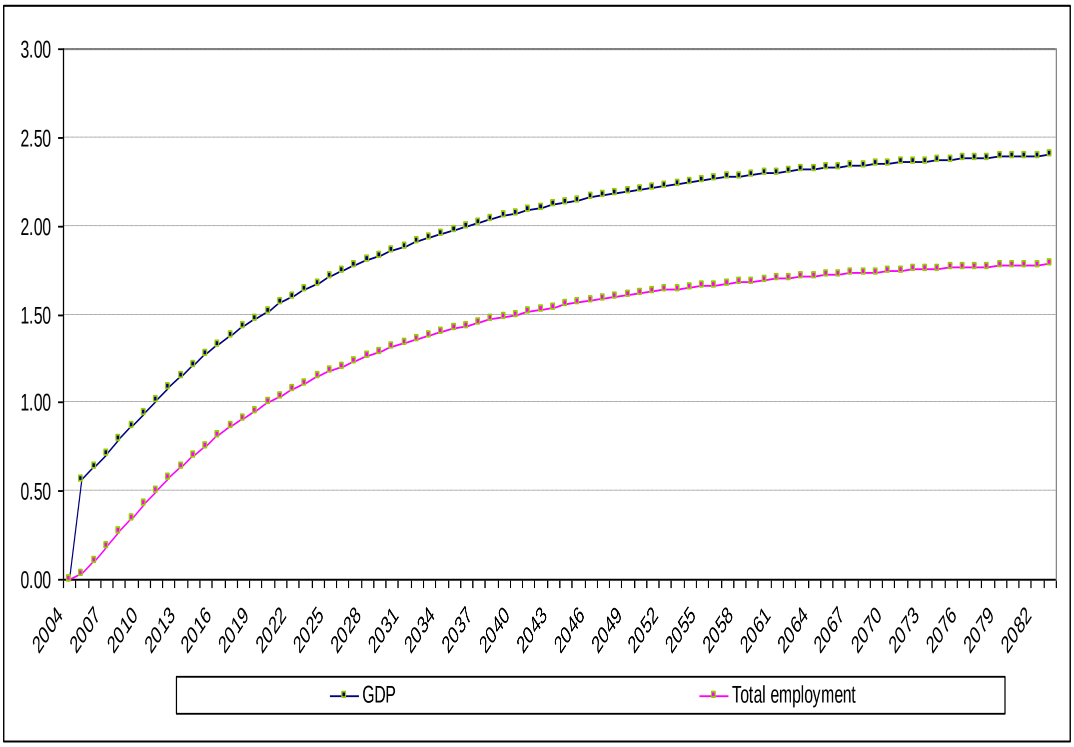


6.4.4 Supply Shock under the Keynesian closure of the labour market and zero migration (1d)

Finally, the impacts of this supply shock when the labour market closure is set to Keynesian and migration is switched off are examined.

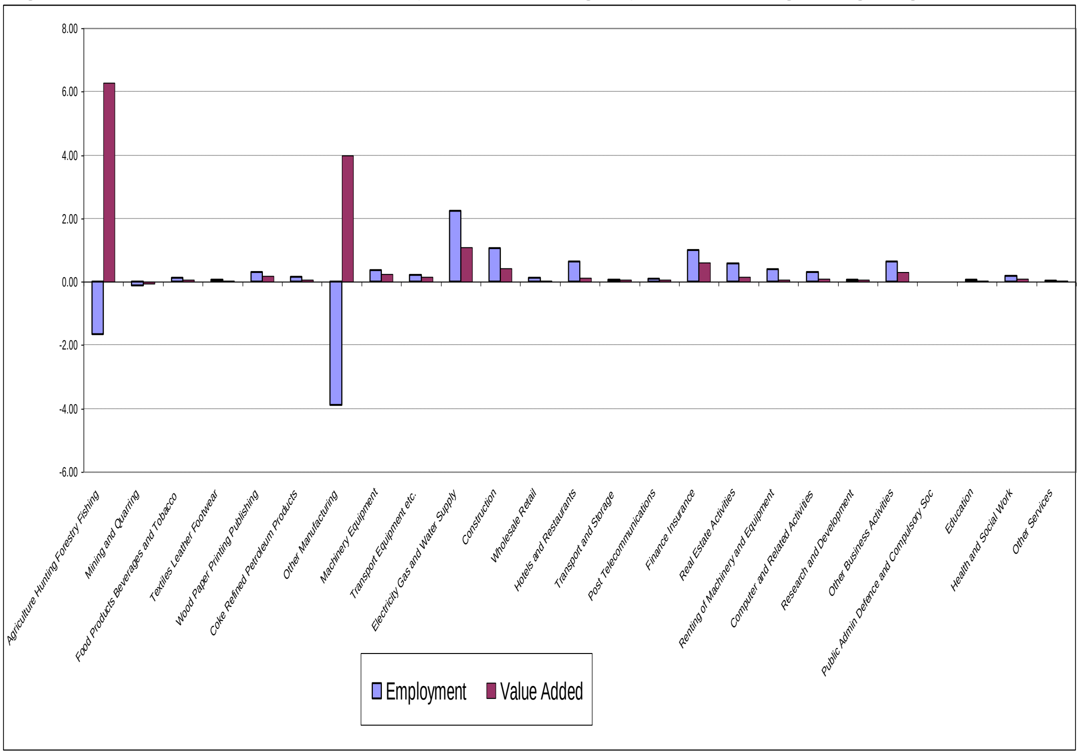
Again GDP and employment increase for the whole of the simulation period. However GDP is stabilised at 2.40% above zero. Employment follows a similar pattern and is stabilised at 1.78%. The level of the impact is less than the previous case because the channel of migration is closed and the labour market tightens relatively more.

Figure 6 36 GDP and Employment % changes after a demand shock, Bargaining Migration Off



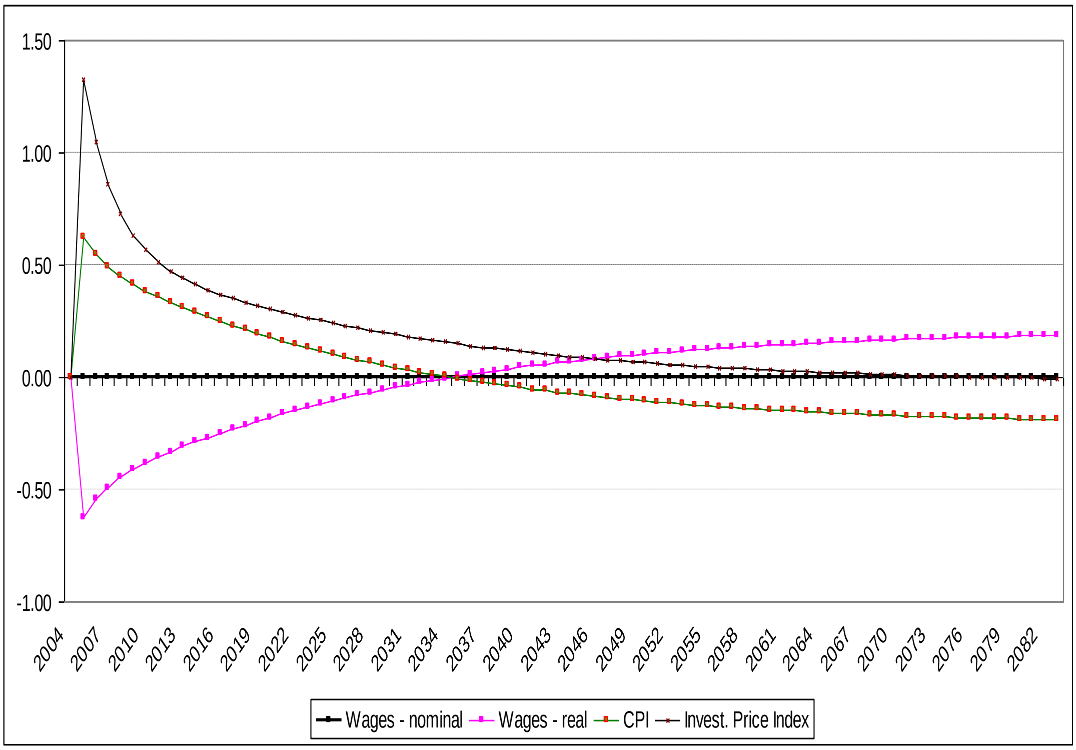
In the histogram below the immediate impact of the shock in individual sectors is shown. Figure 37 below illustrates the impact on individual sectors one period after the shock. Again the sectoral reduction in employment is countered by increased employment in other sectors. The impacts are identical with the ones presented in figure 6.32 as there is no migration in period 1.

Figure 6 37 Value Added and Employment % change by sector - Bargaining Migration Off



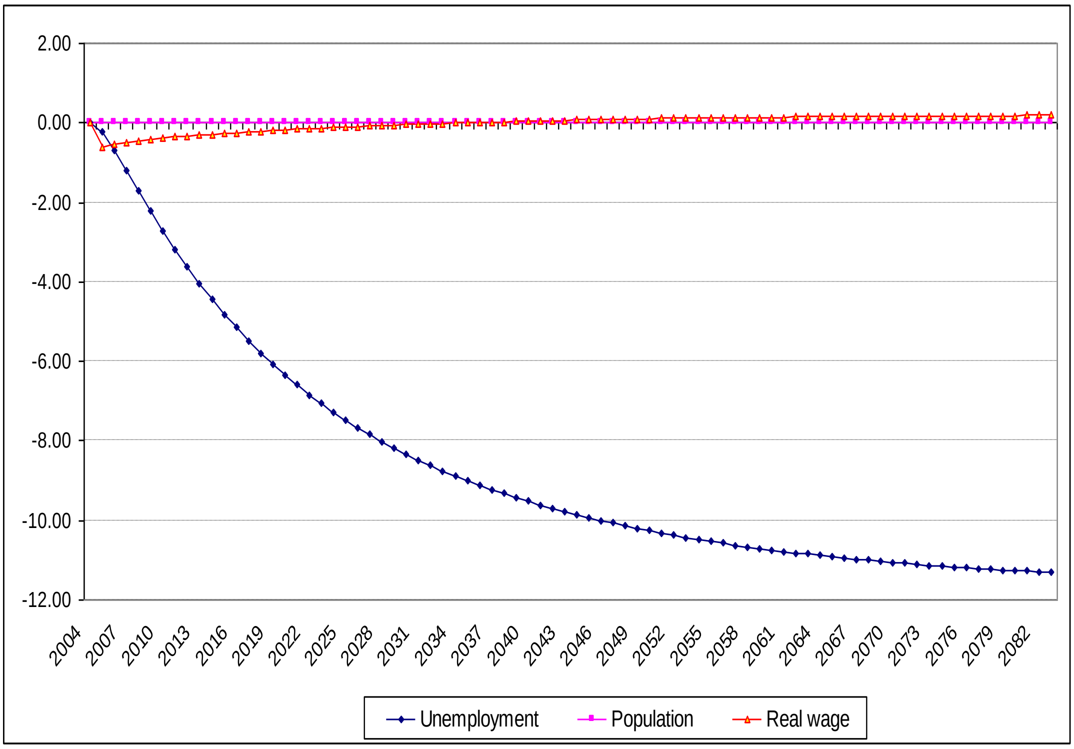
The behaviour of prices is exactly like the one above, with the inverse relation of real wage and CPI being noticeable and a convergence to equilibrium after 30 periods. CPI falls below zero thereafter.

Figure 6 38 CPI, real and nominal wage investment price index, Keynesian, Migration Off



The shock does not alter the population as migration is “switched off”. In the next figure one can see that unemployment keeps falling while population is constant and real wage follows the route which is already discussed above.

Figure 6 39 Population, Real Wage and Unemployment Keynesian Migration Off

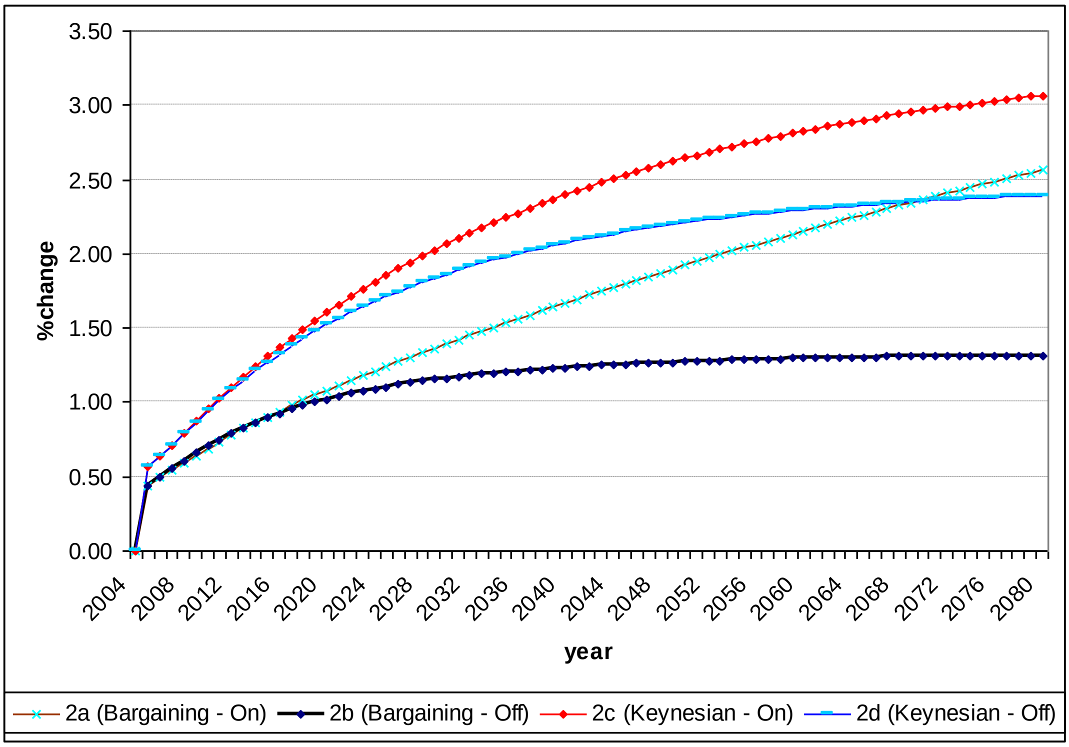


In the next section the results of the different scenarios that are related with the supply shock are compared and their differences are explained and attributed to the different assumption made in each case.

6.4.5 Comparisons of supply shock simulations

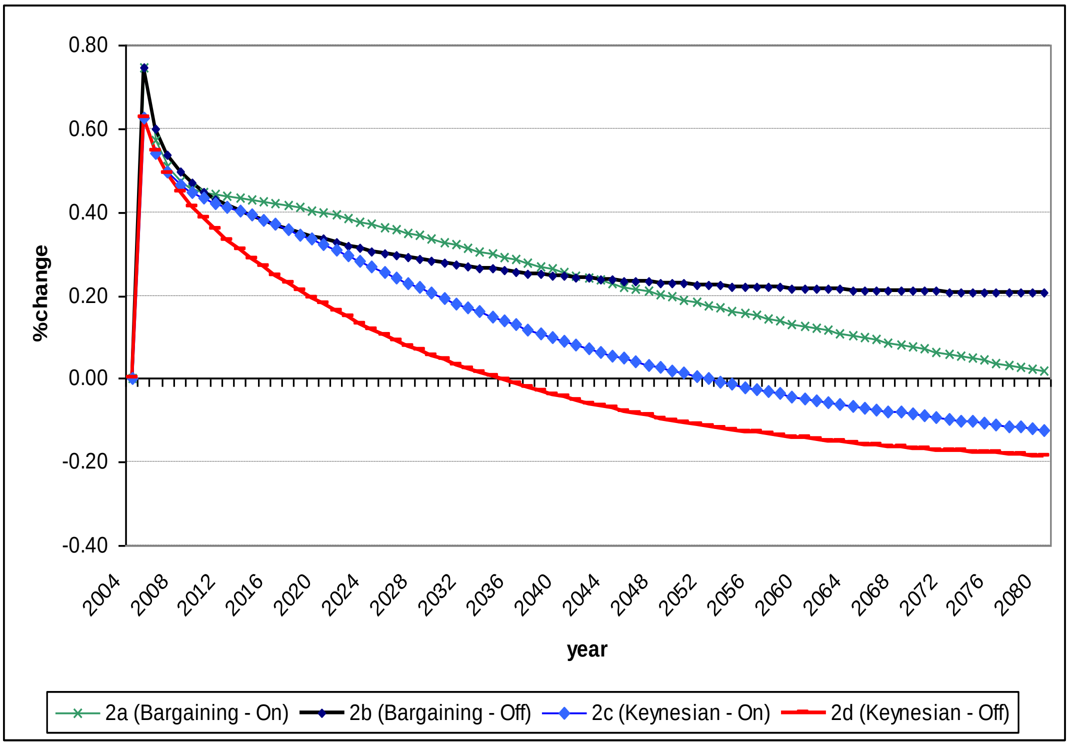
The supply shock has positive effects on GDP under all closures. GDP increases relatively by more when the nominal wage is fixed and migration is switched on. This is because increased labour demand does not push real wage up and at the same time in-migration allows GDP to keep increasing. On the other extreme we have the case of the bargaining closure with migration being switched off. Now, increased labour demand is gradually cancelled from increased real wage. The other two scenarios lie in between the two extremes with their rank changing towards the end of the simulation period.

Figure 6 40 % change in GDP under different closures



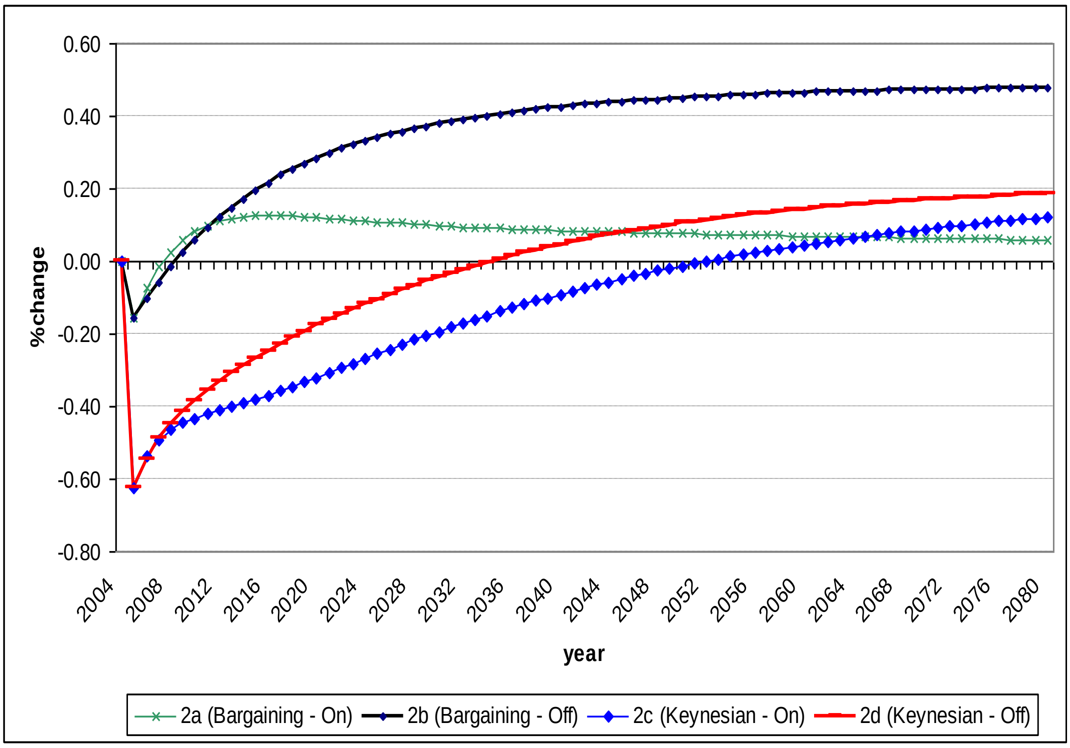
Prices jump up initially, as it has already been shown due to the fact that the relatively small weight of the shocked sectors that become cheaper after the efficiency increase. While output and value added have become cheaper in the sectors that undergo the shock, it takes time for this effect to feed into the rest of the economy through cheaper intermediate inputs. This is why prices start decreasing thereafter. Gillmartin et. al. (2007) report an immediate fall in prices as they input a similar efficiency shock. The difference with the simulations at hand is that I have shocked sectors whose relative output is small in relation to the size of the sectors that is shocked in Gilmartin et. Al (2007).

Figure 6 41 % Change of CPI under different closures



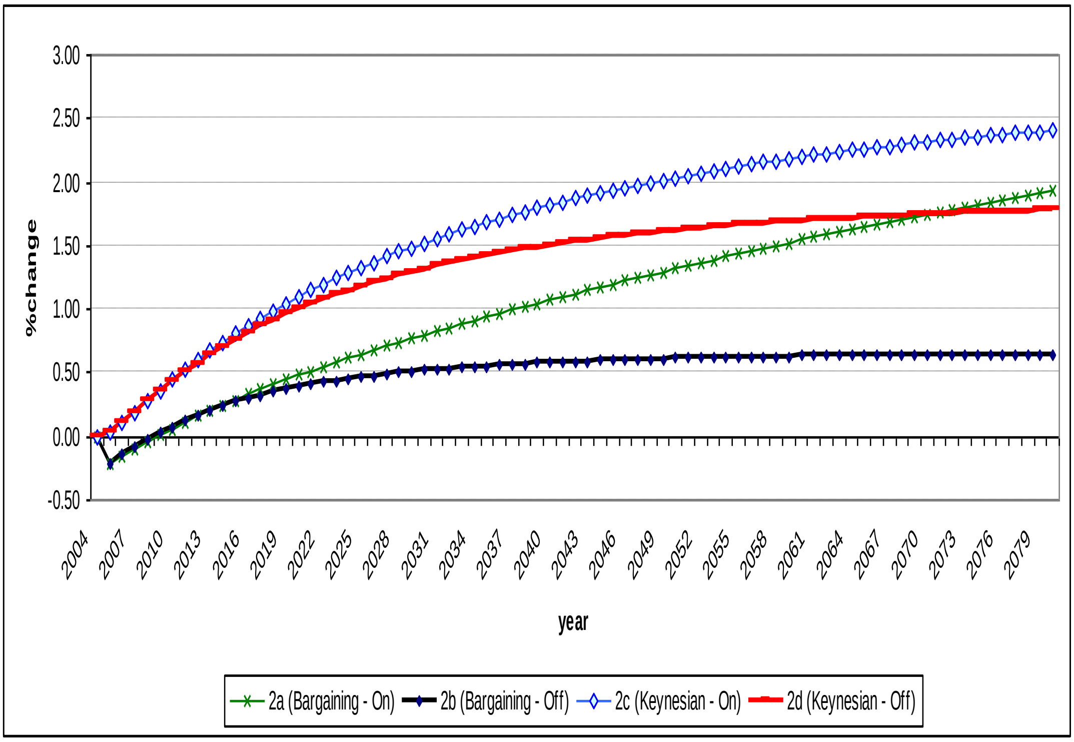
The pace of adjustment however differs between different scenarios. When nominal wage is set to be fixed the adjustment process is faster and prices move below equilibrium during the simulation period. The explanation is that with a fixed nominal wage, real wage is not pushed up by as much as it is under bargaining and therefore the effect of cheaper intermediate inputs is fed in more quickly into the rest of the economy. Indeed the trajectories of real wages under the different closures demonstrate that. In fact, real wages are actually below the base level for more than 30 periods (with migration off) and for almost 50 periods for migration on in the Keynesian simulations.

Figure 6 42 % Change of Real Wage under different closures



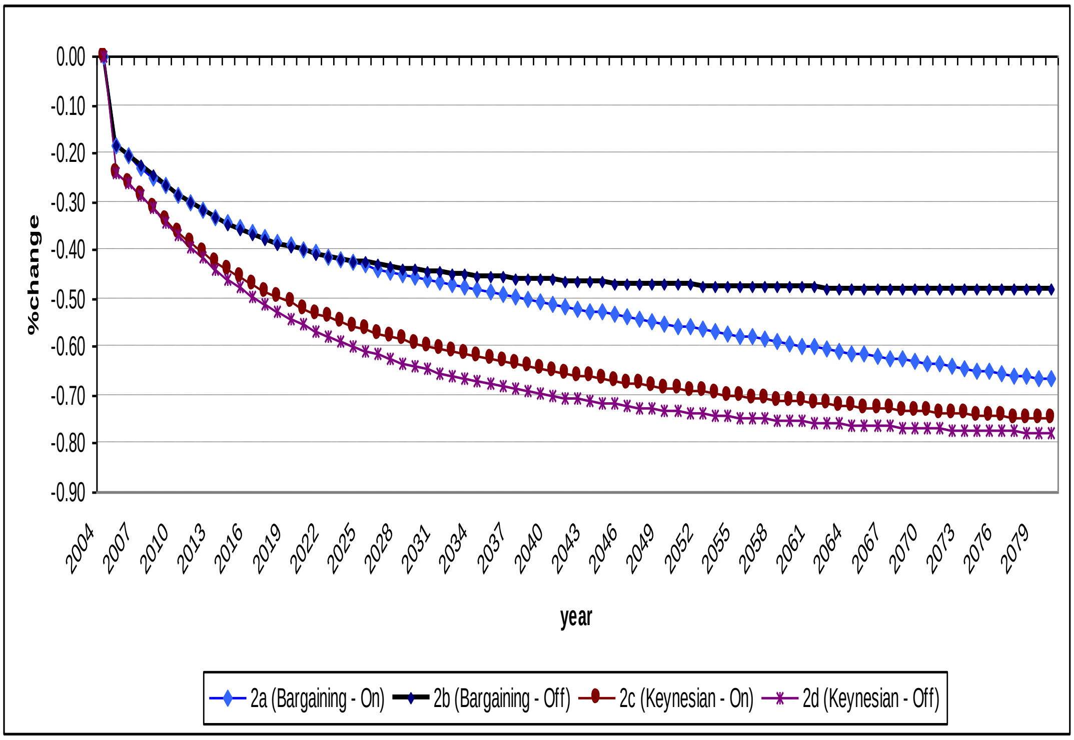
Employment paths tell a story which is to a large extent an inversion of the previous one as expected.

