

**The Transmission Mechanism of Demographic Shocks Between a Large
and a Small Country: the Case of Uzbekistan versus the Rest-of-the-
World.**

by

Furkat O. Abdulahatov

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Supervisor

Professor Marcel Mérette

ECO 7997

Ottawa, Canada

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Abstract

Recently Jean Mercenier and Marcel Mérette (2002) developed a three-region, three good, fifteen overlapping generations model to analyse the inter-regional consequences of population ageing in Canada. This paper uses a simplified version of above overlapping generations model; with only two countries, two goods, and five overlapping generations. With that model, we investigate the effects of population ageing in large country on the economy of a small country. The small country will be Uzbekistan and the large country is the principal trading partners of Uzbekistan, which includes Germany, UK, Switzerland, Russia and South Korea. We defined these five countries as ROTW. Each country of the model produces one differentiated good. Households work the first four periods of their life and retire in the last year. In this model, financial market is assumed perfectly integrated so household can invest their savings either in Uzbekistan or ROTW. In particular, we discuss to what extent international commodity and capital flows provide channels for the transmission of effects of ageing of population in developed countries to the economy of developing countries. The issue is considered in the context of possible affects on Uzbekistan of the demographic shock effects transmitted from its principal trading partners. This research is useful for the following reason. After the collapse of Soviet Union, Uzbekistan is integrating to the world economy. We argue that population ageing may effect terms of trade of Uzbekistan. Our simulation exercises lead to the following conclusions: First, capital flight will occur from ROTW to Uzbekistan as a result of demographic shock. Secondly, wage rates will be higher in ROTW, because of labor scarcity.

1. INTRODUCTION

Over the past few years, the world's population has continued on its remarkable transition path from a state of high birth and death rates to one characterised by low birth and death rates. At the heart of that transition has been the growth in the number and proportion of older persons. Such a rapid and large growth has never been seen in the history of civilisation.¹ Over the next several decades there will be significant changes to the demographic structure of the population in Uzbekistan and its principal trading partners. Principal trading partners of Uzbekistan consist of five countries: Germany, UK, Switzerland, Russia and South Korea. We defined these five countries as ROTW. In ROTW the upcoming demographic change is the result of significant increase in the fertility rate of population during 1940s and 1950s. After that period, the fertility rate started to decline significantly. Nowadays it is even negative in Russia, in Germany and in Switzerland. Moreover, life expectancy improved substantially in these countries except for Russia. All these factors accounts for the process of population ageing in these countries. The fraction of population over 65 in these countries is projected to increase sharply. According to the United Nations' (1996) current demographic projections, the old-age dependency ratio, defined as the number of individuals aged 65 and over divided by those aged 15-64, is expected to more than to double over the next 50 years in ROTW, that is from 19.2 % in 2000 to 45% in 2050. Uzbekistan is also going to see its current very young population to age significantly in the future. According to the United Nations', the old-age dependency ratio is expected to increase more than 4 times over the next 50 years in Uzbekistan from 4.7 % in 2000 to 22.3 % in 2050. The process of ageing in Uzbekistan will however occur later and to a lower extent than in ROTW.

Still, the increase in old-age dependency ratio may have negative effects on the economy of Uzbekistan. First, it may become difficult to economically support older people who no longer participate in the labour force. Second, pressure on health care expenditure will be significant. Third, population ageing will lead to a reduction in the active labour force and national savings, which in turn may lead to a significant reduction in real per capita output and to an erosion of overall tax base. Forth, it is highly possible that the pension system will suffer from ageing. For instance, it was recently declared that in 2001, Uzbekistan's pension system would not anymore be financed by the state budget but rather by payments from business entities and organizations. We have observed the migration of skilled workers from these organizations. As a result these organization possibly cannot provide enough funds for pension system. Uzbekistan has for the moment a great reserve of labour. As much as of 40 percent of the number of workers in Central Asia is in Uzbekistan. Labour force is mobile across Central Asian countries. So the reduction in labour force may affect not only Uzbekistan, but also the whole Central Asian countries. Moreover, Turalay Kenc and Serdar Sayan (2000) found that trade (through prices and interest rate) provides a channel for transmission of the effects of demographic shocks experienced by large countries onto small open economy. Uzbekistan is integrating to the world economy after the collapse of Soviet Union. Hence, the economy of Uzbekistan may be affected by the increase in old-age dependency ratio of many industrialised countries with which Uzbekistan has strong economic ties.

In this paper, we want to investigate the double effect of population ageing. The first effect refers to the fact that in near future Uzbekistan will experience a shift in the composition of its population, as projected by United Nations. So we want to investigate the direct effects of this shift on the economy of Uzbekistan. The second effect is considered in the context of possible effects on Uzbekistan of the demographic shock effects transmitted from its principal trading partners (Germany, UK, Switzerland, Russia and South Korea). Uzbekistan's trading partners will experience a more significant process of population ageing. We want to consider the indirect effects of population ageing of these trading partners on the economy of Uzbekistan. As trade (through prices and interest rate) provides a channel for transmission of the effects of demographic shocks experienced by large countries onto small open economy according to Turalay Kenc and Serdar Sayan (2000), we need information about Uzbekistan's trade, its trading partners and demographic change.

This paper is organized as follows. In Section 2, we summarize the economic features and perspectives in Uzbekistan. Section 3 reports and discusses the demographic projection in Uzbekistan and for its main trading partners. Section 4 reviews the literature. Section 5 describes the model used for simulations and Section 6 explains the calibration procedure. In Section 7, we report the simulation results and we conclude in Section 8. We supply the computable programs in the Annex.

2. FEATURES AND PERSPECTIVES OF UZBEKISTAN ECONOMY

Uzbekistan is one of the Central Asian countries. Uzbekistan shares borders with all the other Central Asia states and is at the centre of the region's transportation. Uzbekistan is one of the most favoured countries by its natural and geographic conditions. The Republic of Uzbekistan has a great productive and mineral and raw material potential.

During the 1917-1991 period, Uzbekistan was one of the Soviet Union republic. During these years everything was regulated by central planning system in Moscow.

Foreign trade was heavily dependent on the Russian Republic. In the 1980s, more than 80 percent of Uzbekistan's foreign trade was within the Soviet Union, with Russia accounting for half of imports and almost 60 percent of exports. The other Central Asian republics accounted for another quarter of Uzbekistan's total foreign trade. Interrepublican trade was directed through Moscow and organized in the interests of centralized planning goals.²

Uzbekistan also benefits from a warm climate, a long growing season, and plentiful sources of water for irrigation. In the Soviet period, those conditions offered high and reliable yields of crops with specialized requirements. Soviet agricultural policy applied Uzbekistan's favourable conditions mainly to cotton cultivation. Cotton industry is a labour intensive industry and hence may have attracted a large number of foreign workers. Massive capital flows have accompanied the large number of immigrants during this period. Table 1 reports the capital investment in agriculture in Uzbekistan between 1956 and 1987.

TABLE 1. *Capital investments in agriculture in Uzbekistan, 1956- 1987 (million roubles)*

Period	
1956 - 1960	1,729
1961 - 1965	3,120
1966 - 1970	5,441
1971-1975	9,226
1976-1980	12,513
1981-1985	14,877
1986	2,738
1987	2,767

Source: Online database on Uzbekistan. It can be found at www.unu.edu/unupress/unupbooks/uu14re/uu14re0b

With the collapse of the Soviet Union, central planing system disappears and the system of interrepublican trade and payments mechanisms does no longer exist. Because of that, Uzbekistan faced serious demographic and economic challenges. After the collapse of Soviet Union, Uzbekistan established its own government. Since then, the Government of Uzbekistan starts to shape the economy. For instance, Uzbekistan opened up to the world economy. Uzbekistan has made aggressive efforts to expand foreign trade and to diversify its trading partners.

Despite relatively high average levels of education in the population, the shortage of skilled workers in Uzbekistan is a major constraint to future development. Russians and other nonindigenous workers traditionally were concentrated in the heavy industrial sectors, including mining and manufacturing. With the independence of Uzbekistan and the outbreak of violence in several parts of Uzbekistan, many of these skilled workers left the country in the early 1990s. In 1990, as many as 90 percent of the workers in Uzbekistan's electric power stations were Russians. Because Russian emigration caused a shortage of skilled technicians, by 1994 half of the power generating units of the Syrdariya Hydroelectric Power Station had been shut down. Moreover, the newly constructed Novoangrenskiy

Thermoelectric Power Station could not go on line because there was nobody to operate it. In the mid-1990s, training programs were implemented to prepare skilled indigenous cadres in these and other industrial sectors. The shortfall has had a strong impact.³

3. DEMOGRAPHIC PERSPECTIVE

The time and course of aging of population is somewhat different between ROTW and Uzbekistan. In ROTW aging of population is the result of significance increase in the fertility rate of population during 1940s and 1950s.

For 2050, it is expected that 28 percent of the total European population, including Russia, will be aged 65 and over, as compared to 14 percent today. In a global perspective, the share of the world population residing in Europe will decline considerably. According to current projections (United Nations 1996), the European population will decrease from 13 to 7 percent of the world population over the next fifty years. The most striking feature in this figure is the large post-war baby boom generation that pass through the European age structure⁴. By 2020, the large baby boom cohorts will have entered old age. Projections by the United Nations (1996) for the ROTW area as a whole show that the old age dependency ratio will rise from 19 % today to 47.5 % in 2050. (See Table 2).

TABLE 2. *Old-age dependency ratio (population age 65+) in Uzbekistan and in ROTW*

	2000	2050
Uzbekistan	4.7	22.3
Germany	23	51
UK	24	39
Switzerland	21	49
Russia	19	35
Korea	9	51

Source: United Nations projections (1996)

Uzbekistan demographic burden

The upcoming demographic shift in Uzbekistan is the result of high immigration rate that occurred between 1959 and 1979, the high birth rate and the increased in life expectancy.

As shown in Table 3, the growth of Uzbekistan's population during the 1959-1979 periods was in some part due to immigration from other parts of the former Soviet Union. Several waves of Russian and Slavic immigrants arrived at various times in response to the industrialization of Uzbekistan in the early part of the Soviet period. This was followed by the evacuations of European Russia during World War II, and in the late 1960s to help reconstruct Tashkent after the 1966 earthquake. At various other times, non-Uzbeks arrived simply to take advantage of opportunities they perceived in Central Asia⁵. From 1959 to 1979, the population in Uzbekistan increased from 6.6 million to 15.4 million. This age cohort will reach retirement age after 2030 and will lead to significant increase in the share of population over 65.

TABLE 3. *Population (millions)*

Soviet republics	1959	1979
Russian Republic (RSFSR)	117.5	137.4
Ukraine (UKR)	41.3	49.6
Bielorussia (BEL)	9.0	9.5
Uzbekistan (UZB)	6.6	15.4
Kazakhstan (KAZ)	6.1	14.7
Georgia (GEO)	3.6	5.0
Armenia (ARM)	1.3	3.0
Azerbaijan (AZER)	3.3	6.0
Lithuania (LIT)	2.9	3.4
Moldavia (MOLD)	2.5	4.0
Latvia (LAT)	1.9	2.5
Estonia (EST)	1.1	1.5
Kirgizia (KIR)	1.5	3.5
Tadjikistan (TAD)	1.5	3.8
Turkmenistan (TURK)	1.3	2.8

Source: Online database on Uzbekistan. It can be found at www.oneworld.org/ni/issue190/facts.

We see from table 3 that massive immigration occurred in Uzbekistan and Kazakhstan. During these years as these countries are rich in natural resources one of the reasons of this high immigration might be the potential economic development that these countries possessed.

The high birth rate during the 1959-1979 period

During the 1959-1979 period, the birth rate was also high. In comparison to the former Soviet Union, Uzbekistan is still largely rural: roughly 60 percent of Uzbekistan's population lives in rural areas. People in rural areas are especially engaged in agriculture. So they prefer to have more children in order to use them as a labour force in the farms.

Drop in fertility rate from 2000

Another reason for ageing of population in ROTW and Uzbekistan is a recent drop in fertility rate. We see from Table 4 that population growth is projected to decrease substantially over the next several decades in Uzbekistan and in their trading partners. Russia, Germany, Switzerland are expected the most important decrease in their populations. Among these countries only Uzbekistan is expected to have positive population growth in year 2050.

TABLE 4. *Annual population growth rate (percentage)*

	1995-2000	2000-2005	2010-2015	2020-2025	2045-2050
Uzbekistan	1.76	1.39	1.37	1.02	0.47
Switzerland	0.15	-0.06	-0.29	-0.39	-0.86
UK	0.27	0.18	0.10	0.10	-0.25
Germany	0.09	-0.04	-0.17	-0.24	-0.52
Russia	-0.36	-0.64	-0.54	-0.63	-0.82
Korea	0.78	0.66	0.40	0.25	-0.25

Source: United Nations (1996)

Improvement in mortality rate

The demographic effects of falling fertility in Uzbekistan have been reinforced by improvement in mortality. In 1985, life expectancy at birth for male was 64.5 years, compared with 68.5 years in 2000. The mortality improvement for women has been more pronounced, with life expectancy at birth increasing from 70.7 years in 1985 to 74.2 in 2000. Current projections (United Nations) call for further improvements in life expectancy at birth, to 71.9 years for men and 77.6 years for women, in 2025. (See Table 5).

TABLE 5. *Life expectancy in Uzbekistan (years)*

	1985-1990	1990-1995	1995-2000	2000-2005	2005-2010	2010-2015	2015-2020	2020-2025
Male	64.5	66.0	67.5	68.5	69.5	70.3	71.1	71.9
Female	70.7	72.2	73.2	74.2	75.2	76.0	76.8	77.6

Source: Online database on Uzbekistan. It can be found at www.unchss.org/habrdd/conditions/socentasia/uzbekist.htm

4. LITERATURE REVIEW

In this paper, we want to examine the economics of ageing in Uzbekistan in the context of broader demographic changes. During the demographic transition that Uzbekistan is now undergoing, the decline of fertility - which is the main factor in ageing - causes not only an increase in proportions of older people, but also, conversely, a reduction in the proportion of younger people. Of particular interest is the proportion of people under 15 years of age, as these are also dependant. So we must place projected ageing within the context of overall age dependency. Most of the literatures argue that high dependency may have negative effect on economies. A faster ageing country behaves as if its “representative agent” was relatively more impatient. Consequently, such a country will experience a larger

decline in private savings as suggested in Buiter (1981). On the other hand, Cuttler et al. (1990) argues that high dependency with a slow labor force growth may induce more technical change. As a result it may have positive effect on the economy. So we have to be careful in making any decisive conclusion. Williamson (1994) argues that high dependency ratio may attract more foreign capital. In the previous section we mentioned that mass inflow of capital occurred in Uzbekistan during the 1956-1987 period. While we cannot state as certain that foreign capital was attracted because of the composition of population during that period, it is a fact that the large capital inflow between 1956 and 1987 occurred when the dependency ratio was high. It is noteworthy that although the Uzbekistan economy was characterized by a high dependency in 2000 (see Table 2), the flow of foreign capital was not so high. It is likely that the reason lies in the multiple exchange rate regime implemented by the Uzbekistan government. Convertibility of the local currency is likely to be postponed for another 4-5 years. So there exist at the moment some significant barriers to investment in Uzbekistan.

In parallel with the current economic transition, from a centralised planning system to a free market system, population aging in Uzbekistan has accelerated and the support system for the elderly is becoming a major issue, which requires urgent attention. As shown in Table 5, Uzbekistan is expected to experience a significant increase in the proportion of its old-aged population over the next 50 years. The rapid increase in population ageing can also be illustrated by the dependency ratio. The population projection⁶ indicates that Uzbekistan's old-age dependency ratio (proportion of age group 65+) will increase more than 4 times over the next several decades, that is, from 4.7 % in 2000 to 22.3 % in 2050.

TABLE 6. *Population age structure in Uzbekistan from 1980 to 2050.*

Age group	1980	1985	1990	1995	2000	2005	2010	2015	2020	2025	2050
0-14	40.9	40.5	40.9	39.9	37.7	34.5	32.0	29.6	27.0	24.8	19.9
15-64	54.0	55.1	55.1	44.3	42.4	60.4	63.3	65.7	67.5	68.2	57.8
65+	5.1	4.4	4.0	4.4	4.7	5.1	4.7	4.7	5.5	7.0	22.3

Source: Online database on Uzbekistan. It can be found at www.unchs.org/habrdd/conditions/socentasia/uzbekist.htm

No study regarding the ageing of population exists in the literature on the case of Uzbekistan, but some analysis can be found on other countries that are experiencing similar demographic perspectives. The first kind of research has been done by Turalay Kenc and Serdar Sayan (2000). They considered the context of possible effects on Turkey of the demographic shock effects transmitted from EU4 (Germany, France, Italy and United Kingdom).

TABLE 7. Population age distributions for EU4 and Turkey

Age Group	1950		1975		1990		2000	
	EU4	Turkey	EU4	Turkey	EU4	Turkey	EU4	Turkey
0-14	23.669	38.330	23.238	40.105	17.725	35.505	17.072	29.849
15-39	43.474	44.822	41.273	42.923	44.244	46.450	42.271	49.647
40-64	22.914	13.557	22.021	12.455	23.014	13.265	24.332	14.475
65 plus	9.943	3.292	13.468	4.517	15.017	4.779	16.324	6.029
Age Group	2010		2025		2050		Steady	State
	EU4	Turkey	EU4	Turkey	EU4	Turkey	EU4	Turkey
0-14	15.907	25.831	15.860	21.742	18.797	18.302	20.946	21.909
15-39	38.572	48.838	34.325	43.851	34.764	34.999	38.713	39.194
40-64	27.428	18.035	29.764	23.744	25.089	26.722	23.647	23.054
65 plus	18.093	7.297	20.051	10.663	21.350	19.997	16.694	15.843

Source: Kence and Sayan (2001)

From Table 7 we see the demographic projections from United Nations sources for the two countries. Kenc and Sayan (2000) consider population by age cohorts over time for both countries by assuming stationary the birth rates at the beginning (1990) and at the end (from 2050 until the end of model horizon). They impose the assumption that in the long run

(after 2050) the birth rate is such that it will gradually push back the dependency ratios for both EU4 and Turkey towards those that would apply if the population followed a balanced growth path with 0.1 % growth per annum for EU4 and 2.25 % for Turkey.

As reported in Table 7, they showed that not only the size but also the timing of demographic transitions differ considerably for Turkey and EU4. We hope that the demographic transition for Uzbekistan and its trading partners differ as well. From Table 7, we see that Turkey has always a relatively younger population as compared to the largest four European countries, mainly because of its higher population growth rate. Kenc and Sayan (2000) report that the ratio of population in the young age up to 19 to the working age in EU4 drops markedly after 2010, and then begins to rise as older baby-boomers retire. They conclude that population gradually becomes older in the EU4 starting from the 1990s whereas Turkey begins to experience population ageing only after 2020.

Kenc and Sayan (2000) simulated two demographic shocks onto Turkish economy. First, they simulate Turkey's demographic change from 1990 until the end of model horizon. Turkey is a small open economy, so world prices and interest rate are taken as given. The second demographic shock originates from the EU4 region. Population outside the working age (those under 20 and those 65 and older) is projected to increase. In that case they argue that the world prices and interest rates facing Turkey change.

In order to capture the demographic shock in EU4 onto Turkey they first simulate the model for EU4 and obtained relevant prices that prevail in the presence of the demographic shock in Europe. Then they treat these as the world prices facing Turkey and plug them into the Turkish economy simulation exercise.

Population ageing leads to a fall in labour supply, because of the decline in share of population in the working age, to an increase in consumption relative to output, and to decline in the national saving rate which slow down capital formation. The expected decline in labour supply and capital formation change the capital-labour ratio. These changes alter relative factor prices that lead to a relocation of the resources. For the other countries, this implies a change in the real exchange rate and in the interest rate they face. This is how the process of ageing in large regions may trigger important macroeconomic implications for small regions.

Kenc and Sayan (2000) conclude that demographic shock that is transmitted from other countries magnifies the time paths of consumption, savings, investment and output. For instance, they found that trade (through prices and interest rate) provides a channel for transmission of the effects of demographic shocks experienced by large countries onto small open economy. This kind of research is also relevant to Uzbekistan economy. Since 1991 Uzbekistan open up to the world economy after the collapse of Soviet Union and most of the principal trading partners are facing population ageing. Williamson and Taylor (1994) also show that there is positive relationship between capital inflow and dependency rate. In their paper, they investigate the capital flow between the old and the new world during the late 19-century. They argue that capital flow into the new world, which is Argentina, Australia and Canada from old world, which is Britain, was mostly because of high dependency rate in these countries.

Next, we present the model that was used to simulate the double ageing shock. In contrast to Kence and Sayan (2000), we use a two-country model. Kence and Sayan simulate the ageing shock of the EU4 countries to determine relative prices and then plug

them in the Turkey model. Unlike them, our two-country model permits us to simulate simultaneously the ageing shock in ROTW and in Uzbekistan.

5. THE MODEL

Recently Jean Mercenier and Marcel Mérette (2002) developed a three-region, three good, fifteen overlapping generations model to analyse the inter-regional consequences of population ageing in Canada. This paper uses a simplified version of above overlapping generations model; that is a two-country, two-good, five overlapping generations model.

