Transmission of Demographic Shock Effects from Large to Small Countries: An Overlapping Generations CGE Analysis

Turalay Kenc
Birkbeck College, London, UK

Serdar Sayan
Bilkent University, Ankara, Turkey

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Abstract

This paper addresses an issue that has been overlooked in the literature on the effects of population ageing: Transmission onto small countries of the economic effects of population ageing, a natural, demographic outcome of the shock that many large industrial countries experienced in the form of a baby boom in the late 1940s and early 1950s. It is argued in the paper that international commodity and capital flows provide channels for the transmission of these effects that include changes in the terms of trade and interest rates in large countries. The issue is considered in the context of possible effects on Turkey of the demographic shock effects transmitted from Europe. The discussion is carried out in reference to the simulation results from an overlapping generations, general equilibrium model parametrised to mimic the current state of four largest members of the EU and Turkey. The simulation exercises lead to the following conclusions: First, changes in the age composition of Turkish population to occur in the course of the country's own demographic transition will affect the time paths of consumption, savings, investment and output substantially. Secondly, when they are transmitted onto Turkey, the economic effects of baby boomers' ageing in the EU will magnify the effects of the demographic transition in this country. This is a finding with implications for long term growth prospects of a country, and appears to be relevant to other small countries whose close economic ties with the industrial nations with ageing populations make them vulnerable to the effects of population ageing even if they have relatively young populations now.

Keywords : Demographic Shocks and Ageing Populations; Overlapping Generations; Simulation Models.

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Contact Information :

Dr. Turalay Kenc
Department of Economics
Birkbeck College, University of London
7-15 Gresse Street
London W1P 1PA
England

Phone : +44(171)631-6418
Fax : +44(171)631-6416
Email : tkenc@econ.bbk.ac.uk

Dr. Serdar Sayan
Department of Economics
Bilkent University
06533 Bilkent
Ankara
Turkey

Phone : +90(312)266-4000x2071
Fax : +90(312)266-5140
Email : sayan@bilkent.edu.tr

1. INTRODUCTION

Most industrial countries are currently experiencing considerable demographic changes with significant long-term consequences. The fraction of the population over 65 in these countries is projected to increase sharply in the next few decades. While this is partly due to increasing life expectancy, a more important reason is the fertility shock of the 1940s and 1950s. The growth in the population share of elderly is becoming increasingly visible in many countries as the so-called baby boom generations (born during the late 1940s and the early 1950s) keep getting older, and will be evident shortly after the year 2000. Projections by the United Nations for the OECD area as a whole show that the share of the population over 65 will rise from 15% today to 22% in 2040, outweighing the decline in the share of younger population projected for the same period. As a result, the ratio of population outside the working age (those under 20 and those 65 and older), to the part of population between the ages of 18 and 64 is projected to increase. Measuring the overall dependency shares of population in the OECD area, this ratio is expected to exceed 0.7 in the 2040s, representing a more than 10 percentage points increase beyond its value in the 1980s.

A higher dependency ratio has a number of important macroeconomic implications following from its direct and indirect effects on national savings and investment. First, by changing the term structure and the level of public pension and health care payments, it affects the budget position of the government –the level of public (dis)savings. Secondly, as shown by various generational accounting studies (e.g, Gokhale, *et.al.*, 1996), a higher dependency ratio increases consumption relative to output, and lowers the national saving rate thereby slowing down capital formation. Thirdly, the decline in the share of population in the working age implies a fall in labour supply. Naturally, such effects are not without microeconomic consequences. The decline in savings and the increasing share of consumption in GDP imply a change in the composition of demand and hence, must be expected to affect the relative prices of consumer and investment goods. On the supply side, the expected decline in labour supply, coupled with the slow down in capital formation, would cause changes in capital-labour ratios.[1] The changing capital-labour ratios, in turn, would alter relative factor prices leading to second-round effects on resource allocation. Furthermore, the changes in the relative capital intensities across traded and non-traded sectors are likely to affect the real exchange and trade patterns creating effects on other countries as well. The effects on other countries could be particularly significant if the countries facing the changes in demographic structure are large in the international trade sense of the term. Under these circumstances, trade provides a channel for transmission of the effects of demographic shocks experienced by large countries onto small open economies through the terms of trade effects it creates. Given their inability to affect world prices individually, most of the developing countries fall into the latter category. This implies that even the small developing countries that have not experienced similar baby boom shocks and hence, not yet faced a population ageing problem themselves are potentially vulnerable to the effects of population ageing in the larger countries of the OECD area. This is an issue that has been overlooked in the literature on the economic effects of population ageing as the overwhelming majority of the existing works focus on social security and related macroeconomic aspects of ageing in developed countries. This paper aims to help fill this gap by addressing the demographic transmission issue within a dynamic general equilibrium framework with overlapping generations.