Figure 6 43 % Change of Employment under different Closures



Finally, it is useful to note that exports increase while the price of exported goods falls. This is something that comes into effect immediately but as high Armington elasticities have been imposed the scale of the impact is relatively small. This is apparent in Figure 6.44. At each point in time the index has been calculated as the weighted average price of the composite exported good.

Figure 6 44 % Change in prices of exported goods



A comprehensive table with the basic macroeconomic indicators for all simulations follows.

Table 6 4 Summary of results for the supply shock

	2004	*2020*	*2030*	*2040*	*2050*	*2060*	*2070*	*2080*
2a (Bargaining - On)								
GDP	0.00	2.25	2.95	3.59	4.16	4.70	5.19	5.64
Real wage	0.00	0.27	0.23	0.19	0.17	0.16	0.14	0.13
unemployment	0.00	-2.38	-1.97	-1.69	-1.52	-1.38	-1.27	-1.17
Unemployment actual.	9.12	8.90	8.94	8.97	8.98	8.99	9.00	9.01
Total employment	0.00	1.09	1.83	2.46	3.02	3.54	4.01	4.45
Competitiveness	0.00	-0.18	-0.24	-0.32	-0.41	-0.49	-0.57	-0.64
CPI	0.00	1.01	0.90	0.76	0.62	0.48	0.36	0.25
2b (Bargaining - Off)								
Gross Domestic Product	0.00	2.10	2.41	2.56	2.63	2.67	2.70	2.71
Real wage	0.00	0.65	0.87	0.98	1.03	1.05	1.07	1.08
unemployment	0.00	-5.56	-7.40	-8.22	-8.63	-8.85	-8.97	-9.04
Unemployment actual.	9.12	8.61	8.45	8.37	8.33	8.31	8.30	8.30
Total employment	0.00	0.88	1.17	1.30	1.36	1.40	1.41	1.43
Competitiveness	0.00	-0.19	-0.22	-0.24	-0.25	-0.26	-0.26	-0.27
CPI	0.00	0.87	0.78	0.73	0.69	0.68	0.67	0.66
2c (Keynesian - On)								
GDP	0.00	3.52	4.69	5.56	6.21	6.69	7.06	7.33
Real wage	0.00	-0.86	-0.60	-0.36	-0.17	-0.03	0.08	0.16
unemployment	0.00	-5.00	-3.63	-2.58	-1.83	-1.28	-0.88	-0.58
Unemployment actual.	9.12	8.66	8.79	8.88	8.95	9.00	9.04	9.07
Total employment	0.00	2.60	3.71	4.49	5.07	5.50	5.82	6.06
Competitiveness	0.00	-0.42	-0.53	-0.64	-0.73	-0.80	-0.85	-0.89
CPI	0.00	0.87	0.61	0.37	0.17	0.03	-0.08	-0.16
2d (Keynesian - Off)								
GDP	0.00	3.32	4.21	4.77	5.15	5.39	5.55	5.66
Real wage	0.00	-0.52	-0.24	-0.03	0.12	0.21	0.28	0.32
unemployment	0.00	-15.01	-20.30	-23.54	-25.60	-26.93	-27.80	-28.38
Unemployment actual.	9.12	7.75	7.27	6.97	6.79	6.66	6.58	6.53
Total employment	0.00	2.37	3.21	3.73	4.06	4.27	4.41	4.50
Competitiveness	0.00	-0.51	-0.66	-0.77	-0.85	-0.90	-0.94	-0.96
CPI	0.00	0.53	0.24	0.03	-0.12	-0.21	-0.28	-0.32

6.5 Conclusion

This chapter examined the impacts of demand and supply shocks to the Greek economy under different closures for the labour market and assumptions on the existence of migration.

The demand shock has a positive impact on the Greek economy under all scenarios. The impact is greater when migration is allowed to ease the consequent tightening of the labour market. However, under all scenarios, GDP starts converging to a new equilibrium with a different pace of course for each scenario. The other thing to notice is that prices converge back to equilibrium faster when the nominal wage is fixed.

Under all configurations the supply shock has a positive impact on the Greek economy. Adjustment takes place after a long time and under particular assumptions it has not taken place after the 80-period simulation horizon. A thing to note is that the ordering of the magnitude changes over time for different set of assumptions. In addition, the time that it takes the economy to reach the new long run equilibrium differs significantly.

Furthermore, employment does not move below equilibrium immediately after the shock when the nominal wage is fixed. In contrast when the bargaining assumption is made, real wage increases crowd out increased labour demand.

Conclusively, the above set of simulations shows that the G-AMOS simulation framework responds as expected to exogenous shocks, while it allows the modeller trace the results back to the chosen configuration.

Chapter 7 . The Impact of Population Change on the Labour Market and the Economy

7.1 Theoretical framework

This section provides the theoretical foundation for the simulation results that are reported later. The main focus is the labour market. It can be analysed by using an aggregate labour supply and demand framework, an appropriate method given the economic issues raised by an ageing population. However, a disaggregated labour market can also be relevant if we take into account that young and old workers differ in productivity (Lisenkova K. Wright R.,2006). The analysis in this chapter is implicitly long run so that the identified equilibrium wage and employment levels are those towards which the economy is being attracted over time.

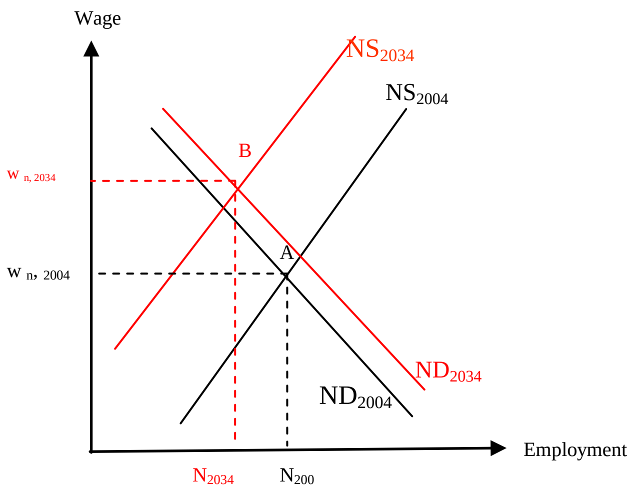
Figure 1 represents the interaction of the labour supply and general equilibrium labour demand curves in the unified Greek labour market. We assume that there are no geographical or skill sub-markets within the Greek economy and that labour can move freely between sectors. The analysis here is comparative static in that it identifies the impact on the equilibrium real wage and employment of an exogenous demographic disturbance.[31] The upward sloping labour supply curve indicates that with a fixed working-age population, an increase in the real wage is required to increase the quantity of labour supplied.[32] The labour demand curve represents the relationship between the quantity demanded of labour and the real wage in long-run

[31] An exogenous disturbance is a change in one of the parameters or variables within the model that is not determined by the model itself. In this case, for example, the working population is taken as determined elsewhere – and therefore exogenous - whilst the employment level is given by the model- and is therefore endogenous.

[32] As explained in chapter 5 we actually use a wage curve specification for the regional labour market. (Blanchflower and Oswald, 1994; Layard *et a1*. 1991). The wage curve approach generates behaviour that is generally observationally equivalent to a labour supply curve, although the interpretation is somewhat different.

equilibrium, with incomes and prices endogenous[33]. An important point is that this general equilibrium labour demand curve takes into account changes in regional competitiveness and household income as wages vary.

Figure 7 1 Impact of an ageing and declining population



In Figure 7.1 we schematically compare the long-run labour market equilibrium in 2034 with that in 2004, under the assumption that the base population projections applies and that real *per capita* expenditure of the Greek government remains constant. This assumption has been used elsewhere (Lisenkova et.al., 2008). At this stage we do not model the impact of changes in the composition of private and public consumption that would accompany changes in the age structure of the Greek population. We would expect that demand patterns are age specific and therefore shifting demographics would alter the composition of demand. However, for now we will assume that government expenditure per head remains constant over the simulation period. That is government expenditure follows the changes of total

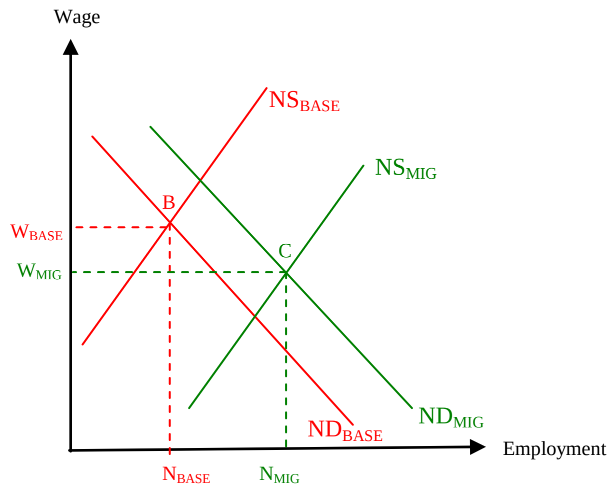
[33] The general-equilibrium labour demand curve is drawn as downward sloping and this is the case in the model of the Greek economy with default parameter values. However, for combinations of extreme product demand and factor substitution elasticities, the general equilibrium labour demand curve can be upward sloping (McGregor *et al*, 1995).

population. The initial equilibrium is represented by point A, where the base-period (2004) labour demand and supply curves ND_{2004} and NS_{2004} intersect. This generates the initial equilibrium employment and real wage levels $w_{n,2004}$, N_{2004}.

According to the base projection, over the period to 2004 to 2034, the total population in Greece will increase but at the same time age. Total population will increase but working age population will fall. These exogenous changes in population size and age composition shift both the labour demand and supply curves. First, the fall in the working age population reduces labour supply at each wage level generating an inward shift of the labour supply curve. This is illustrated in the Figure 1 by the new labour supply curve NS_{2034}, which lies to the left of the original labour supply curve NS_{2004}. However, the change in population also affects labour demand. Because total population has increased, government expenditure is greater, so that labour demand also increases at each wage rate. This shifts the labour demand curve to the right, to ND_{2034}.

The new equilibrium is at point B, the intersection of the general equilibrium labour demand and supply curves ND_{2034} and NS_{2034}. Labour demand shift will tend to increase employment while the supply shift tends to lower employment. However, they both increase the wage. The expectation is that the reduction in labour supply will be much greater than the increase in labour demand. There are two reasons for this. First, the proportionate fall in the working age population is much greater than the increase in the population as a whole. Second, government expenditure is only one of the elements of final demand. In any case, the aforementioned effects will stimulate wage increases as the labour market tightens.

Figure 7 2 The Labour Market in 2034 comparing base projections and higher positive net migration every year



In Figure 2 we broaden the analysis to show the impact on the labour market in 2034 of increased inward migration. Figure 2 compares the labour market in 2034 under two different scenarios. One simply takes the base population projection. The second represents a situation in which there is higher positive net in-migration.

The equilibrium under the base projection is given by point B, which is the intersection of the labour demand and supply functions NS_{2034}, ND_{2034}. This was the final position illustrated in Figure 1. Now impose net in-migration at a rate higher than that assumed under base scenario. Working age population, and therefore the labour force, is going to be higher than under the base prediction for 2034. This is illustrated in Figure 2 by an outward shift of the labour supply curve to NS_{MIG}. Labour demand will also shift outwards to ND_{MIG} as a result of higher population-linked government expenditure. The new equilibrium is at point C, the intersection of the new labour supply and demand curves. In this case the shifts in labour demand and supply both work to increase equilibrium employment (compared to the equilibrium at B). Further, because we expect that the increase in labour supply will dominate the increase in labour demand, pressure in the labour market should ease and the wage fall.

Figures 1 and 2 demonstrate the qualitative impact of population ageing and in-migration on the labour market. These labour market changes will have major impacts on the economy overall. In particular, with an ageing population, we expect a negative effect upon competitiveness due to the increased wage, which is a key production cost. This reduced competitiveness has a negative impact on GDP. On the other hand, in-migration eases the labour market, improves competitiveness and increases GDP. However, the interactions within the economy are naturally more complex than this and are explored in the simulations reported in the next sections. However, note that the figures reported in these simulations are for a time period over which such long-run adjustment is not yet complete. Similarly, where we report period-by-period simulations, we are tracing out the adjustment path to the long-run equilibrium.

7.2 Overall simulation strategy

Population is taken to be exogenous, and we begin with the year-by-year evolution of the Greek total and working-age populations. For the base projection, the values introduced in the economic model are the ones presented in table 2.8. These period-by-period evolutions of the total and working age populations are then used to produce associated labour force and government demand series that are introduced as exogenous variables in the Greek Computable General Equilibrium (CGE) model, G-AMOS. The characteristics of the G-AMOS model are described in chapter 5. The output of the CGE model shows the simulated economic impact of the demographic changes.

There is one thing that should be noted. The current configuration of the G-AMOS modelling framework, does not allow the modeller to impose changes in the working age population on a period by period basis. Instead it only allows for the imposition of a constant and absolute rate of change of the labour supply. Therefore changes in the working age population are linearised so as to match the relevant initial and final working age population points[34]. For example, in the base projection as shown below, in Figure 7.3 working age population falls from 7,344,000 to 6,894,000 between 2004 and 2034. Remember, that on the demand side changes in government expenditure are introduced. The assumption is that government

[34] This is a reduction of 450,000. If this reduction is to occur over thirty periods (years) it would occur at annual rate of 15,000. In addition, as the modeller can only impose changes to the total population the required reduction in total population has to be calculated. That is, by how much the total population has to be reduced annually in order for the working age population to be reduced by 15,000. The G-AMOS modelling framework assumes a constant age composition of the population and an identical age composition of net migration. At the base year the fraction of working age population to total population was roughly 0.66. Dividing this figure with 15,000 we get the figure that has to be imposed to G-AMOS so that the modeller can mimic the demographic changes that are generated by the demographic software FIV-FIV. Thus the corresponding figure is 22,561.

expenditure per head remains constant and thus percentage changes of total population every period are equal to percentage changes of government expenditure.

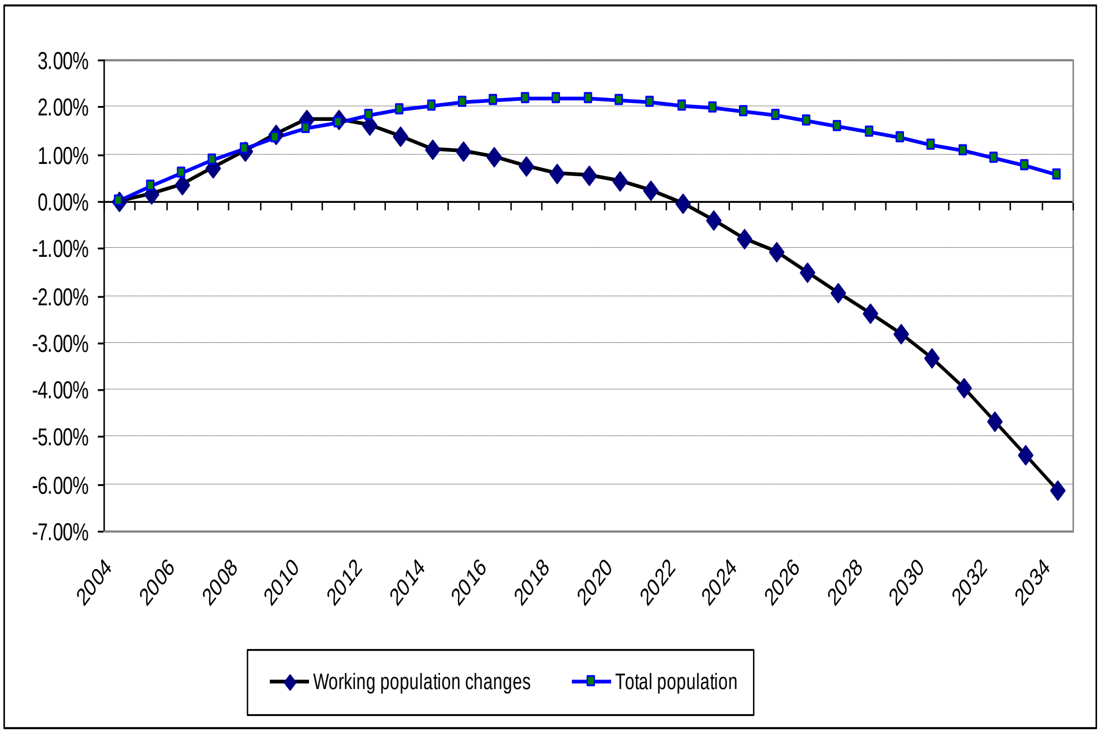
The next section looks in detail at the economic effects of the population changes given by the base projections. This includes some sectoral disaggregation. Next, the extent to which the results are sensitive to the assumptions made about the operation of the Greek labour market is explored. The impact of changing the responsiveness of labour supply to the real wage is examined. The sensitivity of the results to varying the value of the Armington elasticities is also tested. Sensitivity analysis is also undertaken by changing the underlying demographic parameters; that is the fertility, mortality and migration assumptions made in the base projections. The results are more sensitive to variation in the exogenous migration assumptions. Hence I look in more detail at the simulations with alternative migration scenarios, maintaining the principal assumptions for fertility and mortality.

7.3. The Consequences upon the Greek Economy of the Base population projection

7.3.1 The Base population projection

The assumptions underlying the base projection are described above in chapter 2. Total population increases initially, reaches a maximum of 2% above base and ends up above (0.5%) the base level. By 2034 working age population increases initially, reaches a peak in 2010 and then drops. It falls below the base period value in 2022 and by the end of the projection period it has decreased by 6.13%. The key factor is the following. Although immigration has a positive impact on the country's demography, it does not prevent overall impacts of population ageing if immigrants arrive at a rate of 40,000 per year. After 2022 working age population falls below base. Once again the trajectories of total and working age population are presented.

Figure 7 3 Total and working age population under the base scenario



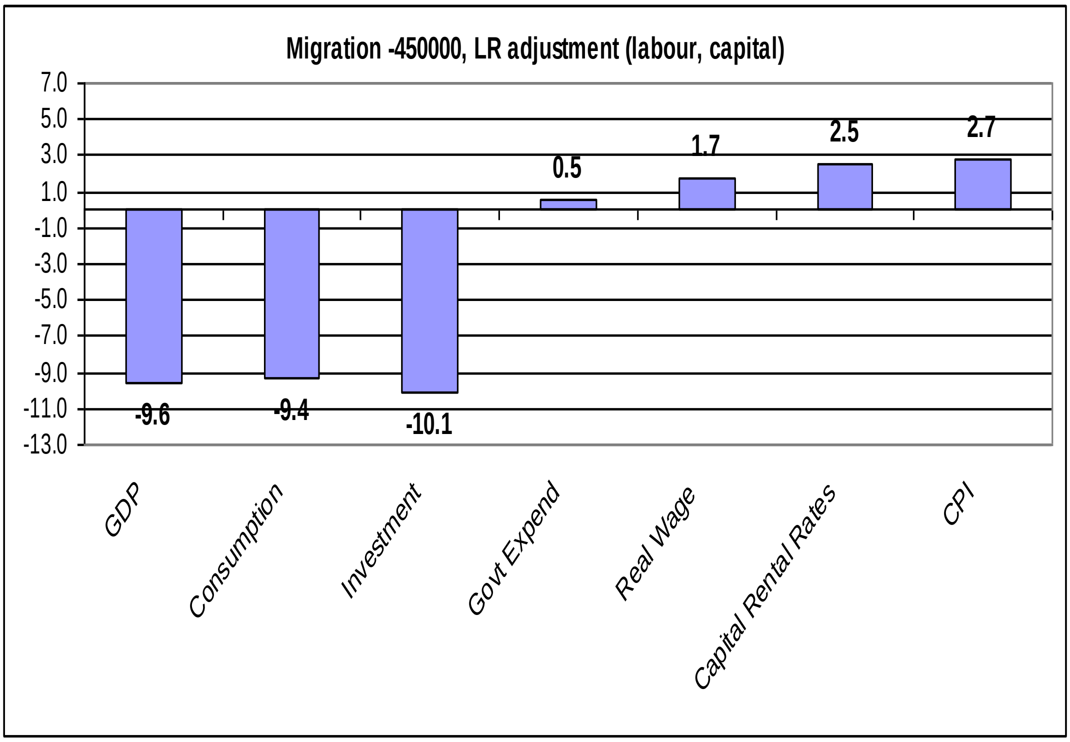
7.3.2 The macroeconomic impact of the base projection in the long run

Initially, an exogenous shock to the model is imposed while letting both capital and labour markets fully adjust. In other words, the long-run implications of demographic change are investigated. The expectation is that quantities will fall and prices will rise as adjustments driving the tightening of the labour market feed into the rest of the economy. As is explained above, the impact of population change is modelled by simultaneously imposing a supply and demand shock. On the supply side there is a total reduction in the working age population that is expected to occur during the projection period under the base scenario. On the demand side a one off shock is imposed that corresponds to the overall change of the total population. In subsequent sections a period by period analysis is conducted.

In particular, under the base scenario, working age population decreases by 450,000 starting from 7,344,000 in 2004 and ending up to 6,894,000 in 2034. The shock that I impose on the supply side is negative migration of 676,532. On the demand side a shock of 0.54% is imposed in government expenditure which corresponds to the increase of total population during the same period.

The results are the ones expected with quantities falling and prices going up. The figure below gives the percentage changes of the main aggregate indicators.

Figure 7 4 Changes of main aggregate indicators



GDP decreases by 9.6% in line with consumption and investment, while the CPI goes up by 2.7% and the real wage by 1.7%. A period by period analysis where capital and labour do not fully adjust follows.

7.3.3 The macroeconomic impact of the base projection using a period by period analysis

The data that correspond to Figure 7.3 produce exogenous disturbances in the G-AMOS model. These give the simulation results summarised in Table 1.

Table 7 1 The impact of the BASE demographic projections on Greek aggregate economic indicators[35].

BASE	2004	2009	2014	2019	2024	2030	2034
GDP	*0.00*	*-0.07*	*-0.34*	*-0.79*	*-1.37*	*-2.20*	*-2.82*
Real wage	*0.00*	*0.65*	*1.18*	*1.62*	*1.97*	*2.30*	*2.48*
Unemployment	*9.12*	*8.62*	*8.22*	*7.91*	*7.67*	*7.46*	*7.34*
Employment	*0.00*	*-0.16*	*-0.52*	*-1.04*	*-1.68*	*-2.58*	*-3.23*
Export price index	*0.00*	*0.09*	*0.16*	*0.21*	*0.26*	*0.32*	*0.35*
CPI	*0.00*	*0.08*	*0.01*	*-0.04*	*-0.07*	*-0.07*	*-0.09*

As explained above, the population change produces two simultaneous exogenous impacts, one operating on the demand side and the other on the supply side. Changes in total population operate on the demand side, generating changes in government demand as we hold real *per capita* government expenditure constant. Changes in working age population are modelled as supply-side changes, operating through adjustments in the labour force, which affect the tightness of the labour market.

One important technical point needs to be made here. We can enter the period-by-period government demand changes so that they precisely match the period-by-period changes in population. However, as the model is presently configured, we can

[35] All indicators are presented as percentage changes from the base year. Only in the case of unemployment the actual unemployment rate is presented.

only impose changes in the labour force by means of a linear trend. Therefore, for example, with the BASE projection shown in Figure 3 above, the 6.13% fall in the working age population over the 30 years between 2004 and 2034 is modelled as a linear reduction in the labour force equal to an annual rate of 0.204% of the original 2004 value. This means that whilst the end-point simulation results are correct, there is some loss of accuracy in the adjustment path.[36]

Figure 7.4 shows the Greek employment and GDP figures associated with the population changes. Remember that these should be interpreted as variations away from what would have occurred with population held constant in both size and age composition. As we expect from the theoretical discussion in the above chapter, employment falls, in this case by 3.23% in 2034, with a corresponding decline in GDP of a little less at 2.82%. Note that because of the linearisation of the change in the working age population in the model, the results shown in Table 1 will overestimate the reduction in the initial years, where an increase in output and employment is expected, but underestimate the rate (but not the level) of decline in the latter period of the simulation where working age population is falling.

Figure 4 reveals two important points. The first is that the fall in employment is much lower than the fall in working age population. Working age population falls by 6.13% whilst employment only declines by 3.23%, implying an increase in the participation rate and a fall in the unemployment rate to partially offset the negative supply side impacts. This tightening of the Greek labour market is apparent in the

[36] In fact, the imposed adjustment path will affect the endpoint results, but this should be small.

results reported in Figure 7.5. Nominal and real Greek take home wage increase by 2.40% and 2.48% respectively by the year 2034.[37]

The second key point is that the fall in GDP closely follows the decline in employment. In considering the fall in GDP, there are both demand and supply side effects to consider. From the demand side, the fall is primarily driven by a reduction in Greek exports generated by the increase of the price of Greek exported goods that accompanies the tighter labour market. However this impact is small in size. The root of this result is the high value of Armington elasticity that is assumed in order to reflect the fact that the country is largely a price-taker[38]. Figure 7.7 shows the CPI and export price indices. Note that consumer prices initially increases and then falls below equilibrium. By 2034 the price of the composite exported good that has been calculated as the weighted average of the price of exported commodities rises by 0.35%. As a consequence, the demand for exported goods falls by 2.85%. From the supply side, in each sector the capital stock will adjust to changes in output demand but more slowly than the changes in employment so that the change in GDP will slightly lag the changes in total employment. There will also be a tendency for production to become more capital intensive as the nominal wage increases, so that there is some substitution of capital for labour.

[37] There is not full pass through of the increased wages to prices, that is prices increase by less than wages, primarily because of the presence of imports from outwith Greece as elements of the consumption basket and as intermediate inputs in production.

[38] Sarris and Zografakis (1999) have also used high values of elasticities, while Ioakimoglou (1999) econometrically estimates a high degree of responsiveness of Greek prices to international prices.