In this model we have the economies of two countries; Uzbekistan and ROTW. We assume that these countries form the whole world economy. Trade between these countries are open to each other. We divide economic agents in each country into 3 types. First, the supply side of the economy is represented by a national firm. The firm produces one differentiated good. A second type consists of five different age groups representing households. The last type of agent is the government. The government in each country spends on public goods, maintains various transfer payments, levies taxes, and issues debt.

As each country produces one differentiated goods, we have two final goods in the model. We assume that output technology in each country is represented by Cobb-Douglas production function. To produce, the firm uses physical capital and labor, the two factors of production. Financial capital market is perfectly integrated between the two countries and consists of bonds and capital ownership

titles.

The model has a multi-period overlapping generations structure, so household behavior follows the life-cycle theory. The horizon of the numerical model consists of 30 periods of 12 years. There are 5 age groups denoted by $g1$ to $g5$. We assume that each individual lives between 17 and 76 years of age in the model. Individuals are assumed to work until age 63, therefore 4 out of the 5 generations are members of the active population. In this model, population growth rate is exogenous. We use subscript t for the time and j for countries. All markets are assumed perfectly competitive.

Production Sector of Economy

A Cobb-Douglas function represents the production technology in each country:

$$Q_{j,t} = A_{j,t} \cdot Kstock_{j,t}^{\alpha_j} \cdot \sum_g (POP_{j,t,g} \cdot EP_{j,t})^{1-\alpha_j}, \quad (1)$$

where $Q_{j,t}$ represents real output in country j at period t , $Kstock_{j,t}^{\alpha_j}$ is the real value of the capital stock in country j at period t , $\sum_g (POP_{j,t,g} \cdot EP_{j,t})^{1-\alpha_j}$ describes the sum of effective labor force in country j at period t , α_j stands the capital income share and $A_{j,t}$ is a constant scaling variable, and $EP_{j,t}$ is a effective labor force. Equation (1) simply states that real supply of output in country

j at period t depends on the two factors in the economy: the capital stock and labor force (population who is in labor market). The demand for productive factors in country j , at time t , are given by the profit maximization first-order conditions:

$$\frac{W_{j,t}}{P_{j,t}} = (1 - \alpha_j) \cdot A_{j,t} \cdot Kstock_{j,t}^{\alpha_j} \cdot \sum_g (POP_{j,t,g} \cdot EP_{j,t})^{1-\alpha_j} \quad (2)$$

This equation represents labor demand by firms. It states that firms hire labor at the wage rate per unit of effective labor up to the point where marginal product of labor is equal to marginal cost of labor. Notice that $\frac{W_{j,t}}{P_{j,t}}$ is the real wage rate per unit of effective labor at time t in country j . The other first order condition is

$$\frac{R_{j,t}}{P_{j,t}} = (1 - \alpha_j) \cdot A_{j,t} \cdot Kstock_{j,t}^{\alpha_j} \cdot \sum_g (POP_{j,t,g} \cdot EP_{j,t})^{1-\alpha_j} \quad (3)$$

which represents capital demand by firms. Firms rent physical capital at the rental rate up to the point where marginal product of capital equal to the marginal cost of capital. Equations (2) and (3) satisfies the equilibrium conditions for the two factors of production, as at the beginning of each period labour force and capital stock are given.

Equation (4) simply states that capital stock in the next period in country j

depends on the investment to this country in this period minus depreciation rate of capital.

$$Kstock_{j,t+1} = Inv_{j,t} + (1 - DepR_j) \cdot Kstock_{j,t} \quad (4)$$

The higher investment in current period the more capital stock is available for the next period. The higher $DepR_j$ depreciation rate of the stock capital in this period the less capital stock is available in two countries for the next period.

Household Sector of the Economy

The modeling of household behavior follows the life-cycle theory. In the model, there are 5 generations living side by side at each point in time. Each new generation has 5 periods to live, with each period corresponding to 12 years of life. Perfect foresight characterize individuals expectations. Individuals know when they will work, retire and die. We assumed here that individuals work 48 years, i.e. when they are members of the $g1$, $g2$, $g3$ and $g4$ age groups. They retire at the age of 64, i.e. when member of $g5$ age group. Young generation are supported by their parents until the age of 17. The 5 generations included a population between 17 and 76 years of age. It is assumed in this model that household live during 76 years. When a household dies, new generation fulfills the gap at the

same time. The model horizon consists of 30 periods of 12 year each. It is useful to represent the life-cycle behavior in matrix form.

<i>period</i>	<i>12years</i>	<i>12years</i>	<i>12years</i>	<i>12years</i>	<i>12years</i>
	<i>g1</i>	<i>g2</i>	<i>g3</i>	<i>g4</i>	<i>g5</i>
<i>t1</i>	<i>individual(A)</i>				
<i>t2</i>		<i>individual(A)</i>			
.....					
<i>t29</i>					
<i>t30</i>					

From the above matrix we see that individual A is included in $g1$ age group in period $t1$, but moves to $g2$ age group in period $t2$ and so on. We assume here that after $g5$ age group, individual A dies. Household maximizes utility represented by a Constant Elasticity of Substitution (CES) form. They maximize utility with respect to consumption $c_{g,t}$ of age group g at time t and bequest beq subject to their total income in whole period. Hence household's utility is given by,

$$U = \sum_{G=1}^5 \left(\frac{1}{1 + DiscR_j} \right)^g (c_{g,t+g-1}^{1-\theta} + B_g^\theta beq_{g,t+g-1}^{1-\theta}), 0 < \theta < 1; \quad (5)$$

$$B_g = 0, g \neq 5; B_g > 0, g = 5.$$

where $DiscR_j$ is the pure rate of time preference and θ is the inverse of the of the intertemporal elasticity of substitution. Notice that beq given only during the last period of life. In this two-country model household has no borrowing constraints. Moreover capital markets are perfectly integrated. Considering the above two assumptions, household budget constraint in each period is given by:

$$\begin{aligned}
& (1 + ContxR_{j,t}) \cdot Pcon_{j,t} \cdot Con_{j,t,g} + Lend_{j,t+1,g+1} \\
= & (1 - WTxR_{j,t} - ctr_t) \cdot W_{j,t} \cdot EP_{j,g} + \sum_i (1 + RintJ_{i,t-1} - KTxR_{j,t}) \\
& \cdot P_{i,t-1} \cdot BIJ_{i,j,t,g} + (1 + RRET_{j,t-1} - KTxR_{j,t}) \cdot \\
& Pinu_{j,t-1} \cdot K_{j,t,g} + (1 - WTxR_{j,t}) \cdot Pen_{j,t,g} + Inh_{j,t,g} - beq_{j,t,g} \quad (6)
\end{aligned}$$

The left-hand side of equation is total household spending and the right-hand side of equation represents household total income. Total spending of household consist of consumption and lending. The first part of left-hand side of equation consists of consumption spending and tax paid on consumption activity $(1+ContxR_{j,t}) \cdot Pcon_{j,t} \cdot Con_{j,t,g}$. The second part of left-hand side of equation consists of saving that will be spend on bonds and on financial capital. The right-hand side of equation represents household total income. It consists of wage

$W_{j,t} \cdot EP_{j,g}$ (for retired generation this equals zero). Also households income benefit from interest earnings from bonds $\sum_i (1 + R_{int} J_{i,t-1} - KTxR_{j,t}) \cdot P_{i,t-1} \cdot BIJ_{i,j,t,g}$ and physical capital.

As the returns from bond and capital ownership title are equal whenever they are issued, the household is indifferent with respect to the composition of his wealth. It is assumed for numerical purposes that capital titles are owned by local residents only and that government bonds are characterized by a partial home bias. On the right-hand side of equation we see other source of income of household: pension ($Pen_{j,t,g}$), inheritance ($Inh_{j,t,g}$), bequest ($beq_{j,t,g}$) and contribution (ctr_t) to pension plan. In the above equation ($Pen_{j,t,g}$) is equal to zero for $g1-g4$ generations because only age-group $g5$ receive pension. Government collect taxes on wage and pension income with wage tax rate ($WTxR_{j,tt}$) ; on asserts holdings with capital tax rate ($KTxR_{j,t}$); and on consumption spending with consumption tax rate $ContxR_{j,t}$. Then:

$$\begin{aligned}
& (1 + Contxr_{j,t} \cdot Pcon_{j,t} \cdot Con_{j,t,gn} \\
= & (1 - WTxR_{j,t} - ctr_t) \cdot W_{j,t} \cdot EP_{j,gn} \\
& + \sum_i (1 + R_{int} J_{i,t-1} - KTxR_{j,t}) \cdot P_{i,t-1}
\end{aligned}$$

$$\begin{aligned}
& \cdot BIJ_{i,j,t,gn} + (1 + RRET_{j,t-1} - KTxR_{j,t}) \cdot \\
& Pinv_{j,t-1} \cdot K_{j,t,gn} + (1 - WTxR_{j,t}) \cdot \\
& Pen_{j,t,gn} + Inh_{j,t,gn} - beq_{j,t,gn}
\end{aligned} \tag{7}$$

The above equation is similar to equation (6), but applies to the last generation. This is why there is no saving. Last generation does not save. In this equation pension income ($Pen_{j,t,gn}$) is greater than zero. ($beq_{j,t,gn}$) Bequest represents a fraction $beqR_{j,g}$ of last period of life consumption.

Equation (8) represents labor income. It depends on a productivity profile ($EP_{j,g}$). We assumed that productivity profile is the same in the two countries, but different among age groups.

$$Lin_{j,g,t} = Wage_{j,t} \cdot EP_{j,g}, \tag{8}$$

$$g = 1, 2, 3, 4, 5.$$

From equation (9) we see that labor income is a quadratic function of age.

$$EP_g = \gamma + \lambda g - \Psi g^2, \tag{9}$$

$$\gamma, \lambda, \Psi \geq 0.$$

The parameters γ , λ and Ψ are chosen such that individuals earn the highest labor earnings at middle age. Pensions depend on the pension replacement rate $PenR_j$ of wage income earnings during working life. That is,

$$Pen_{j,t,gm} = PenR_j \cdot \frac{1}{4} \sum_{gj} W_{t-m+g} h_{t-m+g}^g z_{t-m+g}^g \quad (10)$$

In order to find optimal consumption and bequest of household, we differentiate household utility function represented by equation (5) subject to individual life-time budget constraint represented by equation (6). Equation (11) and (12) represents consumption and bequest of household which were derived by first-order condition of the consumer problem.

$$\frac{C_{j,t+1,g+1}}{C_{j,t,g}} = \left[\frac{1 + RRET_{j,t-1}(1 - KTxR_{j,t})}{1 + DiscR_j} \cdot \frac{Pcon_{j,t}}{Pcon_{j,t+1}} \right]^\sigma \quad (11)$$

Where $C_{j,t,g}$, is consumption in country j at time t for age group g , (i.e., current consumption level) and $C_{j,t+1,g+1}$ is consumption in country j at time $t + 1$ for all age group in the next period (i.e., future consumption level). The equation indicates that consumption behavior over the lifetime depends on the interest rate $RRET$, $DiscR_j$ the pure rate of time preference, σ the inter-temporal elasticity

of substitution, times the price ratio between two period $\frac{P_{con_{j,t}}}{P_{con_{j,t+1}}}$. If $RRET_{j,t-1}$ is higher than the $DiscR_j$, then future consumption is greater than current consumption. The extent to which future consumption is greater than current consumption depends on σ , the inter-temporal elasticity of substitution.

Bequests are distributed at the end of each generation's lifetime and is specified as in Blinder (1994):

$$beq_{j,t,g} = beqR_{j,g} \cdot P_{con_{j,t}} \cdot Con_{j,t,g} \quad (12)$$

The following equation (13) applies for the steady state and simply says that consumption level at period t is equal to the consumption level at period $t + 1$ for the same age group. In this model, there is no technological progress, so steady state means a stationary state with zero growth. In other words, in steady state, $g1$ generation takes the same prices and budget constraint at time $t + 1$ as the $g2$ generation took at time t . As their preferences are also the same, $g1$ generation will repeat the same choice of preference at time $t + 1$ as $g2$ did at time t .

$$C_{j,t+1,g} = C_{j,t,g} \quad (13)$$

Inheritances are assumed to be distributed equally among working generations, so the $InhR_{j,g}$ parameter will be set equals to $\frac{1}{4}$.

$$POP_{j,t,g} \cdot Inh_{j,t,g} = InhR_{j,g} \cdot \sum_{gm} POP_{j,t,gm} \cdot beq_{j,t,gm} \quad (14)$$

In equation (14), the left-hand side of equation represents the amount of inheritances that are received equally by all working generations. The group $g5$ is the retired generation that leaves a bequest to $g1, g2, g3, g4$ age groups equally. The variable $Inh_{j,t,g}$ is the inheritance received by working age groups. In the beginning of this section, we mentioned that there are two final goods in this two-country economy. Thus households must allocate their consumption expenditure between the two goods. Equation (15) represents the share of aggregate consumption of households in j country from i country.

$$ConI_{i,j,t,g} = AlConI_{i,j} \cdot \left(\frac{PCon_{j,t}}{P_{i,t}} \right)^{sigCon_j} \cdot Con_{j,t,g} \quad (15)$$

It says that consumption in country j of goods produced in country i at time t (that is imported from country i by country j). $ConI_{i,j,t,g}$ depends on the preference parameter of imported goods of country j from country i , $AlConI_{i,j}$, times the ratio of consumption price in country j at time t to the price of country

i at time t ($\frac{PC_{j,t}}{P_{i,t}}$), and times home consumption of country j at time t . If the parameter $AlConI_{i,j}$ is large when $i \neq j$, then people prefer imported over domestic goods. From (15) notice that if $(P_{i,t})$ increases then demand decreases, but if the aggregate price $(PCon_{j,t})$ increases with respect to $(P_{i,t})$, then demand increases. The elasticity $(sigCon_j)$ represents to which extent imported and domestic good are substitute. If $sigCon_j$ is smaller than 1, then even large increase in countries i 's price, will not reduce much the demand for good produced in country i . On the other hand, if $sigCon_j$ is larger than 1 then even small increase in the price of country i , will reduce demand for good produced in country i proportionally more than the decline in price.

Given the composition of consumption, $Pcon_{j,t}^{1-sigCon_j}$ in equation (16), gives the explicit form of the aggregate price. The price of consumption, $PCon_{j,t}$ is a composite of the two countries output prices $P_{i,t}$.

$$PCon_{j,t}^{1-sigC_j} = \sum AlConI_{i,j} \cdot P_{i,t}^{1-sigC_j} \quad (16)$$

Equation (17) represents total demand of the two countries. It is equal to sum of population times consumption.

Investment

In this model household can buy two types of assets. The first type is the bonds issued by governments of two countries, which can be owned by residents of any country. The second type, ownership titles of capital stock, is assumed to be owned by local residents only. Households are indifferent between holding bonds or capital, because these two assets are perfect substitutes. As the country stock of physical capital is a composite of the two countries final goods, a CES function describes the investment technology. Therefore, the composition of countries investment $EInv_{i,j,t}$ take a form similar to the composition of countries consumption. Equation (18) represents investment demand from country j for good produce in country i at time t . That demand depends on the investment technology parameter ($ALInv_{i,j}$) and on the own total investment made by country j ($Inv_{j,t}$). If overall investment in region j increases then investment demand for good in i by country j increase. As for countries consumption demands, the countries investment demand depends on the relative prices ($\frac{PInv_{j,t}}{P_{i,t}}$). If the price of investment $PInv_{j,t}$ (investment demand) in country j increases then investment demand for goods produced in country i increases.

$$EInv_{i,j,t} = ALInv_{i,j} \cdot \left(\frac{PInv_{j,t}}{PInv_{i,t}} \right)^{sigInv_j} \cdot Inv_{j,t} \quad (18)$$

Accordingly, the price of aggregate investment, $PInv$, is determined by an equation similar to equation (16) for the price of consumption:

$$Pinv_{j,t}^{1-sigInv_j} = \sum (AllInv_{i,j} \cdot P_{i,t}^{1-SigInv_j}) \quad (19)$$

Equation (20) represents rate of return on capital in country j at time t . It depends on the price ratio of capital in two successive periods (last and current). If the current price of capital ($Pinv_{j,t}$) increases, then rate of return on capital ($RRET_{j,t}$) will increase. The ratio thus captures capital gains or losses. It also depends on the rental return from physical capital ($Rent_{j,t}$). The higher the return of rent the more will be the rate of return on capital. Finally it depends on ($DepR_j$), the depreciation rate of capital. The higher is depreciation rate the less will be return on capital.

$$RRET_{j,t} = \frac{(rent_{j,t} + (1 - DepR_j) \cdot Pinv_{j,t})}{Pinv_{j,t-1}} \quad (20)$$

Equation (21) represents the evolution of the capital stock in steady state. In steady state, increase in investment depends on the population growth rate. Investment increases accordingly with a population growth rate ($NN_{j,t} - 1$) and

depreciation rate $DepR_j$.

$$Inv_{j,t} = ((NN_{j,t} - 1) + DepR_j) \cdot Kstock_{j,t} \quad (21)$$

Government Behaviour

Government behavior consists of the following: government public expenditure on goods, maintenance of various transfer payments, the levying of taxes, and the issuance of debt. Government public expenditure on goods include: expenditure on health ($GHEA_j$), on education ($GEDU_j$) and other expenditures ($GEXP_j$). Government also pays interest on previously issued bonds.

$$\begin{aligned} & P_{j,t} \cdot Bond_{j,t+1} + \sum_g POP_{j,t,g} \cdot WTxR_{j,t} \cdot Wage_{j,t} \cdot \\ & EP_{j,g} + WTxR_{j,t} \cdot Pens_{j,t,g} + ConTxR_{j,t} \cdot Pcon_{j,t} \cdot \\ & Con_{j,t,g} + KTxR_{j,t} \cdot \sum_i \left(\frac{RintJ_{i,t-1} \cdot P_{i,t}}{P_{i,t-1}} \cdot \right. \\ & \left. P_{i,t-1} \cdot Bij_{i,j,t,g} \right) + KTxR_{j,t} \cdot \\ & (RRET_{j,t} - 1) \cdot PInv_{j,t-1} \cdot K_{j,t,g} \\ = & P_{j,t} \cdot (Gov_{j,t} + GovH_{j,t} + GovE_{j,t}) + \\ & (RintJ_{j,t-1} \cdot \frac{P_{j,t}}{P_{j,t-1}} \cdot P_{j,t-1} \cdot Bond_{j,t}) \end{aligned} \quad (22)$$

The left-hand side of equation (21) represents government revenue from taxes and issuing bonds. Government collects taxes on wage and pension income with $(WTxR_{j,tt})$ -wage tax rate ; on asserts holdings with $(KTxR_{j,t})$ -as the capital tax rate; and on consumption spending with $ContxR_{j,t}$ as the tax rate on consumption. Contrary to individual and firm behavior government does not optimize it's behavior in this model.

Equation (23) shows that distribution of contribution among retired generation must be equal to contribution of working generation. Left-hand side of equation shows the number of retired population that will get benefit from contribution, while right-hand side of equation shows the amount of contribution that working generation need to contribute.

$$\sum_j \sum_{g=4}^5 (Pop_{j,t,gm} * Pens_{j,t,gm}) = CTR_t * \sum_j \sum_{g=1}^5 (Pop_{j,t,g} * EP_{j,g} * wage_{j,t}) \quad (23)$$

The pension program is based on the pay as you go system. Individuals contribute to the pension plan while they are working. When they retire they receive pension benefits. In this model, a central body in each country manages pension program.

Good Markets and Aggregation Conditions

In this model we assume that all markets are perfectly competitive. Equation (24) represents income identity. It says that in each countries output must be equal to total demand.

$$Q_{j,t} = \sum_{i=1}^j (ECon_{j,i,t} + EInv_{j,i,t}) + (Gov_{j,t} + GovH_{j,t} + GovE_{j,t}) \quad (24)$$

Markets for labor and physical capital exists in each country, because labor and physical capital can not move from one country to another. Equation (25) states that total saving of the two countries must be equal to total demand. The left-hand side of the equation represents saving and the left-hand side of equation represents total supply of government bonds and physical capital.

$$\sum_j \sum_{g=1}^5 (Pop_{j,t+1,g+1}) * Lend_{j,t+1,g+1} = \sum_j (P_{j,t} * Bond_{j,t+1} + Pinv_{j,t} * Kstock_{j,t+1}) \quad (25)$$

In steady state condition Bonds are issued as fraction of population growth. We can see this from equation (26).

$$Bond_{j,t+1} = NNP_{j,t} * Bond_{j,t} \quad (26)$$

Integrated asset markets

In the previous discussion we mentioned that bonds and physical capital are perfectly substitutes. So the expected returns of these two assets are equal. In equation (27) we can see this.

$$\frac{Rint_{j,t} \cdot P_{j,t+1}}{P_{j,t}} = RRET_{j,t+1} \quad (27)$$

Financial capital market is perfectly integrated, households can easily buy bonds from other countries. These two assets are perfect substitutes in a view of households. Thus interest rate is equal in two countries From equation (28) we see that

$$Rint_t = Rint_{j,t} * \frac{P_{j,t+1}}{P_{j,t}} \quad (28)$$

6. CALIBRATION

The calibration procedure proceeds in 4 steps. First, it determines demographic parameters and factor prices by using the equations of the supply side of the economy. In a second step, households take factor prices as given and maximize utility subject to budget constraints. This determines private consumption and private savings. In addition to that on the demand side, a third step, government spends on health, education and other types of expenditure. In this model we assume that all markets are perfectly competitive. So the final step is to ensure that equilibrium and aggregation conditions are satisfied.