Given the universal trend of declining mortality rates, the small open economies in the developing world are also anticipated to face the consequences of population ageing and related

[1] While the resulting change in capital-labour ratios may be in either direction depending upon the relative magnitudes of the effects on capital formation and labour supply, Auerbach, *et.al.* (1989) predict an increase in economywide capital-labour ratios in the developed economies.

demographic issues eventually, even if they have not had any demographic shocks in the form of a baby boom. Had they not been exposed to the effects transmitted through trade, however, such issues would have been expected to surface at a later stage during the course of these countries' own demographic transition. So, the need for an investigation of the direction and the magnitude of transmitted effects arises as developing countries become exposed to the effects of demographic shocks in the developed world through trade and capital flows. In this paper, we undertake such an investigation for the case of EU and Turkey. More precisely, we investigate the economic impact on Turkey of the demographic shock in Europe as well as the effects of Turkey's own demographic transition, using an overlapping generations (OG) computable general equilibrium (CGE) model.[2] We argue that in the context of the Customs Union Agreement that Turkey recently signed with the EU, such an analysis of the EU-Turkey interaction is especially appropriate.

The novelty of the question posed aside, the present study aims to contribute to the existing empirical literature on the economic effects of population ageing, and links up particularly well with the recent literature on the overlapping generations analysis of ageing within a general equilibrium setup. These empirical analyses have their theoretical roots in the life-cycle models of 1950s and 1960s, and have become increasingly popular starting from the mid-1980s. The growth of this literature within the last decade began first with the appearance of the generational accounting studies that examine the first-round economic impacts of ageing through simple projections –see, for example, Heller, *et.al.* (1986), Halter and Hemming (1987), Hagemann and Nicoletti (1989), and Gokhale, *et.al.* (1996). Introducing general equilibrium aspects, Auerbach and Kotlikoff (1987) examined population ageing through a dynamic model (see also Auerbach *et.al.*, 1989), which was later modified by others and extended in various directions. The model in this paper can be viewed as such an extension as it generalizes the set up in the 1987 and 1989 papers by Auerbach and his co-authors by allowing for variable terms of trade and an imperfectly elastic supply of world savings. It can also be viewed as a generalization of the model in Perraudin and Pujol (1991) as we incorporate non-stationary population dynamics and technological change. Other recent research that employs similar techniques includes Broer, *et.al.* (1994), Imrohoroglu, *et.al.* (1995), Huang, *et.al.* (1997) and the papers in Broer and Lassila (1996), commonly emphasizing social security issues in an overlapping generations framework.[3] A similar overlapping generations, general equilibrium analysis with a broader emphasis on macroeconomic effects of ageing can be found in Thoenissen (1997).

This study also relates to the recent literature on dynamic general equilibrium analysis of trade policy issues in developing countries (for a brief survey, see Devarajan and Go, 1998), and nicely complements them by introducing OG-aspects. Three recent studies that provide especially relevant examples of this literature are Mercenier and Yeldan (1997) and Diao, *et.al.* (1996 and 1997). The paper by Mercenier and Yeldan (1997) is particularly interesting as it addresses the resource allocation and welfare effects of the Customs Union Agreement between Turkey and the EU, using a dynamic general equilibrium model that overlooks the OG-aspects –introduced to our model through consumption, bequest and labour supply decisions that overlapping generations of households make over their life-cycle. We consider households that mature at the age of twenty and then live for a total of twelve periods of five years each in the EU and ten periods in Turkey, and allow non-stationary population dynamics with the only restriction that the population growth is assumed to start and end on a balanced path on which each age cohort makes up a constant fraction of the population.

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[2] For a comparative analysis of the demographic transition in the Middle East (including Turkey) and the rest of the developing world, see Yousef (1997).

[3] See Feldstein (1996) for a survey of studies addressing social security reform.

While lacking mechanisms for such population dynamics capable of capturing complicated patterns of baby boom and bust along the transition path, the latter group of studies cited above tend to use a more disaggregated classification of sectors. As compared to nine sectors explicitly modeled in Mercenier and Yeldan (1997), for example, we distinguish three sectors so as to keep the model structure manageable. Two of the sectors we model are domestic sectors, one producing a non-tradable and the other, an export good. The demand for the country's export is incompletely elastic, as is the supply of savings from the rest of the world. Besides domestically produced goods, households consume one imported good. They possess nested CES utility functions over three consumption goods and leisure, and also derive a utility from the bequests they make. The production technology employed by domestic firms is characterized by Constant Elasticity of Substitution (CES) production functions of capital and labour, with the firms maximising profits over time, and altering their capital stocks subject to convex costs of adjustment.