Figure 7 5 Percentage Change of GDP and Employment

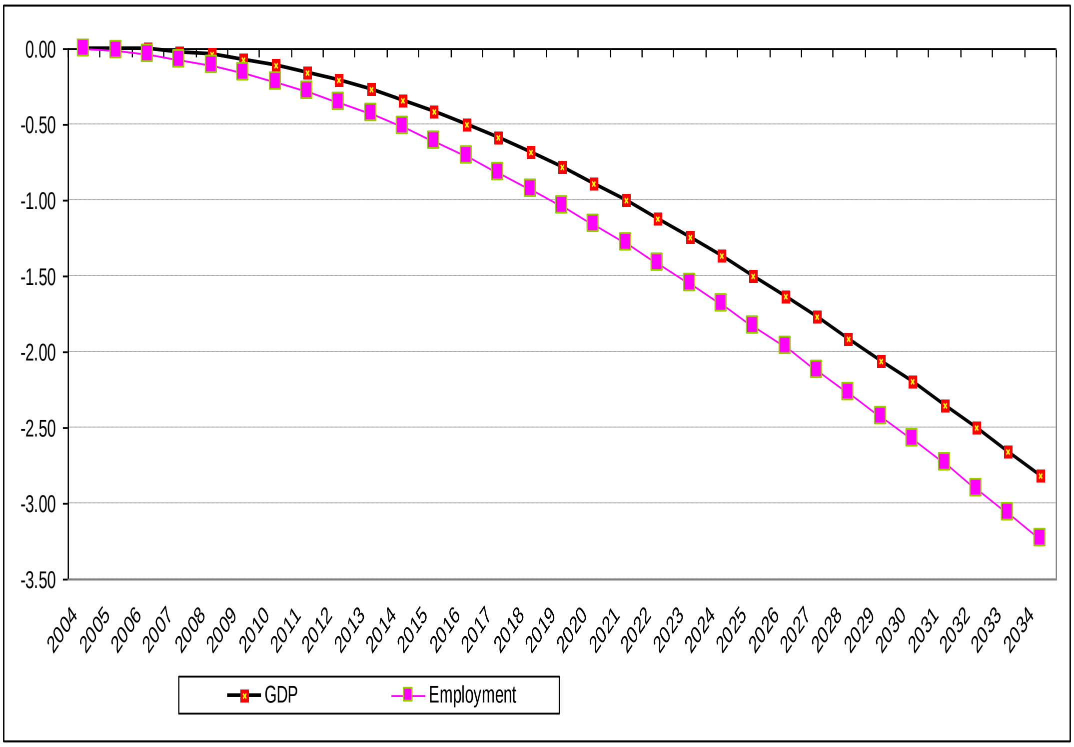


Figure 7 6 Percentage changes of nominal and real after tax wage

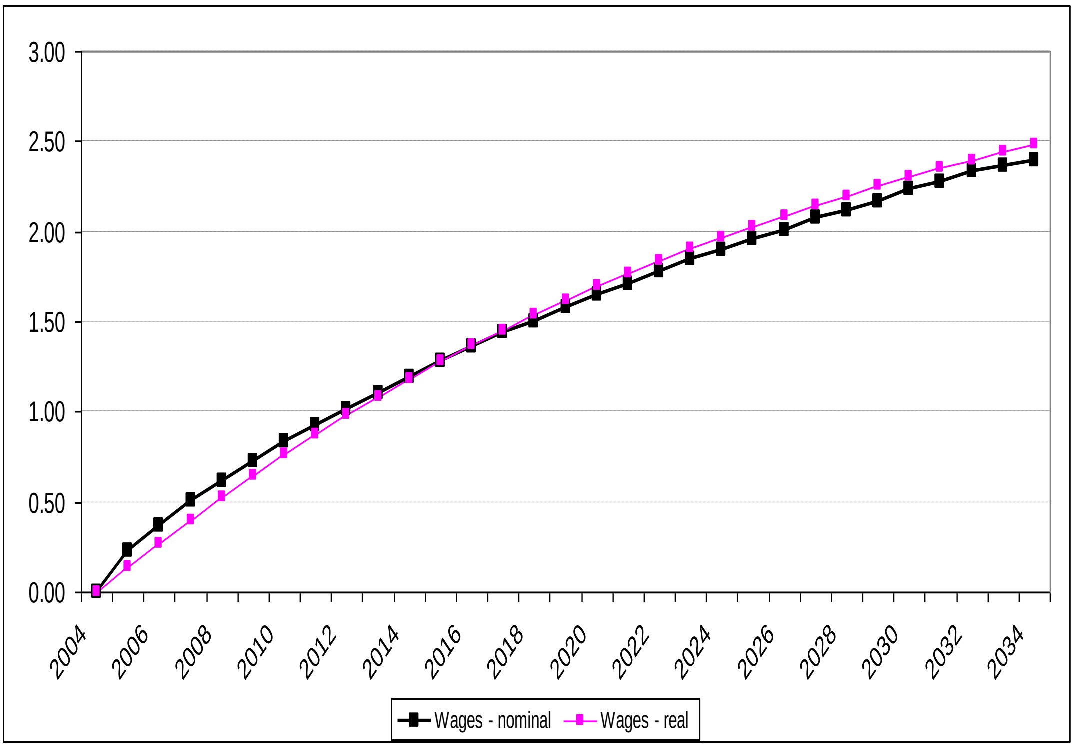
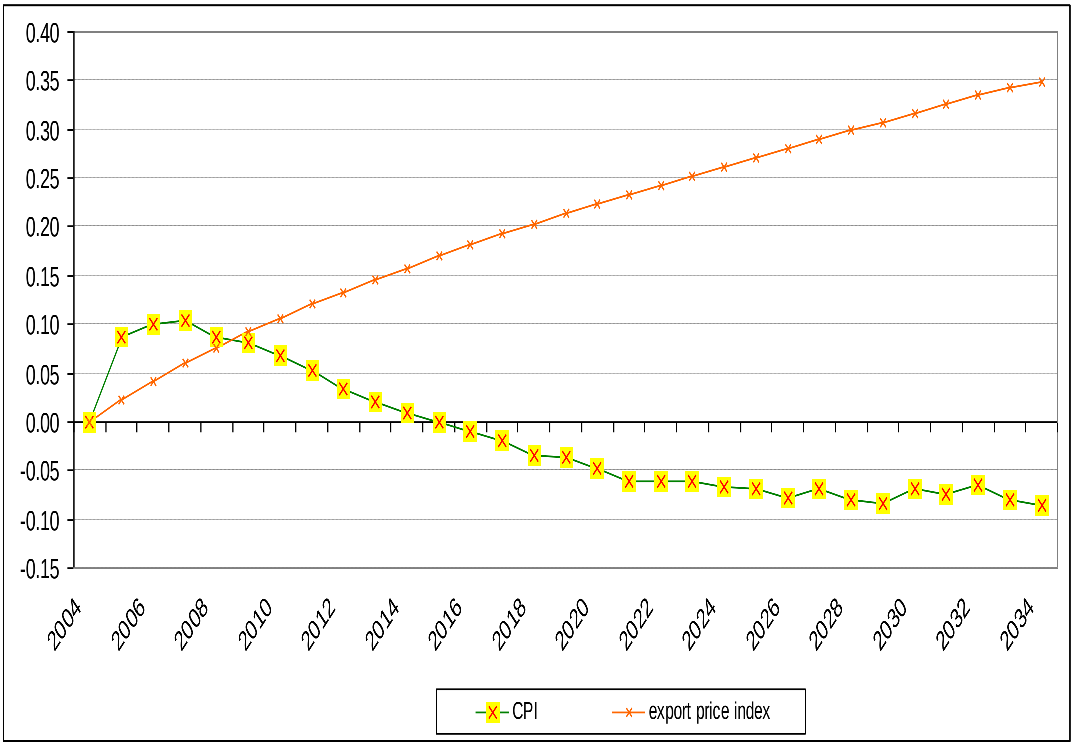


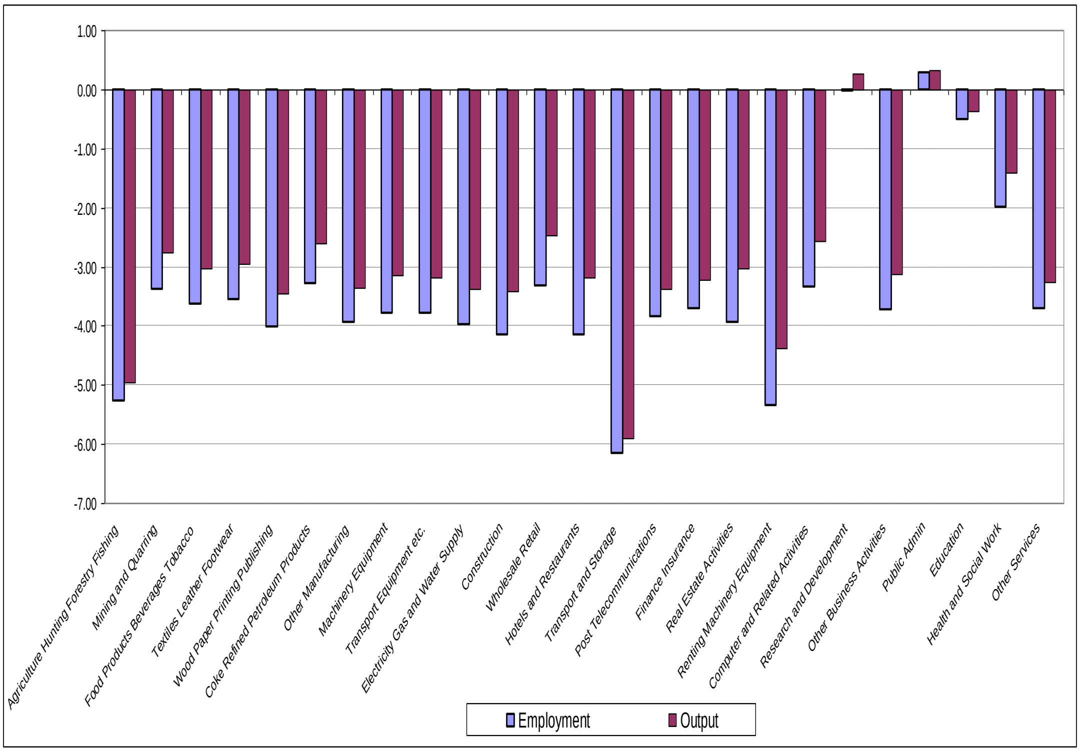
Figure 7 7 Percentage changes for cpi and the exported price index



The fact that prices do not move upwards is something to notice. It is in contrast to what one would expect and to what has been found by Lisenkova et.al. (2008). However, in a simple back of the envelope model of a two good price taker economy and under fixed capital stock that is presented in appendix, it can be shown that in the short run prices will move up or down depending on the relative labour intensity of the exporting and non exporting sectors. It should also be noted that when a lower value of Armington elasticity (i.e. 2) is imposed prices move upwards. (see later section 7.4.3) It should also be noted that when running the model forward for more periods than our conventional projection horizon prices do move upwards.

Figure 7.11 shows the expected changes by 2034 in sectoral output and employment generated by the base demographic projection for Greece. Note first that these simulations do not take into account any variation in the composition of government and household consumption demand that will be driven by population ageing. For example, there is much discussion of the implications for health care and education provision resulting from longer life expectancy (Economic Policy Committee and European Commission, 2006). Such compositional demand changes are likely to be important but they are not the subject of this thesis. These disaggregated results therefore primarily reflect more general demand-side factors. These are the extent to which the sector supplies export, investment, household consumption or government demand.

Figure 7 8 Impact on sectoral output and employment. (Percentage changes by the year 2034)



The figure above indicates that by 2034 most sectors will exhibit lower employment and output than in the initial equilibrium. There is a wide variation in the impacts, ranging from an output increase of 0.323% for Public Administration output to a decrease of 5.9% for Transport and Storage. In general those sectors selling most of their output to government demand (Public Administration, Health and Social Work, Education) are affected least because government expenditure, which in these simulations is linked to total population, remains relatively constant over the whole simulation period, and it actually increases by only 0.54% by 2034. In addition these sectors are sheltered in the sense that they are not subject to international competition.

The extent of the negative effect upon other sectors (which are mostly hit much harder) is determined by two factors. First, labour intensive sectors are worst affected because of the increased cost of labour. Second, the sectors that are more exposed to international trade feel the negative competitiveness effect more strongly. For example, sectors such as Agriculture Hunting Forestry Fishing clearly suffer these negative competitiveness effects. Transport and Storage is the sector that realises the biggest decrease. This is something that should be attributed to the high labour intensity and export propensity of the sector. However, Coke and refined Petroleum Products is exporting a lot (31% of output) but is not so labour intensive (7% of input goes to wages) and thus the negative impact appears to be only -2.6%. As argued above, in all sectors employment falls by more than output because as the price of labour rises firms substitute labour for capital. Also, it takes more time to optimally adjust the capital stock.

7.3.4 Further investigation of the movement of Consumer Price Index

Before concluding this section and in order to further explore the behaviour of prices in this simulation, additional scenarios that assume no exogenous demand disturbance have been simulated. Only the negative supply shock is imposed so as to isolate the impact of a reduced labour force. The first scenario employs the same labour market closures as the "base" scenario. The second scenario assumes a higher than the standard speed of adjustment of actual to desired capital (0.45 as opposed to 0.3). The third scenario assumes fixed nominal wage (Keynesian closure) in the labour market. The table and figures below compare the base scenario with the scenarios just discussed and further clarify the surprising result that relates to the movement of the CPI during the simulation period. Note that for illustrative purposes the results of the base scenario are included in the relevant figures.

Table 7 2 – Impact of a negative supply shock upon main aggregate indicators

	2004	2009	2014	2019	2024	2029	2034
Base No Demand							
GDP	*0.00*	*-0.17*	*-0.50*	*-0.97*	*-1.53*	*-2.17*	*-2.87*
Real wage	*0.00*	*0.56*	*1.03*	*1.44*	*1.81*	*2.13*	*2.43*
Nominal wage	*0.00*	*0.29*	*0.72*	*1.15*	*1.58*	*2.00*	*2.43*
Unemployment	*9.12*	*8.68*	*8.33*	*8.03*	*7.78*	*7.57*	*7.37*
Employment	*0.00*	*-0.27*	*-0.70*	*-1.24*	*-1.86*	*-2.55*	*-3.29*
Export price index	*0.00*	*-0.02*	*0.00*	*0.04*	*0.11*	*0.20*	*0.31*
Capital Rental Rates	*0.00*	*-0.59*	*-0.99*	*-1.25*	*-1.41*	*-1.50*	*-1.52*
CPI	*0.00*	*-0.27*	*-0.31*	*-0.29*	*-0.23*	*-0.13*	*0.01*
Speed 0.45							
GDP	*0.00*	*-0.37*	*-0.79*	*-1.34*	*-2.00*	*-2.73*	*-3.50*
Real wage	*0.00*	*0.66*	*0.96*	*1.28*	*1.55*	*1.78*	*2.00*
Nominal wage	*0.00*	*0.298*	*0.701*	*1.099*	*1.494*	*1.888*	*2.287*
Unemployment	*9.12*	*8.73*	*8.38*	*8.13*	*7.93*	*7.76*	*7.62*
Employment	*0.00*	*-0.49*	*-0.96*	*-1.56*	*-2.26*	*-3.01*	*-3.80*
Export price index	*0.00*	*0.01*	*0.04*	*0.10*	*0.18*	*0.29*	*0.42*
Capital Rental Rates	*0.00*	*-0.88*	*-0.90*	*-1.00*	*-1.03*	*-0.99*	*-0.90*
CPI	*0.00*	*-0.36*	*-0.26*	*-0.17*	*-0.05*	*0.10*	*0.28*
Base No Demand (Fixed Nominal Wage)							
GDP	*0.00*	*-0.08*	*-0.21*	*-0.39*	*-0.60*	*-0.83*	*-1.08*
Real wage	*0.00*	*0.31*	*0.42*	*0.49*	*0.56*	*0.61*	*0.65*
Nominal wage	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
Unemployment	*9.12*	*8.59*	*8.07*	*7.55*	*7.05*	*6.55*	*6.05*
Employment	*0.00*	*-0.12*	*-0.26*	*-0.43*	*-0.63*	*-0.86*	*-1.10*
Export price index	*0.00*	*-0.05*	*-0.10*	*-0.14*	*-0.17*	*-0.20*	*-0.22*
Capital Rental Rates	*0.00*	*-0.44*	*-0.65*	*-0.80*	*-0.92*	*-1.02*	*-1.10*
CPI	*0.00*	*-0.31*	*-0.41*	*-0.49*	*-0.55*	*-0.60*	*-0.64*

Figure 7 9 – Real wage under different scenarios

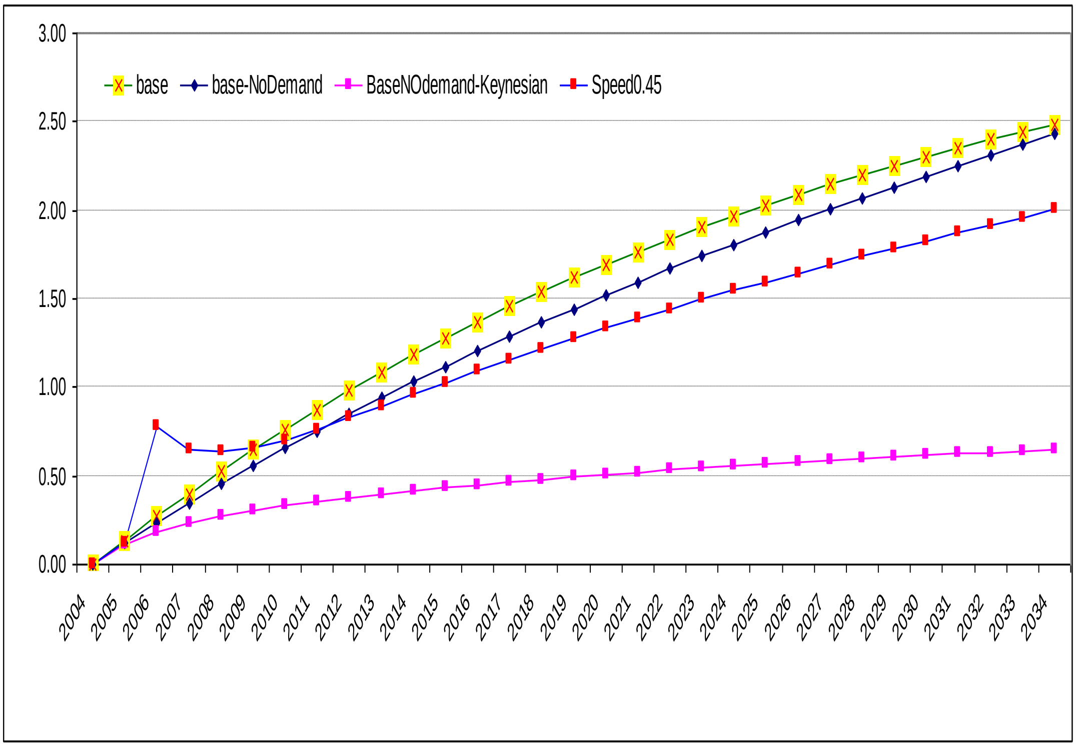
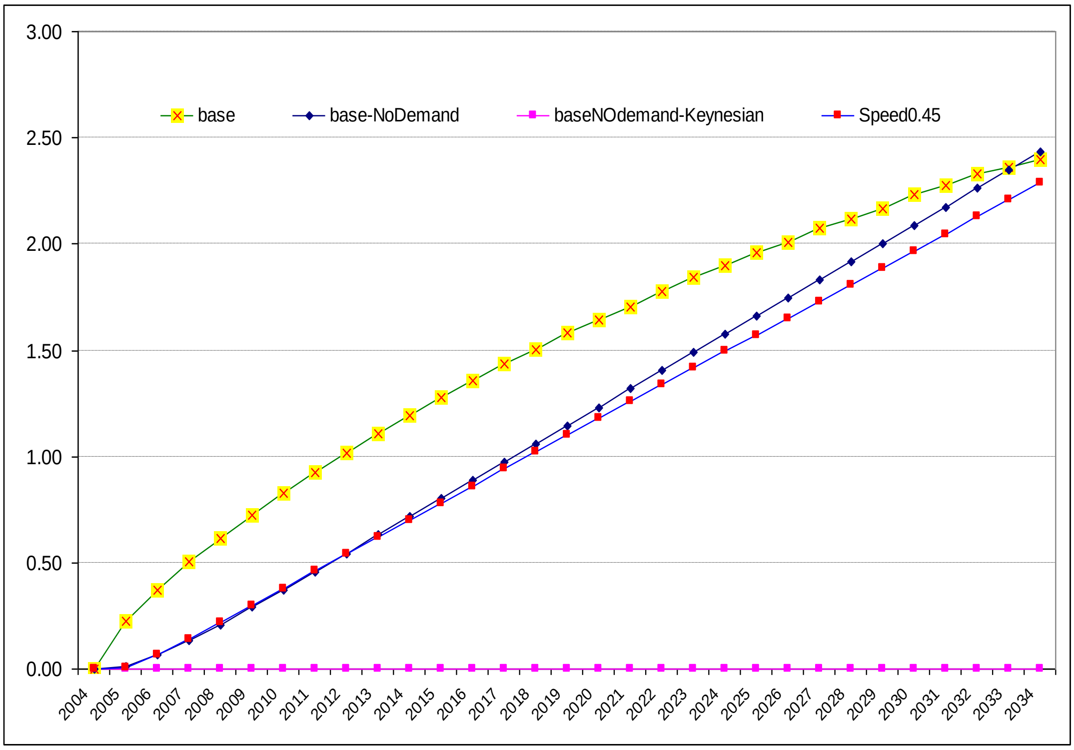
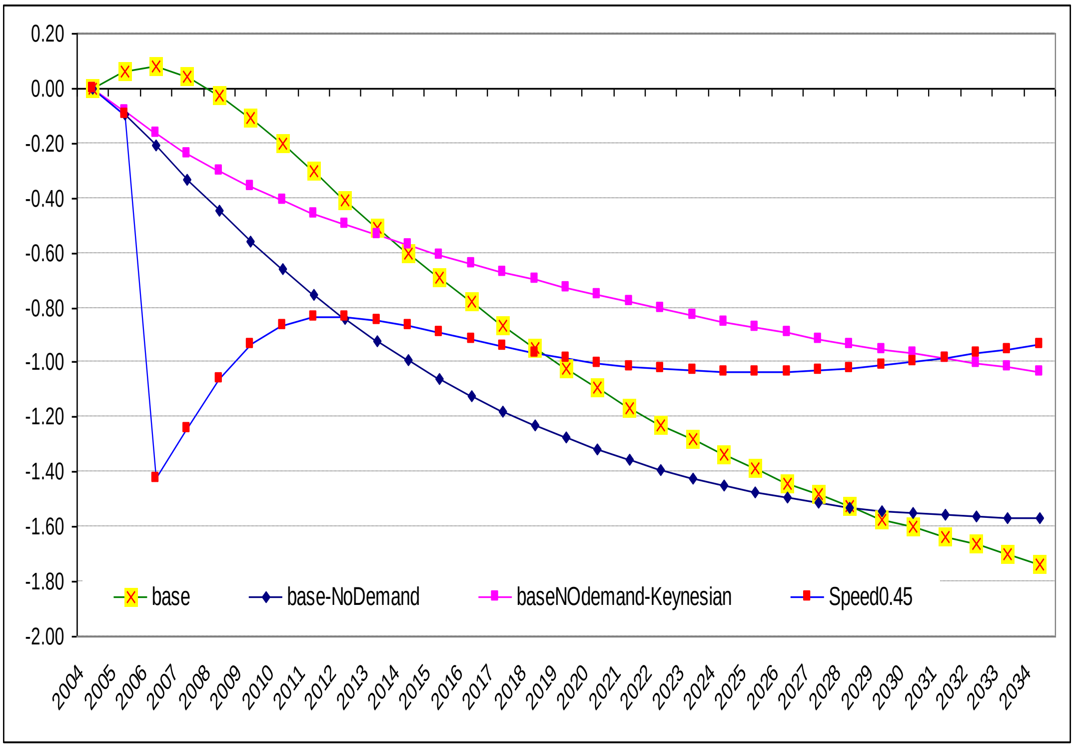


Figure 7 10 – Nominal wage under different scenarios



As can be seen above, in all cases the nominal wage increases apart of course from the case that is assumed to be constant. Nominal wage increase is greater under the base scenario due to the presence of the exogenous demand shock. Real wage goes up due to the negative supply shock (reduction in the labour force). It increases the most under the base case as a result of the additional pressure from the associated demand shock. The rest of the scenarios isolate the impact of the reduction of the labour force as the demand shock is not applied. The smallest increase is realised under the scenario with the fixed nominal wage (Keynesian). Next is the scenario with a higher speed of adjustment than the base case (0.45 as opposed to 0.3) where the real wage increases by 2% by the end of the simulation period. The two scenarios, with and without the demand shock almost coincide as the demand shock is positive initially and negative later on but small in magnitude.

Figure 7 11 – Capital rental rates under different scenarios



Capital rental rates fall in all cases. The reduction of the labour force reduces the optimal (profit maximizing) capital stock. Firms do not invest and this results in a fall of capital rental rates. However, under the scenario that assumes a higher speed of adjustment for capital rental rates start moving upwards before the end of the simulation period[39].