The calibration procedure is implemented with the assumption that the economies are in steady state at the initial period, which in the model is year 1942. In this model we have two countries: Uzbekistan and rest of the world. Rest-of- the world is the major trading partners of Uzbekistan and includes Germany, UK, Russia, Switzerland and South Korea. In terms of their export/import shares they account for about 30-35 % of Uzbekistan's trade.

Table 8 reports variables and parameter values over which other parameters were calibrated. The sum of output of the two countries equals to 1 for simplification. Uzbekistan output is 0.11 and for the rest of the world it is 0.89. Various tax and growth parameters are allowed to differ across countries. Uzbekistan has relatively higher tax rates compare to ROTW.

TABLE 8. Parameters and Exogenous Variables

	Equation	Uzbekistan	Rest of the world
GDP	24	0.110	.890
Government debt	22	0.050	0.050
Trade balance	24	-0.347	0.347
wage tax rate	22	0.368	0.358
Capital tax rate	22	0.231	0.221
consumption tax rate	22	0.190	0.180
Share value of capital	1	0.260	0.300
Production scaling parameter	1	0.332	0.342

Even though the utility function parameters are likely to differ across Uzbekistan and ROTW we impose here the assumption that they are identical, as we do not have better information.

TABLE 9. Utility Function Parameters

	Equation	Uzbekistan	Rest of the world
Inter-temporal rate of substitution	10	1.21	1.21
Bequest rate	7	0.3	0.3
pure rate of time preference	10	0.021	0.021
pension contribution rate	10	0.072	0.072

Table 10 reports the dollar share received by individuals of different age groups for public health care and education expenditures. We assume that this distribution is identical across countries. As shown in table, an individual belonging to age group 17-28 receives 10.96 percent of each per capita dollar spent in public health care, but 33 percent of each per capita dollar spent in public education. From table 10 we see that last generation receives the highest health care service 42.49 percent, whereas *g1* and *g2* age groups benefit a lot from education expenditure.

TABLE 10. Public expenditure per Age Group (Dollar share per capita in percentage terms)

Age-group	g1(17-28)	g2(29-40)	g3(41-52)	g4(53-64)	g5(65-76)
Health	.1096	.1213	.1399	.2043	.4249
Education	.330	.360	.190	.10	.065

The last table of our calibration is a trade flow matrix between Uzbekistan and ROTW.

TABLE 11. Trade flow

Table 5.	Uzbekistan	Rest of the world
Uzbekistan	0.11	0.013
Rest of the world	0.047	.89

Data source: International Monetary fund. Trade flow year book (2000).

From table 11 we see that Uzbekistan's demand for its own product equals 0.11, whereas it exports 0.013 to the rest of the world. Similarly Rest of the world's demand for its own product equals 0.89 whereas it exports 0.047 to Uzbekistan.

The demographic trends of Uzbek and Rotw in the model

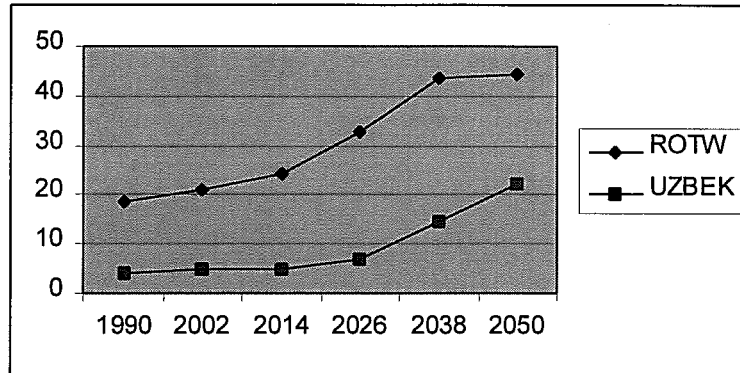
The two countries of the model are Uzbekistan and its principle-trading partners. We defined its principle trading partners as ROTW. ROTW is composed of the five countries, which are Germany, UK, Switzerland and Russia. From chart 1 we see that the age-group composition of the population is different between Uzbekistan and ROTW.

By the way ROTW in chart 1 represents the average of five above countries old-age dependency ratio. As we mentioned before, the old-age dependency ratio, defined as the number of individuals 65+ divided by those aged between 15-64, is expected to rise

dramatically in ROTW and in less extent in Uzbekistan. The old-age dependency ratio in ROTW takes an upward trend from 2015, while in Uzbekistan it starts form 2026.

CHART 1.

Old-age dependency ratio.



From Chart 1 we see the demographic shock that is coming is more severe in ROTW than in Uzbekistan.

7. SIMULATION RESULTS

In this simulation exercise, we introduce the demographic shocks to the economy of Uzbekistan and ROTW. To solve the model over the model horizon, we use the General Algebraic Modelling System (GAMS) software. In order to investigate the demographic shock, twenty-five iterations are required to find the equilibrium state variables of the dynamic economy.

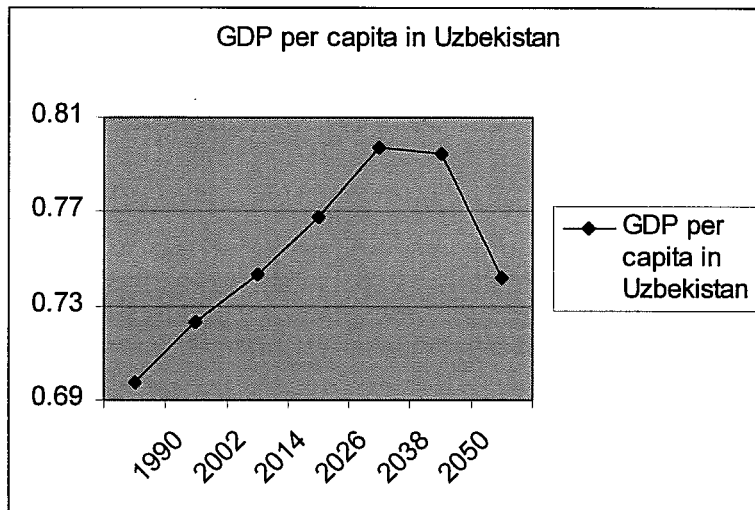
We have two states of the economy in simulation exercise. First, we have the economic state of the two countries in 1990 that is before the ageing shock. The second state is the economy of the two countries from 1991 to 2050 when we impose the ageing shock. We will compare the above two states of the economy of the two countries.

The simulation horizon extends over a longer period in order to reach a long-run steady state. In this section, we only report the dynamic transition of the economy from year 1990 to year 2050.

We start to analyse the ageing effect on the supply side of the economy. Ageing of population leads to an increase in the number of individuals 65+ divided by those aged between 15-64. As a result the labour force declines relative to physical capital.

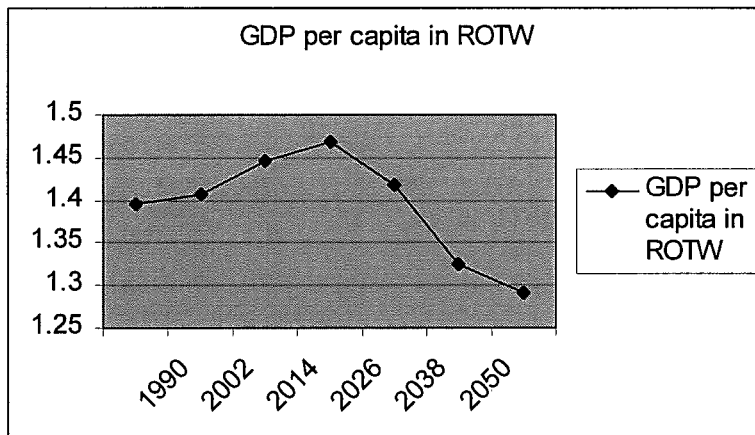
Recall that labour is immobile across countries. Hence, the labour factor becomes more expensive in countries whose population ages more rapidly. In contrast, the capital factor becomes relatively more abundant. So this rental return on capital could decline. As there is negative relationship between rental return on capital and ageing process decline of capital return will be more in faster aging country. For instance the speed of ageing process is more severe in ROTW compare in Uzbekistan. Interestingly to note that change in GDP per capita is closely linked to the change in old-age dependency ratio reported in Chart 1. Chart 2 and 3 represents GDP per capita for each country.

CHART 2.



From Chart 2 we see that GDP per capita in Uzbekistan decreases with population ageing. A similar behaviour of GDP per capita occurred for ROTW as we can see from Chart 3 for ROTW. But in Uzbekistan the decline is more pronounced.

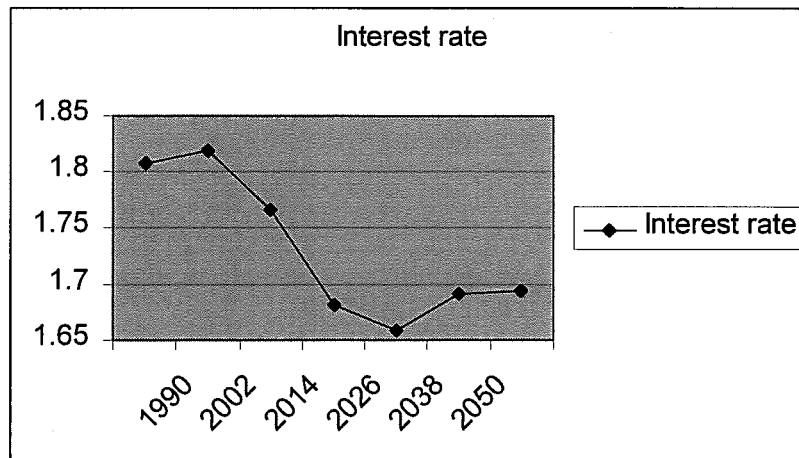
CHART 3.



In the previous discussion we mentioned that bonds and physical capital are perfectly substitutes. So expected returns of these two assets are equal. Moreover,

financial capital market is perfectly integrated. So a decrease in rental return of capital puts downward pressure on interest rate. Chart 4 represents the declines in interest rate.

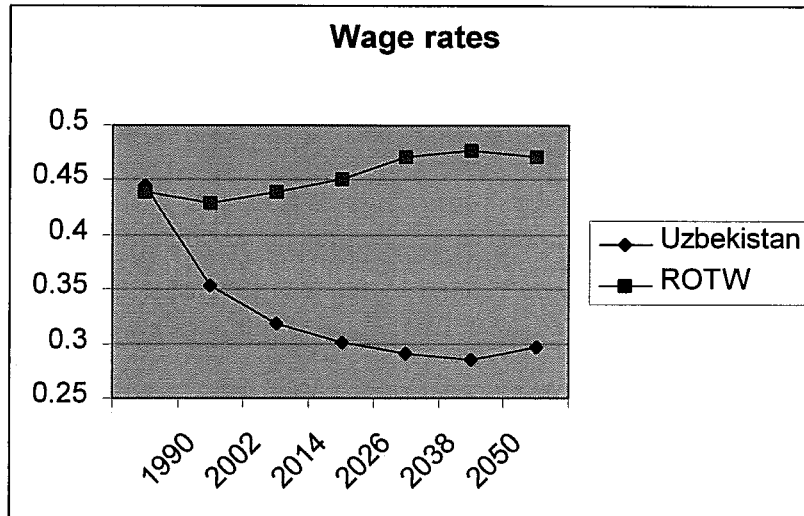
CHART 4.



The reaction of wage rates differs between two countries. As a result of ageing of population, labour force growth declines and makes labour more expensive. Moreover labour immobility across countries makes wage levels different between them. This will lead to increase in wage rate in faster ageing countries. Chart 5 represents the ageing effect on wage rates in both countries. We can see that wage rate increases in ROTW, but declines in Uzbekistan. Increase in wage rates is closely linked with ageing of population. Interestingly to note that real wage increases in Uzbekistan, because price level decreases.

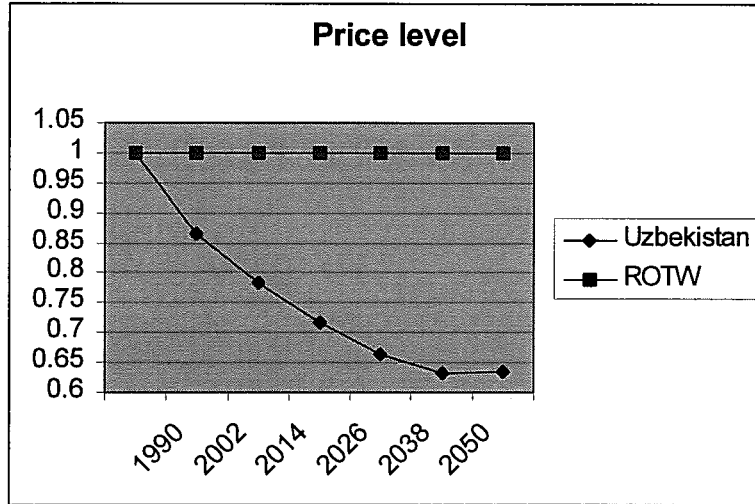
We can see this by comparing Chart 1 and Chart 5

CHART 5.



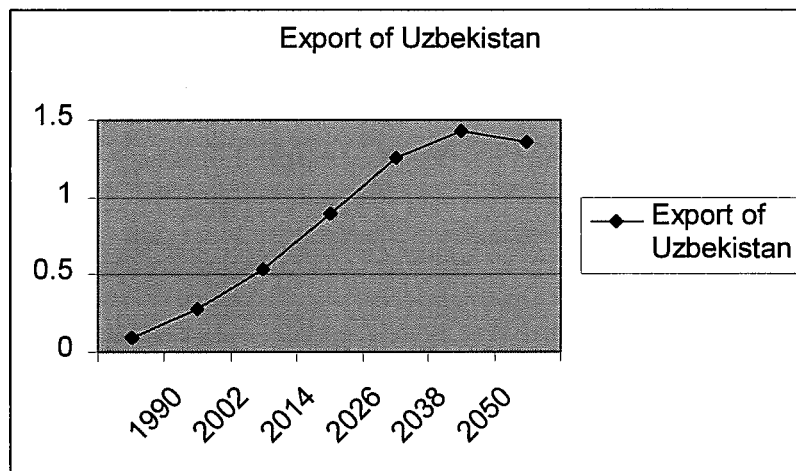
Substantial increase in output in Uzbekistan puts downward pressure on output price level. The output price of the ROTW is considered to be constant at one. Chart 6 represents the price behaviour of the output of the two countries. The chart indicates a decline in the output price of Uzbekistan relative to the price of ROTW. The output price of ROTW remains constant as it represents the numeraire of the model. The decline of the output price in Uzbekistan represents a deterioration of its terms of trade.

CHART 6.



The decline of price in Uzbekistan increases competitiveness of their goods. This will lead to increase of export of Uzbekistan to ROTW. Chart 7 reports the exportation of Uzbekistan.

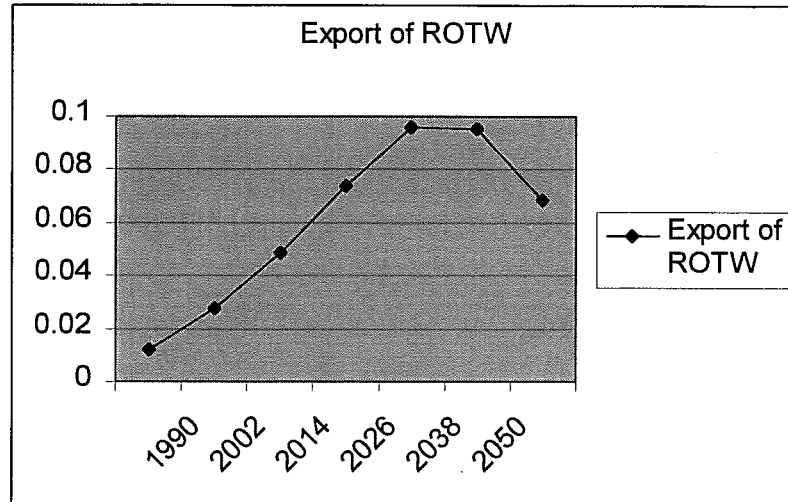
CHART 7.



At the same time export of ROTW decreased to Uzbekistan, while import increased.

Chart 8 reports exportations from ROTW. Exports increase but to a much smaller degree than for Uzbekistan.

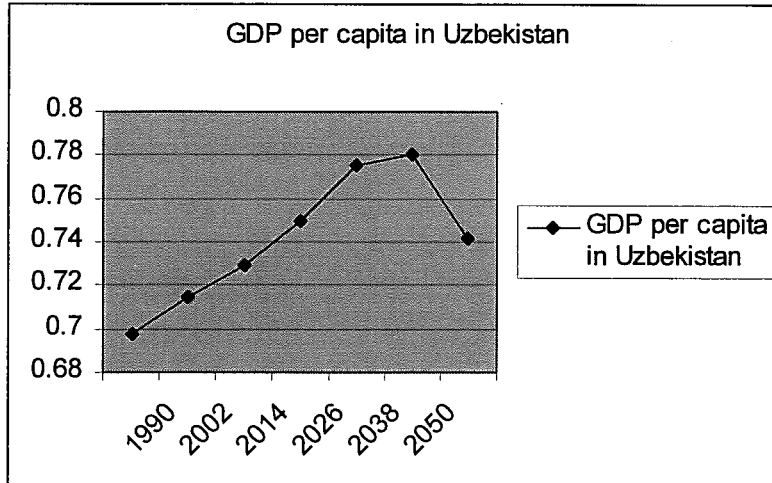
CHART 8.



Ageing shift in Uzbekistan only.

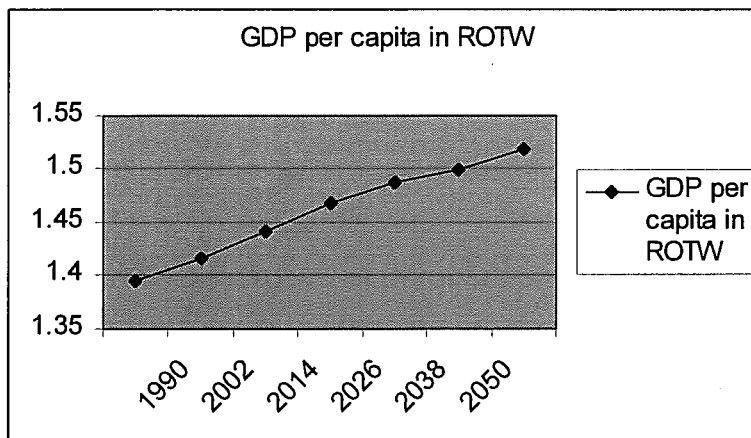
Now we assume that only Uzbekistan experiences a demographic shock. We will compare the results with the case where both countries age. Chart 9 and 10 represents behaviour of GDP per capita after the demographic shock only to Uzbekistan. Comparing Charts 9 and 10 to Charts 2 and 3 we see that change in GDP per capita is closely linked with demographic shock. Only Uzbekistan GDP per capita is effected by demographic shock.

CHART 9.



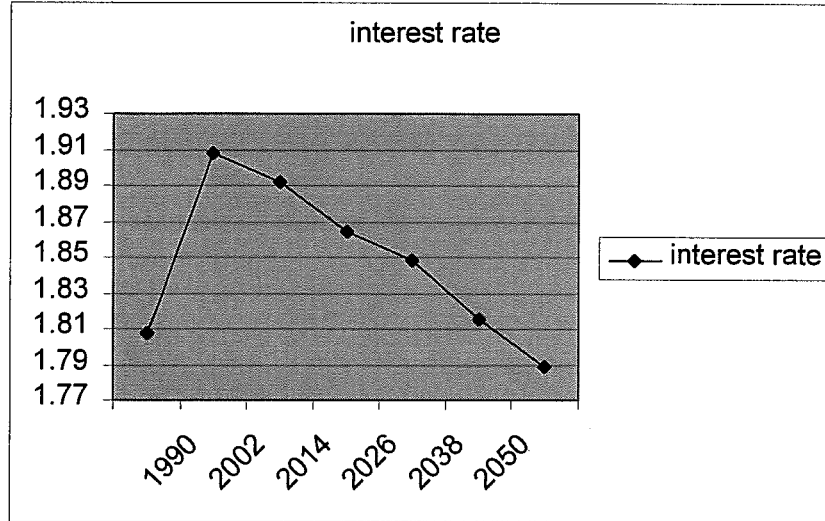
From Chart 10 we see that GDP per capita in ROTW is not affected by demographic shock in Uzbekistan.

CHART 10.



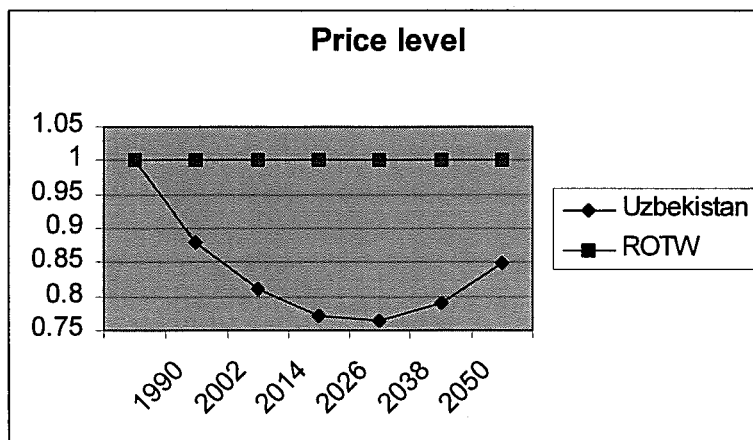
Interest rate decreased as a result of demographic shock in Uzbekistan, but not by as much compared to the case where ROTW also ages.