We take the model horizon as extending into 71 periods of five years each after 1990. To solve the model over the model horizon, we employ a Gauss-Seidel algorithm written in the programming language Gauss. The algorithm is quite robust and works well with a range of different starting values. Starting from a guessed vector of prices in each of the five-year periods considered, we calculate an updated vector by sequentially solving for each period's prices so as to eliminate excess demands in the different markets with future prices held fixed at the currently guessed values. Roughly fifty such iterations are required to find equilibrium state variables to a satisfactory degree of precision. We first simulate the model for a scaled down version of EU with four countries (hereafter, EU4): Germany, France, Italy and United Kingdom. These are the major trade partners of Turkey. In terms of their export/import shares, they, together with the US, typically make up the top five destinations of Turkish exports (with Germany being the top) and rank among the top sources of imports (with Germany ranking the first). Typically accounting for about 30-40% of Turkey's trade, EU4 countries can be taken as a close proxy for the Rest of the World for Turkey. Hence, feeding the relevant set of resulting prices from the EU4 simulation into the Turkish economy simulation as world prices, we can observe the effects of demographic shocks transmitted from the large country (EU4) onto the small open economy of Turkey along with the changes brought about by this country's own demographic transition.

The effects observed from the simulation exercises suggest that the demographic developments leading to population ageing and changes in age composition of Turkish population will affect the time paths of major macroeconomic variables considerably. Furthermore, the demographic shock in Europe must be expected to magnify these effects visibly. The transmission of demographic shock effects from Europe will therefore have implications for such variables as consumption, savings, investment, output and labour supply in Turkey, as well as the wage, exchange and interest rates in the country. Given that the formation of the Customs Union between Turkey and the EU clearly facilitates the transmission of these effects, Turkish policy makers will have to watch closely the demographic developments in Europe as these appear to have a bearing on the country's long term growth prospects. The same also applies to other small countries with close economic ties with the large industrial countries that began to experience the effects of population ageing as a result of the demographic shock of the 1950's in the form of a baby boom. Other than Turkey, a country that is immediately remembered within this context is Mexico due to its NAFTA membership, but other countries in Latin America and Asia are perhaps equally vulnerable to the developments in Europe, North America and Japan.

The plan of the paper is as follows. The next section sets out the model, explicitly showing how the assumptions about household and firm behaviour are modelled. Section 3 explains the parametrisation of the model. Section 4 describes the simulation scenarios and reports the results, and

Section 5 concludes the paper.

2. THE MODEL

The model employed in this paper is a multi-period overlapping generations model. Auerbach and Kotlikoff (1987) first developed a numerical overlapping generations model to study the United States economy. Its realism in capturing heterogenities among age groups encouraged researchers to extend the Auerbach-Kotlikoff model in various directions. Perraudin and Pujol (1991) generalized Auerbach-Kotlikoff framework by introducing a demand curve for exports, a supply curve for savings from the rest of the world and export- and non-tradable-producing domestic industries. Several researchers added further realism into consumer behaviour by introducing bequests and probability of dying.[4]

The model described here generalizes the Perraudin-Pujol framework by introducing bequests,[5] labour-endowment-augmenting technological change and a growing population. Furthermore, the solution algorithms employed here are new to this study.

2.1. Household Behaviour

The modelling of household behaviour follows the life-cycle approach. Aggregate consumption, saving and labour supply are derived from the intertemporal optimising behaviour of forward-looking individual age cohorts. In modelling EU4, each cohort is assumed to have an economic life of 60 years, becoming active at age 21 and dying at 80. On account of the relatively shorter life expectancy in Turkey, the dying age for this country is taken as 75.[6] To limit the computational burden, we assume that a time period equals five years. Hence, in any given period, 12 cohorts of different ages are economically active. We differentiate generations by birth date, t_0. Thus, at any given period t , households that belong to generation t_0 will be at the age of t-t_0. We suppose that during transition periods, the population varies over time, while at the steady-state it increases at a constant rate.