Figure 7 12 – Consumer price index under different scenarios

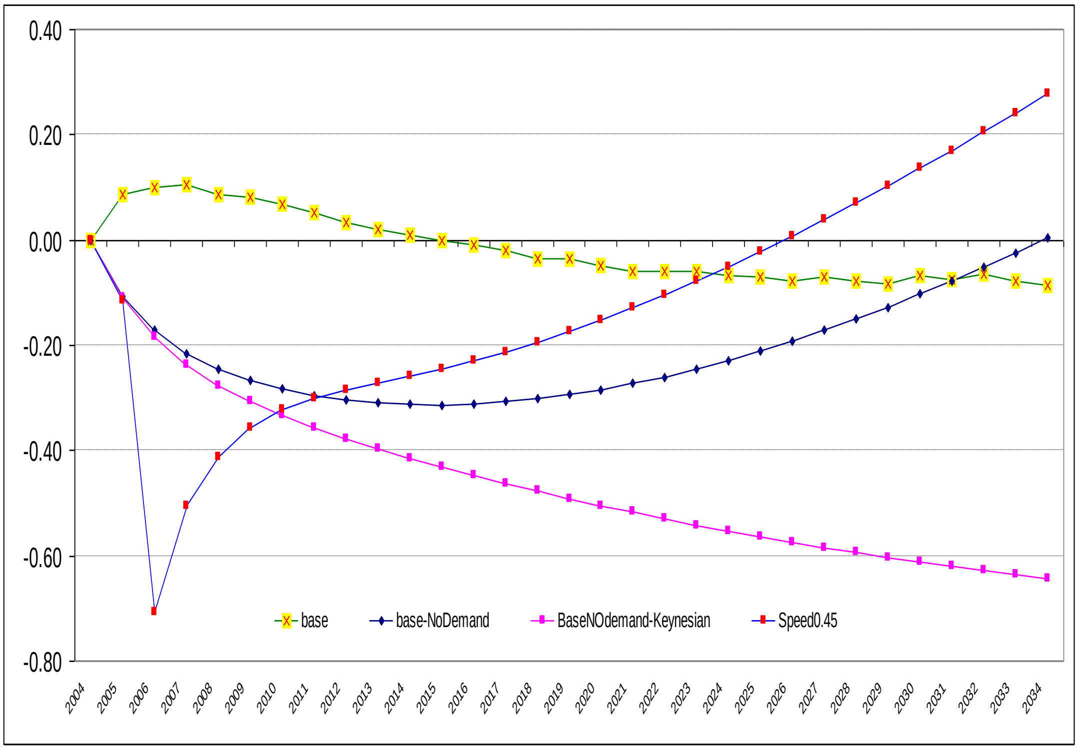


Figure 7.10 illustrates that the CPI moves up initially in the base scenario due to the demand shock. In all other scenarios, in the absence of the demand shock it moves down initially. In the base case without the demand shock CPI starts moving downwards and reaches base value by the end of the simulation period. As expected, when the speed of adjustment is assumed to be higher CPI moves upwards faster due

[39] Similar results are produced when greater substitutability between capital and labour is assumed. This result is reasonable as in both cases capital stock is more responsive.

to the greater pressure upon capital rental rates. CPI in all cases reveals the combined effect of wages and capital rental rates as presented in the two previous figures.

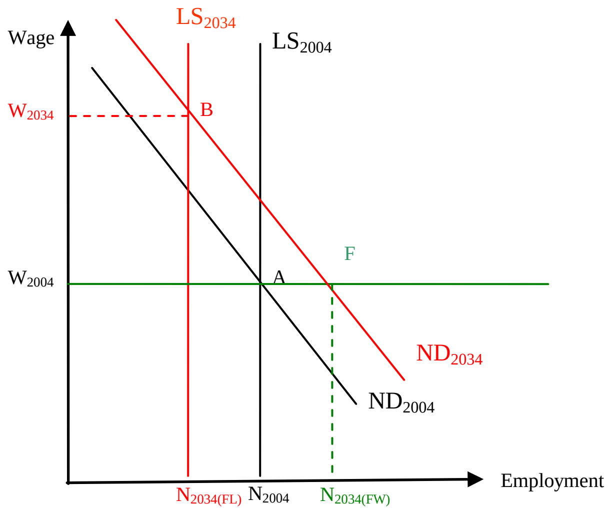
7.4 Sensitivity analysis for different labour market closures, production function elasticities, Armington elasticities

7.4.1 Different labour market closures

The AMOS modelling framework allows a range of labour market closures. In order to test how sensitive the results are to variation in labour market assumptions, I conducted simulations using the base population projection under two limiting cases.

The first imposes within-period fixed labour supply. This means that labour supply is a given proportion of the labour force, where the labour force is adjusted period-by-period through demographic changes. There is therefore assumed to be no unemployment or participation rate adjustment as the labour market tightens. In any individual time period, this situation is represented by a vertical labour supply curve. The second, alternative, assumption is that there is so much slack in the local labour market that an increase in labour demand is met by a change in employment but no change in the real wage. In this case, in each time period the labour supply curve would be horizontal and employment adjusts to changes in labour demand through changes in the unemployment and participation rates. These alternative situations are represented in Figure 7.9 below.

Figure 7 13 The Labour Market in 2004 and in 2034 under the GAD population projections



This diagram is similar to Figure 7.1 above, except that here the elasticity of the labour supply takes alternative (limiting) values. Just as in Figure 2, as a result of the slight increase in total population the labour demand curve shifts outwards (from ND_{2004} to ND_{2034}) as government expenditure increases. However, the reduction in the labour force pushes inwards the vertical labour supply curve from (N_{2004} to N_{2034}).

Under the fixed labour supply closure, the labour supply curve shifts inwards from LS_{2004} to LS_{2034}. The new equilibrium is at B with employment $N_{2034(FL)}$ and wage w_{2034}. Alternatively, where we impose the fixed real wage closure, the horizontal labour supply curve, LS_{FW}, is unchanged. In this case, the new equilibrium is at F, with the original wage of w_{2004} and employment given by $N_{2034(FW)}$. The increase in employment relative to the labour force, identified by the distance $N_{2034(FW)}$ - $N_{2034(FL)}$ is driven by a reduction in the unemployment rate and an increase in the participation rate. In the fixed labour supply case we expect the employment reduction and the wage increase to be larger than under our preferred case, given in

Figure 2.1. In the fixed real wage scenario, the opposite results hold: we expect the fall in employment and the wage increase to be of smaller magnitude than what they would be on the case of the conventional wage curve account.

When we attempt to run the model with a fixed real wage, we get a relatively stable GDP trend while under the fixed labour supply closure GDP follows the linear reduction that we exogenously impose to the labour force. In a simulation with fixed labour supply by Lisenkova et. al (2008) the model fails to solve because it produces a negative unemployment rate. The key practical point is simply this: the population constraints implied by demographic projections, combined with fixed government expenditure per head, put upward pressure on wages and continuously reduce unemployment. This makes the fixed real wage scenario unfeasible[40]. This result prevails in the case of Greece after 76 periods.

On the other hand, where labour supply is completely inelastic, the whole adjustment to the labour force contraction must come through higher wages. As we have argued already, we expect employment and output to fall by more under this labour market closure, as participation and unemployment rates are not allowed to adjust. This will be combined with an even greater pressure upon wages. The figure below shows GDP trends for the different labour market closures. In Table 2 I present the percentage changes in the main aggregate indicators for 2034 under the fixed labour supply, fixed real wage and wage curve labour market closures.

[40] Such a result prevails in the case of Greece after 76 periods. The result suggests that if working age population keeps decreasing with the same pace as in the base projection, and the real wage is fixed, after 76 periods unemployment falls below zero.

Figure 7 14 GDP trends under different labour market closures

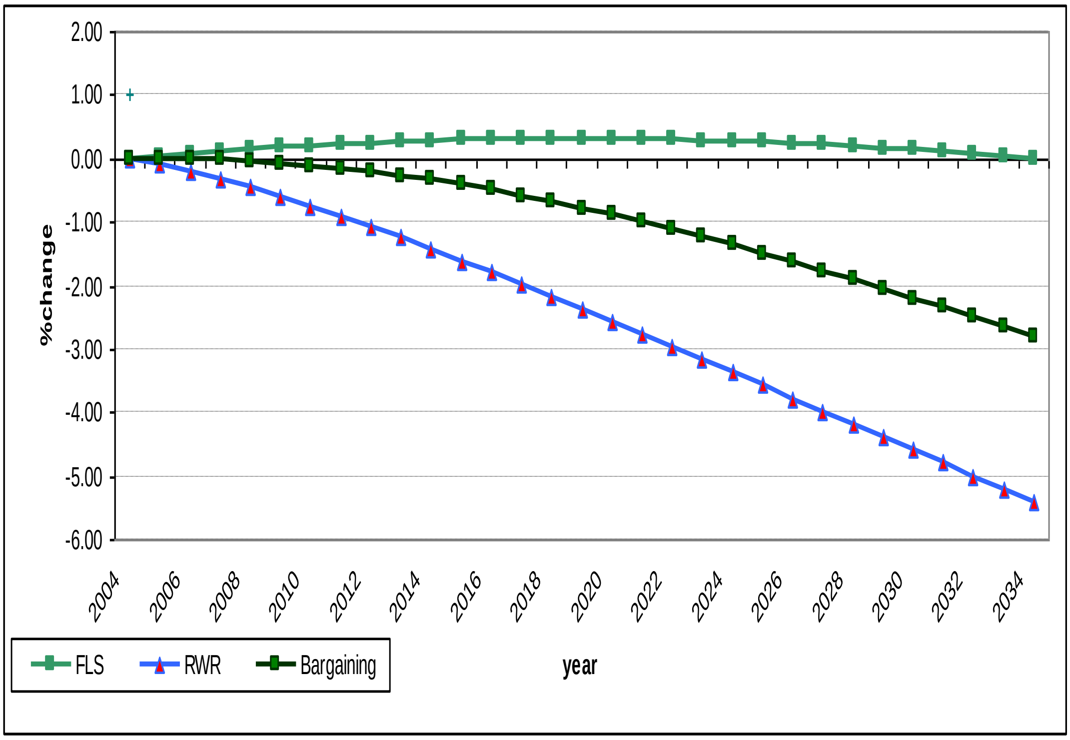


Table 7 3 Main aggregate indicators in 2034 under different labour market closures (% change from base, unemployment rate)

	Bargaining (LNJ estimates)	Fixed Real Wage	Fixed Labour Supply
Gross Domestic Product	-2.82	-0.01	-5.41
Employment	-3.23	0.14	-6.13
Unemployment	7.34	5.30	9.12
Consumer Price Index	-0.09	-1.08	1.00
Real after tax consumption wage	2.48	0.00	4.11

Remember, that in all the above cases there is a reduction of the working age population by 6.13% and an increase of the total population by 0.5%. Indeed our results are consistent with what economic theory suggests. Employment with fixed labour supply is expected to fall by 6.13%, exactly in line with the reduction in the labour force (and working age population), whilst under the bargaining closure the employment reduction is only -3.23%. In the case of fixed real wage we have a minor change of 0.14% which is generated by the demand changes that I have exogenously imposed. The corresponding figures for GDP are -5.41%, -2.82% and -0.01%[41] respectively. The wage rate shows a reduction of an increase of 2.48% under the Bargaining closure and of 4.11% increase under fixed labour supply. By definition there is no change under the fixed real wage closure. Unemployment falls to 7.34% (from 9.12%) under Bargaining while under fixed real wage at 5.30% as the labour market is purely quantity clearing. By definition, under fixed labour supply, the unemployment rate remains unaltered. The importance of the labour market closure is apparent. While assuming fixed labour supply or a fixed real wage are both extreme cases the bargaining closure is a more realistic option and this is the closure that the rest of the simulations will be performed with. The bargaining function is parameterised using the regional econometric work reported in Layard *et al.* (1991. Empirical support for such a specification is now widespread (Blanchflower and Oswald 1994). Blanchflower and Oswald (1998) estimate wage curves for a series of countries and conclude that they exhibit very similar characteristics.

[41] GDP is practically stable in this case. However, the slight decrease should attributed to the reallocation of labour between sectors

7.4.2 Different values of elasticities of substitution between capital and labour

In this section I present the results that are generated by imposing different values of elasticities for the substitution of capital and labour in the production of final output. The value that has been used in all simulations is 0.3. I have replicated the simulation of base scenario by imposing a value of 0.8 and also by assuming that the final output is produced by a Cobb-Douglas function. The Cobb-Douglas function imposes an elasticity of substitution equal to unity.

The expectation is, that with the introduction of a negative labour supply shock employment will fall more rapidly in the cases where substitutability is easier. Indeed employment falls most under the Cobb-Douglas assumption and least with the elasticity of supply equal to 0.3. Conversely, the wage rate increases by more the lower the substitutability between capital and labour. In particular, by the year 2034 employment falls by 4.58%, 4.38% and 3.23% for the substitution elasticity values of unity (Cobb-Douglas), 0.8 and 0.3. The corresponding figures for GDP are 3.93%, 3.79% and 2.82%. For the real wage, not surprisingly, the ranking is reversed and the corresponding impacts are 1.26%, 1.43%, 2.48%.

In the figures 7.11, 7.12, 7.13 below I present trajectories of Employment, GDP and Real Wage for these different scenarios. Table 3 shows the main aggregate indicators for every five year period. I should note that although the results are obviously depending on the values of elasticities, the magnitude of the variation can be considered of minor importance in relation to the variation that is caused by varying demographic parameters as we shall see in the next section.

Figure 7 15 Employment trends under different values of elasticity of substitution between capital and labour

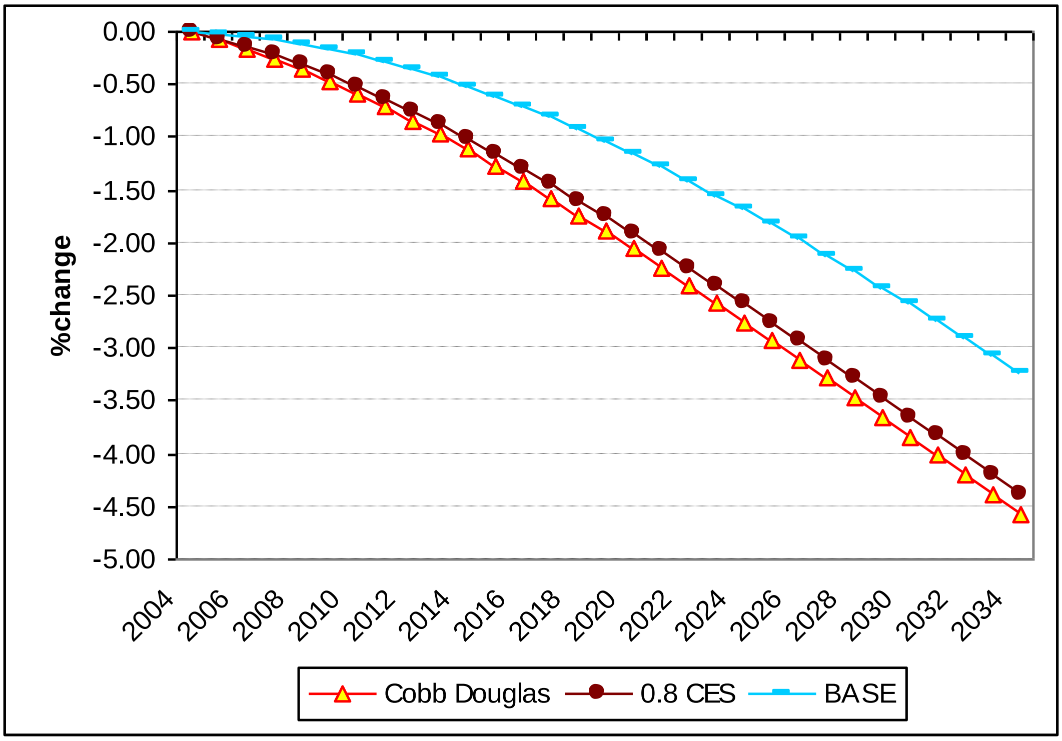


Figure 7 16 GDP trends under different values of elasticity of substitution between capital and labour

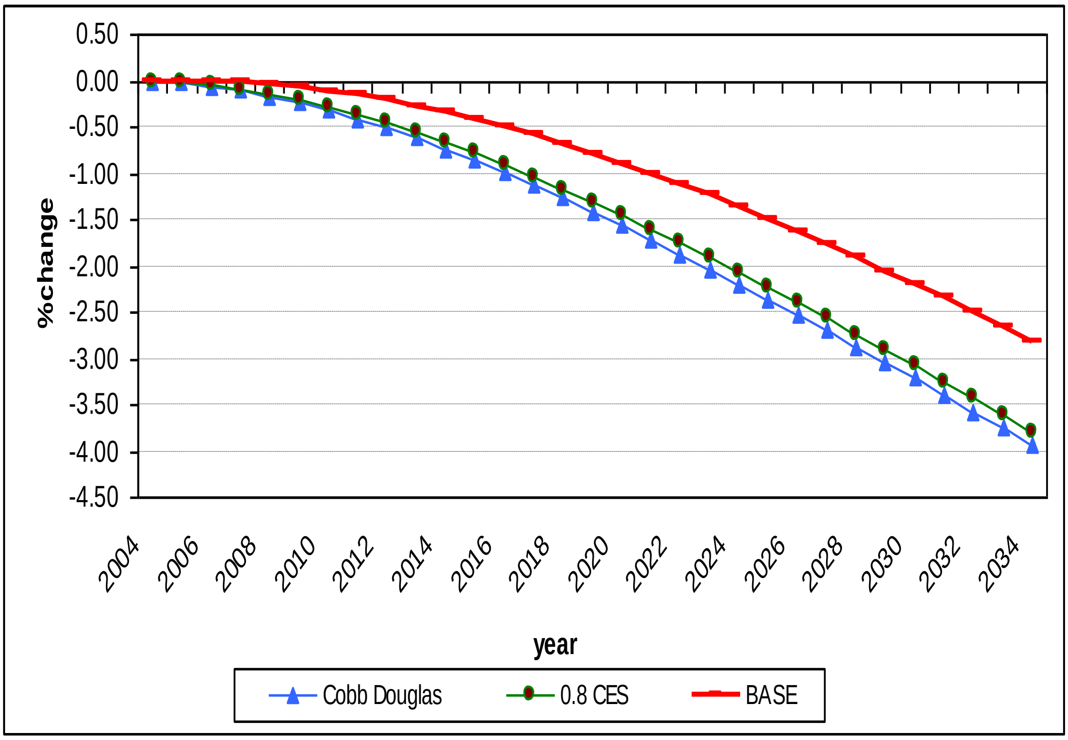


Figure 7 17 Real Wage trends under different values of elasticity of substitution between capital and labour

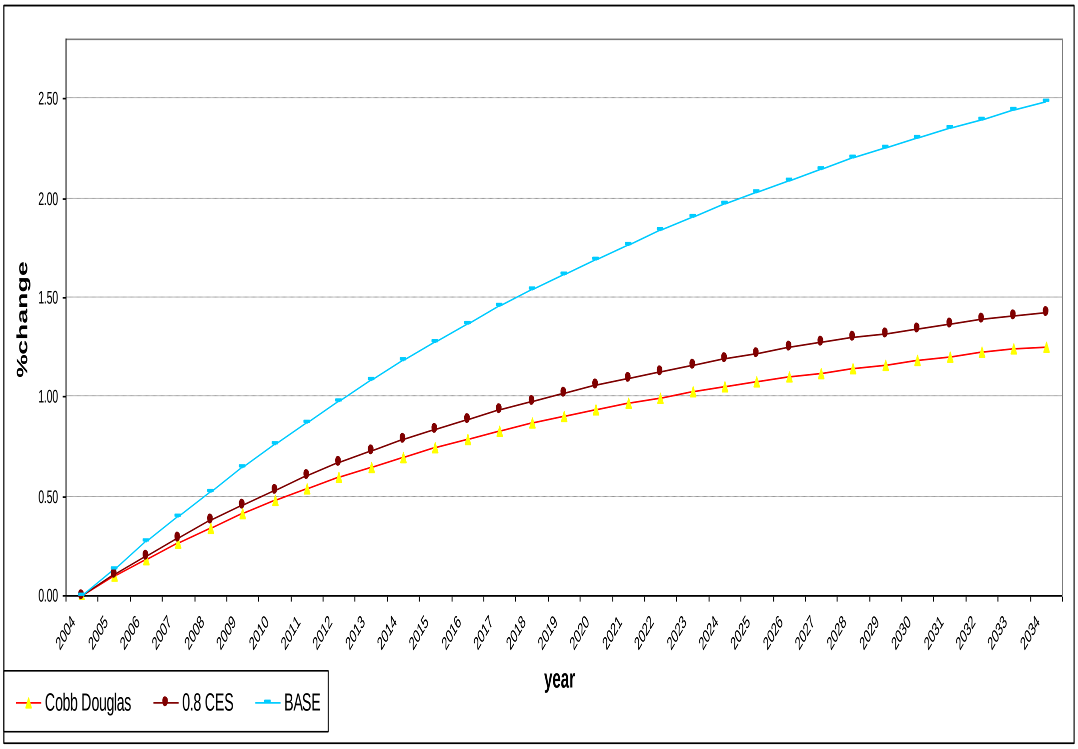


Table 7 4 Main aggregate economic indicators for different values of elasticity of substitution between capital and labour

	2004	2009	2014	2019	2024	2029	2034
Cobb Douglas							
GDP	*0.00*	*-0.24*	*-0.74*	*-1.41*	*-2.19*	*-3.04*	*-3.93*
Real wage	*0.00*	*0.41*	*0.70*	*0.90*	*1.05*	*1.16*	*1.26*
Unemployment	*9.12*	*8.79*	*8.57*	*8.42*	*8.31*	*8.23*	*8.17*
Total employment	*0.00*	*-0.47*	*-1.12*	*-1.90*	*-2.75*	*-3.65*	*-4.58*
Export price index	*0.00*	*0.10*	*0.19*	*0.29*	*0.38*	*0.46*	*0.53*
CPI	*0.00*	*0.08*	*0.17*	*0.28*	*0.38*	*0.48*	*0.56*
0.8 CES							
GDP	*0.00*	*-0.21*	*-0.67*	*-1.31*	*-2.07*	*-2.90*	*-3.79*
Real wage	*0.00*	*0.46*	*0.79*	*1.02*	*1.19*	*1.32*	*1.43*
Unemployment	*9.12*	*8.76*	*8.51*	*8.34*	*8.21*	*8.12*	*8.05*
Total employment	*0.00*	*-0.41*	*-1.01*	*-1.75*	*-2.58*	*-3.46*	*-4.38*
Export price index	*0.00*	*0.10*	*0.19*	*0.28*	*0.36*	*0.44*	*0.51*
CPI	*0.00*	*0.08*	*0.14*	*0.23*	*0.32*	*0.40*	*0.49*
BASE (0.3 CES)							
GDP	*0.00*	*-0.07*	*-0.34*	*-0.79*	*-1.37*	*-2.06*	*-2.82*
Real wage	*0.00*	*0.65*	*1.18*	*1.62*	*1.97*	*2.25*	*2.48*
Unemployment	*9.12*	*8.62*	*8.22*	*7.91*	*7.67*	*7.49*	*7.34*
Total employment	*0.00*	*-0.16*	*-0.52*	*-1.04*	*-1.68*	*-2.42*	*-3.23*
Export price index	*0.00*	*0.09*	*0.16*	*0.21*	*0.26*	*0.31*	*0.35*
CPI	*0.00*	*0.08*	*0.01*	*-0.04*	*-0.07*	*-0.08*	*-0.09*

7.4.3 Different values of elasticities of substitution between local and imported goods (Armington Elasticities)

In this section the results that are generated by imposing different values of elasticities for the substitution of local and foreign produced goods are presented. The results of these sections are important in the sense that in the core of simulations a value of elasticity that is not normally used with the AMOS modelling framework is applied The "common" value of elasticity used is 2. The chosen value here is 8. This is to reflect the fact that the country is considered to be a "price taker" in international markets. Sarris and Zografakis (1999) also applied a high value of Armington elasticities while Ioakimoglou (1999) econometrically estimated that 80% of variation of prices in Greece is attributable to international price changes. The values that I am going to use for this sensitivity analysis exercise are 2, 5 and 8.

In this case the expectation is that the easier it is for firms to substitute local with foreign inputs the more dampening the impact of population ageing will be for the local economy. As the labour market tightens, producing goods locally becomes more expensive and local goods are substituted by imports. The easier this "switch" the worse the news for the local economy's employment and GDP.

Conversely, the wage rate increases by more the lower the substitutability between local and imported goods. When import substitution is difficult firms are more likely to source inputs locally. Finally, it is anticipated that the higher the value of elasticity the less the price of exported goods (inverse of competitiveness) will deviate from zero. In fact imposing elasticity to equal infinity would be equivalent to assuming that the law of one price holds.

Indeed by year 2034, one can observe the following. Employment falls by 2.77% when the value of elasticity is 2, by 3.11% when elasticity is 5 and 3.23% when it is 8. For GDP the corresponding falls are 2.30%, 2.69% and 2.82% respectively. As expected the ranking is again reversed when one looks at the behaviour of real wages and price of exported goods. Hence the corresponding increases of real wage are 2.94%, 2.60% and 2.48% respectively. The figures for competitiveness are 1.12%, 0.53% and 0.35% with the impact of elasticity being even clearer. Again, as before the magnitude of deviations in the results is small and one can claim that the values of these elasticities are not the factors that generate the results.

In the figures 7.14 to 7.17 below I present trajectories of Employment, GDP Real Wage and Price of Exported Goods for these different scenarios. Table 4 shows the main aggregate indicators for every five year period.