CHART 11.



Price level decreased as a result of demographic shock to Uzbekistan. Again, comparing Chart 6 when there is demographic shock to both countries to Chart 12 when there is only demographic shock to Uzbekistan we see that price level decreased by much more in first case.

CHART 12.



Consequently, the above two simulation experiments show that the ageing

process in the Rest-of-the-World will have an important impact on the relative prices faced by Uzbekistan.

Conclusion

Demographic projections for Uzbekistan and its principle trading partners indicate that that the fraction of the population over 65 will increase in the next few decades, because of high emigration, increase in life expectancy and low birth rate.

The speed of ageing process is different between Uzbekistan and ROTW. In ROTW ageing process starts much earlier than Uzbekistan.

As a result of ageing of population in ROTW labour force declined and hurt rental return on capital. This leads to flight of capital from ROTW to Uzbekistan. At the same time wage rate increases in ROTW, because of labour scarcity and decrease in Uzbekistan, because of labour relative abundance.

Overall impact of ageing leads to a substantial decline in the terms of trade of Uzbekistan. Ageing of population is likely accelerating the trade between Uzbekistan and ROTW. In the model, export of Uzbekistan to ROTW increased substantially. This evolution might be not happened, if the Uzbekistan government maintains its multiple exchange rate regime. For the moment there exist some significant barriers to investment in Uzbekistan. Output increased in Uzbekistan, whereas decrease in ROTW. Output per capita is closely linked with population ageing.

From above result we can conclude that Uzbekistan is benefited from ageing of its

trading partners. This might not happen if Uzbekistan stay with it's multiple exchange rate regime. So Uzbekistan needs to implement flexible exchange rate regime.

Endnotes:

- 1) United Nations source. It can be found at www.un.org/esa/socdev/ageing/agewpop.htm
- 2) Online database on Uzbekistan. It can be found at www.luptravel.com/country-guide-study/uzbekistan/uzbekistan50.
- 3) Online database on Uzbekistan. It can be found at iicas.org/english/an_en_06_04_01.htm
- 4) Online database on Europe. It can be found at www.eu2001.se/education/eng/docs/uppsala_diskussion_sommestad1
- 5) Online database on Uzbekistan. It can be found at www.luptravel.com/country-guide-study/uzbekistan/uzbekistan24.html
- 6) Online database on Uzbekistan. It can be found at www.unchs.org/habrdd/conditions/socentasia/uzbekist.htm

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Annex

```

1 * CALIB.GMS
2
3 $OFFLISTING
4 $OFFSYMREF OFFSYMLIST OFFUELLIST OFFUELXREF
5 * =====
6 * September 9 2001 --- Overlapping Generations Model ---
7 *
8 * This version
9 * - Multicountry (J)
10 * - Multisector (S)
11 * - Multi professional categories (IPROF)
12 * - Multi labor qualifications per professional categories (IQUAL)
13 * - Non stationary demographics
14 * - Financial and physical capital internationally owned
15 * - Dynamics vs steady state effects
16 *
17 * =====
18 * Tested for - Calibration
19 * - Change of numeraire
20 * - Demographic shocs
21 * - Productivity shocks
22 * =====
23
24 * Choose the number of generations
25 * =====
26
27 SET G GENERATIONS / G1 * G5 /
28 GI(G) FIRST GENERATION
29 GJ(G) GENERATIONS WORKING / G1 * G4 /
30 GM(G) RETIRED GENERATIONS / G5 /
31 GN(G) LAST GENERATION
32 ;
33 GN(G) = YES$(ORD(G) EQ CARD(G));
34 GI(G) = YES$(ORD(G) EQ 1);
35
36
37 SET J / UZB, ROW /; ALIAS (I,J), (I,II), (J,JJ), (G,GG);
38 SET S / S1 /; ALIAS (S,SS);
39
40 OPTION DECIMALS=6;
41
42 PARAMETERS
43 RR final interest rate
44 EP9(J,G) human capital profile
45 BR(J) benefit ratio
46 SIG(J) (inverse of) inter-temporal rate of substitution
47 BEC(J,G) bequest parameter
48 IDC(G) inheritance distribution
49 NGR(J) population growth rate (is determined in the demog.gms file when the
50 * latter is used; otherwise is fixed at 1 or 1.156)
51 ALFA(J) production function parameter
52 YY0(J) base year output
53 LLO(J) base year labor
54 KK0(J) base year capital
55 WTAX(J) wage-income tax rate
56 KTAX(J) capital tax
57 CTAX(J) consumption tax

```

58 FA(J) foreign assets (must sum to zero)
 59 GHEA(J) health care expenditures
 60 GEDU(J) education expenditures
 61 DH(G) distribution parameter of health care by age
 62 DE(G) distribution parameter of health care by age
 63 B (J) net government debt
 64 WW(J) final wage rate
 65 NCl(J,G) population
 66 HAC(J,G) financial assets accumulated
 67 BiExp(J,J) Bilateral Exports
 68 ;
 69
 70 \$ONTEXT
 71 ALFA,WTAX,KTAX,CTAX,EP9, AND BR were taken from Hviding AND Merette (1998), of
 72 which data were taken from official OECD statistics
 73
 74 FA(JP) and FA(US) were taken from OECD (2000), "National Accounts of OECD
 Countries: Detailed
 75 Tables 1988/1998: Volume II", OECD, Paris.
 76 FA(EZ) was assumed to be the residual of FA(US) and FA(JP)
 77
 78 Note that except for relative GDP size, France is assumed to represent EZ. That
 is,
 79 tax, production parameter, demographic and other data corresponds to the case of
 France.
 80 The demographic projection of France is similar to that of Europe as it can be
 seen
 81 in Turner et al. (1998)
 82
 83 * Relative sizes of Regional GDP (YY.FX in the model) were taken from
 84 * OECD Statistics (www.oecd.org/std/gdp.htm),
 85 * and corresponds to year 2000 data at current prices and exchange rates.
 86 * Data for KK, LL, and B with respect to GDP were taken from Hviding and Merette (
 1998)
 87
 88 \$OFFTEXT
 89
 90 SIG(J) =1.1*2 ;
 91
 92 NGR(J) = 1.0 ;
 93 RR = 0.3231*2.5 ;
 94 GHea("UZB") = 0.00246; GHea("ROW") = 0.0224;
 95 GEdu("UZB") = 0.00147; GEdu("ROW") = 0.0134;
 96 DH(G) = 0;
 97 DE(G) = 0;
 98
 99 **TABLE** BiExp(I,J)
 100 UZB ROW
 101 UZB 88 12
 102 ROW 20 880
 103
 104 ;
 105 ALFA("UZB") = 0.3322; ALFA("ROW") = 0.3423;
 106 WTAX("UZB") = 0.3586; WTAX("ROW") = 0.3586;
 107 KTAX("UZB") = 0.2214; KTAX("ROW") = 0.2214;
 108 KTAX(J) = 0;
 109 CTAX("UZB") = 0.1807; CTAX("ROW") = 0.1807;

```

110 BEC(J,G) = 0; BEC(J,GN) =.3;
111 IDC(G) = 1/CARD(GJ); IDC(GM) = 0;
112 EP9("UZB",G) = 1+.237*ORD(G)-.038*(ORD(G)**2); EP9("ROW",G)=2*EP9("UZB",G);
113 BR(J) = 0.5216*(SUM(GJ,EP9(J,GJ))/CARD(GJ));
114
115
116 YY0(I) = SUM(J, BiExp(I,J));
117 FA(I) = SUM(J, BiExp(I,J)-BiExp(J,I));
118 FA(I) = FA(I) /SUM(JJ,YY0(JJ));
119 BiExp(I,J) = BiExp(I,J) /SUM(JJ,YY0(JJ));
120 YY0(I) = YY0(I) /SUM(JJ,YY0(JJ));
121
122 PARAMETER BID; BID=SUM(I,FA(I)); DISPLAY BID;
123 DISPLAY YY0,FA;
124
125 FA(I) = -FA(I)/RR;
126
127 display fa;
128
129 KK0("UZB") = .3*YY0("UZB"); KK0("ROW") = .3*YY0("ROW");
130 LLO("UZB") = 1.5*YY0("UZB"); LLO("ROW") = 1.5*YY0("ROW");
131 B("UZB") = 0.05*YY0("UZB"); B("ROW") = 0.05*YY0("ROW");
132
133 POSITIVE VARIABLES
134
135 RC(J) rental cost of capital
136 LL(J) labour supply
137 KK(J) capital stock
138 YY(J) output
139 CC(J,G) consumption level
140 WC(J) initial wage rate
141 BEQC(J,G) bequest
142 INHC(J,G) inheritance
143 TT(J) tax income
144 AA(J) scalar in the production function
145 GEXP(J) government expenditure
146 NNJ(J) pop level adjustment (to normalize pop when demog.gms is used, otherwi
se fix to 1)
147 NC(J,G) population
148 HEAC(J,G) health care expenditure by age-group
149 EDUC(J,G) education expenditure by age-group
150 CTR00(J) Contribution rate on pay-as-you-go pension plan
151
152 FREE VARIABLES
153
154 DEP(J) physical depreciation rare of capital
155 DELTAC(J) consumers rate of time preference
156 SC(J,G) private savings
157 HA(J,G) households assets
158 DIC(J,G) after tax income
159 WAL00(J) walras variable
160 OBJ
161
162 EQUATIONS
163
164 EL1eq(J)
165 EL2eq(J,G)

```

```

166
167 Eleq(J)
168 E2eq(J)
169 E3eq(J)
170
171 EC1eq(J,G)
172 EC2eq(J,G)
173 EC3eq(J,G)
174 EC4eq(J,G)
175 EC5eq(J,G)
176 EC6eq(J,G)
177 EC7eq(J,G)
178 EC8eq(J,G)
179
180 EE1eq(J)
181 EE2eq(J)
182
183 EG1eq(J)
184 EG2eq(J)
185 EG3eq(J)
186
187 OBJeq
188 ;
189 *      POPULATION CALIBRATION
190
191 EL1eq(J)..      LL(J)      =E= SUM(GJ, NNJ(J)*NC(J,GJ)*EP9(J,GJ) )
192 ;
193 EL2eq(J,G+1)..  NC(J,G+1) =E= NC(J,G) / NGR(J)
194 ;
195 *      FIRM'S PROBLEM
196
197 Eleq(J)..      WC(J)      =E= (1-ALFA(J))*AA(J)*(KK(J)/LL(J))**ALFA(J)
198 ;
199 E2eq(J)..      RC(J)      =E= ALFA(J)*AA(J)*(LL(J)/KK(J))**(1-ALFA(J))
200 ;
201 E3eq(J)..      YY(J)      =E= AA(J)*KK(J)**ALFA(J)*LL(J)**(1-ALFA(J))
202 ;
203 *      CONSUMER PROBLEM
204
205 EC1eq(J,G+1)..  CC(J,G+1) =E= ( (1+RR*(1-KTAX(J))) / (1+DELTAC(J)) )**SIG(J) *
CC(J,G)
206 ;
207 EC2eq(J,GJ)..  DIC(J,GJ) =E= WW(J)*EP9(J,GJ)*(1-WTAX(J)-CTRO0(J)) + RR*HA(J,GJ)
*(1-KTAX(J)) - CTAX(J)*CC(J,GJ)
208 ;
209 EC3eq(J,GM)..  DIC(J,GM) =E= WW(J)*BR(J) *(1-WTAX(J)) + RR*HA(J,GM)*(
1-KTAX(J)) - CTAX(J)*CC(J,GM)
210 ;
211 EC4eq(J,G)..   SC(J,G)    =E= DIC(J,G) + INHC(J,G) - CC(J,G) - BEQC(J,G)
212 ;
213 EC5eq(J,GN)..  SC(J,GN)   =E= - HA(J,GN)
214 ;
215 EC6eq(J,G+1).. HA(J,G+1) =E= HA(J,G) + SC(J,G)
216 ;
217 EC7eq(J,G)..   BEQC(J,G) =E= BEC(J,G)*CC(J,G)
218 ;
219 EC8eq(J,G)..   INHC(J,G) =E= IDC(G)*SUM(GM, NC1(J,GM)*BEQC(J,GM) ) / NC1(J,G)

```

```

220 ;
221 * AGGREGATION AND EQUILIBRIUM CONDITIONS
222
223 EE1eq(J)..      KK(J) + FA(J) =E= SUM(G, NC1(J,G)*HA(J,G) ) - B(J)
224 ;
225 EE2eq(J)..      WAL00(J)      =E= YY(J) - (NGR(J)-1+DEP(J))*KK(J)
226                                     - (GEXP(J)+GHEA(J)+GEDU(J) )
227                                     - SUM(G, NC1(J,G)*CC(J,G) )
228                                     - RR* (B(J)+KK(J)-SUM(G,NC1(J,G)*HA(J,G)
    ))
229 ;
230 * GOVERNMENT
231
232 EG1eq(J)..      TT(J)          =E= SUM(GJ, NC1(J,GJ)*EP9(J,GJ)*WW(J)*WTAX(J) )+
233                                     SUM(GM, NC1(J,GM)*BR(J) *WW(J)*WTAX(J) )+
234                                     SUM(G, NC1(J,G) *RR      *HA(J,G)*KTAX(J) )+
235                                     SUM(G, NC1(J,G) *CC(J,G)*CTAX(J) )
236 ;
237 EG2eq(J)..      GEXP(J) + GHEA(J) + GEDU(J) =E= TT(J) - (RR-(NGR(J)-1))*B(J)
238 ;
239 EG3eq(J)..      SUM(GM,NC1(J,GM)*WW(J)*BR(J) ) =E=
240                                     CTR00(J)*SUM(GJ,NC1(J,GJ)*EP9(J,GJ)*WW(J) )
241 ;
242 OBJeq..         OBJ =E= 0
243 ;
244
245 * Restrictions
246
247 HA.FX(J,GI) = 0.0;
248 YY.FX(J)    = YY0(J);
249 LL.FX(J)    = LL0(J);
250 KK.FX(J)    = KK0(J);
251
252 * Initial guesses
253
254 WC.L(J)      =.7;
255 NNJ.FX(J)   = 1;
256 * NGR.l(J)  = NNGR(J,"T6") ;
257 NC.L(J,G)   = 1;
258 TT.L(J)     = 0.17;
259 GEXP.L(J)   = 0.17;
260 AA.L(J)     = 1.25;
261 WAL00.FX(J) = 0;
262 CTR00.L(J)  =.10;
263
264 RC.L(J)     = .12;
265 LOOP(GJ, HA.L(J,GJ+1) =.4+HA.L(J,GJ));
266 LOOP(G$(ORD(G) EQ CARD(GJ)), HA.L(J,G) =.5*HA.L(J,G-1)); LOOP(GM, HA.L(J,GM+
1) =.5*HA.L(J,GM));
267 DELTAC.L(J) = .11;
268
269 CC.L(J,GI)  = .1; LOOP(G, CC.L(J,G+1) = ((1+RR)/(1+DELTAC.L(J)))*SIG(J)*CC.L(J,G)
);
270 BEQC.L(J,G) = 0; BEQC.L(J,GN) = .5*CC.L(J,GN);
271 INHC.L(J,G) = IDC(G)*SUM(GN, NC.L(J,GN)*BEQC.L(J,GN))/NC.L(J,G);
272 DIC.L(J,GJ) = WC.L(J)*(1-WTAX(J))+RR*HA.L(J,GJ)*(1-KTAX(J))-CC.L(J,GJ)*CTAX(J)
+INHC.L(J,GJ);

```

```

273 DIC.L(J,GM) = BR(J)*WC.L(J)*(1-WTAX(J))+RR*HA.L(J,GM)*KTAX(J) -CC.L(J,GM)*CTAX(J)
-BEQC.L(J,GM);
274 SC.L(J,G) = DIC.L(J,G)-CC.L(J,G);
275
276 MODEL CA1 / Eleq, E2eq, E3eq, EL1eq, EL2eq, OBJeq /;
277 MODEL CA2 / EC1eq, EC2eq, EC3eq, EC4eq, EC5eq, EC6eq, EC7eq, EC8eq, EE1eq, EE2eq,
278 EG1eq, EG2eq, EG3eq, OBJeq / ;
279
280 CA2.HOLDFIXED = 1;
281
282 *---> Determine demographic and production parameters and prices
283
284 OPTIONS SOLPRINT=ON, LIMCOL=0, LIMROW=0, ITERLIM=1000;
285 SOLVE CA1 USING NLP MINIMIZING OBJ;
286
287 *---> Throw factor prices from CA1 into consumer problem and fix pop structure
288
289 NC1(J,G) = NNJ.L(J)*NC.L(J,G);
290 WW(J) = WC.L(J);
291 DEP.FX(J) = RC.L(J)-RR ;
292 DISPLAY WW,NC1,DEP.L,AA.L;
293
294 OPTIONS SOLPRINT=ON, LIMCOL=0, LIMROW=0, ITERLIM=1000;
295 SOLVE CA2 USING NLP MINIMIZING OBJ;
296
297 PARAMETER
298 DEF(J) DEFICIT-GDP RATIO
299 TR(J) TRANSFER TO THE OLD
300 BX(J) BEQUEST CHECK
301 PSR(J) PRIVATE SAVING RATE
302 NS(J) NATIONAL SAVING RATE
303 SA(J,G) SAVING BY AGE
304 CCI(I,J,G) INTER-REGIONAL CONSUMPTION
305 INVI(I,J) INTER-REGIONAL INVESTMENT
306 NX(J) NET EXPORTS
307 WALOX(J) GOODS MARKET BALANCE
308 ;
309 DEF(J) = (NGR(J)-1)*B(J);
310 TR(J) = SUM(GM,NC1(J,GM))*WW(J)*BR(J);
311 BX(J) = SUM(G,BEQC.L(J,G)*NC1(J,G))-SUM(G,INHC.L(J,G)*NC1(J,G));
312 PSR(J) = (SUM(G,NC1(J,G)*SC.L(J,G))+DEP.L(J)*KK.L(J))/YY.L(J);
313 NS(J) = (YY.L(J)-SUM(G,CC.L(J,G)*NC1(J,G))-(GEXP.L(J)+GHEA(J)+GEDU(J)
314 +RR*FA(J))/YY.L(J);
315 SA(J,G) = (SC.L(J,G)+BEQC.L(J,G))/(DIC.L(J,G)+INHC.L(J,G));
316
317
318 POSITIVE VARIABLE
319 E9(I,J) TRADE FLOW MATRIX BETWEEN REGION I AND J
320 ;
321
322 E9.L(I,J) = BiExp(I,J);
323 E9.L(I,I) = E9.L(I,I)-GEXP.L(I)-GHEA(I)-GEDU(I); DISPLAY E9.L;
324 CCI(I,J,G) = E9.L(I,J)*CC.L(J,G)/
325 ( SUM(GG,NC1(J,GG)*CC.L(J,GG))+(NGR(J)-1+DEP.L(J))*KK.L(J) );
326 INVI(I,J) = E9.L(I,J)*(NGR(J)-1+DEP.L(J))*KK.L(J)/
327 ( SUM(GG,NC1(J,GG)*CC.L(J,GG))+(NGR(J)-1+DEP.L(J))*KK.L(J) );
328 E9.L(I,J) = SUM(G,NC1(J,G)*CCI(I,J,G))+INVI(I,J) ;