Households derive utility from consumption, leisure, and bequest-giving. The lifetime utility $U(t, t_0)$ of generation t_0 as of period t takes the following additively separable form:

$$U(t,t_0) \equiv \frac{1}{\alpha}\left(\sum_{s=t}^{t_0+n-1} \frac{u(s,t_0)^{\alpha}}{(1+\delta)^{s-t}} + \alpha_B \frac{b(t_0+n-1,t_0)^{\alpha}}{(1+\delta)^{n-1}} \right), \qquad \textbf{(1)}$$

where δ is the rate of time preference, $u(s,t_0)$ is an index showing the utility that the generation t_0 derives from leisure, l, and consumption, c, of goods 1, 2 and 3, and from the bequest, $b(t_0+n-1,$

[4] See, for instance, Auerbach, *et.al.* (1989) for models with bequests and Broer, *et.al.* (1993) for models with the probability of dying.

[5] Empirical studies by Kotlikoff and Summers (1981) and Gale and Scholz (1994) on savings behaviour suggest that bequest motives are important determinants of savings behaviour.

[6] While the dying ages may seem high, the life expectancy is currently increasing in both EU4 and Turkey. Moreover, the dying age in the model must be viewed as the maximum lifespan of the two members of a given household.

$t_0)$, made at the beginning of the last period of life, n. In the equation, α_B is a parameter showing the intensity of utility from bequests made, and $\alpha = 1 - 1/a$ where $a>0$ is the elasticity of substitution between utilities in different periods. $u(s, t_0)$, i.e., the household's utility at time s from leisure, l, and the consumption of non-tradable, c_1, imported, c_2, and exportable, c_3, goods is decomposed as follows:

$$u(s,t_0) \equiv [(1-\alpha_L)c(s,t_0)^{\rho} + \alpha_L l(s,t_0)^{\rho}]^{1/\rho} \quad \textbf{(2)}$$

$$c(s,t_0) \equiv [(1-\alpha_T)c_1(s,t_0)^{\rho_1} + \alpha_T c_0(s,t_0)^{\rho_1}]^{1/\rho_1} \quad \textbf{(3)}$$

$$c_0(s,t_0) \equiv [(1-\alpha_X)c_2(s,t_0)^{\rho_2} + \alpha_X c_3(s,t_0)^{\rho_2}]^{1/\rho_2} \quad \textbf{(4)}$$

where ρ, ρ_1, ρ_2 are parameters used to define the elasticity of substitution between consumption and leisure, non-tradables and tradables, and imports and exportables, respectively. Likewise, $\alpha_L, \alpha_T, \alpha_X$ are parameters showing intensity of utility from leisure, consumption of tradables, and consumption of exportables, respectively.

We assume that all households retire at the beginning of some given period, and that households' marginal labour productivities vary over the life cycle. Within each group, productivity and hence, wages are assumed to increase initially, peaking at period 5 (age 45) and declining slightly thereafter.

Taxation and transfers affect household behaviour through their influence on income and prices. Lump-sum transfers have a direct impact on income, VAT affects consumer prices, and direct taxation (including social security contributions) has an influence on interest rates and wages. Households maximise utility subject to an intertemporal wealth constraint. Letting $W(t,t_0)$ represent the lifetime wealth of generation t_0 at period t, r_t the interest rate at t, and τ_r the tax rate on household interest income, the lifetime wealth constraint is given by:

$$W(t,t_0) = b(t_0+n-1,t_0)d^H(n,t) + \sum_{s=t}^{t_0+n-1}(1+\tau_v)p(s)c(s,t_0)d^H(s,t) \quad \textbf{(5)}$$

where τ_v is the rate of VAT and $p(s)$ is a price index involving parameters of the utility function. The discounting factor for period s at current period t, $d^H(s,t)$ is defined as

$$d^H(s,t) \equiv \begin{cases} \prod_{v=t}^{s-1}[1+(1-\tau_v)r_v]^{-1} & \forall v > t \\ 1 & v = t. \end{cases}$$

Total lifetime wealth, W, equals the sum of human wealth, W_h, pension wealth, W_p, and anticipated future bequests, W_b. Let τ_i for i = x, w, r, d, g, v denote the rates of employee social security contributions, wage income tax, interest income tax, dividend income tax, capital gains tax and value added tax, respectively. If $z(s, t_0)$ denotes the lump-sum transfers received from the government, w(s) the wage rate, and $e(t-t_0)$ the "effective labour input", human wealth inclusive of lump sum transfer payments can then be written as:

$$W_h(t,t_0) = \sum_{s=t}^{t_0+n-1} [(1-\tau_x - \tau_w) w(s) e(t-t_0)(1-l(s,t_0)) + z(s,t_0)] d^H(s,t) \quad \textbf{(6)}$$