Figure 7 18 Employment trends under different values of elasticity of substitution between local and imported goods (Armington Elasticities)

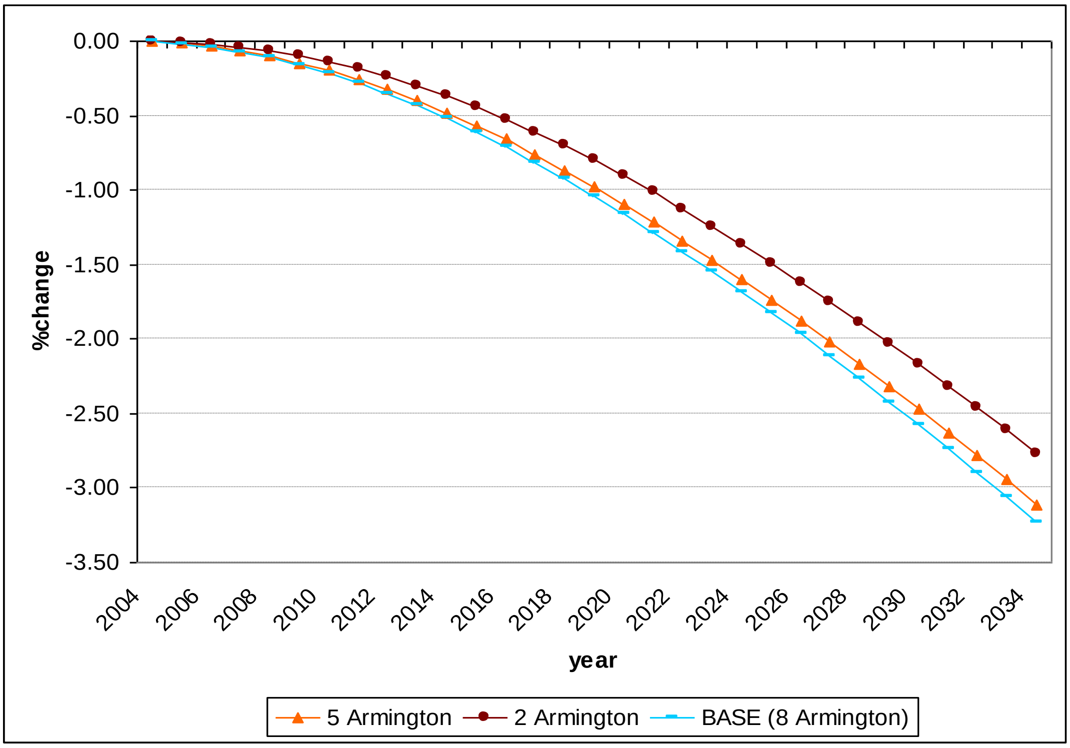


Figure 7 19 GDP trends under different values of elasticity of substitution between local and imported goods

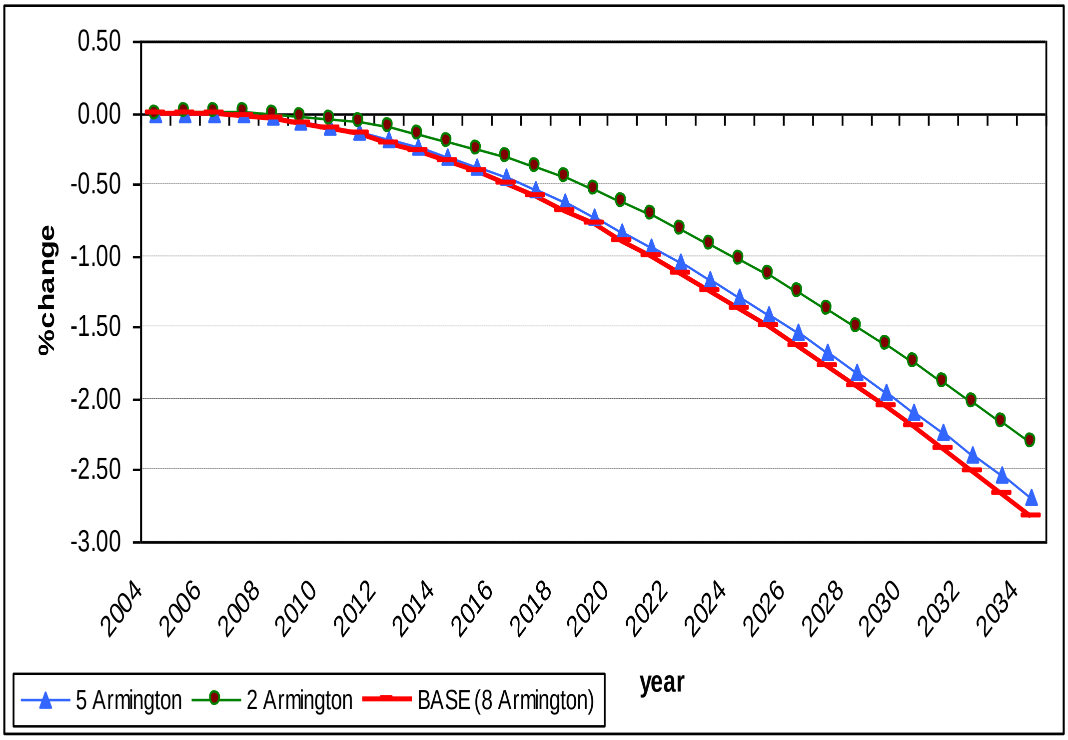


Figure 7 20 Real wage trends under different values of elasticity of substitution between local and imported goods

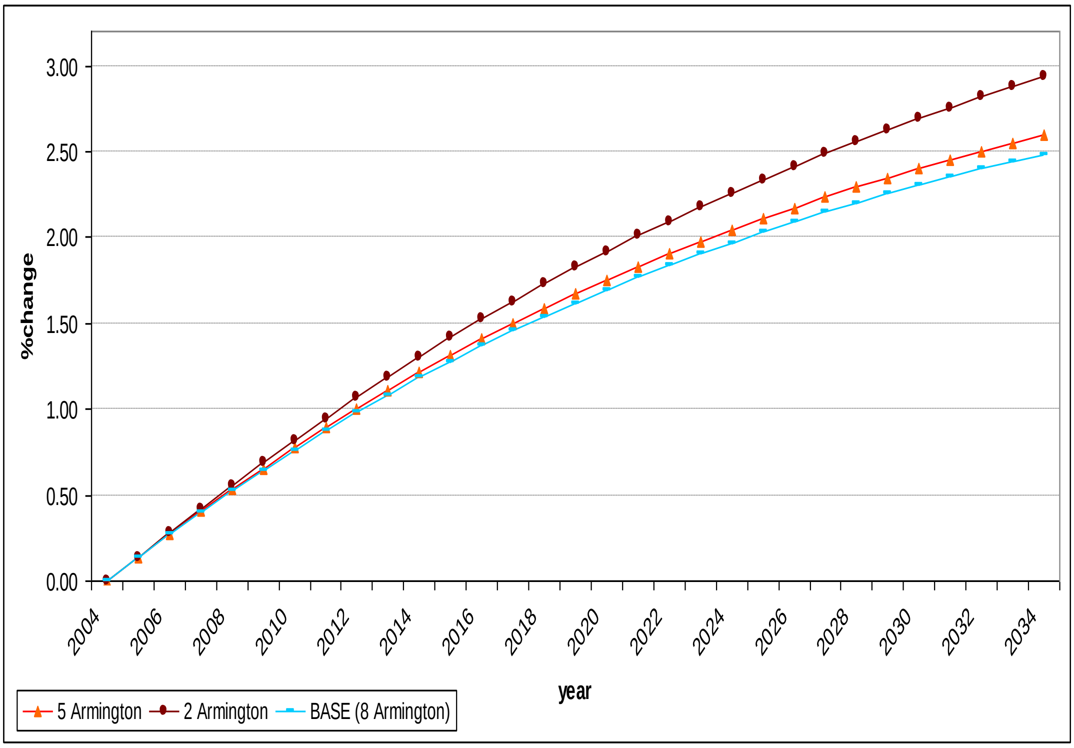


Figure 7 21 Price of exported goods under different values of elasticity of substitution between local and imported goods

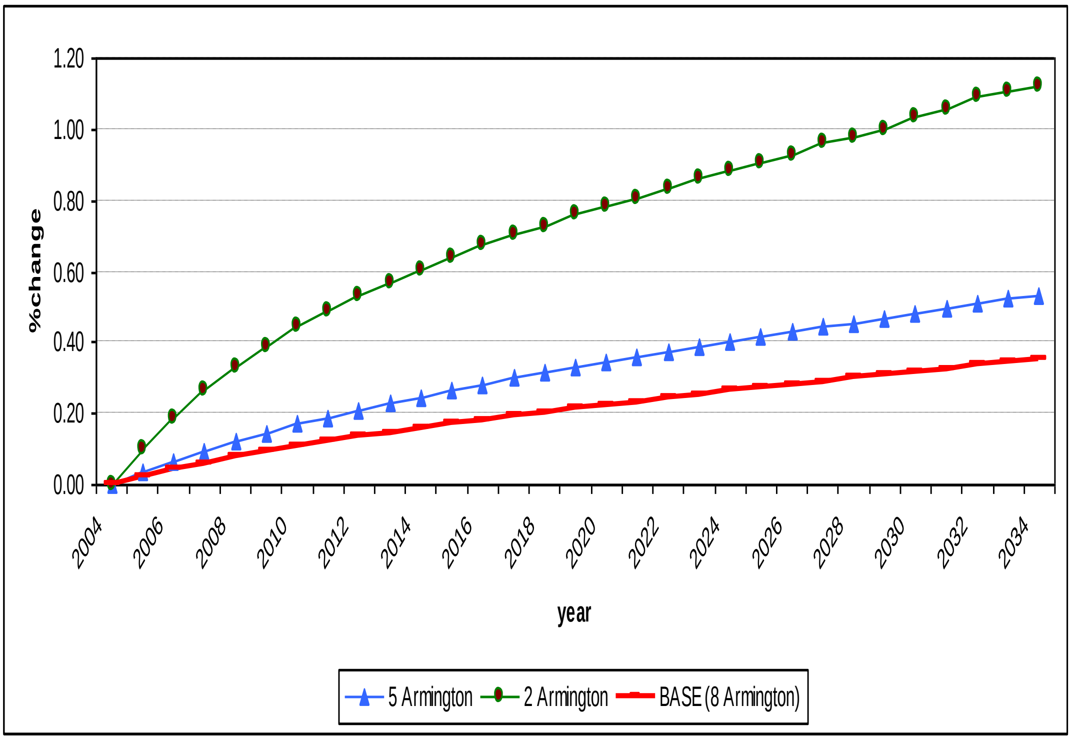


Table 7 5 Main Aggregate Indicators under different values of elasticity of substitution between local and imported goods

	2004	2009	2014	2019	2024	2029	2034
2 Armington							
GDP	0.00	-0.02	-0.19	-0.53	-1.02	-1.62	-2.30
Real wage	0.00	0.69	1.30	1.83	2.26	2.63	2.94
Unemployment	9.12	8.58	8.13	7.77	7.48	7.25	7.06
Total employment	0.00	-0.10	-0.37	-0.80	-1.36	-2.03	-2.77
Export price index	0.00	0.39	0.61	0.76	0.88	1.00	1.12
CPI	0.00	0.61	0.72	0.79	0.85	0.93	1.03
5 Armington							
GDP	0.00	-0.06	-0.30	-0.72	-1.28	-1.94	-2.69
Real wage	0.00	0.66	1.21	1.67	2.04	2.35	2.60
Unemployment	9.12	8.61	8.20	7.88	7.63	7.43	7.27
Total employment	0.00	-0.15	-0.48	-0.98	-1.60	-2.32	-3.11
Export price index	0.00	0.15	0.25	0.33	0.40	0.47	0.53
CPI	0.00	0.18	0.15	0.13	0.13	0.14	0.17
BASE (8 Armington)							
GDP	0.00	-0.07	-0.34	-0.79	-1.37	-2.06	-2.82
Real wage	0.00	0.65	1.18	1.62	1.97	2.25	2.48
Unemployment	9.12	8.62	8.22	7.91	7.67	7.49	7.34
Total employment	0.00	-0.16	-0.52	-1.04	-1.68	-2.42	-3.23
Export price index	0.00	0.09	0.16	0.21	0.26	0.31	0.35
CPI	0.00	0.08	0.01	-0.04	-0.07	-0.08	-0.09

7.5 The Economic Impact of Demographic Variations around the Base ESYE Projections

7.5.1 Introduction

In this section the economic impact of varying the demographic assumptions that underlie the base ESYE projection is examined. We conduct simulations where the modelled fertility, life expectancy and migration conditions differ from those used in the base estimates. This tests the sensitivity of the economic impacts to changes in the forces that are driving demographic change.

The assumptions that underlie the ESYE projections have been extensively discussed previously. The values of the key demographic parameters used in deriving the estimates for the Greek population have been also been presented. These demographic parameters are the fertility rate, the male and female life expectancy rates and the migration rate. For each of these parameters, ESYE uses one value to generate the principal projections, but it also produces alternative high and low values for these same parameters. This procedure has been replicated in the relevant chapter 2, where two of the three relevant parameters are set to their base values, but with the third taking a high or low value.

The table below summarises the combination of assumptions that have been used in each scenario.

Table 7 6 Combination of assumptions for each demographic scenario

Scenario		Fertility	Life expectancy	Migration
1	**Base projection**	Base	Base	Base
2	**High fertility**	High	Base	Base
3	**Low fertility**	Low	Base	Base
4	**High life expectancy**	Base	High	Base
5	**Low life expectancy**	Base	Low	Base
6	**High migration**	Base	Base	High
7	**Low migration**	Base	Base	Low
8	**Natural change only**	Base	Base	Zero

The values that have been used for all parameters in each scenario have also been analytically presented in the chapter 2.

As in the previous section, demographic projections are used in order for the relevant demand- and supply-side exogenous shocks for the economic model to be calculated. The subsequent simulation outputs will shed light on the sensitivity of the economic results for my base projection case to changes in each of the demographic parameters. Later on, a scenario in which migration is zero is examined, so that only natural demographic forces are determining population size and age composition. Natural change refers to changes that occur due to births and deaths with zero net migration.

7.5.2 Impact of varying Life Expectancy assumptions

It has been shown in chapter 2, that when varying the assumptions about life expectancy, the projected working age population exhibits only minor changes.

Therefore the results of the economic model will not show large deviations either. Indeed as shown in Table 6 below the deviations are very small.

Table 7 7 main Aggregate Indicators under different life expectancy assumptions

	2004	*2009*	*2014*	*2019*	*2024*	*2029*	*2034*
Low Life Expectancy							
GDP	*0.00*	*-0.18*	*-0.53*	*-1.01*	*-1.59*	*-2.26*	*-2.99*
Real wage	*0.00*	*0.58*	*1.08*	*1.51*	*1.89*	*2.23*	*2.54*
Unemployment	*9.12*	*8.66*	*8.30*	*7.99*	*7.73*	*7.50*	*7.31*
Total employment	*0.00*	*-0.28*	*-0.73*	*-1.29*	*-1.94*	*-2.66*	*-3.43*
Export price index	*0.00*	*-0.02*	*0.00*	*0.05*	*0.12*	*0.21*	*0.32*
CPI	*0.00*	*-0.28*	*-0.32*	*-0.31*	*-0.24*	*-0.13*	*0.01*
High Life Expectancy							
GDP	*0.00*	*-0.06*	*-0.29*	*-0.70*	*-1.23*	*-1.87*	*-2.57*
Real wage	*0.00*	*0.62*	*1.15*	*1.57*	*1.92*	*2.21*	*2.45*
Unemployment	*9.12*	*8.63*	*8.25*	*7.94*	*7.71*	*7.52*	*7.36*
Total employment	*0.00*	*-0.14*	*-0.46*	*-0.93*	*-1.52*	*-2.20*	*-2.95*
Export price index	*0.00*	*0.10*	*0.18*	*0.25*	*0.31*	*0.37*	*0.43*
CPI	*0.00*	*0.13*	*0.09*	*0.07*	*0.06*	*0.08*	*0.12*
BASE							
GDP	*0.00*	*-0.07*	*-0.34*	*-0.79*	*-1.37*	*-2.06*	*-2.82*
Real wage	*0.00*	*0.65*	*1.18*	*1.62*	*1.97*	*2.25*	*2.48*
Unemployment	*9.12*	*8.62*	*8.22*	*7.91*	*7.67*	*7.49*	*7.34*
Total employment	*0.00*	*-0.16*	*-0.52*	*-1.04*	*-1.68*	*-2.42*	*-3.23*
Export price index	*0.00*	*0.09*	*0.16*	*0.21*	*0.26*	*0.31*	*0.35*
CPI	*0.00*	*0.08*	*0.01*	*-0.04*	*-0.07*	*-0.08*	*-0.09*

One can observe that GDP falls by less when life expectancy is higher. In particular under low life expectancy it falls by 2.99%, under high life expectancy it falls by 2.57% while in the base scenario it falls by 2.82%. This result stems from the fact that under higher life expectancy the projected total population is higher and hence the demand shock introduced is also higher. The same pattern applies for the results on employment with the corresponding figures being -3.43%, -2.95%, -3.23%. Prices -as expected- exhibit reversed ranking but nevertheless the discrepancies are very small. The figures that correspond to real wage changes (increases) are 2.54%, 2.45% and 2.48%. The price of exported goods rises under all scenarios with the ranking matching the ranking of demand shocks in each scenario. CPI changes are small and have been discussed above.

The figures 15-19 below present trajectories of the main aggregate indicators under the three scenarios.

Figure 7 22 Employment trends under different assumptions for life expectancy

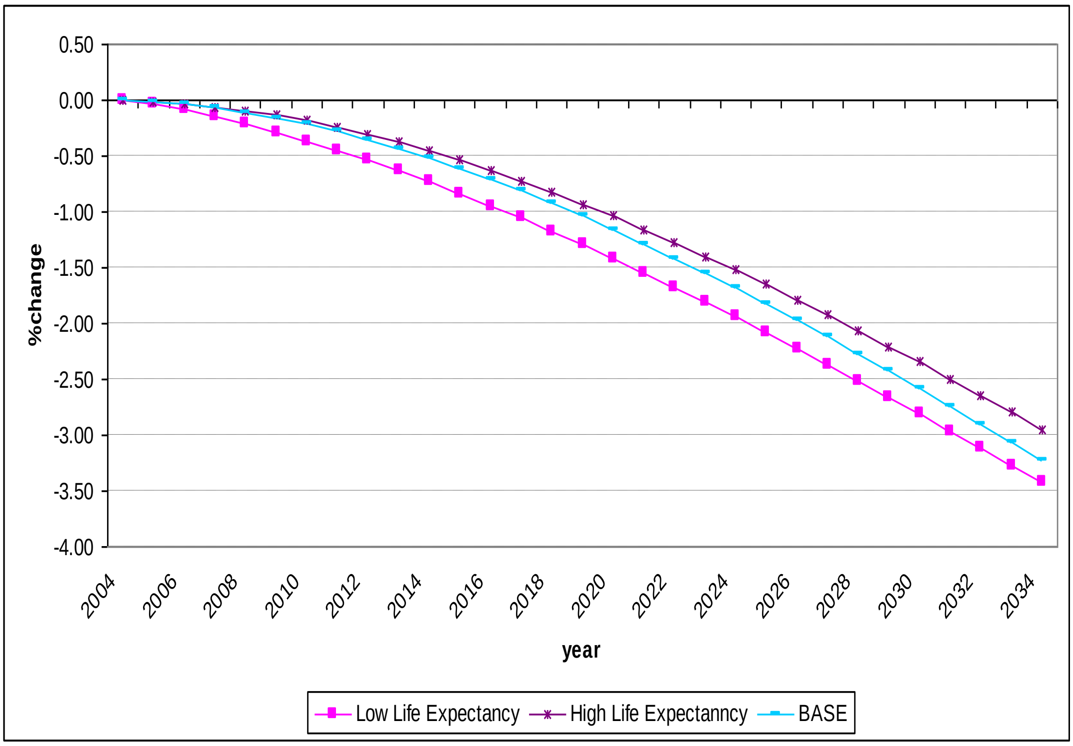


Figure 7 23 GDP trends under different assumptions for life expectancy

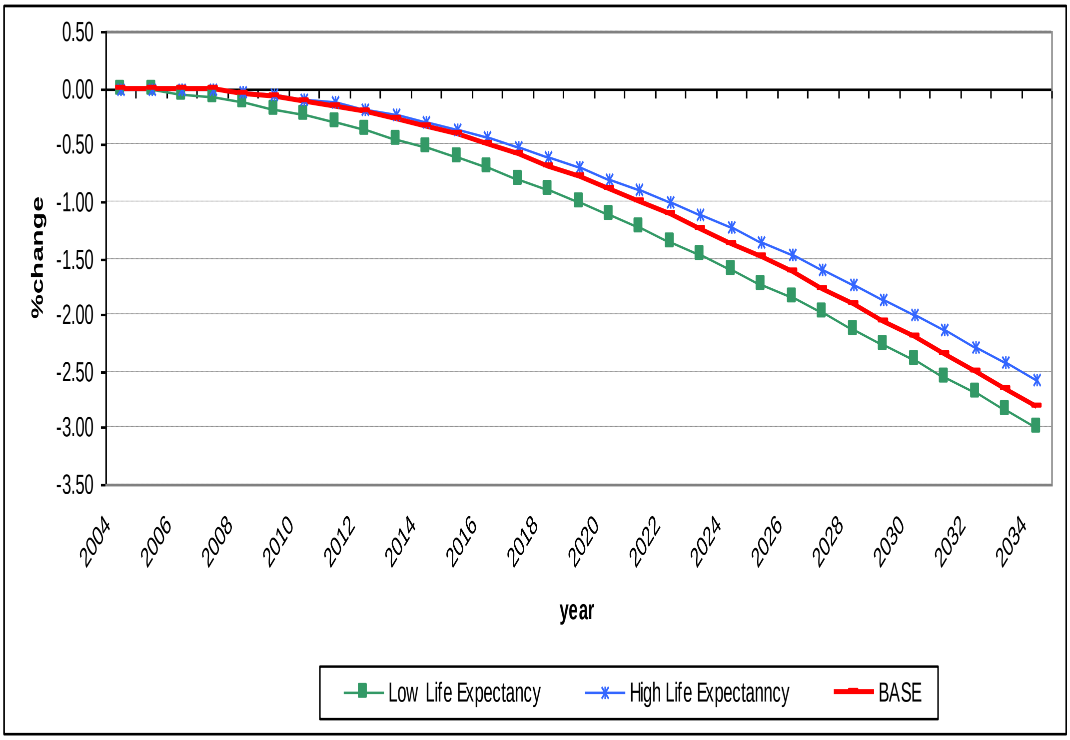


Figure 7 24 Price of exported goods under different assumptions for life expectancy

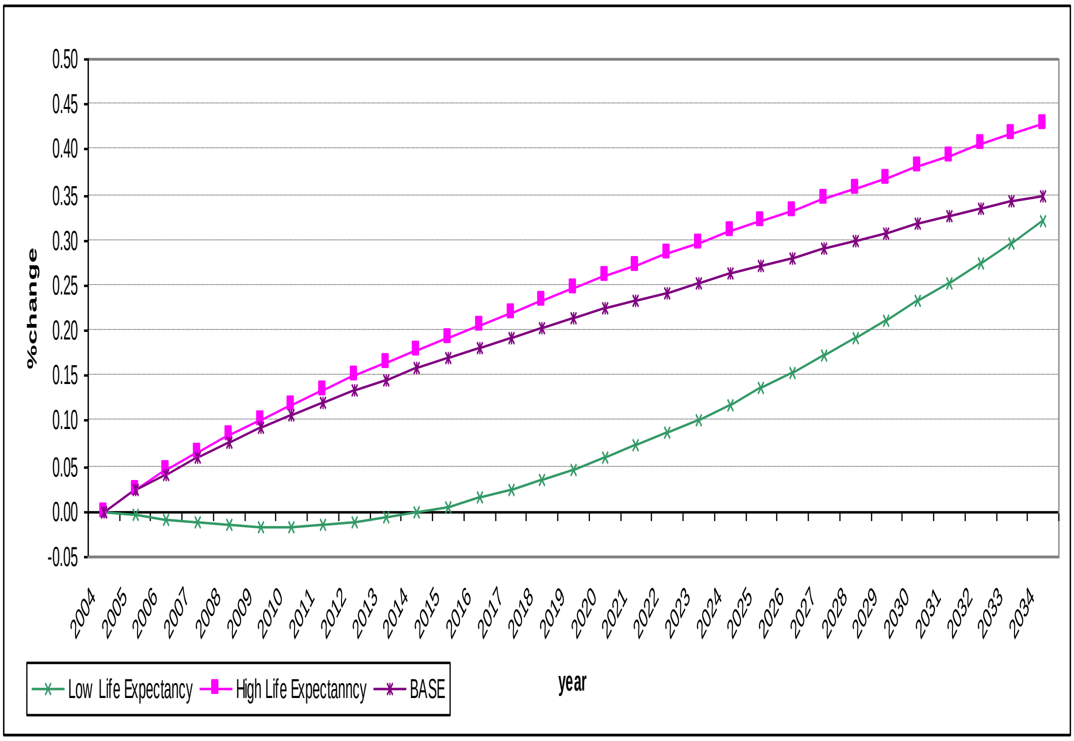
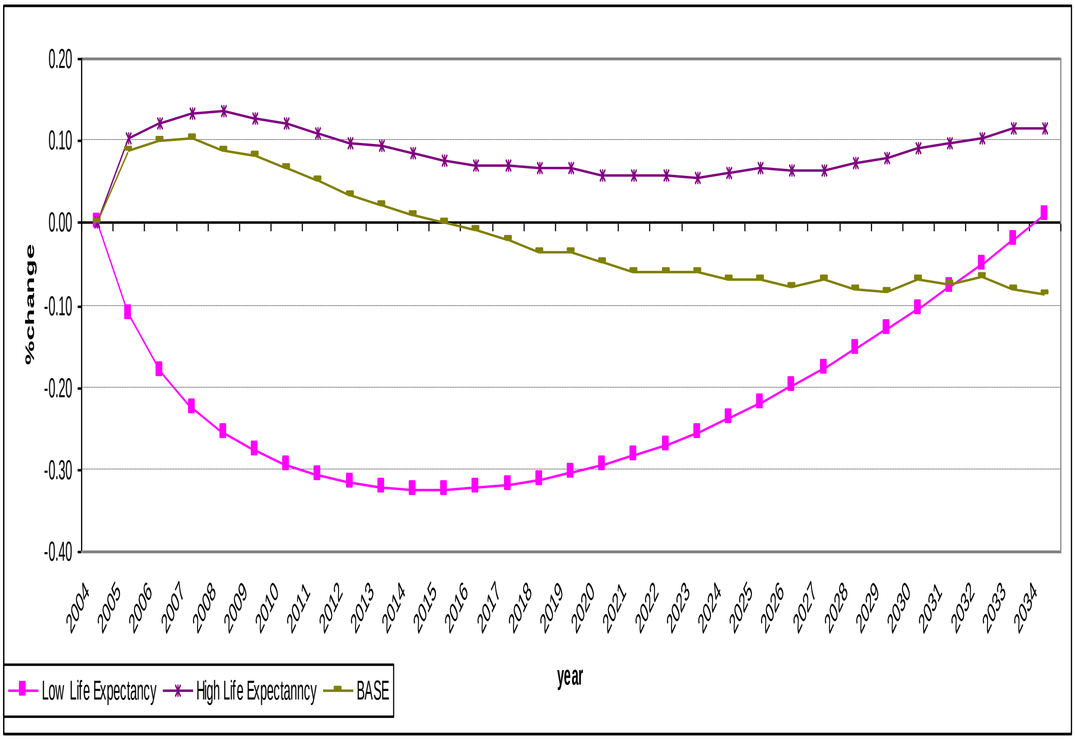


Figure 7 25 CPI under different assumptions for life expectancy



7.5.3 Impact of varying Fertility assumptions

Again the demographic projections that involve varying the fertility rates have been extensively analysed in the relevant section. The projected total and working age population does not change by a lot in the initial years while the difference becomes greater as the time passes. The projections have been discussed in paragraph 2.5.3 earlier on. Table 7.8 below summarises the trends of the main aggregate indicators.