```

```
329 E9.L(I,I) = E9.L(I,I)+GEXP.L(I)+GHEA(I)+GEDU(I) ; DISPLAY E9.L;
330 NX(J)      = SUM((G,I), NC1(I,G)*CCI(J,I,G)) + SUM(I,INVI(J,I)) -
331            SUM((G,I), NC1(J,G)*CCI(I,J,G)) - SUM(I,INVI(I,J))
332 ;
333 WALOX(J)   = YY.L(J) - SUM((I,G), NC1(I,G)*CCI(J,I,G) ) -GEXP.L(J) - GHEA(J)-
GEDU(J) -
334            SUM(I, INVI(J,I) ) ;
335
336
337 *DISPLAY RR, EP9, BR, SIG, BEC, IDC, NGR, ALFA, YY0, WTAX, KTAX, CTAX, FA, GHEA,
GEDU, DH, DE, B, WW, NC1 ;
338 DISPLAY DEF, TR, BX, PSR, NS, SA, NX, WALOX, CCI, GEXP.L, NC1, CTR00.L, DELTAC.L, EP9;
339
340 $ONLISTING
```

```

1
2 SET IPROF / PROF1 /;
3 SET IQUAL / QUAL1 /;
4
5 *$INCLUDE Calib.gms
6
7 PARAMETERS
8 FlDyn      Flag for Dynamic vs Static simulation
9 FlComp     Flag for Compact version
10 FlWalras   Flag for taking advantage of Walras law
11 FlCalib   Flag for Calibration test
12 FlNumer   Flag for Numeraire test
13 FlDemog   Flag for Demographic shock test
14 FlProdu   Flag for Productivity shock test
15 FlMinos   Flag for Minos5 solver
16 FlInterm  Flag for Intermediate goods
17 ;
18
19 FlCalib    = 1;
20 FlNumer    = 0;
21 FlDemog    = 0;
22 FlProdu    = 0;
23 FlComp     = 1;
24 FlWalras   = 1;
25 FlInterm   = 0;
26 FlMinos    = 0;
27
28 * --- CHOOSE DYNAMIC (FlDyn=1) OR STATIC (FlDyn=0) SIMULATION
29
30 FlDyn = 1;
31
32 * --- CHOOSE HORIZON CONSISTENT WITH NUMBER OF GENERATIONS
33
34 * -----> 6 GENERATIONS
35
36 $ONTEXT
37 SET TTP      TOTAL TIME HORIZON           /T1 * T61 /
38     TP(TTP)  PERIODS OF PREVIOUSLY BORN    /T1 * T5 /
39 $OFFTEXT
40
41 * -----> 15 GENERATIONS
42 $ONTEXT
43 SET TTP      TOTAL TIME HORIZON           /T1 * T101 /
44     TP(TTP)  PERIODS OF PREVIOUSLY BORN    /T1 * T14 /
45 $OFFTEXT
46
47 SET TTP      TOTAL TIME HORIZON /
48
49 1894,1906,1918,1930,1942,1954,1966,1978,
50 1990,2002,2014,2026,2038,2050,2062,2074,2086,2098,2110,2122,2134,2146,2160,2172
51 2184,2196,2208,2220,2232,2244 /
52
53     TP(TTP)  PERIODS OF PREVIOUSLY BORN /
54     1894,1906,1918,1930
55
56 ;
57 SET T(TTP) ; T(TTP) = YES$(ORD(TTP) GT CARD(TP) AND ORD(TTP) LT CARD(TTP));

```

```

58 SET TI(TTP); TI(TTP)= YES$(ORD(TTP) EQ CARD(TP)+1);
59 ALIAS(TTP, TTP1);
60 ABORT$(CARD(G) NE CARD(TP)+1)"!!! CHOOSEN HORIZON NOT CONSISTENT WITH NUMBER OF
GENERATIONS !!!";
61
62 *+++++
63 PARAMETERS
64 *+++++
65 RkG(G)
66 RkT(TTP)
67 *--->Producers J
68 ScCoZ(J, S, TTP)
69 AlQ(J, S)
70 SigX(J, S)
71 AlXS(SS, J, S)
72 ScCoQ(J, S, TTP)
73 AlK(J, S)
74 AlProf(J, S, IProf)
75 AlQual(J, S, IProf, IQual)
76 SigLdem(J, S)
77 SigLProf(J, S, IProf)
78 *--->Households J
79 DiscR(J)
80 DiscJ(J, G)
81 AlConS(J, S, G)
82 SigCon(J, G)
83 BeqR(J, G)
84 InhR(J, G)
85 NN(J, TTP)
86 TPOP(J, TTP)
87 NNP(J, TTP)
88 Pop(J, TTP, G)
89 LsupMatrix(J, IProf, IQual, G)
90 EP(J, G)
91 Bij00(I, J)
92 Kij00(I, J)
93 DepR(J)
94 AlInvS(J, S)
95 SigInv(J)
96 *--->Government J
97 KTxR(J, TTP)
98 ConTxR(J, TTP)
99 PensR(J)
100 ExoBonds(J, TTP)          Choose tax (1) vs Bond (0) financed deficits
101 AlGovS(J, S)
102 SigGov(J)
103 GovH(J, S, TTP)
104 GovE(J, S, TTP)
105 *--->Market J
106 SigC(J, S)              Armington
107 AlCI(I, J, S)
108 *---> Tests
109 TRADEBAL(I, TTP)
110 WTRADEBAL(TTP)
111 WALRASJ(J, S, TTP)
112 WASSETBAL(TTP)
113

```

```

114 *---> Pension Reforms: moving from a PAYGo to a partially funded pension system
115 FlPAYGo(J)      Flag for Pay-as-you-go pension system
116 NYPenTrans(J)  Number of Years of Transition between full Pay-as-you-go and
partial Funded
117 DPF(J)         % of PAYGo policy funding parameter (Between 0 = PAYGo AND 1 =
Fully funded)
118 DelCtr(J)      Additional contribution rate on pensions to FULLY finance the
fund
119 CoDelCtr(J,TTP)  Weights applied to DelCTR(J) to generate an exogenous linear
profile of CTR
120 DPFMin
121 DPFMax
122 ;
123 FlPAYGo(J)     = 1;
124 NYPenTrans(J) = 0;
125 DPF(J)        = 0;
126 DelCtr(J)     = 0;
127 CoDelCtr(J,TTP)= 0;
128 DPFMin       = 0;
129 DPFMax       = 0;
130
131 RkT(TTP)      = ORD(TTP);
132 RkG(G)       = ORD(G);
133
134 *+++++
135 VARIABLES
136 *+++++
137 *--->Producers J
138 Z(J,S,TTP)
139 X(J,S,TTP)
140 Q(J,S,TTP)
141 PX(J,S,TTP)
142 XS(SS,J,S,TTP)
143 PQ(J,S,TTP)
144 Kdem(J,S,TTP)
145 Wage(J,S,TTP)
146 WProf(J,S,IProf,TTP)
147 WQual(J,IProf,IQual,TTP)
148 Ldem(J,S,TTP)
149 LProf(J,S,IProf,TTP)
150 LQual(J,S,IProf,IQual,TTP)
151 *--->Households J
152 Lend(J,TTP,G)
153 Bij(I,J,TTP,G)
154 Kij(I,J,TTP,G)
155 Con(J,TTP,G)
156 PCon(J,TTP,G)
157 ConS(J,S,TTP,G)
158 Beq(J,TTP,G)
159 Inh(J,TTP,G)
160 Pens(J,TTP,G)
161 * Investor J
162 Inv(J,TTP)
163 PInv(J,TTP)
164 InvS(J,S,TTP)
165 RRet(J,TTP)
166 *--->Government J

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167 Bond(J, TTP)
168 Gov(J, TTP)
169 PGov(J, TTP)
170 GovS(J, S, TTP)
171 WTxR(J, TTP)
172 CTR(J, TTP)          Contribution rate for pensions
173 PFund(J, TTP)       Pension fund
174 *--->Markets
175 PC(J, S, TTP)
176 E(I, J, S, TTP)
177 P(J, S, TTP)
178 Kstock(J, TTP)
179 Rent(J, TTP)
180 Rint(TTP)
181 RintJ(J, TTP)
182 EXC(J, S, TTP)     EXCess Walras if POP Grow NE across regions at B.Y.
183 ;
184
185 *+++++
186 EQUATIONS
187 *+++++
188 *--->Producers J
189 ZEq(J, S, TTP)
190 QdemEq(J, S, TTP)
191 XdemEq(J, S, TTP)
192 PXEq(J, S, TTP)
193 XdemSEq(S, J, S, TTP)
194 QEq(J, S, TTP)
195 KdemEq(J, S, TTP)
196 LdemEq(J, S, TTP)
197 WageEq(J, S, TTP)
198 LProfEq(J, S, IProf, TTP)
199 WProfEq(J, S, IProf, TTP)
200 LQualEq(J, S, IProf, IQual, TTP)
201 *--->Household J
202 HBudgEq1(J, TTP, G)
203 HBudgEq11(J, TTP, G)
204 HBudgEq12(J, TTP, G)
205 HBudgEq2(J, TTP, G)
206 HBudgEq21(J, TTP, G)
207 HBudgEq22(J, TTP, G)
208 HBudgEqST1(J, TTP, G)
209 HBudgEqST2(J, TTP, G)
210 BeqEq(J, TTP, G)
211 InhEq(J, TTP, G)
212 PensEq(J, TTP, G)
213 PensEqST(J, TTP, G)
214 ConEq(J, TTP, G)
215 ConEqSS(J, TTP, G)
216 ConEqST(J, TTP, G)
217 PConEq(J, TTP, G)
218 ConSEq(J, S, TTP, G)
219 BijEq(I, J, TTP, G)
220 BijEqST(I, J, TTP, G)
221 KijEq(I, J, TTP, G)
222 KijEqST(I, J, TTP, G)

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223 RRetKEq(J, TTP)
224 RRetKEqST(J, TTP)
225 InvEq(J, TTP)
226 PInvEq(J, TTP)
227 InvSEq(J, S, TTP)
228 InvEqST(J, TTP)
229 KstockEq(J, TTP)
230 KstockEqSS(J, TTP)
231 KstockEqST(J, TTP)
232 *--->Government J
233 GBudgEq1(J, TTP)
234 GBudgEq11(J, TTP)
235 GBudgEq12(J, TTP)
236 GBudgEqSS(J, TTP)
237 GBudgEqSS1(J, TTP)
238 GBudgEqST(J, TTP)
239 GBudgEq2(J, TTP)
240 GBudgEq3(J, TTP)
241 PGovEq(J, TTP)
242 GovSEq(J, S, TTP)
243 GPens(J, TTP)
244 GPensP1(J, TTP)
245 GPensP2(J, TTP)
246 *--->Markets
247 PCEq(J, S, TTP)
248 EEq(I, J, S, TTP)
249 PEq(J, S, TTP)
250 WQualEq(J, IProf, IQual, TTP)
251 RentEq(J, TTP)
252 RintEq(J, TTP)
253 RintEqST(J, TTP)
254 AssetEq(TTP)
255 AssetEqST(TTP)
256 ;
257 *+++++++
258 * MODEL
259 *+++++++
260
261 *=====
262 * Producers J
263 *=====
264
265 * Gross Output
266 ZEq(J, S, TTP)          $( ORD(TTP) GT CARD(TP) AND ORD(TTP) LE CARD(TP)+CARD(
T) )..
267 LOG(Z(J, S, TTP)) =E= LOG(ScCoZ(J, S, TTP)) + AlQ(J, S)*LOG(Q(J, S, TTP)) + ((1-AlQ(J, S)
)*LOG(X(J, S, TTP)))$FlInterm
268 ;
269 * Value added demand
270 QdemEq(J, S, TTP)      $( ORD(TTP) GT CARD(TP) AND ORD(TTP) LE CARD(TP)+CARD(
T) )..
271 PQ(J, S, TTP)*Q(J, S, TTP) =E= AlQ(J, S) *P(J, S, TTP)*Z(J, S, TTP)
272 ;
273 * Intermediate demand
274 XdemEq(J, S, TTP)      $( (ORD(TTP) GT CARD(TP) AND ORD(TTP) LE CARD(TP)+CAR
D(T) )
275                          AND FlInterm EQ 1)..

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276 PX(J,S,TTP)*X(J,S,TTP) =E= (1-ALQ(J,S))*P(J,S,TTP)*Z(J,S,TTP)
277 ;
278 * Price of intermediate
279 PXEq(J,S,TTP)          $( (ORD(TTP) GT CARD(TP) AND ORD(TTP) LE CARD(TP)+CAR
D(T))
280                          AND FlInterm EQ 1)..
281 PX(J,S,TTP)**(1-SigX(J,S)) =E= SUM(SS$(ALXS(SS,J,S) GT 1.E-13),ALXS(SS,J,S)*PC(
J,SS,TTP)**(1-SigX(J,S)))
282 ;
283 * Sectoral composition of intermediate demand
284 XdemSEq(SS,J,S,TTP)    $( ((ORD(TTP) GT CARD(TP) AND ORD(TTP) LE CARD(TP)+CA
RD(T)) AND ALXS(SS,J,S) GT 1.E-13)
285                          AND FlInterm EQ 1)..
286 XS(SS,J,S,TTP) =E= ALXS(SS,J,S)*(PX(J,S,TTP)/PC(J,SS,TTP))**SigX(J,S)*X(J,S,TTP)
287 ;
288 * Value added
289 QEq(J,S,TTP)          $( ORD(TTP) GT CARD(TP) AND ORD(TTP) LE CARD(TP)+CARD(
T) )..
290 Q(J,S,TTP) =E= ScCoQ(J,S,TTP)*Kdem(J,S,TTP)**ALK(J,S)*Ldem(J,S,TTP)**(1-ALK(J,S))
291 ;
292 * Capital demand
293 KdemEq(J,S,TTP)      $( ORD(TTP) GT CARD(TP) AND ORD(TTP) LE CARD(TP)+CARD(
T) )..
294 Rent(J,TTP)*Kdem(J,S,TTP) =E= ALK(J,S)*PQ(J,S,TTP)*Q(J,S,TTP)
295 ;
296 * Labor demand
297 LdemEq(J,S,TTP)     $( ORD(TTP) GT CARD(TP) AND ORD(TTP) LE CARD(TP)+CARD(
T) )..
298 Wage(J,S,TTP)*Ldem(J,S,TTP) =E= (1-ALK(J,S))*PQ(J,S,TTP)*Q(J,S,TTP)
299 ;
300 * Aggreagate labor cost
301 WageEq(J,S,TTP)     $( ORD(TTP) GT CARD(TP) AND ORD(TTP) LE CARD(TP)+CARD(
T) )..
302 Wage(J,S,TTP)**(1-SigLdem(J,S)) =E=
303 SUM(IProf$(AlProf(J,S,IProf) GT 1.E-13), AlProf(J,S,IProf)*WProf(J,S,IProf,TTP)**
(1-SigLdem(J,S)))
304 ;
305 * PROF-Labor demand
306 LProfEq(J,S,IProf,TTP) $( (ORD(TTP) GT CARD(TP) AND ORD(TTP) LE CARD(TP)+CAR
D(T)) AND AlProf(J,S,IProf) GT 1.E-13)..
307 LProf(J,S,IProf,TTP) =E=
308 AlProf(J,S,IProf)*(Wage(J,S,TTP)/WProf(J,S,IProf,TTP))**SigLdem(J,S)* Ldem(J,S,
TTP)
309 ;
310 * PROF-labor cost
311 WProfEq(J,S,IProf,TTP) $( ORD(TTP) GT CARD(TP) AND ORD(TTP) LE CARD(TP)+CARD(
T) )..
312 WProf(J,S,IProf,TTP)**(1-SigLProf(J,S,IProf)) =E=
313 SUM(IQual$(AlQual(J,S,IProf,IQual) GT 1.E-13), AlQual(J,S,IProf,IQual)*WQual(J,
IProf,IQual,TTP)**(1-SigLProf(J,S,IProf)))
314 ;
315 * QUAL-Labor demand
316 LQualEq(J,S,IProf,IQual,TTP)$( (ORD(TTP) GT CARD(TP) AND ORD(TTP) LE CARD(TP)+CAR
D(T)) AND AlQual(J,S,IProf,IQual) GT 1.E-13)..
317 LQual(J,S,IProf,IQual,TTP) =E=
318 AlQual(J,S,IProf,IQual)*(WProf(J,S,IProf,TTP)/WQual(J,IProf,IQual,TTP))**
SigLProf(J,S,IProf)* LProf(J,S,IProf,TTP)

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319 ;
320 *=====
321 * Household J
322 *=====
323 * Budget constraint
324 HBudgEq1(J,TTP+1,G+1) $( (ORD(TTP) GT CARD(TP) AND ORD(TTP) LT CARD(TP)+CARD(T)
325 AND FlDyn*(1-FlComp) EQ 1 )..
326 (1+ConTxR(J,TTP)) *Pcon(J,TTP,G) *Con(J,TTP,G)+Lend(J,TTP+1,G+1)
327 =E=
328 (1-WTxR(J,TTP)-CTR(J,TTP)) *
329 SUM((IProf,IQual) ,WQual(J,IProf,IQual,TTP)*LsupMatrix(J,IProf,IQual,G))*EP(J,
G) + (
330 SUM(I, (RintJ(I,TTP-1)*PGov(I,TTP)/PGov(I,TTP-1) ) *PGov(I,TTP-1) *
Bij(I,J,TTP,G) )
331 - KTxR(J,TTP) *SUM(I, (RintJ(I,TTP-1)*PGov(I,TTP)/PGov(I,TTP-1)-1) *PGov(I,TTP-1) *
Bij(I,J,TTP,G) )
332 + SUM(I, (RRet(I,TTP) ) *PInv(I,TTP-1) *
Kij(I,J,TTP,G) )
333 - KTxR(J,TTP) *SUM(I, (RRet(I,TTP) -1) *PInv(I,TTP-1) *
Kij(I,J,TTP,G) )
334 ) $(ORD(G) GT 1)
335 +
336 (1-WTxR(J,TTP)) *Pens(J,TTP,G)+Inh(J,TTP,G)-Beq(J,TTP,G)
337 ;
338 HBudgEq11(J,TTP+1,G+1) $( (ORD(TTP) EQ CARD(TP)+1)
339 AND FlDyn*FlComp EQ 1 )..
340 (1+ConTxR(J,TTP)) *Pcon(J,TTP,G) *Con(J,TTP,G)+Lend(J,TTP+1,G+1)
341 =E=
342 (1-WTxR(J,TTP)-CTR(J,TTP)) *
343 SUM((IProf,IQual) ,WQual(J,IProf,IQual,TTP)*LsupMatrix(J,IProf,IQual,G))*EP(J,
G) + (
344 SUM(I, (RintJ(I,TTP-1)*PGov(I,TTP)/PGov(I,TTP-1) ) *PGov(I,TTP-1) *
Bij(I,J,TTP,G) )
345 - KTxR(J,TTP) *SUM(I, (RintJ(I,TTP-1)*PGov(I,TTP)/PGov(I,TTP-1)-1) *PGov(I,TTP-1) *
Bij(I,J,TTP,G) )
346 + SUM(I, (RRet(I,TTP) ) *PInv(I,TTP-1) *
Kij(I,J,TTP,G) )
347 - KTxR(J,TTP) *SUM(I, (RRet(I,TTP) -1) *PInv(I,TTP-1) *
Kij(I,J,TTP,G) )
348 ) $(ORD(G) GT 1)
349 +
350 (1-WTxR(J,TTP)) *Pens(J,TTP,G)+Inh(J,TTP,G)-Beq(J,TTP,G)
351 ;
352 HBudgEq12(J,TTP+1,G+1) $( (ORD(TTP) GT CARD(TP)+1 AND ORD(TTP) LT CARD(TP)+CARD(
T))
353 AND FlDyn*FlComp EQ 1 )..
354 (1+ConTxR(J,TTP)) *Pcon(J,TTP,G) *Con(J,TTP,G)+Lend(J,TTP+1,G+1)
355 =E=
356 (1-WTxR(J,TTP)-CTR(J,TTP)) *
357 SUM((IProf,IQual) ,WQual(J,IProf,IQual,TTP)*LsupMatrix(J,IProf,IQual,G))*EP(J,
G) + (
358 (RRet(J,TTP) ) *Lend(J,TTP,G)
359 - KTxR(J,TTP) * (RRet(J,TTP) -1) *Lend(J,TTP,G)
360 ) $(ORD(G) GT 1)
361 +
362 (1-WTxR(J,TTP)) *Pens(J,TTP,G)+Inh(J,TTP,G)-Beq(J,TTP,G)
363 ;

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364 HBudgEq2(J,TTP,GN) $( (ORD(TTP) GT CARD(TP) AND ORD(TTP) LE CARD(TP)+CARD(T)
365 AND FLDyn*(1-FlComp) EQ 1 )..
366 (1+ConTxR(J,TTP))*Pcon(J,TTP,GN)*Con(J,TTP,GN)
367 =E=
368 (1-WTxR(J,TTP)-CTR(J,TTP))*
369 SUM((IProf,IQual),WQual(J,IProf,IQual,TTP)*LsupMatrix(J,IProf,IQual,GN))*EP(J,
GN) +
370 SUM(I, (RintJ(I,TTP-1)*PGov(I,TTP)/PGov(I,TTP-1)) *PGov(I,TTP-1)*
Bij(I,J,TTP,GN) )
371 - KTxR(J,TTP)*SUM(I, (RintJ(I,TTP-1)*PGov(I,TTP)/PGov(I,TTP-1)-1)*PGov(I,TTP-1)*
Bij(I,J,TTP,GN) )
372 + SUM(I, (RRet(I,TTP) ) *PInv(I,TTP-1)*
Kij(I,J,TTP,GN) )
373 - KTxR(J,TTP)*SUM(I, (RRet(I,TTP) -1)*PInv(I,TTP-1)*
Kij(I,J,TTP,GN) )
374 +
375 (1-WTxR(J,TTP))*Pens(J,TTP,GN)+Inh(J,TTP,GN)-Beq(J,TTP,GN)
376 ;
377 HBudgEq21(J,TTP,GN) $( (ORD(TTP) EQ CARD(TP)+1)
378 AND FLDyn*FlComp EQ 1 )..
379 (1+ConTxR(J,TTP))*Pcon(J,TTP,GN)*Con(J,TTP,GN)
380 =E=
381 (1-WTxR(J,TTP)-CTR(J,TTP))*
382 SUM((IProf,IQual),WQual(J,IProf,IQual,TTP)*LsupMatrix(J,IProf,IQual,GN))*EP(J,
GN) +
383 SUM(I, (RintJ(I,TTP-1)*PGov(I,TTP)/PGov(I,TTP-1)) *PGov(I,TTP-1)*
Bij(I,J,TTP,GN) )
384 - KTxR(J,TTP)*SUM(I, (RintJ(I,TTP-1)*PGov(I,TTP)/PGov(I,TTP-1)-1)*PGov(I,TTP-1)*
Bij(I,J,TTP,GN) )
385 + SUM(I, (RRet(I,TTP) ) *PInv(I,TTP-1)*
Kij(I,J,TTP,GN) )
386 - KTxR(J,TTP)*SUM(I, (RRet(I,TTP) -1)*PInv(I,TTP-1)*
Kij(I,J,TTP,GN) )
387 +
388 (1-WTxR(J,TTP))*Pens(J,TTP,GN)+Inh(J,TTP,GN)-Beq(J,TTP,GN)
389 ;
390 HBudgEq22(J,TTP,GN) $( (ORD(TTP) GT CARD(TP)+1 AND ORD(TTP) LE CARD(TP)+CARD(T)
)
391 AND FLDyn*FlComp EQ 1 )..
392 (1+ConTxR(J,TTP))*Pcon(J,TTP,GN)*Con(J,TTP,GN)
393 =E=
394 (1-WTxR(J,TTP)-CTR(J,TTP))*
395 SUM((IProf,IQual),WQual(J,IProf,IQual,TTP)*LsupMatrix(J,IProf,IQual,GN))*EP(J,
GN) +
396 (RRet(J,TTP) ) *Lend(J,TTP,GN)
397 - KTxR(J,TTP)* (RRet(J,TTP) -1)*Lend(J,TTP,GN)
398 +
399 (1-WTxR(J,TTP))*Pens(J,TTP,GN)+Inh(J,TTP,GN)-Beq(J,TTP,GN)
400 ;
401 HBudgEqST1(J,TTP,G+1) $( (ORD(TTP) GT CARD(TP) AND ORD(TTP) LE CARD(TP)+CARD(T) )
402 AND FLDyn EQ 0 )..
403 (1+ConTxR(J,TTP))*Pcon(J,TTP,G)*Con(J,TTP,G)+Lend(J,TTP,G+1)
404 =E=
405 (1-WTxR(J,TTP)-CTR(J,TTP))*
406 SUM((IProf,IQual),WQual(J,IProf,IQual,TTP)*LsupMatrix(J,IProf,IQual,G))*EP(J,
G) + (
407 SUM(I, (RintJ(I,TTP)*PGov(I,TTP)/PGov(I,TTP) ) *PGov(I,TTP)*Bij(

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I, J, TTP, G) )
408 - KTxR(J, TTP) *SUM(I, (RintJ(I, TTP) *PGov(I, TTP) /PGov(I, TTP) -1) *PGov(I, TTP) *Bij(I,
J, TTP, G) )
409 + SUM(I, (RRet(I, TTP) ) *PInv(I, TTP) *
Kij(I, J, TTP, G) )
410 - KTxR(J, TTP) *SUM(I, (RRet(I, TTP) -1) *PInv(I, TTP) *
Kij(I, J, TTP, G) )
411 )$(ORD(G) GT 1)
412 +
413 (1-WTxR(J, TTP)) *Pens(J, TTP, G) +Inh(J, TTP, G) -Beq(J, TTP, G)
414 ;
415 HBudgEqST2(J, TTP, GN) $( (ORD(TTP) GT CARD(TP) AND ORD(TTP) LE CARD(TP) +CARD(T) )
416 AND F1Dyn EQ 0) ..
417 (1+ConTxR(J, TTP)) *Pcon(J, TTP, GN) *Con(J, TTP, GN)
418 =E=
419 (1-WTxR(J, TTP) -CTR(J, TTP)) *
420 SUM((IProf, IQual) , WQual(J, IProf, IQual, TTP) *LsupMatrix(J, IProf, IQual, GN)) *EP(J,
GN) +
421 SUM(I, (RintJ(I, TTP) *PGov(I, TTP) /PGov(I, TTP) ) *PGov(I, TTP) *Bij(
I, J, TTP, GN) )
422 - KTxR(J, TTP) *SUM(I, (RintJ(I, TTP) *PGov(I, TTP) /PGov(I, TTP) -1) *PGov(I, TTP) *Bij(I,
J, TTP, GN) )
423 + SUM(I, (RRet(I, TTP) ) *PInv(I, TTP) *
Kij(I, J, TTP, GN) )
424 - KTxR(J, TTP) *SUM(I, (RRet(I, TTP) -1) *PInv(I, TTP) *
Kij(I, J, TTP, GN) )
425 +
426 (1-WTxR(J, TTP)) *Pens(J, TTP, GN) +Inh(J, TTP, GN) -Beq(J, TTP, GN)
427 ;
428 * Bequests
429 BeqEq(J, TTP, G) $( (ORD(TTP) GT CARD(TP) AND ORD(TTP) LE CARD(TP) + CARD(T) )
430 AND BeqR(J, G) NE 0) ..
431 Beq(J, TTP, G) =E= BeqR(J, G) *Pcon(J, TTP, G) *Con(J, TTP, G)
432 ;
433 * Inheritance
434 InhEq(J, TTP, G) $( (ORD(TTP) GT CARD(TP) AND ORD(TTP) LE CARD(TP) +CARD(T) )
435 AND InhR(J, G) NE 0) ..
436 Pop(J, TTP, G) *Inh(J, TTP, G) =E= InhR(J, G) *SUM(GM, Pop(J, TTP, GM) *Beq(J, TTP, GM))
437 ;
438 * Pensions
439 PensEq(J, TTP, GM) $( (ORD(TTP) GT CARD(TP) AND ORD(TTP) LE CARD(TP) +CARD(T) )
440 AND (PensR(J) NE 0 AND F1Dyn EQ 1) ) ..
441 Pens(J, TTP, GM) =E=
442 PensR(J) *SUM(GJ, SUM((IProf, IQual) , EP9(J, GJ) *WQual(J, IProf, IQual, TTP - (ORD(GM) -
1 +ORD(GJ))) *LsupMatrix(J, IProf, IQual, GJ) ) /CARD(GJ)
443 ;
444 PensEqST(J, TTP, GM) $( (ORD(TTP) GT CARD(TP) AND ORD(TTP) LE CARD(TP) +CARD(T) )
445 AND (PensR(J) NE 0 AND F1Dyn EQ 0) ) ..
446 Pens(J, TTP, GM) =E=
447 PensR(J) *SUM(GJ, SUM((IProf, IQual) , EP9(J, GJ) *WQual(J, IProf, IQual, TTP) *
LsupMatrix(J, IProf, IQual, GJ) ) /CARD(GJ)
448 ;
449 * Consumption
450 ConEq(J, TTP+1, G+1) $( (ORD(TTP) GT CARD(TP) AND ORD(TTP) LT CARD(TP) +CARD(T) )
451 AND F1Dyn EQ 1) ..
452 Con(J, TTP+1, G+1) /Con(J, TTP, G) =E=
453 (

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454 ( ( 1 + (1 - KTxR(J,TTP)) * (RRet(J,TTP)-1) ) * PCon(J,TTP,G) ) /
455 ( ( 1 + DiscR(J) ) * PCon(J,TTP+1,G) )
456 )**Sig(J)
457 ;
458 ConEqSS(J,TTP+1,G) $( (ORD(TTP) EQ CARD(TP)+CARD(T)-1 AND ORD(G) LT CARD(G))
459 AND FlDyn EQ 1 )..
460 Con(J,TTP+1,G) =E= Con(J,TTP,G)
461 ;
462 ConEqST(J,TTP,G+1) $( (ORD(TTP) GT CARD(TP) AND ORD(TTP) LE CARD(TP)+CARD(T))
463 AND FlDyn EQ 0 )..
464 Con(J,TTP,G+1)/Con(J,TTP,G) =E=
465 (
466 ( ( 1 + (1 - KTxR(J,TTP)) * (RRet(J,TTP)-1) ) * PCon(J,TTP,G) ) /
467 ( ( 1 + DiscR(J) ) * PCon(J,TTP,G) )
468 )**Sig(J)
469 ;
470 * Price of consumption
471 PConEq(J,TTP,G) $( ORD(TTP) GT CARD(TP) AND ORD(TTP) LE CARD(TP)+CARD(T) ) .
.
472 PCon(J,TTP,G)**(1-SigCon(J,G)) =E= SUM(S$(AlConS(J,S,G) GT 1.E-13),AlConS(J,S,G)*
PC(J,S,TTP)**(1-SigCon(J,G)))
473 ;
474 * Sectoral composition of consumption
475 ConSEq(J,S,TTP,G) $( (ORD(TTP) GT CARD(TP) AND ORD(TTP) LE CARD(TP)+CARD(T)) A
ND AlConS(J,S,G) GT 1.E-13)..
476 ConS(J,S,TTP,G) =E= AlConS(J,S,G)*(PCon(J,TTP,G)/PC(J,S,TTP))**SigCon(J,G)*Con(J,
TTP,G)
477 ;
478 * Holding of bonds
479 BijEq(I,J,TTP+1,G+1) $( (ORD(TTP) GT CARD(TP) AND ORD(TTP) LT CARD(TP)+CARD(T))
480 AND FlDyn*(1-FlComp) EQ 1 )..
481 PGov(I,TTP)*Bij(I,J,TTP+1,G+1) =E= (Bij00(I,J)/SUM(II,Bij00(II,J))) *
482 (Lend(J,TTP+1,G+1)-SUM(II,PInv(II,TTP)*Kij(II,
J,TTP+1,G+1)))
483 ;
484 BijEqST(I,J,TTP,G+1) $( (ORD(TTP) GT CARD(TP) AND ORD(TTP) LE CARD(TP)+CARD(T))
485 AND FlDyn EQ 0 )..
486 PGov(I,TTP)*Bij(I,J,TTP,G+1) =E= (Bij00(I,J)/SUM(II,Bij00(II,J))) *
487 (Lend(J,TTP,G+1)-SUM(II,PInv(II,TTP)*Kij(II,J,
TTP,G+1)))
488 ;
489 * Holding of physical capital
490 KijEq(I,J,TTP+1,G+1) $( (ORD(TTP) GT CARD(TP) AND ORD(TTP) LT CARD(TP)+CARD(T))
491 AND FlDyn*(1-FlComp) EQ 1 )..
492 Kij(I,J,TTP+1,G+1) =E= SUM(TI,Kij(I,J,TI,G+1)/Kstock(I,TI))*Kstock(I,TTP+1)
493 ;
494 KijEqST(I,J,TTP,G+1) $( (ORD(TTP) GT CARD(TP) AND ORD(TTP) LE CARD(TP)+CARD(T))
495 AND FlDyn EQ 0 )..
496 Kij(I,J,TTP,G+1) =E= SUM(TI,Kij(I,J,TI,G+1)/Kstock(I,TI))*Kstock(I,TTP)
497 ;
498 * Rate of return on capital
499 RRetKeq(J,TTP) $( (ORD(TTP) GT CARD(TP) AND ORD(TTP) LE CARD(TP)+CARD(T))
500 AND FlDyn EQ 1 )..
501 RRet(J,TTP) =E= (Rent(J,TTP)+(1-DepR(J))*PInv(J,TTP))/PInv(J,TTP-1)
502 ;
503 RRetKEqST(J,TTP) $( (ORD(TTP) GT CARD(TP) AND ORD(TTP) LE CARD(TP)+CARD(T))
504 AND FlDyn EQ 0 )..