Table 7 8 Main Aggregate Indicators under different fertility assumptions

Low Fertility	**2004**	**2009**	**2014**	**2019**	**2024**	**2029**	**2034**
GDP	*0.00*	*-0.11*	*-0.47*	*-1.03*	*-1.75*	*-2.60*	*-3.55*
Real wage	*0.00*	*0.74*	*1.35*	*1.84*	*2.24*	*2.54*	*2.78*
Unemployment	*9.12*	*8.54*	*8.10*	*7.76*	*7.50*	*7.30*	*7.15*
Total employment	*0.00*	*-0.22*	*-0.69*	*-1.35*	*-2.15*	*-3.06*	*-4.06*
Export price index	*0.00*	*0.08*	*0.13*	*0.16*	*0.19*	*0.22*	*0.23*
CPI	*0.00*	*-0.01*	*-0.15*	*-0.26*	*-0.30*	*-0.38*	*-0.45*
High Fertility							
GDP	*0.00*	*-0.02*	*-0.19*	*-0.50*	*-0.91*	*-1.40*	*-1.94*
Real wage	*0.00*	*0.54*	*0.99*	*1.36*	*1.68*	*1.94*	*2.17*
Unemployment	*9.12*	*8.70*	*8.36*	*8.09*	*7.87*	*7.69*	*7.54*
Total employment	*0.00*	*-0.09*	*-0.32*	*-0.68*	*-1.13*	*-1.66*	*-2.23*
Export price index	*0.00*	*0.11*	*0.20*	*0.28*	*0.36*	*0.44*	*0.52*
CPI	*0.00*	*0.19*	*0.20*	*0.21*	*0.28*	*0.32*	*0.42*
BASE							
GDP	*0.00*	*-0.07*	*-0.34*	*-0.79*	*-1.37*	*-2.06*	*-2.82*
Real wage	*0.00*	*0.65*	*1.18*	*1.62*	*1.97*	*2.25*	*2.48*
Unemployment	*9.12*	*8.62*	*8.22*	*7.91*	*7.67*	*7.49*	*7.34*
Total employment	*0.00*	*-0.16*	*-0.52*	*-1.04*	*-1.68*	*-2.42*	*-3.23*
Export price index	*0.00*	*0.09*	*0.16*	*0.21*	*0.26*	*0.31*	*0.35*
CPI	*0.00*	*0.08*	*0.01*	*-0.04*	*-0.07*	*-0.08*	*-0.09*

In this case the variation in GDP is greater than in the case of varying life expectancy. As expected, high fertility mitigates the impact of ageing and as it generates a higher total population and higher (than base) working age population with a lag of 16 years. The GDP fall by 2034 is 1.94% for high fertility, -3.55% for low fertility and -2.82% for the base scenario which lies in between the two results as it should. The corresponding figures for employment are -2.23%, -4.06% and -3.23%. Real wage increases by 2.17% for high fertility, 2.78% for low fertility and 2.48% for the base scenario. The price of exported goods tells a similar story. The corresponding changes by 2034 are 0.52%, 0.23% and 0.35%.

Notice that the further we are from 2004 the wider the discrepancy of results. The results are consistent with expectations, in that a higher fertility rate tends to limit the problem of the ageing population and eases the pressure on the labour market and the economy overall. However, a key point is that even in the high fertility scenario, population change has a depressing effect on the Greek economy over the period 2004-2034.

Care must be taken in interpreting the period-by-period adjustment over time. In initial periods there will be no labour supply impact as a result of the changing fertility: only very small demand side effects will be operating. These are coming through government expenditure's being linked to total population. However, because we linearise the effect of population on the labour force, a small supply-side effect is modelled as applying right from the start. Again the 2034 result should be sound but the deviation from the principal results will be overestimated in the early period of this simulation.

Here, the sensitivity of the results is higher than in the case of varying life expectancy. In this case there is an direct impact upon the total population and an impact upon working age population after some time. In figures 7.22 to 7.25 the trajectories of the main aggregate indicators are presented.

Figure 7 26 Employment trends under different assumptions for fertility

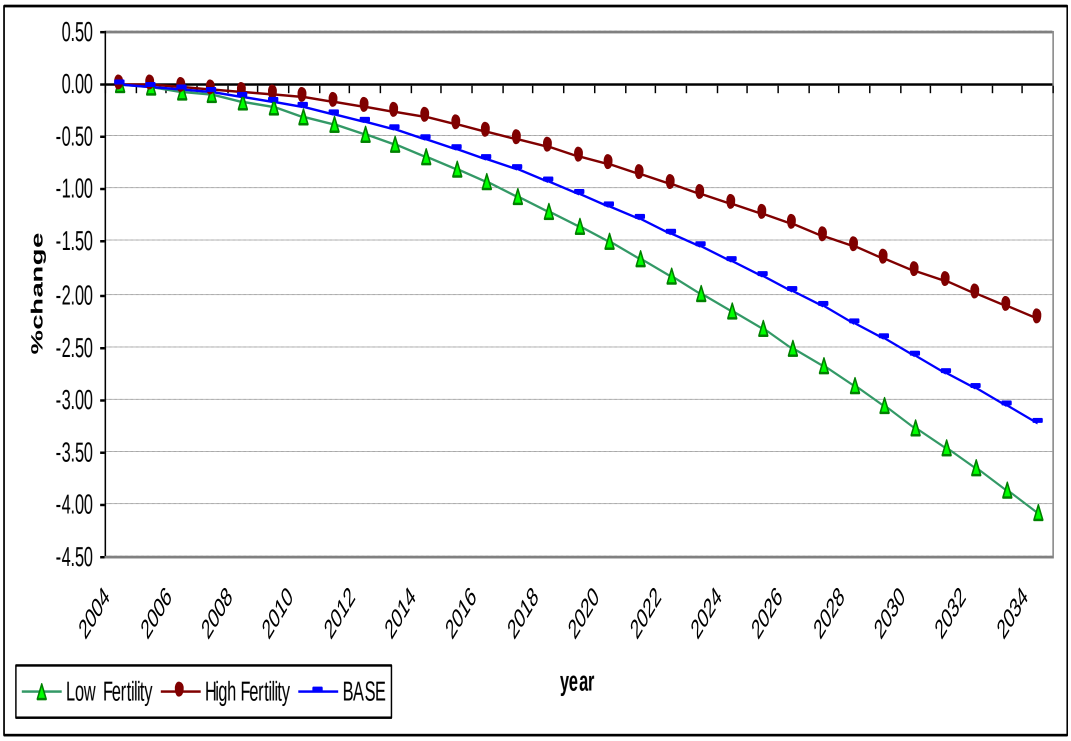


Figure 7 27 GDP trends under different assumptions for fertility

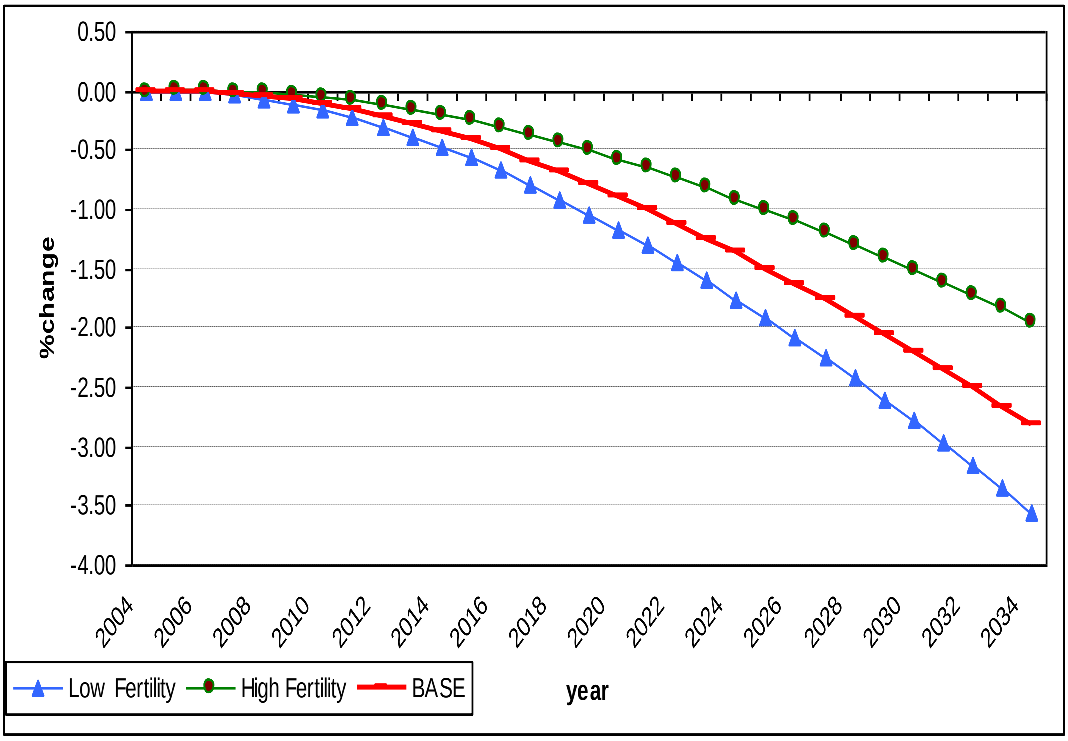


Figure 7 28 Price of exported goods under different assumptions for fertility

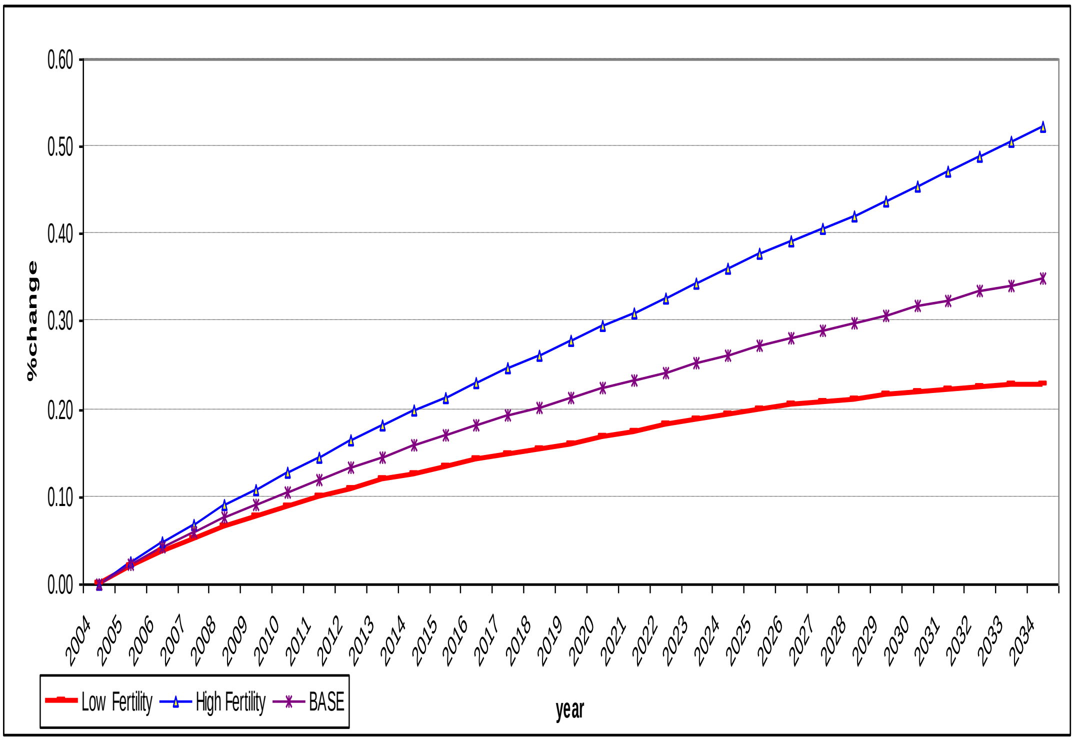
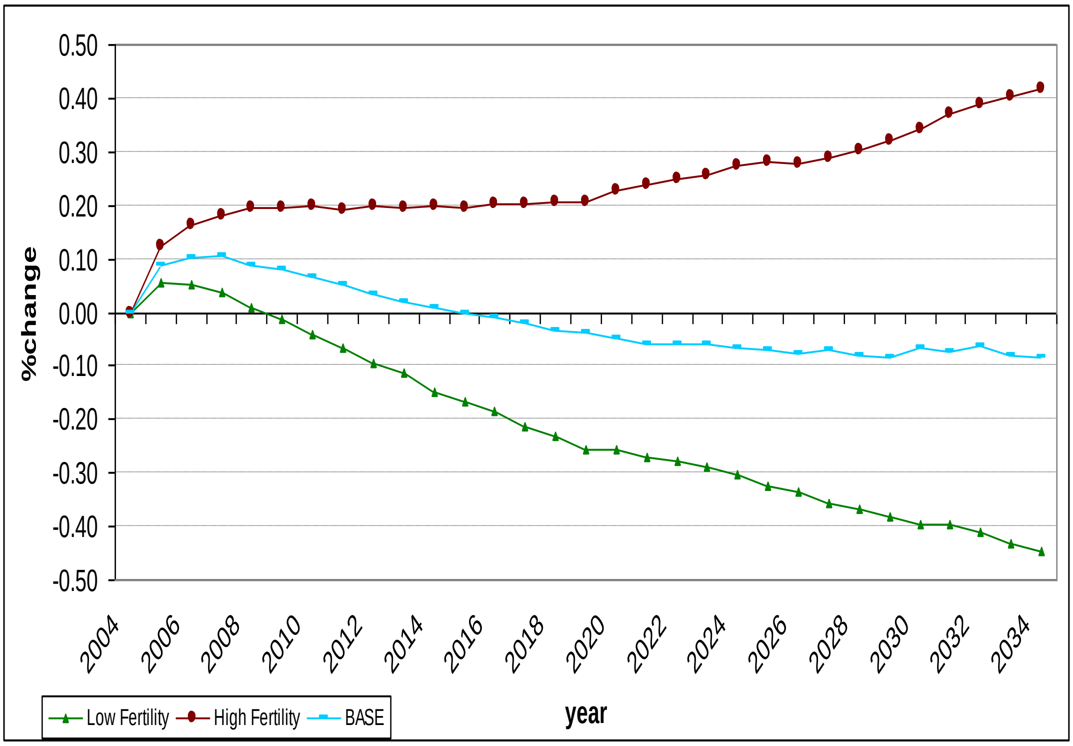


Figure 7 29 CPI under different assumptions for fertility



7.5.4 Impact of varying net-migration assumption

In order to complete the demographic sensitivity exercise the impact of varying the migration assumptions is identified. It is immediately apparent that this generates much greater variation in GDP. This is consistent with our expectations, as the labour market impacts of changes in migration will occur much more rapidly than those associated with changes in the other two demographic parameters. Therefore when we adopt the low value for migration (20,000 positive net migration GDP is expected to decrease by 6.86% by 2034. However, with high in-migration (of 60,000 net-migrants *per annum*) GDP is projected to rise up to 0.88% above its initial level equilibrium. Table 8 below summarises the results for low and high migration scenarios. Again, the base scenario is included.

Table 7 9 Main Aggregate Indicators under different net migration assumptions

	2004	*2009*	*2014*	*2019*	*2024*	*2029*	*2034*
High Migration							
GDP	*0.00*	*0.18*	*0.37*	*0.53*	*0.67*	*0.78*	*0.88*
Real wage	*0.00*	*0.08*	*0.16*	*0.21*	*0.23*	*0.24*	*0.24*
Unemployment	*9.12*	*9.06*	*9.00*	*8.96*	*8.94*	*8.93*	*8.93*
Total employment	*0.00*	*0.22*	*0.44*	*0.62*	*0.77*	*0.90*	*1.01*
Export price index	*0.00*	*0.18*	*0.31*	*0.39*	*0.44*	*0.47*	*0.48*
CPI	*0.00*	*0.64*	*0.75*	*0.80*	*0.81*	*0.81*	*0.78*
BASE							
GDP	*0.00*	*-0.07*	*-0.34*	*-0.79*	*-1.37*	*-2.06*	*-2.82*
Real wage	*0.00*	*0.65*	*1.18*	*1.62*	*1.97*	*2.25*	*2.48*
Unemployment	*9.12*	*8.62*	*8.22*	*7.91*	*7.67*	*7.49*	*7.34*
Total employment	*0.00*	*-0.16*	*-0.52*	*-1.04*	*-1.68*	*-2.42*	*-3.23*
Export price index	*0.00*	*0.09*	*0.16*	*0.21*	*0.26*	*0.31*	*0.35*
CPI	*0.00*	*0.08*	*0.01*	*-0.04*	*-0.07*	*-0.08*	*-0.09*
Low Migration							
GDP	*0.00*	*-0.34*	*-1.10*	*-2.20*	*-3.58*	*-5.15*	*-6.86*
Real wage	*0.00*	*1.24*	*2.31*	*3.23*	*4.02*	*4.69*	*5.28*
Unemployment	*9.12*	*8.18*	*7.45*	*6.88*	*6.44*	*6.08*	*5.79*
Total employment	*0.00*	*-0.56*	*-1.54*	*-2.83*	*-4.35*	*-6.05*	*-7.87*
Export price index	*0.00*	*0.00*	*0.02*	*0.06*	*0.12*	*0.20*	*0.29*
CPI	*0.00*	*-0.47*	*-0.70*	*-0.83*	*-0.88*	*-0.87*	*-0.82*

The first thing to notice is that the range of results is much wider than any of the above cases. Employment ends up being 1.01% above equilibrium by 2034 with high migration and -7.87% under low migration. Under the base scenario there is a decrease of -3.23%. The impact of migration upon the labour market is apparent. The tightening of the labour market which is expected to occur due to ageing is practically eliminated in the scenario of 60,000 annual net-migration. Real wage increases by only 0.24% and the price of exported goods by 0.48% while CPI goes up by 0.78%. Figures 7.26 to 7.29 below illustrate clearly that migration is the demographic parameter that has the largest impact upon the economy. This result has additional importance as net migration is a direct policy parameter in the case of Greece. Therefore in the next section I will further explore the impact of more net-migration scenarios.

Figure 7 30 Employment trends under different scenarios for annual net- migration