```

```

505 RRet(J,TTP) =E= (Rent(J,TTP)+(1-DepR(J))*PInv(J,TTP))/PInv(J,TTP)
506 ;
507 * Investment
508 InvEq(J,TTP+1) $( (ORD(TTP) GT CARD(TP) AND ORD(TTP) LT CARD(TP)+CARD(T)
509 AND FlDyn EQ 1 ) ..
510 RintJ(J,TTP)*PGov(J,TTP+1)/PGov(J,TTP) =E= RRet(J,TTP+1)
511 ;
512 InvEqST(J,TTP) $( (ORD(TTP) GT CARD(TP) AND ORD(TTP) LE CARD(TP)+CARD(T)
513 AND FlDyn EQ 0 ) ..
514 RintJ(J,TTP) =E= RRet(J,TTP)
515 ;
516 * Price of investment
517 PInvEq(J,TTP) $( ORD(TTP) GT CARD(TP) AND ORD(TTP) LE CARD(TP)+CARD(T) ).
.
518 PInv(J,TTP)**(1-SigInv(J)) =E= SUM(S$(AlInvS(J,S) GT 1.E-13),AlInvS(J,S)*PC(J,S,
TTP)**(1-SigInv(J)))
519 ;
520 * Sectoral composition of investment
521 InvSEq(J,S,TTP) $( (ORD(TTP) GT CARD(TP) AND ORD(TTP) LE CARD(TP)+CARD(T) ) A
ND AlInvS(J,S) GT 1.E-13 ) ..
522 InvS(J,S,TTP) =E= AlInvS(J,S)*(PInv(J,TTP)/PC(J,S,TTP))**SigInv(J)*Inv(J,TTP)
523 ;
524 KstockEq(J,TTP+1) $( (ORD(TTP) GT CARD(TP) AND ORD(TTP) LT CARD(TP)+CARD(T)
525 AND FlDyn EQ 1 ) ..
526 Kstock(J,TTP+1) =E= Inv(J,TTP)+(1-DepR(J))*Kstock(J,TTP)
527 ;
528 KstockEqSS(J,TTP) $( (ORD(TTP) EQ CARD(TP)+CARD(T) )
529 AND FlDyn EQ 1 ) ..
530 Inv(J,TTP) =E= ((NN(J,TTP)-1)+DepR(J))*Kstock(J,TTP)
531 ;
532 KstockEqST(J,TTP) $( (ORD(TTP) GT CARD(TP) AND ORD(TTP) LE CARD(TP)+CARD(T)
533 AND FlDyn EQ 0 ) ..
534 Inv(J,TTP) =E= ((NN(J,TTP)-1)+DepR(J))*Kstock(J,TTP)
535 ;
536 *=====
537 * Government J
538 *=====
539 * Budget constraint
540 GBudgEq1(J,TTP+1) $( (ORD(TTP) GT CARD(TP) AND ORD(TTP) LT CARD(TP)+CARD(T) )
541 AND FlDyn*(1-FlComp) EQ 1 ) ..
542 PGov(J,TTP)*Bond(J,TTP+1) + SUM(G,POP(J,TTP,G)*
543 (
544 WTxR(J,TTP)*SUM(IProf,IQual),WQual(J,IProf,IQual,TTP)*LsupMatrix(J,IProf,
IQual,G))*EP(J,G)
545 + WTxR(J,TTP)*Pens(J,TTP,G) + ConTxR(J,TTP)*Pcon(J,TTP,G)*Con(J,TTP,G)
546 + KTxR(J,TTP)*SUM(I,(RintJ(I,TTP-1)*PGov(I,TTP)/PGov(I,TTP-1)-1)*PGov(I,TTP-1)*
Bij(I,J,TTP,G) )
547 + KTxR(J,TTP)*SUM(I,(RRet(I,TTP) -1)*PInv(I,TTP-1)*
Kij(I,J,TTP,G) )
548 ))
549 =E=
550 PGov(J,TTP)* Gov(J,TTP)
551 +SUM(S,PQ(J,S,TTP)*(GovH(J,S,TTP)+GovE(J,S,TTP)) )
552 +(RintJ(J,TTP-1)*PGov(J,TTP)/PGov(J,TTP-1))*PGov(J,TTP-1)*Bond(J,TTP)
553 ;
554 GBudgEq11(J,TTP+1) $( (ORD(TTP) EQ CARD(TP)+1)
555 AND FlDyn*FlComp EQ 1 ) ..

```

```

556 PGov(J, TTP) *Bond(J, TTP+1) + SUM(G, POP(J, TTP, G) *
557 (
558     WTxR(J, TTP) *SUM((IProf, IQual) , WQual(J, IProf, IQual, TTP) *LsupMatrix(J, IProf,
IQual, G) ) *EP(J, G)
559 + WTxR(J, TTP) *Pens(J, TTP, G) + ConTxR(J, TTP) *Pcon(J, TTP, G) *Con(J, TTP, G)
560 + KTxR(J, TTP) *SUM(I, (RintJ(I, TTP-1) *PGov(I, TTP) /PGov(I, TTP-1) -1) *PGov(I, TTP-1) *
Bij(I, J, TTP, G) )
561 + KTxR(J, TTP) *SUM(I, (RRet(I, TTP) -1) *PInv(I, TTP-1) *
Kij(I, J, TTP, G) )
562 ))
563 =E=
564 PGov(J, TTP) * Gov(J, TTP)
565 +SUM(S, PQ(J, S, TTP) * (GovH(J, S, TTP) +GovE(J, S, TTP) ) )
566 + (RintJ(J, TTP-1) *PGov(J, TTP) /PGov(J, TTP-1) ) *PGov(J, TTP-1) *Bond(J, TTP)
567 ;
568 GBudgEq12(J, TTP+1) $( (ORD(TTP) GT CARD(TP)+1 AND ORD(TTP) LT CARD(TP)+CARD(T)
)
AND FlDyn*FlComp EQ 1 ) ..
570 PGov(J, TTP) *Bond(J, TTP+1) + SUM(G, POP(J, TTP, G) *
571 (
572     WTxR(J, TTP) *SUM((IProf, IQual) , WQual(J, IProf, IQual, TTP) *LsupMatrix(J, IProf,
IQual, G) ) *EP(J, G)
573 + WTxR(J, TTP) *Pens(J, TTP, G) + ConTxR(J, TTP) *Pcon(J, TTP, G) *Con(J, TTP, G)
574 + KTxR(J, TTP) * (RRet(J, TTP) -1) *Lend(J, TTP, G)
575 ))
576 =E=
577 PGov(J, TTP) * Gov(J, TTP)
578 +SUM(S, PQ(J, S, TTP) * (GovH(J, S, TTP) +GovE(J, S, TTP) ) )
579 + (RintJ(J, TTP-1) *PGov(J, TTP) /PGov(J, TTP-1) ) *PGov(J, TTP-1) *Bond(J, TTP)
580 ;
581 GBudgEqSS(J, TTP) $( (ORD(TTP) EQ CARD(TP)+CARD(T) )
AND FlDyn*(1-FlComp) EQ 1 ) ..
583 NN(J, TTP) *PGov(J, TTP) *Bond(J, TTP) + SUM(G, POP(J, TTP, G) *
584 (
585     WTxR(J, TTP) *SUM((IProf, IQual) , WQual(J, IProf, IQual, TTP) *LsupMatrix(J, IProf,
IQual, G) ) *EP(J, G)
586 + WTxR(J, TTP) *Pens(J, TTP, G) + ConTxR(J, TTP) *Pcon(J, TTP, G) *Con(J, TTP, G)
587 + KTxR(J, TTP) *SUM(I, (RintJ(I, TTP-1) *PGov(I, TTP) /PGov(I, TTP-1) -1) *PGov(I, TTP-1) *
Bij(I, J, TTP, G) )
588 + KTxR(J, TTP) *SUM(I, (RRet(I, TTP) -1) *PInv(I, TTP-1) *
Kij(I, J, TTP, G) )
589 ))
590 =E=
591 PGov(J, TTP) * Gov(J, TTP)
592 +SUM(S, PQ(J, S, TTP) * (GovH(J, S, TTP) +GovE(J, S, TTP) ) )
593 + (RintJ(J, TTP-1) *PGov(J, TTP) /PGov(J, TTP-1) ) *PGov(J, TTP-1) *Bond(J, TTP)
594 ;
595 GBudgEqSS1(J, TTP) $( (ORD(TTP) EQ CARD(TP)+CARD(T) )
AND FlDyn*FlComp EQ 1 ) ..
597 NN(J, TTP) *PGov(J, TTP) *Bond(J, TTP) + SUM(G, POP(J, TTP, G) *
598 (
599     WTxR(J, TTP) *SUM((IProf, IQual) , WQual(J, IProf, IQual, TTP) *LsupMatrix(J, IProf,
IQual, G) ) *EP(J, G)
600 + WTxR(J, TTP) *Pens(J, TTP, G) + ConTxR(J, TTP) *Pcon(J, TTP, G) *Con(J, TTP, G)
601 + KTxR(J, TTP) * (RRet(J, TTP) -1) *Lend(J, TTP, G)
602 ))
603 =E=

```

```

604   PGov(J, TTP) * Gov(J, TTP)
605   +SUM(S, PQ(J, S, TTP) * (GovH(J, S, TTP) + GovE(J, S, TTP)) )
606   + (RintJ(J, TTP-1) * PGov(J, TTP) / PGov(J, TTP-1)) * PGov(J, TTP-1) * Bond(J, TTP)
607 ;
608   GBudgEqST(J, TTP)          $( (ORD(TTP) GT CARD(TP) AND ORD(TTP) LE CARD(TP) + CARD(T))
609                               AND FlDyn EQ 0) ..
610   NN(J, TTP) * PGov(J, TTP) * Bond(J, TTP) + SUM(G, POP(J, TTP, G) *
611   (
612     WTxR(J, TTP) * SUM((IProf, IQual) , WQual(J, IProf, IQual, TTP) * LsupMatrix(J, IProf,
613     IQual, G)) * EP(J, G)
614     + WTxR(J, TTP) * Pens(J, TTP, G) + ConTxR(J, TTP) * Pcon(J, TTP, G) * Con(J, TTP, G)
615     + KTxR(J, TTP) * SUM(I, (RintJ(I, TTP) * PGov(I, TTP) / PGov(I, TTP) - 1) * PGov(I, TTP) * Bij(I,
616     J, TTP, G) )
617     + KTxR(J, TTP) * SUM(I, (RRet(I, TTP) - 1) * PInv(I, TTP) * Kij(I,
618     J, TTP, G) )
619     )
620   =E=
621   PGov(J, TTP) * Gov(J, TTP)
622   +SUM(S, PQ(J, S, TTP) * (GovH(J, S, TTP) + GovE(J, S, TTP)) )
623   + (RintJ(J, TTP) * PGov(J, TTP) / PGov(J, TTP)) * PGov(J, TTP) * Bond(J, TTP)
624 ;
625   GBudgEq2(J, TTP+1)        $( (ORD(TTP) GT CARD(TP) AND ORD(TTP) LT CARD(TP) + CARD(T))
626                               AND (ExoBonds(J, TTP+1) EQ 1 AND FlDyn EQ 1) ) ..
627   Bond(J, TTP+1) =E= NNP(J, TTP) * Bond(J, TTP)
628 ;
629   GBudgEq3(J, TTP)          $( (ORD(TTP) GT CARD(TP) AND ORD(TTP) LE CARD(TP) + CARD(T))
630                               AND (ExoBonds(J, TTP+1) EQ 0 AND FlDyn EQ 1) ) ..
631   WTxR(J, TTP) =E= WTxR(J, TTP-1)
632 ;
633   * Price of government consumption
634   PGovEq(J, TTP)           $( ORD(TTP) GT CARD(TP) AND ORD(TTP) LE CARD(TP) + CARD(T) ) .
635 ;
636   PGov(J, TTP) ** (1 - SigGov(J)) =E= SUM(S$(AlGovS(J, S) GT 1.E-13), AlGovS(J, S) * PC(J, S,
637   TTP) ** (1 - SigGov(J)))
638 ;
639   * Sectoral composition of government consumption
640   GovSEq(J, S, TTP)        $( (ORD(TTP) GT CARD(TP) AND ORD(TTP) LE CARD(TP) + CARD(T)) AND
641   AlGovS(J, S) GT 1.E-13 ) ..
642   GovS(J, S, TTP) =E= AlGovS(J, S) * (PGov(J, TTP) / PC(J, S, TTP)) ** SigGov(J) * Gov(J, TTP)
643 ;
644   GPens(J, TTP)           $( ORD(TTP) GT CARD(TP) AND ORD(TTP) LE (CARD(TP) + CARD(T)) *
645   FlPAYGo(J) + (RkT("2002") - 1) * (1 - FlPAYGo(J))) ..
646   SUM(GM, Pop(J, TTP, GM) * Pens(J, TTP, GM)) =E=
647   CTR(J, TTP) * SUM(G, Pop(J, TTP, G) * EP(J, G) * SUM((IProf, IQual) , WQual(J, IProf, IQual, TTP)
648   * LsupMatrix(J, IProf, IQual, G)))
649 ;
650   GPensP1(J, TTP+1)        $( (ORD(TTP) GE RkT("2002") AND ORD(TTP) LT CARD(TP) + CARD(T)
651   AND FlPAYGo(J) EQ 0) ..
652   PInv(J, TTP) * PFund(J, TTP+1) =E=
653   RRet(J, TTP) * PInv(J, TTP-1) * PFund(J, TTP)
654   + CTR(J, TTP) * SUM(G, Pop(J, TTP, G) * EP(J, G) * SUM((IProf, IQual) , WQual(J, IProf, IQual,
655   TTP) * LsupMatrix(J, IProf, IQual, G)))
656   - SUM(GM, Pop(J, TTP, GM) * Pens(J, TTP, GM))
657 ;
658   GPensP2(J, TTP+1)        $( (ORD(TTP) GT (RkT("2002") + NYPenTrans(J)) AND ORD(TTP) LT
659   CARD(TP) + CARD(T)
660   AND FlPAYGo(J) EQ 0) ..

```

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651 PInv(J,TTP)*PFund(J,TTP+1) =E= PInv(J,TTP-1)*PFund(J,TTP)
652 ;
653 *=====
654 * Markets
655 *=====
656 * Price of sectoral composit
657 PCEq(J,S,TTP) $( ORD(TTP) GT CARD(TP) AND ORD(TTP) LE CARD(TP)+CARD(
T) )..
658 PC(J,S,TTP)**(1-SigC(J,S)) =E= SUM(I$(ALCI(I,J,S) GT 1.E-13),ALCI(I,J,S)*P(I,S,
TTP)**(1-SigC(J,S)))
659 ;
660 * Composition of sectoral composit (countries I of origin)
661 EEq(I,J,S,TTP) $( (ORD(TTP) GT CARD(TP) AND ORD(TTP) LE CARD(TP)+CAR
D(T))
AND ALCI(I,J,S) GT 1.E-13)..
662
663 E(I,J,S,TTP) =E= ALCI(I,J,S)*(PC(J,S,TTP)/P(I,S,TTP))**SigC(J,S)*
664 (SUM(G,Pop(J,TTP,G)*ConS(J,S,TTP,G))+InvS(J,S,TTP)+GovS(J,S,
TTP)+SUM(SS,XS(S,J,SS,TTP)))
665 ;
666 * Goods
667 PEq(J,S,TTP) $( ORD(TTP) GT CARD(TP) AND ORD(TTP) LE CARD(TP)+CARD(
T) )..
668 Z(J,S,TTP) =E= SUM(I, E(J,I,S,TTP) ) + GovH(J,S,TTP) + GovE(J,S,TTP) + EXC(J,S,
TTP)
669 ;
670 * QUAL-Labor
671 WQualEq(J,IProf,IQual,TTP) $( ORD(TTP) GT CARD(TP) AND ORD(TTP) LE CARD(TP)+CARD(
T) )..
672 SUM(G,Pop(J,TTP,G)*LsupMatrix(J,IProf,IQual,G)*EP(J,G)) =E= SUM(S, LQual(J,S,
IProf,IQual,TTP))
673 ;
674 * Physical Capital
675 RentEq(J,TTP) $( ORD(TTP) GT CARD(TP) AND ORD(TTP) LE CARD(TP)+CARD(
T) )..
676 Kstock(J,TTP) =E= SUM(S, Kdem(J,S,TTP))
677 ;
678 * Integrated asset markets
679 RintEq(J,TTP+1) $( (ORD(TTP) GT CARD(TP) AND ORD(TTP) LT CARD(TP)+CAR
D(T))
AND FlDyn EQ 1 )..
680
681 Rint(TTP) =E= RintJ(J,TTP)*PGov(J,TTP+1)/PGov(J,TTP)
682 ;
683 RintEqST(J,TTP) $( (ORD(TTP) GT CARD(TP) AND ORD(TTP) LE CARD(TP)+CAR
D(T))
AND FlDyn EQ 0 )..
684
685 Rint(TTP) =E= RintJ(J,TTP)
686 ;
687 AssetEq(TTP+1) $( (ORD(TTP) GT CARD(TP) AND ORD(TTP) LT CARD(TP)+CAR
D(T))
AND FlDyn*(1-FlWalras) EQ 1 )..
688
689 SUM((J,G),Pop(J,TTP+1,G+1)*LEND(J,TTP+1,G+1)) + SUM(J,PInv(J,TTP)*PFund(J,TTP+1))
=E=
690 SUM(J,PGov(J,TTP)*Bond(J,TTP+1)+PInv(J,TTP)*Kstock(J,TTP+1))
691 ;
692 AssetEqST(TTP) $( (ORD(TTP) GT CARD(TP) AND ORD(TTP) LE CARD(TP)+CAR
D(T))
AND (1-FlDyn)*(1-FlWalras) EQ 1 )..
693

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```
694 SUM((J,G), Pop(J, TTP, G) * LEND(J, TTP, G+1)) + SUM(J, PInv(J, TTP) * PFund(J, TTP)) =E=
695 SUM(J, PGov(J, TTP) * Bond(J, TTP) + PInv(J, TTP) * Kstock(J, TTP))
696 ;
697
698 MODEL OLG /
699
700 *---> Producers J
701 ZEq
702 QdemEq
703 XdemEq
704 PXEq
705 XdemSEq
706 QEq
707 KdemEq
708 LdemEq
709 WageEq
710 LProfEq
711 WProfEq
712 LQualEq
713 *--->Household J
714 HBudgEq1
715   HBudgEq11
716   HBudgEq12
717 HBudgEq2
718   HBudgEq21
719   HBudgEq22
720 HBudgEqST1
721 HBudgEqST2
722 BeqEq
723 InhEq
724 PensEq
725 PensEqST
726 ConEq
727 ConEqSS
728 ConEqST
729 PConEq
730 ConSEq
731 BijEq
732 BijEqST
733 KijEq
734 KijEqST
735 RRetKeq
736 RRetKEqST
737 InvEq
738 PInvEq
739 InvSEq
740 InvEqST
741 KstockEq
742 KstockEqSS
743 KstockEqST
744 *--->Government J
745 GBudgEq1
746   GBudgEq11
747   GBudgEq12
748 GBudgEqSS
749   GBudgEqSS1
750 GBudgEqST
```

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751 GBudgEq2
752 GBudgEq3
753 PGovEq
754 GovSEq
755 GPens
756 GPensP1
757 GPensP2
758 *--->Markets
759 PCEq
760 EEq
761 PEq
762 WQualEq
763 RentEq
764 RintEq
765 RintEqST
766 AssetEq
767 AssetEqST
768 OBJEQ          /
769 ;
770 OLG.HOLDFIXED = 1;
771 OLG.OPTFILE   = 1;
772
773 FILE MAR    c:\windows\gammdir\lacea2\Margins.chk/;
774 * FILE TABLES c:\windows\gammdir\lacea2\ OLG.tab  /;
775
776 *+++++
777 * Initialisation
778 *+++++
779
780 *===Parameters
781 *---> Population (assumed constant before TI)
782 NN(J,TTP)      = NGR(J) ;
783 Pop(J,TTP,G)$ (ORD(TTP) EQ CARD(G))                = NC1(J,G) ;
784 LOOP(TTP      $(ORD(TTP) GT CARD(TP)), Pop(J,TTP+1,G) = NN(J,TTP)*Pop(J,TTP,G) ) ;
785 LOOP(TP,      POP(J,TP,G)=SUM(TTP$(ORD(TTP) EQ CARD(G)), POP(J,TTP,G)););
786 TPop(J,TTP) $(ORD(TTP) LT CARD(TTP))                = SUM(G,Pop(J,TTP,G));
787 LOOP(TTP      $(ORD(TTP) LT CARD(TTP)), NNP(J,TTP)   = TPop(J,TTP+1)/TPop(J,TTP)
;
788 * DISPLAY POP,NNP;
789 DISPLAY TPop;
790 EP9(J,GM)      = 0;
791 EP(J,G)        = EP9(J,G);
792 *--->Producers
793 SigX(J,S)      = 3;
794
795 AlK(J,S)       = Alfa(J);
796 ScCoQ(J,S,TTP) = ((1/CARD(S))*YY.L(J))/
797                ((1/CARD(S))*KK.L(J)**AlK(J,S)*
798                ((1/CARD(S))*SUM(G,POP(J,TTP,G)*EP(J,G))** (1-AlK(J,S))));
799 SigLdem(J,S)   = 3;
800 SigLProf(J,S,IProf) = 3;
801 * AlProf(J,S,IProf) = SUM(TI, (LProf.L(J,S,IProf,TI)/Ldem.L(J,S,TI))/(Wage.
L(J,S,TI)**SigLdem(J,S)) ) ;
802 * AlQual(J,S,IProf,IQual) = SUM(TI, LQual.L(J,S,IProf,IQual,TI)/LProf.L(J,S,IProf,
TI)) ;
803 *--->Households J
804 DiscR(J)      = DELTAC.L(J);

```

```

805 SigCon(J,G) = 5;
806 AlConS(J,S,G) = (1/CARD(S));
807 DepR(J) = DEP.L(J);
808 SigInv(J) = 5;
809 AlInvS(I,S) = (1/CARD(S));
810 BeqR(J,G) = BEC(J,G);
811 InhR(J,G) = IDC(G);
812 *--->Government J
813 KTxR(J,TTP) = KTAX(J);
814 ConTxR(J,TTP) = CTAX(J);
815 PensR(J) = BR(J)*(CARD(GJ)/SUM(GJ,EP9(J,GJ)));
816 ExoBonds(J,TTP) = 1;
817 SigGov(J) = 5;
818 AlGovS(I,S) = (1/CARD(S));
819 GovH(J,S,TTP) = GHea(J);
820 GovE(J,S,TTP) = GEdu(J);
821
822 SigC(J,S) = 5;
823
824 *===Variables
825 *--->Producers
826 P.L(J,S,TTP) = 1;
827 PQ.L(J,S,TTP) = 1;
828 Ldem.L(J,S,TTP) = (1/CARD(S))*SUM(G,POP(J,TTP,G)*EP(J,G));
829 Kdem.L(J,S,TTP) = (1/CARD(S))*KK.L(J);
830 Q.L(J,S,TTP) = (1/CARD(S))*YY.L(J);
831 *----> Introducing fictitious intermediate demands
832 Z.L(J,S,TTP)$FlInterm = 1.5* Q.L(J,S,TTP);
833 Z.L(J,S,TTP)$(1-FlInterm) = 1.0* Q.L(J,S,TTP);
834 *----<
835 PX.L(J,S,TTP) $FlInterm = 1;
836 AlQ(J,S) $FlInterm = SUM(TI,Q.L(J,S,TI)/Z.L(J,S,TI));
837 X.L(J,S,TTP) $FlInterm = (1-AlQ(J,S))*Z.L(J,S,TTP);
838 ScCoZ(J,S,TTP) $FlInterm = Z.L(J,S,TTP)/(Q.L(J,S,TTP)**AlQ(J,S)*X.L(J,S,TTP)**(
1-AlQ(J,S)));
839 XS.L(SS,J,S,TTP)$FlInterm = X.L(J,S,TTP)/CARD(S);
840 AlXS(SS,J,S) $FlInterm = SUM(TI,XS.L(SS,J,S,TI)/X.L(J,S,TI));
841
842 PX.FX(J,S,TTP) $(1-FlInterm) = 1;
843 AlQ(J,S) $(1-FlInterm) = 1;
844 X.FX(J,S,TTP) $(1-FlInterm) = 0;
845 ScCoZ(J,S,TTP) $(1-FlInterm) = 1;
846 XS.FX(SS,J,S,TTP)$(1-FlInterm) = 0;
847 AlXS(SS,J,S) $(1-FlInterm) = 0;
848
849 LOOP(TTP $(ORD(TTP) GT CARD(TP) ),Z.L(J,S,TTP+1)=NNP(J,TTP)*Z.L(J,S,TTP));
850 LOOP(TTP $(ORD(TTP) GT CARD(TP) ),Q.L(J,S,TTP+1)=NNP(J,TTP)*Q.L(J,S,TTP));
851
852 Wage.L(J,S,TTP) = WW(J);
853 LsupMatrix(J,IProf,IQual,G) = WW(J)/(CARD(IProf)*CARD(IQual));
854 WProf.L(J,S,IProf,TTP) = 1;
855 LQual.L(J,S,IProf,IQual,TTP) = (1/CARD(S))*SUM(G,LsupMatrix(J,IProf,IQual,G)*
POP(J,TTP,G)*EP(J,G));
856 LProf.L(J,S,IProf,TTP) = SUM(IQual,LQual.L(J,S,IProf,IQual,TTP));
857 Ldem.L(J,S,TTP) = SUM(IProf,LProf.L(J,S,IProf,TTP))/WAGE.L(J,S,TTP);
858
859 AlProf(J,S,IProf) = SUM(TI,(LProf.L(J,S,IProf,TI)/Ldem.L(J,S,TI))/(Wage.L(

```

```

      J,S, TI)**SigLdem(J,S) ) ;
860 AlQual(J,S,IProf,IQual) = SUM(TI, LQual.L(J,S,IProf,IQual, TI)/LProf.L(J,S,IProf,
      TI)) ;
861
862 *--->Households J
863 Con.L(J,TTP,G) = CC.L(J,G);
864 Lend.L(J,TTP,G) = HA.L(J,G);
865 Pcon.L(J,TTP,G) = 1;
866 ConS.L(J,S,TTP,G)= 0; ConS.L(J,S,TTP,G) = (1/CARD(S))*Con.L(J,TTP,G);
867 Beq.L(J,TTP,G) = BEQC.L(J,G);
868 Inh.L(J,TTP,G) = INHC.L(J,G);
869 Pens.L(J,TTP,GM) = WW(J)*BR(J); Pens.FX(J,TTP,GJ) = 0;
870
871 Inv.L(J,TTP) = ((NGR(J)-1)+DEP.L(J))*KK.L(J);
872 LOOP(TTP$(ORD(TTP) GT CARD(TP)), Inv.L(J,TTP+1)=NNP(J,TTP)*Inv.L(J,TTP));
873 PInv.L(J,TTP) = 1;
874 InvS.L(J,S,TTP) = (1/CARD(S))*Inv.L(J,TTP);
875 *--->Government J
876 Bond.L(J,TTP) = B(J);
877 LOOP(TTP$(ORD(TTP) GT CARD(TP)), Bond.L(J,TTP+1)=NNP(J,TTP)*Bond.L(J,TTP));
878 Gov.L(J,TTP) = GEXP.L(J);
879 LOOP(TTP$(ORD(TTP) GT CARD(TP)), Gov.L(J,TTP+1)=NNP(J,TTP)*Gov.L(J,TTP));
880 PGov.L(J,TTP) = 1;
881 GovS.L(J,S,TTP) = (1/CARD(S))*Gov.L(J,TTP);
882 WTxR.L(J,TTP) = WTAX(J);
883 CTR.L(J,TTP) = CTR00.L(J);
884 PFund.L(J,TTP) = 0;
885 *--->Markets
886 PC.L(J,S,TTP) = 1;
887
888 *-----> Choosing an (arbitrary) matrix of bilateral trade flows by sector
      consistent with data
889 E.L(I,J,S,TTP) = E9.L(I,J);
890 $ontext
891 E.L(I,J,S,TTP) = 0;
892 EQUATIONS BiTradeEq1(I,S,TTP),BiTradeEq2(I,S,TTP),OBJEQ00;
893 BiTradeEq1(J,S, TI).. Z.L(J,S, TI) =E= SUM(I, E(J,I,S, TI) )+GovH(J,S,
      TI)+GovE(J,S, TI);
894 BiTradeEq2(J,S, TI).. SUM(I, E(I,J,S, TI)) =E= SUM(G, Pop(J, TI, G)*ConS.L(J,S,
      TI, G))+InvS.L(J,S, TI)+GovS.L(J,S, TI)+SUM(SS, XS.L(S,J, SS, TI));
895 OBJEQ00.. OBJ =E= SUM((I,S, TI), (E(I,I,S, TI)-.8*Z.L(I,
      S, TI))* (E(I,I,S, TI)-.8*Z.L(I,S, TI)) );
896 MODEL BiTrade / BiTradeEq1, BiTradeEq2, OBJEQ00 / ;
897 BiTrade.OPTFILE = 1;
898 E.L(J,J,S, TI) = .80*(SUM(G, Pop(J, TI, G)*ConS.L(J,S, TI, G))+InvS.L(J,S, TI)+
      GovS.L(J,S, TI)+SUM(SS, XS.L(S,J, SS, TI)));
899 LOOP((I,J)$ (ORD(I) NE ORD(J)), E.L(I,J,S, TI) =
900 .80*(SUM(G, Pop(J, TI, G)*ConS.L(J,S, TI, G))+InvS.L(J,S, TI)+
      GovS.L(J,S, TI)+SUM(SS, XS.L(S,J, SS, TI)))/(CARD(I)-1); );
901 E.LO(I,J,S, TI) = .05*Z.L(I,S, TI); E.UP(I,J,S, TI) = Z.L(J,S, TI);
902 OPTION NLP=MINOS5;
903 OPTION SOLPRINT=off, LIMROW=0, LIMCOL=0, ITERLIM=5000;
904 SOLVE BiTrade MINIMIZING OBJ USING NLP;
905 $offtext
906 *-----<
907 LOOP(TTP$(ORD(TTP) EQ CARD(TP)+1),
908 AlCI(I,J,S) = E.L(I,J,S, TTP)/