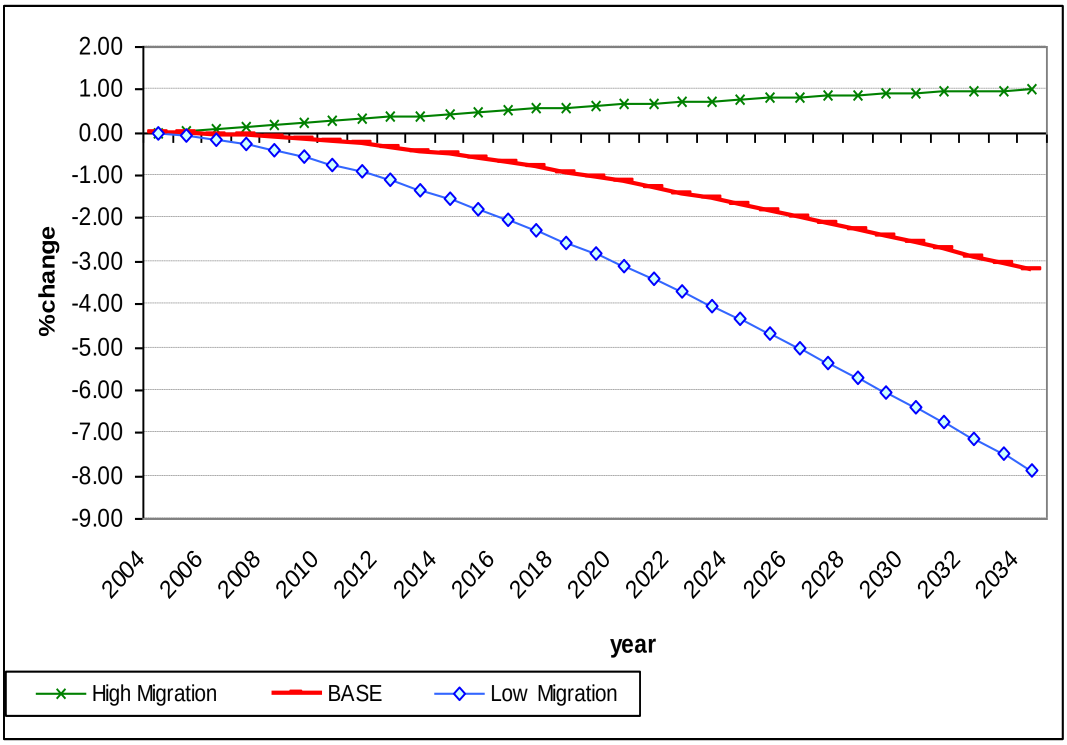


Figure 7 31 GDP trends under different scenarios for annual net- migration

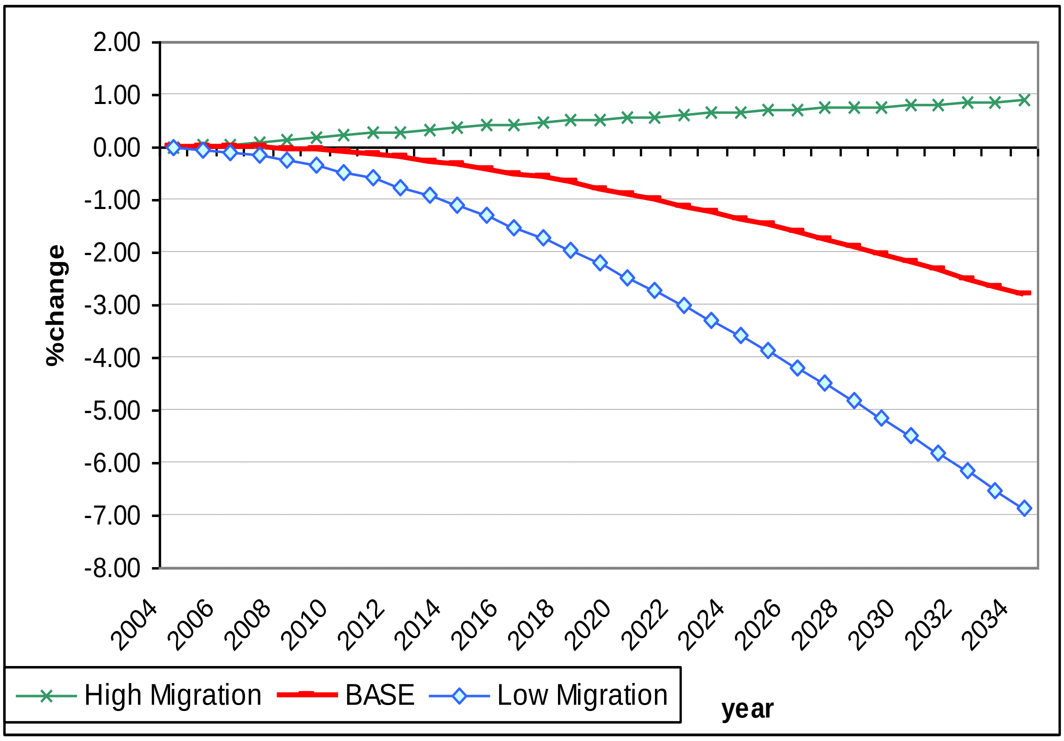


Figure 7 32 Real wage under different scenarios for annual net-migration

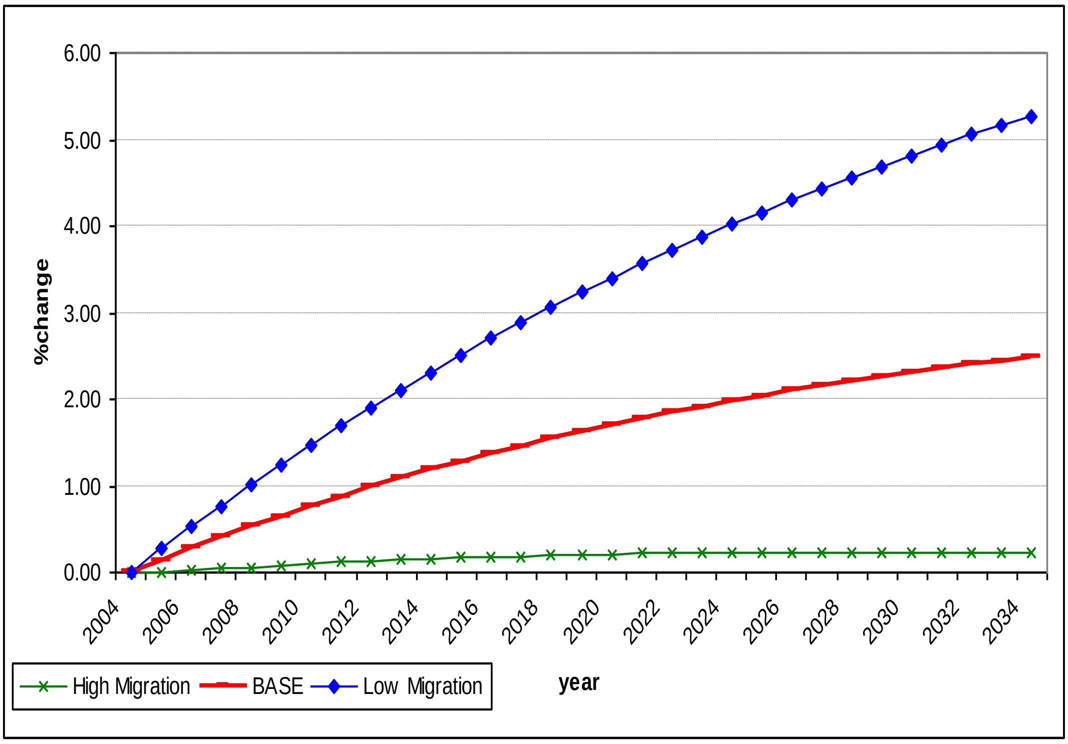


Figure 7 33 CPI under different scenarios for annual net-migration

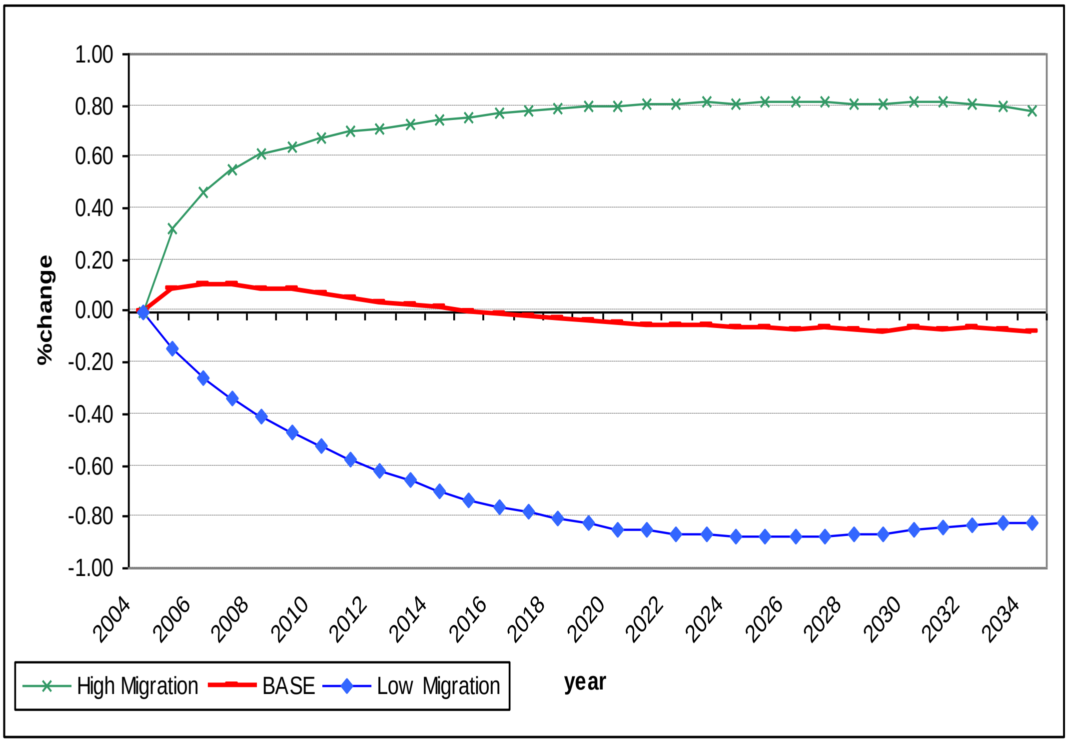
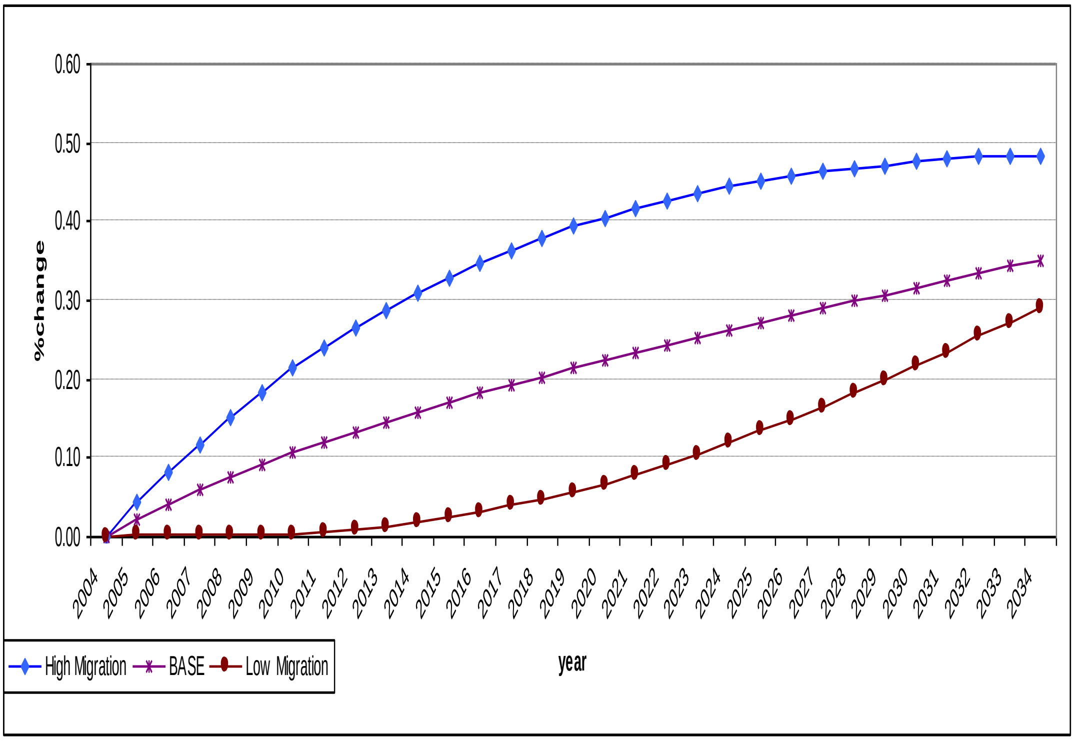


Figure 7 34 Price of exported goods under different scenarios for annual net-migration



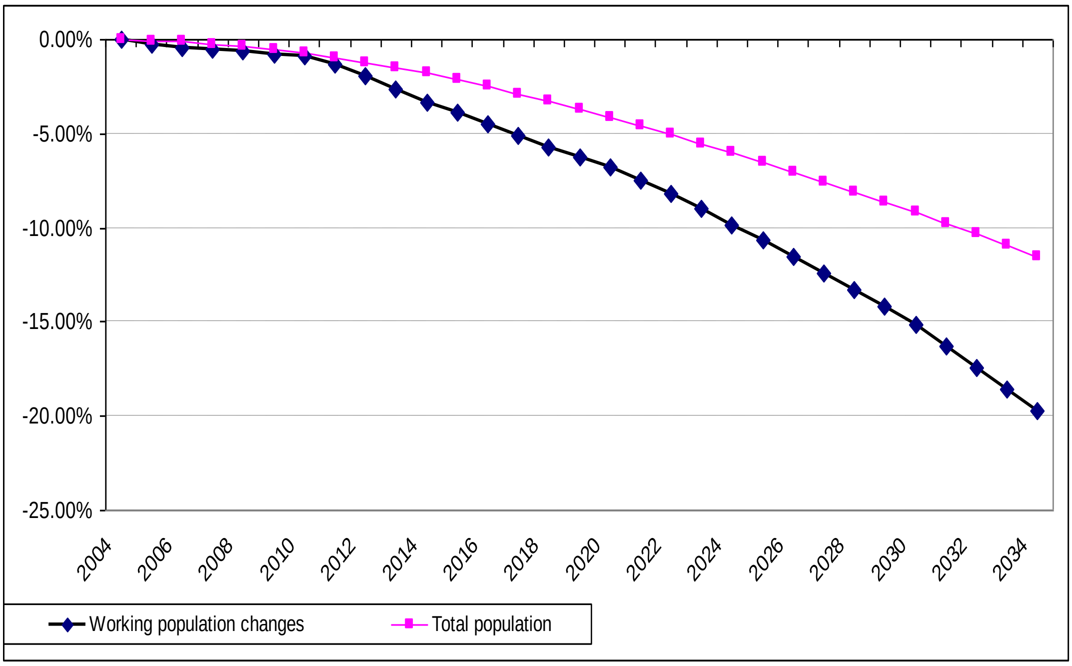
7.5.5 More migration scenarios

In the light of the results of the previous section further population projections by involving greater variations of the annual net-migration assumption have been generated. The scenarios examined assume that fertility and mortality take the values that underlie the base scenario while net migration is assumed to take in turn the values of zero, eighty thousand and one hundred thousand.

The zero net-migration scenario assumes that only the natural change is fed into the population stock and that the channel of migration is completely switched off. In this case, there is a decrease of the total population and an even more rapid decrease of working age population. By 2034 total population is projected to be

11.5% below the 2004 while working age population is decreased by 19.76%. The figure below presents the trajectories of the two variables.

Figure 7 35 Total and working age population percentage changes under zero annual net-migration



The above figure in conjunction with our modelling strategy, implies that there a negative demand as well as a negative supply shock. The expectation is that GDP and employment would fall by even more than in the scenarios analysed in the previous sections.

For the scenarios that involve an assumption of 80,000 and 100,000 annual net migration the expectation is that both employment and GDP will increase with the ranking of impacts to reflect the size of the assumed annual net-migration. Total population increases by 12.62% and 18.65%, while working age population increases by 7.50% and 14.31% respectively. The two figures below show the relevant trends.

Figure 7 36 Total and working age population percentage changes under eighty thousend annual net-migration

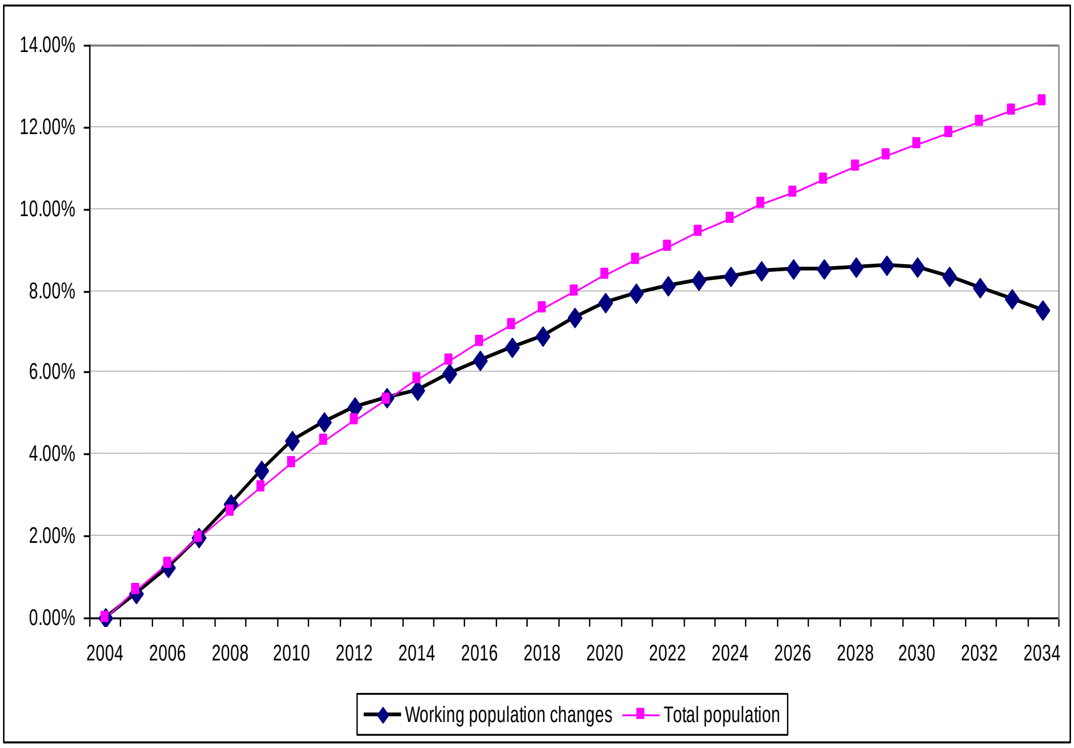
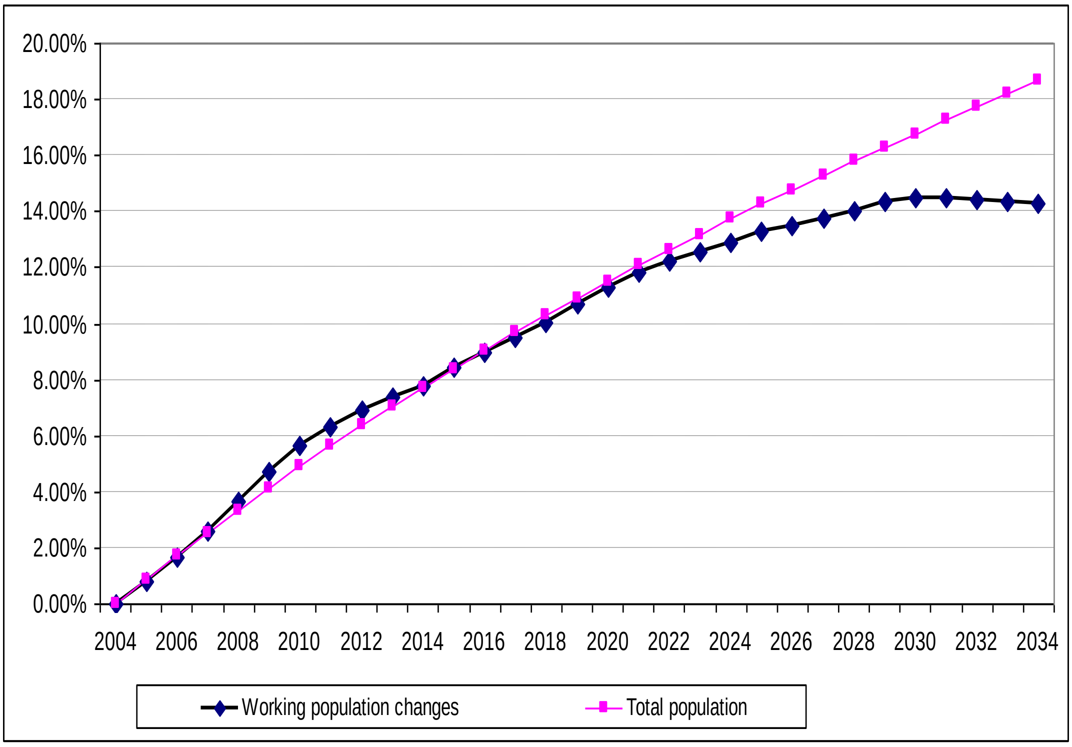


Figure 7 37 Total and working age population percentage changes under one hundred thousand annual net-migration



The economic impacts of results are the ones one would expect with GDP increasing in the high migration scenarios and falling under the natural change scenario. Table 7.9 below shows the values of the main aggregate indicators for the three scenarios.

Table 7 10 Main aggregate indicators under the assumption of zero annual net-migration

	2004	2009	2014	2019	2024	2029	2034
Zero							
Gross Domestic Product	*0.00*	*-0.61*	*-1.90*	*-3.74*	*-5.98*	*-8.54*	*-11.33*
Real wage	*0.00*	*1.88*	*3.57*	*5.10*	*6.47*	*7.70*	*8.83*
Unemployment	*9.12*	*7.74*	*6.68*	*5.87*	*5.24*	*4.73*	*4.31*
Total employment	*0.00*	*-0.98*	*-2.63*	*-4.77*	*-7.27*	*-10.04*	*-12.99*
Export price index	*0.00*	*-0.09*	*-0.11*	*-0.07*	*0.02*	*0.15*	*0.32*
CPI	*0.00*	*-1.01*	*-1.38*	*-1.56*	*-1.60*	*-1.52*	*-1.37*
Eighty							
GDP	*0.00*	*0.43*	*1.05*	*1.77*	*2.56*	*3.41*	*4.31*
Real wage	*0.00*	*-0.46*	*-0.78*	*-1.04*	*-1.26*	*-1.45*	*-1.61*
Unemployment	*9.12*	*9.50*	*9.77*	*10.00*	*10.20*	*10.37*	*10.52*
Total employment	*0.00*	*0.59*	*1.35*	*2.18*	*3.05*	*3.97*	*4.92*
Export price index	*0.00*	*0.28*	*0.47*	*0.60*	*0.66*	*0.69*	*0.68*
CPI	*0.00*	*1.23*	*1.51*	*1.67*	*1.76*	*1.78*	*1.76*
Hundred							
GDP	*0.00*	*0.66*	*1.69*	*2.93*	*4.33*	*5.86*	*7.49*
Real wage	*0.00*	*-0.97*	*-1.63*	*-2.14*	*-2.54*	*-2.86*	*-3.13*
Unemployment	*9.12*	*9.94*	*10.55*	*11.05*	*11.45*	*11.79*	*12.08*
Total employment	*0.00*	*0.94*	*2.20*	*3.63*	*5.17*	*6.82*	*8.54*
Export price index	*0.00*	*0.38*	*0.65*	*0.82*	*0.92*	*0.95*	*0.95*
CPI	*0.00*	*1.81*	*2.29*	*2.60*	*2.76*	*2.83*	*2.82*

The tightening of the labour market is apparent and quite significant in the case of zero migration as the real wage increases by 8.83% while unemployment is more than halved. The price of exported goods increases by 0.32%. CPI moves initially to the negative and then it starts moving upwards again. The figures below show the relevant trajectories. On the other hand, with 80,000 and 100,000 annual net migration GDP increases by 4.31% and 7.49%, and Employment by 4.92% and 8.54% respectively. Notice that very high levels of migration start having negative impacts upon the real wage. The figures below show the path of the aggregate indicators for the above scenarios.

Figure 7 38 Employment trends under different net-migration scenarios

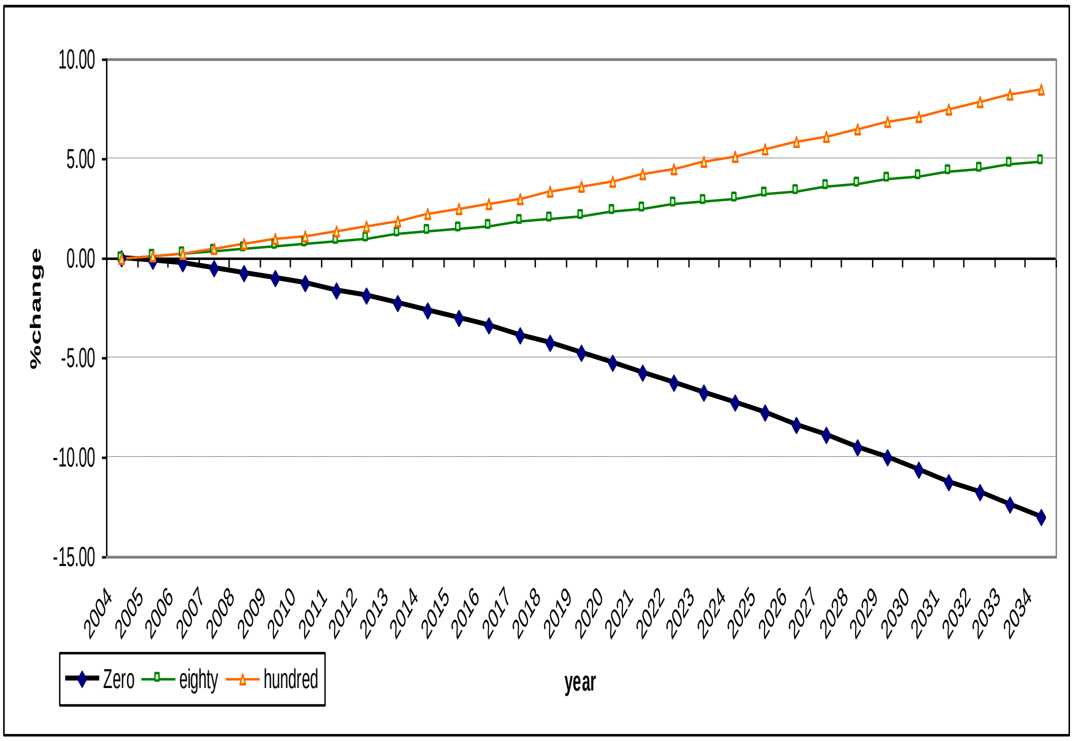


Figure 7 39 GDP trends under different net-migration scenarios

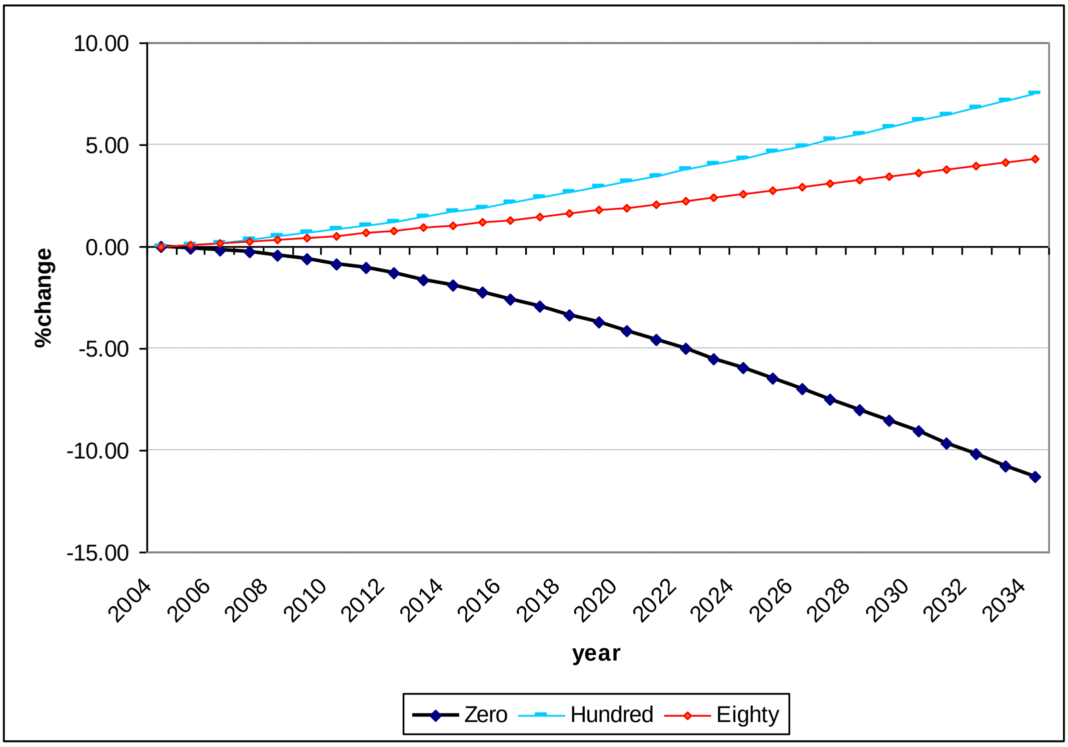
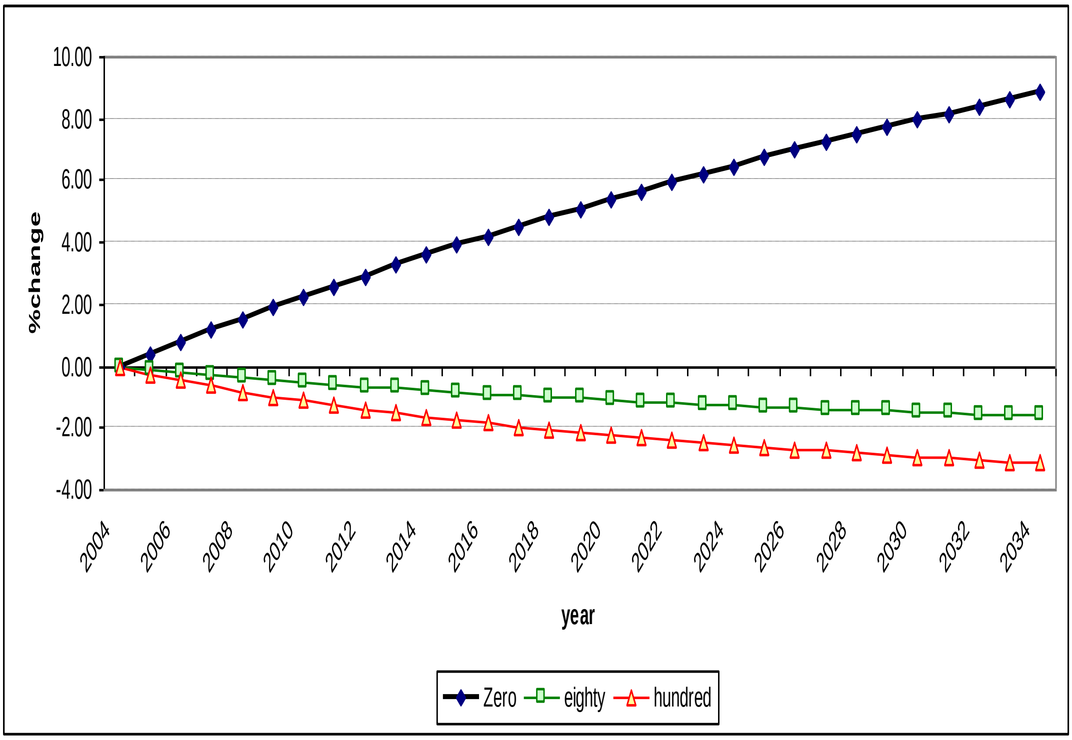


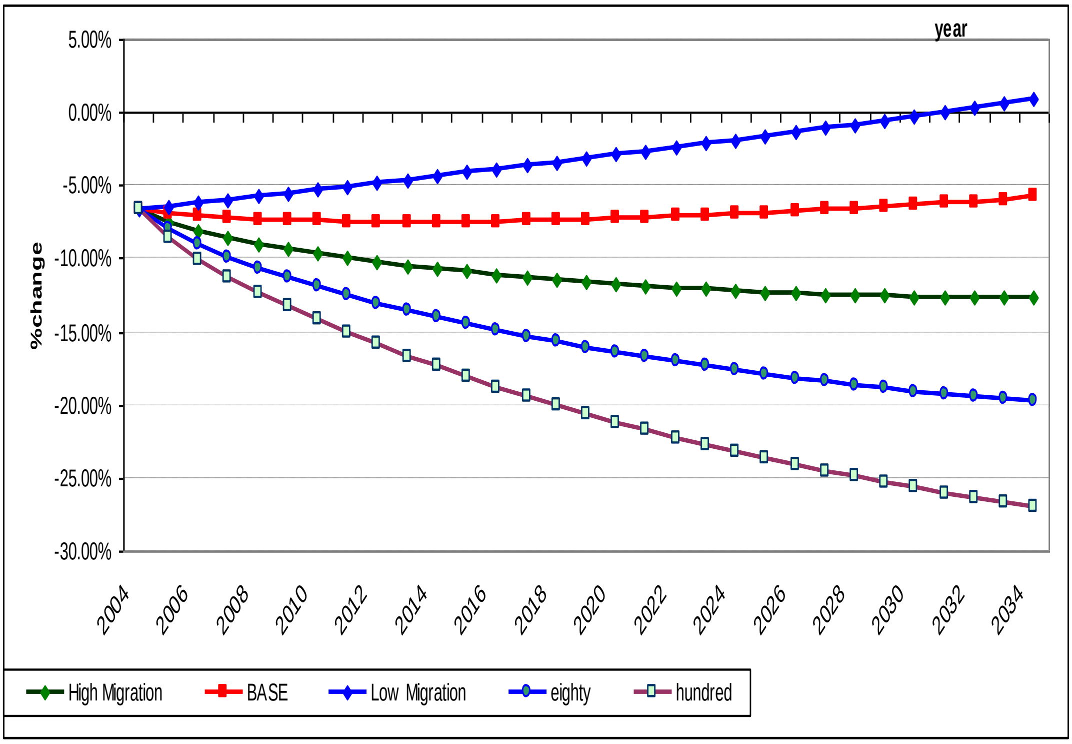
Figure 7 40 Real Wage trends under different net-migration scenarios



7.6 Budgetary issues

Greece is a country that has to abide to the criteria of the Stability and Growth Pact (SGP). Therefore the issue is worth investigating. The figure below shows the trend of Deficit/GDP. The results indicate that issues related to public finances cannot be ignored. They suggest that the implications are quite negative when we assume large numbers of annual migration i.e. 80,000 and 100,000. Under the base scenario Deficit to GDP decreases slightly without however reaching the target of 3% that is dictated by the SGP. Under the low migration scenario Deficit is decreased to the extend that the government runs a surplus by the end of the simulation period. Obviously, the main driver of results is the level of total population which my analysis dictates the level of government expenditure. The issue is quite important but it can be better analysed and understood if the impacts of demographic change upon the composition of private and public demand are consistently modelled. This should be one of the next steps in my research.