```

```

909          (SUM(G, Pop(J, TTP, G) * ConS.L(J, S, TTP, G)) + InvS.L(J, S, TTP) + GovS.L(
J, S, TTP) + SUM(SS, XS.L(S, J, SS, TTP))) ;
910      );
911      E.L(I, J, S, TTP) = AlCI(I, J, S) *
912          (SUM(G, Pop(J, TTP, G) * ConS.L(J, S, TTP, G)) + InvS.L(J, S, TTP) + GovS.L(
J, S, TTP) + SUM(SS, XS.L(S, J, SS, TTP))) ;
913      WQual.L(J, IProf, IQual, TTP) = 1;
914      Kstock.L(J, TTP) = KK.L(J);
915      LOOP(TTP $(ORD(TTP) GT CARD(TP)), Kstock.L(J, TTP+1) = NNP(J, TTP) * Kstock.L(J, TTP));
916      Rent.L(J, TTP) = RR + DEP.L(J);
917      P.L(J, S, TTP) = 1;
918      Rint.L(TTP) = 1 + RR;
919      RRet.L(I, TTP) = Rint.L(TTP);
920      RintJ.L(J, TTP) = Rint.L(TTP);
921
922      *-----> Choosing an (arbitrary) matrix of bilateral bond holding
consistent with data
923
924      VARIABLES Bij0v(I, J), Kij0v(I, J);
925      EQUATIONS PortEQ1(I, TTP), PortEQ2(I, TTP), PortEQ3(I, TTP), OBJPortEQ;
926      Kij0v.L(I, I) = .7 * KK.L(I); Kij0v.L(I, J) $(ORD(I) NE ORD(J)) = (KK.L(I) - Kij0v.L(I,
I)) / (CARD(J) - 1);
927      PortEQ1(I, TI) .. Bond.L(I, TI) =E= SUM(J, Bij0v(I, J));
928      PortEQ2(I, TI) .. Kstock.L(I, TI) =E= SUM(J, Kij0v(I, J));
929      PortEQ3(J, TI) .. SUM(I, Bij0v(I, J) + Kij0v(I, J)) =E= SUM(G, Pop(J, TI, G) * Lend.L(J, TI,
G));
930      OBJPortEQ .. OBJ =E= 0;
931      MODEL PORTFO / PortEQ1, PortEQ2, PortEQ3, OBJPortEQ / ;
932      PORTFO.OPTFILE = 1;
933
934      OPTION NLP=MINOS5;
935      OPTION SOLPRINT=OFF, LIMROW=0, LIMCOL=0, ITERLIM=5000;
936      SOLVE PORTFO MINIMIZING OBJ USING NLP;
937      Bij00(I, J) = Bij0v.L(I, J);
938      Kij00(I, J) = Kij0v.L(I, J);
939      Bij.L(I, J, TTP+1, G+1) = (Bij00(I, J) / SUM(II, Bij00(II, J) + Kij00(II, J))) * Lend.L(J,
TTP+1, G+1) / PGov.L(I, TTP);
940      Kij.L(I, J, TTP+1, G+1) = (Kij00(I, J) / SUM(II, Bij00(II, J) + Kij00(II, J))) * Lend.L(J,
TTP+1, G+1) / PInv.L(I, TTP);
941
942      *-----<
943
944      $INCLUDE BOUNDS.INC
945
946      *****
947      * TEST Calibration
948      *****
949      IF(FlCalib EQ 1,
950
951      $INCLUDE BOUNDS.INC
952
953      OPTIONS SOLPRINT=ON, LIMROW=0, LIMCOL=0, ITERLIM=50000, RESLIM=50000;
954      IF(FlMinos EQ 1, OPTION NLP=MINOS5 ; ELSE OPTION NLP=CONOPT2; );
955      SOLVE OLG USING NLP MINIMIZING OBJ;
956
957      $INCLUDE Margins.inc
958      );

```

```

959 *****
960 * TEST OF NUMERAIRE
961 *****
962 IF(F1Numer EQ 1,
963
964   P.FX("ROW", "S1", TTP) = 1.2;
965   P.FX(J, S, TTP) $(ORD(TTP) LE CARD(TP)) = 1.2;
966   Lend.FX(J, TTP, G) $(ORD(TTP) LE CARD(TP)+1) = 1.2*Lend.L(J, TTP, G);
967   Beq.FX(J, TTP, G) $(ORD(TTP) LE CARD(TP)) = 1.2*Beq.L(J, TTP, G);
968   Inh.FX(J, TTP, G) $(ORD(TTP) LE CARD(TP)) = 1.2*Inh.L(J, TTP, G);
969   Pens.FX(J, TTP, G) $(ORD(TTP) LE CARD(TP)) = 1.2*Pens.L(J, TTP, G);
970   PInv.FX(J, TTP) $(ORD(TTP) LE CARD(TP)) = 1.2*PInv.L(J, TTP);
971   PGov.FX(J, TTP) $(ORD(TTP) LE CARD(TP)) = 1.2*PGov.L(J, TTP);
972   WQual.FX(J, IProf, IQual, TTP)$(ORD(TTP) LE CARD(TP)) = 1.2*WQual.L(J, IProf, IQual,
TTP);
973   Rent.FX(J, TTP) $(ORD(TTP) LE CARD(TP)) = 1.2*Rent.L(J, TTP);
974
975 $INCLUDE BOUNDS.INC
976
977   OPTIONS SOLPRINT=OFF, LIMROW=0, LIMCOL=0, ITERLIM=10000, RESLIM=50000;
978   OPTION NLP=CONOPT2;
979   SOLVE OLG USING NLP MINIMIZING OBJ;
980
981   OPTIONS SOLPRINT=On, LIMROW=0, LIMCOL=0, ITERLIM=10000, RESLIM=50000;
982   IF(F1Minos EQ 1, OPTION NLP=MINOS5 ; ELSE OPTION NLP=CONOPT2; );
983   SOLVE OLG USING NLP MINIMIZING OBJ;
984
985 $INCLUDE Margins.inc
986 );
987 *****
988 * TEST DEMOGRAPHICS (with ini. popul. growth rate at 1.0)
989 *****
990 IF(F1Demog EQ 1,
991
992 $INCLUDE BOUNDS.INC
993
994   IF(F1Dyn EQ 1,
995     LOOP(TTP $( (ORD(TTP) GE CARD(G)) AND (ORD(TTP) LE CARD(G)+5) ), NN(J, TTP) = 1.
01*NN(J, TTP) ; );
996     LOOP(TTP $(ORD(TTP) GT CARD(TP)), Pop(J, TTP+1, GI) = NN(J, TTP)*Pop(J, TTP, GI));
997     LOOP(TTP $(ORD(TTP) GT CARD(TP)), Pop(J, TTP+1, G+1) = Pop(J, TTP, G) );
998     TPop(J, TTP)$(ORD(TTP) LT CARD(TTP)) = SUM(G, Pop(J, TTP, G));
999     LOOP(TTP $(ORD(TTP) LT CARD(TTP)), NNP(J, TTP) = TPop(J, TTP+1)/TPop(J, TTP)
);
1000   DISPLAY POP, TPop, NNP;
1001   ELSE
1002     POP(J, TTP, G)$(ORD(TTP) GT CARD(TP)+2 AND ORD(TTP) LT CARD(TTP)) = 1.02*POP(J,
TTP, G);
1003     TPop(J, TTP) $(ORD(TTP) LT CARD(TTP)) = SUM(G, Pop(J, TTP, G));
1004     DISPLAY POP, TPop;
1005   );
1006   LOOP(TTP$(ORD(TTP) GT CARD(TP)), Gov.L(J, TTP+1) = NNP(J, TTP)*Gov.L(J, TTP));
1007
1008   OPTIONS SOLPRINT=OFF, LIMROW=0, LIMCOL=0, ITERLIM=10000, RESLIM=20000;
1009   OPTION NLP=CONOPT2;
1010   SOLVE OLG USING NLP MINIMIZING OBJ;
1011

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```

1012  OPTIONS SOLPRINT=ON, LIMROW=0, LIMCOL=0, ITERLIM=10000, RESLIM=20000;
1013  IF(FlMinos EQ 1, OPTION NLP=MINOS5 ; ELSE OPTION NLP=CONOPT2; );
1014  SOLVE OLG USING NLP MINIMIZING OBJ;
1015
1016  $INCLUDE Margins.inc
1017 );
1018
1019  *****
1020  * TEST PRODUCTIVITY SHOCK
1021  *****
1022  IF(FlPRODU EQ 1,
1023
1024  $INCLUDE BOUNDS.INC
1025
1026  IF(FlDyn EQ 1,
1027    ScCoQ(J,S,TTP) $( ORD(TTP) GT CARD(TP) AND ORD(TTP) LE CARD(TP)+3 ) = 1.01*
    ScCoQ(J,S,TTP);
1028    ScCoQ(I,S,TTP) $( (ORD(TTP) GT CARD(TP) AND ORD(TTP) LE CARD(TP)+4
1029                      AND ORD(I) EQ 1 ) ) = 1.03*
    ScCoQ(I,S,TTP);
1030    ScCoQ(I,S,TTP) $( (ORD(TTP) GT CARD(TP) AND ORD(TTP) LE CARD(TP)+5
1031                      AND (ORD(I) EQ CARD(I)
1032                      AND ORD(S) EQ CARD(S)) ) ) = .99*
    ScCoQ(I,S,TTP);
1033  ELSE
1034    ScCoQ(J,S,TTP) $( ORD(TTP) GT CARD(TP)) = 1.01*ScCoQ(J,S,
    TTP);
1035    ScCoQ(I,S,TTP) $( ORD(TTP) GT CARD(TP) AND ORD(I) EQ 1) = 1.03*ScCoQ(I,S,
    TTP);
1036    ScCoQ(I,S,TTP) $( (ORD(TTP) GT CARD(TP) AND ORD(I) EQ CARD(I))
1037                      AND ORD(S) EQ CARD(S)) = .99*ScCoQ(I,S,
    TTP);
1038 );
1039
1040  * Choose periods of BOND-financed government deficits (default is tax financing)
1041  * ExoBonds(J,TTP)$( (ORD(TTP) GT CARD(TP)+1) AND (ORD(TTP) LE CARD(TP)+3)) = 0;
1042
1043  OPTIONS SOLPRINT=OFF, LIMROW=0, LIMCOL=0, ITERLIM=10000, RESLIM=50000;
1044  OPTION NLP=CONOPT2;
1045  SOLVE OLG USING NLP MINIMIZING OBJ;
1046
1047  $INCLUDE BOUNDS.INC
1048
1049  OPTIONS SOLPRINT=On, LIMROW=0, LIMCOL=0, ITERLIM=10000, RESLIM=50000;
1050  IF(FlMinos EQ 1, OPTION NLP=MINOS5 ; ELSE OPTION NLP=CONOPT2; );
1051  SOLVE OLG USING NLP MINIMIZING OBJ;
1052
1053  $INCLUDE Margins.inc
1054 );
1055
1056  $INCLUDE EquilChk.inc
1057
1058  *$INCLUDE Print-OLG.inc
1059
1060  *$INCLUDE Demo-Sim.inc
1061
1062  DISPLAY CTR.L,Pop;

```

```

1
2 PARAMETER NNF(J,TTP);
3   NNF(J,TTP)=1;
4 *$ONTEXT
5   NNF("UZB","1942")=1.07; NNF("ROW","1942")=1.03;
6   NNF("UZB","1954")=1.87; NNF("ROW","1954")=1.045;
7   NNF("UZB","1966")=1.91; NNF("ROW","1966")=1.245;
8   NNF("UZB","1978")=1.95; NNF("ROW","1978")=1.045;
9   NNF("UZB","1990")=1.85; NNF("ROW","1990")=0.795;
10  NNF("UZB","2002")=1.35; NNF("ROW","2002")=0.765;
11  NNF("UZB","2014")=0.95; NNF("ROW","2014")=0.745;
12  NNF("UZB","2026")=0.7; NNF("ROW","2026")=0.773;
13  NNF("UZB","2038")=0.6; NNF("ROW","2038")=0.801;
14  NNF("UZB","2050")=0.9; NNF("ROW","2050")=0.829;
15  NNF("UZB","2062")=1.0; NNF("ROW","2062")=1.00;
16
17 DISPLAY NNF;
18 *OFFTEXT
19
20 *$ONTEXT
21 SET ITER / 1 * 50 /;
22 PARAMETERS LAMBDA, ITERMAX;
23   ITERMAX = 50 ;
24   LAMBDA = .99;
25
26   LOOP(ITER$(ORD(ITER) LE ITERMAX+1),
27 * LOOP(ITER$(ORD(ITER) LE 40),
28     DISPLAY LAMBDA;
29     NN(J,T) = LAMBDA*NGR(J) + (1-LAMBDA)*NNF(J,T);
30     LAMBDA = (1-ORD(ITER)/ITERMAX);
31     LOOP(TTP$(ORD(TTP) GT CARD(TP)), Pop(J,TTP+1,GI) = NN(J,TTP)*Pop(J,TTP,GI));
32     LOOP(TTP$(ORD(TTP) GT CARD(TP)), Pop(J,TTP+1,G+1) = Pop(J,TTP,G));
33     TPop(J,TTP) = SUM(G, Pop(J,TTP,G));
34     NNP(J,TTP) = TPop(J,TTP+1)/TPop(J,TTP) ;
35
36     LOOP(TTP$(ORD(TTP) GT CARD(TP)), Gov.FX(J,TTP+1)=NNP(J,TTP)*Gov.L(J,TTP));
37
38 $INCLUDE BOUNDS.INC
39
40     OPTIONS SOLPRINT=OFF, LIMROW=0, LIMCOL=0, ITERLIM=10000, RESLIM=50000;
41     OPTION NLP=CONOPT2;
42     SOLVE OLG USING NLP MINIMIZING OBJ;
43
44 $INCLUDE MARGINS.INC
45   );
46
47 *$OFFTEXT;
48
49 $ONTEXT
50 PARAMETERS LAMBDA, ITERMAX;
51   ITERMAX = 10 ;
52   LAMBDA = .05;
53
54
55 * LOOP(ITER$(ORD(ITER) LE 1),
56   DISPLAY LAMBDA;
57   NN(J,T) = LAMBDA*NGR(J) + (1-LAMBDA)*NNF(J,T);

```

```

58
59     LOOP(TTP$(ORD(TTP) GT CARD(TP)), Pop(J,TTP+1,GI) = NN(J,TTP)*Pop(J,TTP,GI));
60     LOOP(TTP$(ORD(TTP) GT CARD(TP)), Pop(J,TTP+1,G+1) = Pop(J,TTP,G));
61     TPop(J,TTP) = SUM(G, Pop(J,TTP,G));
62     NNP(J,TTP) = TPop(J,TTP+1)/TPop(J,TTP);
63
64     LOOP(TTP$(ORD(TTP) GT CARD(TP)), Gov.FX(J,TTP+1)=NNP(J,TTP)*Gov.L(J,TTP));
65
66 $INCLUDE BOUNDS.INC
67
68     OPTIONS SOLPRINT=ON, LIMROW=9999, LIMCOL=0, ITERLIM=10000, RESLIM=50000;
69     OPTION NLP=CONOPT2;
70     SOLVE OLG USING NLP MINIMIZING OBJ;
71
72 $INCLUDE MARGINS.INC
73
74
75 *$ONTEXT
76
77     LAMBDA = .95;
78
79
80 * LOOP(ITER$(ORD(ITER) LE 1),
81     DISPLAY LAMBDA;
82     NN(J,T) = LAMBDA*NGR(J) + (1-LAMBDA)*NNF(J,T);
83
84     LOOP(TTP$(ORD(TTP) GT CARD(TP)), Pop(J,TTP+1,GI) = NN(J,TTP)*Pop(J,TTP,GI));
85     LOOP(TTP$(ORD(TTP) GT CARD(TP)), Pop(J,TTP+1,G+1) = Pop(J,TTP,G));
86     TPop(J,TTP) = SUM(G, Pop(J,TTP,G));
87     NNP(J,TTP) = TPop(J,TTP+1)/TPop(J,TTP);
88
89     LOOP(TTP$(ORD(TTP) GT CARD(TP)), Gov.FX(J,TTP+1)=NNP(J,TTP)*Gov.L(J,TTP));
90
91 $INCLUDE BOUNDS.INC
92
93     OPTIONS SOLPRINT=OFF, LIMROW=0, LIMCOL=0, ITERLIM=10000, RESLIM=50000;
94     OPTION NLP=CONOPT2;
95     SOLVE OLG USING NLP MINIMIZING OBJ;
96
97 $INCLUDE MARGINS.INC
98
99 *$ONTEXT
100
101     LAMBDA = .8;
102
103
104 * LOOP(ITER$(ORD(ITER) LE 1),
105     DISPLAY LAMBDA;
106     NN(J,T) = LAMBDA*NGR(J) + (1-LAMBDA)*NNF(J,T);
107
108     LOOP(TTP$(ORD(TTP) GT CARD(TP)), Pop(J,TTP+1,GI) = NN(J,TTP)*Pop(J,TTP,GI));
109     LOOP(TTP$(ORD(TTP) GT CARD(TP)), Pop(J,TTP+1,G+1) = Pop(J,TTP,G));
110     TPop(J,TTP) = SUM(G, Pop(J,TTP,G));
111     NNP(J,TTP) = TPop(J,TTP+1)/TPop(J,TTP);
112
113     LOOP(TTP$(ORD(TTP) GT CARD(TP)), Gov.FX(J,TTP+1)=NNP(J,TTP)*Gov.L(J,TTP));
114

```

```

115 $INCLUDE BOUNDS.INC
116
117     OPTIONS SOLPRINT=OFF, LIMROW=0, LIMCOL=0, ITERLIM=10000, RESLIM=50000;
118     OPTION NLP=CONOPT2;
119     SOLVE OLGMultiR USING NLP MINIMIZING OBJ;
120
121 $INCLUDE MARGINS.INC
122
123     LAMBDA = .7;
124
125
126 * LOOP(ITER$(ORD(ITER) LE 1),
127     DISPLAY LAMBDA;
128     NN(J,T) = LAMBDA*NGR(J) + (1-LAMBDA)*NNF(J,T);
129
130     LOOP(TTP$(ORD(TTP) GT CARD(TP)), Pop(J,TTP+1,GI) = NN(J,TTP)*Pop(J,TTP,GI));
131     LOOP(TTP$(ORD(TTP) GT CARD(TP)), Pop(J,TTP+1,G+1) = Pop(J,TTP,G));
132     TPop(J,TTP) = SUM(G, Pop(J,TTP,G));
133     NNP(J,TTP) = TPop(J,TTP+1)/TPop(J,TTP) ;
134
135     LOOP(TTP$(ORD(TTP) GT CARD(TP)), Gov.FX(J,TTP+1)=NNP(J,TTP)*Gov.L(J,TTP));
136
137 $INCLUDE BOUNDS.INC
138
139     OPTIONS SOLPRINT=OFF, LIMROW=0, LIMCOL=0, ITERLIM=10000, RESLIM=50000;
140     OPTION NLP=CONOPT2;
141     SOLVE OLGMultiR USING NLP MINIMIZING OBJ;
142
143 $INCLUDE MARGINS.INC
144
145     LAMBDA = .6;
146
147
148 * LOOP(ITER$(ORD(ITER) LE 1),
149     DISPLAY LAMBDA;
150     NN(J,T) = LAMBDA*NGR(J) + (1-LAMBDA)*NNF(J,T);
151
152     LOOP(TTP$(ORD(TTP) GT CARD(TP)), Pop(J,TTP+1,GI) = NN(J,TTP)*Pop(J,TTP,GI));
153     LOOP(TTP$(ORD(TTP) GT CARD(TP)), Pop(J,TTP+1,G+1) = Pop(J,TTP,G));
154     TPop(J,TTP) = SUM(G, Pop(J,TTP,G));
155     NNP(J,TTP) = TPop(J,TTP+1)/TPop(J,TTP) ;
156
157     LOOP(TTP$(ORD(TTP) GT CARD(TP)), Gov.FX(J,TTP+1)=NNP(J,TTP)*Gov.L(J,TTP));
158
159 $INCLUDE BOUNDS.INC
160
161     OPTIONS SOLPRINT=OFF, LIMROW=0, LIMCOL=0, ITERLIM=10000, RESLIM=50000;
162     OPTION NLP=CONOPT2;
163     SOLVE OLGMultiR USING NLP MINIMIZING OBJ;
164
165 $INCLUDE MARGINS.INC
166
167     LAMBDA = .55;
168
169
170 * LOOP(ITER$(ORD(ITER) LE 1),
171     DISPLAY LAMBDA;

```

```
172     NN(J,T)      = LAMBDA*NGR(J) + (1-LAMBDA)*NNF(J,T) ;
173
174     LOOP(TTP$(ORD(TTP) GT CARD(TP)), Pop(J,TTP+1,GI) = NN(J,TTP)*Pop(J,TTP,GI) );
175     LOOP(TTP$(ORD(TTP) GT CARD(TP)), Pop(J,TTP+1,G+1) = Pop(J,TTP,G) );
176     TPop(J,TTP) = SUM(G, Pop(J,TTP,G) );
177     NNP(J,TTP) = TPop(J,TTP+1)/TPop(J,TTP) ;
178
179     LOOP(TTP$(ORD(TTP) GT CARD(TP)), Gov.FX(J,TTP+1)=NNP(J,TTP)*Gov.L(J,TTP) );
180
181 $INCLUDE BOUNDS.INC
182
183     OPTIONS SOLPRINT=OFF, LIMROW=0, LIMCOL=0, ITERLIM=10000, RESLIM=50000;
184     OPTION NLP=CONOPT2;
185     SOLVE OLGMultiR USING NLP MINIMIZING OBJ;
186
187 $INCLUDE MARGINS.INC
188
189 $OFFTEXT
190     OPTIONS SOLPRINT=OFF, LIMROW=0, LIMCOL=0, ITERLIM=10000, RESLIM=20000;
191     OPTION NLP=MINOS5;
192 * SOLVE OLG USING NLP MINIMIZING OBJ;
193
194
195 $INCLUDE PRINT-OLG.INC
196
197     PARAMETER QPOP(J,S,TTP) ;
198     QPOP(J,S,TTP)=Q.L(J,S,TTP)/TPOP(J,TTP) ;
199
200     DISPLAY Q.L, Pop, Idem.L, QPOP;
```