Figure 7 41- Deficit to GDP under different net-migration scenarios



7.7 Chapter conclusions

In this chapter I have outlined the theoretical framework underpinning the analyses and explained in detail the simulation strategy followed. I have discussed the macroeconomic impacts of the base population scenario. The main conclusion is that current demographic trends will have negative consequences upon economy through a tightening of the labour market. Under this scenario GDP falls by 2.82% and the real wage increases by 2.48% by 2034.

I have also a performed sensitivity analysis exercise around the base scenario and showed that different values of Armington elasticities and elasticities of substitution between capital and labour do not result in great discrepancies on the results of the economic model. I have shown that the closure of the labour market is particularly important. I have chosen to take the bargaining closure as the base case, as opposed to the extreme cases of a fixed real wage and fixed labour supply. This closure has been used in many CGE applications (Gillmartin et.al., 2007, Turner, 2002) and has been empirically supported by Blanchflower and Oswald (1998) who show that labour markets across many countries exhibit similar behaviour.

I have then moved on to examine various demographic scenarios and showed that the level of net-migration is the most important demographic variable in terms of economic impacts during the simulation period. The level of net-migration that allows the Greek economy to remain above equilibrium for the whole simulation period is 60,000 per annum. In the light of the importance of net-migration I have examined more scenarios by varying the value of this demographic parameter. The results that highlight the importance of net-migration and are quite illuminating result are the ones associated with a scenario of zero net migration (natural change only). In this case GDP falls by 11.33% and the real wage increases by 8.83%. I have also shown that there are issues related to public finances that require further investigation.

Conclusively, not only current levels of net-migration are not enough but even maintaining them at a sufficient level can be of paramount importance. If nothing changes in Greece in terms of demographic trends, population ageing is going to affect competitiveness negatively by putting pressure upon wages in a tightening labour market with a serious shortage of workers.

Chapter 8 . Conclusions

The impacts of an ageing population upon the economy are attracting significant analysis and comment internationally and are high on the political and economic agenda. A range of issues such as the labour market implications, the funding of pensions and of health care costs are widely discussed, typically with a particular focus on budgetary impacts.

Greece is an ageing society. The main objective of this thesis is to build a computable general equilibrium modeling framework for the Greek Economy and use it in order to assess the macroeconomic impacts of projected demographic changes, with a particular focus on the labour market and macroeconomic implications. Extensive work with population and microeconomic macroeconomic data was required.

Chapter two of the thesis discusses the demographic fundamentals and the demographic history of Greece. It includes a short discussion of population trends in developed countries and provides a detailed discussion of the demographic history and profile of Greece. Greece is described by the relevant data of the national statistics agency as a country with an ageing population, low fertility and increasing life expectancy.

Greece has been a country of out-migration. The beginning of the twentieth century and the period after the second World War are the periods during which out-migration waves were extremely large.

Most countries of Western Europe, experienced a baby boom immediately after the second world war. However this was a time of civil war and political turbulence for Greece, and the increase in fertility came almost ten years after the war and it was of smaller magnitude. In other words the country has experienced a "small and late" baby boom.

However, close to the end of the twentieth century, and after the collapse of the regimes of the Eastern Block, large waves of in-migration from neighbouring countries have transformed Greece into a country of positive net in-migration.It has been shown that this tendency has practically mitigated or even offset the tendency of the population to age. Data show that, due to the waves of in-migration, the ratio of people of working age to the total population has not changed dramatically. Remember that in-migration constitutes annual injections of people who are young and of working age.

The chapter discusses the data and population projections presented by the national statistics agency. According to the analysis of the agency the population of the country is expected to shrink slowly, but the percentage of people of working age is expected to shrink faster. This means that the population is shrinking slowly but ageing faster.

Next, the chapter provides a mathematical presentation of the software that is used to produce population projections. The base projection of the statistics agency has been very closely replicated. Potential sources of small discrepancies were identified.

Net migration has been identified as the single most important demographic characteristic affecting population trends, when compared with fertility and life expectancy. This result suggests that extensive scenarios of various migration levels must be examined.

The conclusion of the chapter is that migration waves can mitigate or even offset population ageing, but not in the long run as migrants themselves grow old (Robolis, 2008). Actually even when high levels of annual migration are assumed the population is projected to decrease and age after 2030.

Chapter 3 discusses the nature, roots, strengths and weaknesses of CGE models. CGE models are compared to other modeling techniques. The GAMOS modeling framework successfully resists the “black box” critique that is often leveled against CGE modelling. That is because it is a transparent modeling framework with a range of options of closures for all markets, and an almost unlimited freedom of choice for the values of parameters. In the course of the thesis, and especially in chapter 6, particular simulations has been performed in order to test the backward tractability of results in relation to the closures and parameter values chosen.

Chapter 4 describes the construction of the required data base. Certain difficulties had to be overcome as the only starting point was the input output table of 1994 for Greece. The table has been rolled forward to 2004 in such a way that changes in the composition of output are incorporated. For example the expansion of the telecommunication and construction sectors are captured as we take into account the levels of 2004 sectoral value added as presented by the national statistics agency tables.

The constructed SAM would allow the modeler to perform a modeling exercise of the most straightforward type of general equilibrium model, an Input – Output or fixed coefficients SAM model. However the present thesis builds a flexible general equilibrium model for Greece, one which incorporates substitution and relative price effects within a fully specified structural model of the economy.

Chapter five provides a detailed account on how the required database is completed and the model is parameterized and calibrated. G-AMOS stands for Greek-AMOS while AMOS is an acronym for *A M*acro-Micro Model *O*f *S*cotland. It has been developed by a team of researchers in the University of Strathclyde. (Harrigan *et al*, 1991, p. 424). It incorporates an array of closures and values for the parameters and it has been widely used to model the impacts of Scottish fiscal autonomy. (McGregor et. al., 2004b). It has also been extensively used in economic-environmental modelling. See (Allan et.al (2006b), Hanley et.al (2006), Turner (2002).

The chapter explains the particular similarities between Greece and Scotland that make building a model for Greece on similar lines to AMOS a reasonable choice. Both countries can be considered as small open economies in a monetary union. Scotland is part of the common currency area of Great Britain. In the same manner, Greece is a small open economy in the common currency area of the eurozone. The chapter discusses and justifies the functional forms and parameter values chosen for the model. It is worth noting that high values of elasticity of substitution are used in order to reflect the fact that the country is very much a price taker in international markets. Sarris and Zografakis (1999) also applied a high value of Armington elasticities[42] while Ioakimoglou (1999) econometrically estimated that 80% of variation of prices in Greece is attributable to international price changes.

In Chapter 6 we perform a set of simulations involving various demand and supply shocks, that help us to check the behavioural characteristics of the model, and ensure that they are in line with those that theory leads us to expect. Different

[42] The authors do not explicitly state the value they choose, they refer to it as “high but not infinity”

closures of the labour market are used. This chapter examines the impacts of demand and supply shocks to the Greek economy under different closures for the labour market and different assumptions about net migration.

The demand stimulus has a positive impact on the Greek economy under all scenarios. The impact is greater when migration is allowed to ease the consequent tightening of the labour market. However, under all scenarios, GDP starts converging to its new equilibrium level, although with different speeds of adjustment for each scenario. Another distinctive feature of the results is that prices converge back to equilibrium faster when the nominal wage is fixed.

Under all configurations the supply stimulus has a positive impact on the Greek economy. Adjustment takes place over a long period and under particular assumptions it has incomplete even by the end of the 80-period simulation horizon. One thing to note is that the ordering of the magnitude of impacts changes over time for different set of assumptions. In addition, the time that it takes the economy to reach the new long run equilibrium differs significantly.

Furthermore, employment does not move below its initial equilibrium level immediately after the shock when the nominal wage is fixed. In contrast when the bargaining assumption is made, real wage increases crowd out increased labour demand.

The above set of simulations establishes that the G-AMOS simulation framework responds as expected to exogenous shocks, while it allows the modeler trace the results back to the chosen configuration.

Chapter 7 contains the core simulation exercise. In this chapter I outline the theoretical framework underpinning the analyses and explain in detail the simulation strategy followed. I have discussed the macroeconomic impacts of the base population scenario. The main conclusion is that current demographic trends will have negative consequences upon the economy through a tightening of the labour market. Under this scenario GDP falls by 2.82% and the real wage increases by 2.48% by 2034.

The sensitivity analysis performed on different values of Armington elasticities and the elasticities of substitution between capital and labour, do not result in great differences in the results of the economic model. However, the closure of the labour market proves to be particularly important. The bargaining closure is chosen for the core simulation exercise of the thesis, as opposed to the limiting cases of a fixed real wage and fixed labour supply. This closure has been used in many CGE applications (Gillmartin et.al., 2007, Turner, 2002) and has been empirically supported by Blanchflower and Oswald (1998) who show that labour markets across many countries exhibit similar relationships between the real wage and the unemployment rate.

Next, various demographic scenarios are examined. The level of net-migration is the most important demographic variable in terms of economic impacts during the simulation period. 60,000 per annum net in-migration is the level that allows the Greek economy to remain above its initial equilibrium level of GDP for the whole simulation period. More scenarios, involving a greater range of migration scenarios, have also been examined. Looking upon the results produced by a demographic scenario that involves only natural change gives an idea of what would happen if the country followed a successful policy of “closed borders”. In this case GDP falls by 11.33% and the real wage increases by 8.83%.

I conclude that if current demographic trends continue, as under what we call the "base scenario", there will be a negative impact upon economic activity, which will stem from a tightening of the labour market.

Under this scenario GDP will fall by 2.82% while the real wage will increase by 2.48% in the next three decades. Employment also falls by 3.23%. The importance of net-migration is apparent in the results of the "zero net-migration" scenario. This is the "worst" scenario we examine and it reveals to a great extent the positive impact that migrants have had and will continue to have in the years to come. According to this scenario, GDP and employment fall by 11.33% and 12.99% respectively while the real wage increases by 8.33%.

Recall that in the course of this thesis I have not examined the impacts of a change in the composition of public and private demand that may occur due to a change in the demographics, neither we have explored the impact of the likely changes of the overall productivity that is associated with the presence of younger and older workers in the labour market.

The level of annual net-migration is of paramount importance for the demographic future of Greece and that the current levels of migration are not sufficient to completely offset the negative impacts of ageing. In our simulation exercise there is no distinction between legal and illegal migrants. Full legalisation of the existing foreign population could be the first step towards a consistent and viable migration policy. Legalisation would increase the proceeds of national insurance and income tax while it could also reduce remittances and the leakage of funds outside the country (Kontis et. al., 2006). An active migration policy thereafter is necessary in order to ensure sufficient flows of migration. However, as migrants do grow old themselves they cannot be relied upon forever. Family friendly policies that could enhance fertility rates as well as non discrimination against older workers in the labour market could ease the problems generated by the existing demographic trends.

There are of course a number of issues that have not been explored in this paper. First of all there are demand effects of demographic change. There are likely to be major shifts in the composition of demand as a consequence of population ageing. The present framework could be extended to accommodate such effects by disaggregating households by average age of occupants. Consumption patterns are known to vary significantly by age and that can be captured by modeling consumption by broad age group.

In addition, if younger and older workers have different productivities ageing will generate induced changes in the overall productivity of the labour force. Again the framework could be extended to allow us to explore the impact of such changes. Also, if labour force participation is itself age dependant, as seems likely, the size of the labour force will be affected even more significantly than is assumed in this thesis. Finally, if ageing is defined in a different way (as age from death) as Shoven (2007) argues is appropriate, the whole discussion is radically altered (as are the implications for policy). The current configuration of G-AMOS allows us to explore the questions mentioned above.

The value added of this thesis is that it constitutes, as far as we know, the first attempt to model the behavior of the Greek economy, in response to at least partially exogenous demographic shocks using a CGE model.

Further work with this model would require an update of the initial database. Note that the model constructed in the course of this thesis is based upon data with year of reference 2004. As this thesis is coming to an end the latest available data refers to the year 2010. Thus an update of the Social Accounting Matrix on the basis of the new data collected and constructed by the National Statistics Agency is required. This will allow the modeler to capture more accurately the differences in the composition of output that has been taking place between 2004 and 2010.

Greece under the troika (IMF-ECB-EU) intervention, has been implementing a policy mix of severe fiscal consolidation. Exogenous shocks of fiscal policy have been applied to the economy. G-AMOS could be utilized in order to replicate the path of the macroeconomic indicators. This procedure will test and improve parameter values for the model of the Greek economy.

In addition a reasearcher could utilize the feature of GAMOS to examine impacts of particular policies in isolation. So, for example the modeler could quantify the macroeconomic impact of the sharp increase of special consumer tax in petrol that has taken place in Greece. In the same manner the impact of increasing VAT to 23% could also assessed.

Another interesting question that can also be assessed is what is the impact of the great wave of out-migration that has taken place in Greece? In fact, tens of thousands of young educated Greeks have left the country in the course of the last three years. As this part of the labour force is characterized by high productivity, a negative supply shock should be imposed within GAMOS, together with the demand shock that occurs through total population change (see chapter 7, on how total population changes are modeled).

The loss of population and human capital would have a major adverse impact on the Greek economy. Policies to avert “brain drain” must be implemented as this is a phenomenon that significantly adversely impacts the competitiveness of the economy.

The current economic crisis has deepened the problems of the Greek economy that stem from the age structure of its population. The core conclusion drawn by the analysis performed in this thesis is that there is an urgent need to develop policies that can mitigate the ageing of the population and prevent the least attractive alternative futures.

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Appendix 1: The Sectoral Disaggregation in AMOS

Table A1.1 Sectors (Activities/Commodities) Identified in AMOS

	Sector Name	**ISIC**
1	*AGRICULTURE, HUNTING, FORESTRY AND FISHING*	*01-05*
2	*MINING AND QUARRYING*	*10-14*
3	*FOOD PRODUCTS, BEVERAGES AND TOBACCO*	*15-16*
4	*TEXTILES, TEXTILE PRODUCTS, LEATHER AND FOOTWEAR*	*17-19*
5	*WOOD, PAPER, PRINTING, PUBLISHING*	*20-22*
6	*COKE, REFINED PETROLEUM PRODUCTS AND NUCLEAR FUEL*	*23*
7	*OTHER MANUFACTURING*	*24-28*
8	*MACHINERY, EQUIPMENT*	*29-33*
9	*TRANSPORT EQUIPMENT ETC.*	*34-37*
10	*ELECTRICITY, GAS AND WATER SUPPLY*	*40-41*
11	*CONSTRUCTION*	*45*
12	*WHOLESALE AND RETAIL TRADE; REPAIRS*	*50-52*
13	*HOTELS AND RESTAURANTS*	*55*
14	*TRANSPORT AND STORAGE*	*60-63*
15	*POST AND TELECOMMUNICATIONS*	*64*
16	*FINANCE, INSURANCE*	*65-67*
17	*REAL ESTATE ACTIVITIES*	*70*
18	*RENTING OF MACHINERY AND EQUIPMENT*	*71*
19	*COMPUTER AND RELATED ACTIVITIES*	*72*
20	*RESEARCH AND DEVELOPMENT*	*73*
21	*OTHER BUSINESS ACTIVITIES*	*74*
22	*PUBLIC ADMIN. AND DEFENCE; COMPULSORY SOCIAL SECURITY*	*75*
23	*EDUCATION*	*80*
24	*HEALTH AND SOCIAL WORK*	*85*
25	*OTHER SERVICES*	*90-99*

Appendix 2: The G-AMOS Model

Table A2.1: A Condensed Version of the AMOS CGE Model

1. Commodity Price	$p_i = p_i(w_n, w_{ki})$
2. Consumer Price Index	$cpi = \sum_i \theta_i p_i + \sum_i \theta_i^{REU} \overline{p}_i^{REU} + \sum_i \theta_i^{ROW} \overline{p}_i^{ROW}$
3. Capital Price Index	$kpi = \sum_i \gamma_i p_i + \sum_i \gamma_i^{REU} \overline{p}_i^{REU} + \sum_i \gamma_i^{ROW} \overline{p}_i^{ROW}$
4. User Cost of Capital	$uck = uck(kpi)$
5. Wage Equation	$w_n = w_n(N, \overline{L}, cpi)$
6. Capital Stock	$K_{i,t}^S = (1-d_i)K_{i,t-1} + \Delta K_{i,t-1}$
7. Labour Demand	$N_i^D = N_i^D(Q_i, w_n, w_{k,i})$
8. Capital Demand	$K_i^D = K_i^D(Q_i, w_n, w_{k,i})$
9. Labour Market Clearing	$\sum_i N_i^D = N$
10. Capital Market Clearing	$K_i^S = K_i^D$
11. Household Income	$Y = \Psi_n N w_n + \Psi_k \sum_i K_i w_{k,i}$
12. Commodity Demand	$Q_i = C_i + I_i + G_i + X_i$
13. Consumption Demand	$C_i = C_i\left(p_i, \overline{p}_i^{REU}, \overline{p}_i^{ROW}, Y, cpi\right)$
14. Desired Capital Stock	$K_i^* = K_i^D(Q_i, w_n, uck)$
15. Capital Stock Adjustment	$\Delta K_i = \lambda_i(K_i^* - K_i)$
16. Investment Demand	$I_i = I_i\left(p_i, \overline{p}_i^{REU}, \overline{p}_i^{ROW}, \sum_i b_{i,j}\Delta K_j\right)$
17. Government Demand	$G_i = \varphi_i p_i \overline{P}$
18. Export Demand	$X_i = X_i\left(p_i, \overline{p}_i^{REU}, \overline{p}_i^{ROW}, \overline{D}^{REU}, \overline{D}^{ROW}\right)$

NOTATION

Activity-Commodities

i, j are activity/commodity subscripts.

Transactors

UK = United Kingdom, ROW = Rest of World

Functions

p (.)	cost function
w_n(.)	wage equation
uck(.)	user cost of capital formulation
K^D(.), N^D(.)	factor demand functions
C(.), I(.), X(.)	Armington consumption, investment and export demand functions, homogenous of degree zero in prices and one in quantities

Variables

C	consumption
D	exogenous export demand
G	government demand for local goods
I	investment demand for local goods
ΔK	investment demand by activity
K^D, K^S, K^*, K	capital demand, capital supply, desired and actual capital stock
L	labour force
N^D, N	labour demand and total employment
P	population
Q	commodity/activity output
X	exports
Y	household nominal income
b	elements of capital matrix

cpi, kpi	consumer and capital price indices
d	physical depreciation
p	price of commodity/activity output
t	time subscript
uck	user cost of capital
w_n, w_k	wage, capital rental
Ψ	share of factor income retained in region
θ	cpi weights
γ	kpi weights
φ	government expenditure coefficient
λ	capital stock adjustment parameter

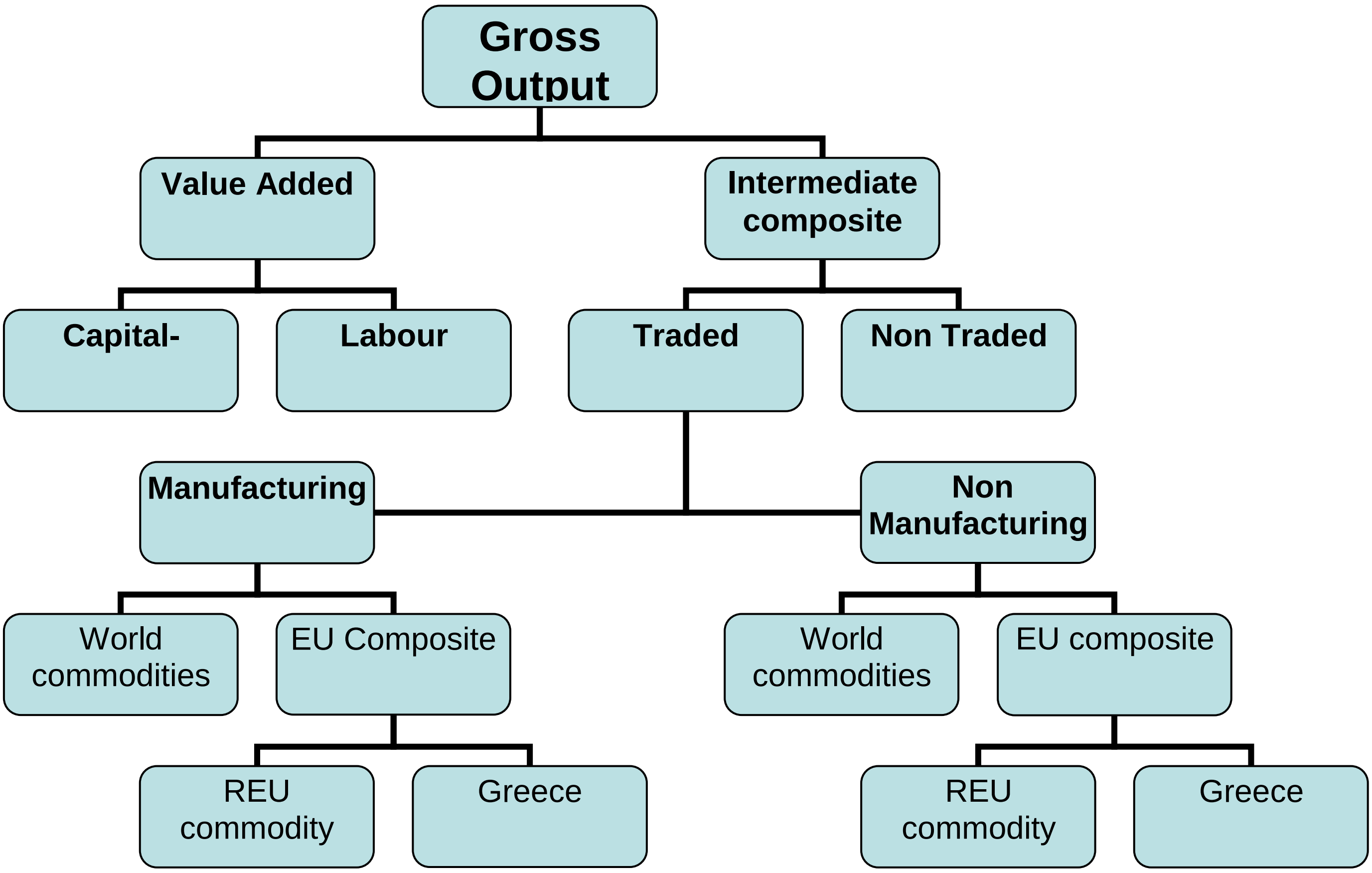
***Notes*:**

Variables with a bar are exogenous.

A number of simplifications are made in this condensed presentation of AMOS

1. Intermediate demand is suppressed throughout e.g. only primary factor demands are noted in price determination in equation (1) and final demands in the determination of commodity demand in equation (12).
2. Income transfers are generally suppressed.
3. Taxes are ignored.
4. There are implicit time subscripts on all variables. These are only stated explicitly in the capital updating equation (6).

Appendix 3: Production function of GAMOS



Appendix 4 : A stylised model

Prices in a Cobb-Douglas World with two goods

E= export sector, D= domestic sector

α = labour intensity in export sector

β = labour intensity in domestic sector

Fixed non labour inputs in both export and domestic sector

All non labour income goes outwith the region

Export sector faces parametric world price = numeraire

Constant share of wage income is spent on domestic output

Production

(1) $Q_E = AL_E^{\alpha}$

(2) $Q_D = BL_D^{\beta}$

Distribution

(3) $\frac{wL_E}{1 \times Q_E} = \alpha$

(4) $\frac{wL_D}{p_D Q_D} = \beta$

Demand

(5) $p_D Q_D = \gamma L w$

STEP 1: Employment shares

Substitute (5) in (4) and rearrange

$$L_D = \gamma \beta L$$

Total labour force

(7) $L = L_E + L_D$

Substituting (7) in (6)

(8) $L_E = (1-\gamma\beta)L$

(9) $\dot{L_E} = \dot{L_D} = \dot{L}$

The dot notation implies proportional changes

STEP 2: Wage determination

Substitute equation (1) into (3) and rearrange.

(10) $$w = \frac{\alpha A}{L_E^{1-\alpha}}$$

Which gives (using equation 9)

(11) $\dot{w} = -(1-\alpha)\dot{L}_E = -(1-\alpha)\dot{L}$

A fall in the labour supply increases the wage in the export goods sector (relative to fixed export prices)

STEP 3: Determination of price of domestic good

Substitute (2) into (4) and rearrange

(12) $$\frac{w}{p_D} \times \frac{L_D}{\mathrm{B}L_D^{\beta}} = \beta \qquad \Rightarrow w = \frac{p_D \beta \mathrm{B}}{L_D^{1-\beta}}$$

(13) $\dot{w} = \dot{p}_D - (1-\beta)\dot{L}_D = -(1-\beta)\dot{L}$

Substitute equation (11) into (13)

(14) $\dot{p}_D - (1-\beta)\dot{L} = -(1-a)\dot{L}$

(15) $\dot{p}_D = (a-\beta)\dot{L}$

Therefore the price of the domestic good will rise (relative to the export good) when labour supply is reduced if β>α. (i.e. the labour intensity of the domestic sector is greater than the labour intensity of the traded sector.

STEP 4: Change in CPI

If all income is consumed, γ is spent on domestic goods whose price is parametric

$$cpi = \gamma \dot{p}$$