Let us define the parameters of the pension system as follows. γ_{ac} is the accrual factor, n_r is the retirement age, $\bar{n}$ is the number of years worked to qualify for the maximum level of old age pension benefit, $\bar{w}(t_0)$ is the average wage rate calculated by taking into account wage income and working hours during the period specified for this purpose by the pension authorities, and λ is the factor used to index pension income to wages. Then, social security wealth may be written as:

$$W_p(t,t_0) = \begin{cases} \gamma_{ac} \sum_{s=t_0+n_r}^{t_0+n-1} [\bar{n} \cdot \bar{w}(t_0)^{\lambda} w(s)^{1-\lambda}] d^H(s,t) & if\ t_0 + n_r \geq t \\ \gamma_{ac} \sum_{s=t}^{t_0+n-1} [\bar{n} \cdot \bar{w}(t_0)^{\lambda} w(s)^{1-\lambda}] d^H(s,t) & if\ t_0 + n_r < t \end{cases} \quad \textbf{(7)}$$

Finally, if $b_r(t+n_b, t_0)$ is bequests received in period $t+n_b$ with n_b denoting the age bequest received, anticipated bequest wealth may be written as:

$$W_b(t,t_0) = \begin{cases} b_r(t_0 + n_b - 1, t_0) d^H(s,t) & if\ t_0 + n_b - 1 \geq t \\ 0 & if\ t_0 + n_b - 1 < t \end{cases} \quad \textbf{(8)}$$

We assume in our simulations that bequests are made in the last period of life. Households have offspring in the first period of adult life (i.e., at the age of 20 to 25 years) and hence children receive bequests at the age of 60, i.e., n_b=60 (55 for Turkey).

If there were no further constraints, solving the dynamic programming problem for a given household would be easy enabling us to derive closed form consumption and leisure demands. However, we assume that the household is not allowed to supply labour after the retirement age, n_r. One may think of this as reducing the shadow wage just sufficiently that the household wishes to supply zero labour in its last few periods. Since the shadow wage can not be obtained in closed form, neither can the associated consumption and leisure demands. We must therefore solve the household's programme numerically.

2.2. Firm Behaviour

We suppose that the economy contains two domestic industries labelled 1 and 3, respectively producing non-tradable and tradable (exportable) goods under perfect competition. Each sector is made up of identical firms whose technologies are characterized by constant returns-to-scale CES production functions with capital,[7] *K(t)*, and labour, *L(t)* as the arguments. Scaling up variables, the production function for the industry as a whole is:

$$F_i[K(t), L(t)] \equiv \bar{\in}_i [\in_{i0} K(t)^{-\theta_i} + (1 - \in_{i0}) L(t)^{-\theta_i}]^{-1/\theta_i} \quad i = 1,3 . \quad \textbf{(9)}$$

In each period, producers decide on cost minimising intensities of labour given the current stock of capital. They alter the stock of capital through investment so as to maximise the value of firms' equity.

[7] In fact, capital is a composite good made up of the domestic and imported goods each with a fixed share.

Optimal investment involves balancing the costs of new capital (acquisition and installation costs) against the higher future revenues made possible by a larger capital stock. Adjustment costs are assumed to take the form:

$$CK(I_t / K_{t-1}) \equiv \begin{cases} \dfrac{\xi}{2} \dfrac{[I_t / K_{t-1} - \kappa]^2}{I_t / K_{t-1}} & for\ I / K > \kappa \\ 0 & for\ I / K \leq \kappa \end{cases} \quad \textbf{(10)}$$

where ξ, κ are adjustment cost parameters. If firms invest in this way and adjustment costs are convex, the capital stock will follow a smooth transition path. In equilibrium, it must be the case that dividends and capital gains equal the required return:

$$(1-\tau_d)D(t) + (1-\tau_g)[V(t+1) - VN(t) - V(t)] = (1-\tau_r)r(t)V(t) \quad \textbf{(11)}$$

where *V* is the equity value of the firm at the beginning of the year (BoY), *D* is dividend payments at the end of the year (EoY), *VN*, the proceeds from share issues, and τ_d, τ_r, τ_g are the tax rates on dividend and interest income, and the accrual-equivalent capital gains tax rate, respectively. Ruling out bubbles, we can write this as

$$V(t) = \sum_{s=t}^{\infty} \left[\frac{1-\tau_d}{1-\tau_g} D(s) - VN(s) \right] d^F(s,t) \quad \textbf{(12)}$$

where

$$d^F(s,t) \equiv \prod_{v=t}^{s} [1 + (1-\tau_r) r_v / (1-\tau_g)]^{-1} .$$

To solve the firms' programming problems, we must make assumptions concerning their financial behaviour. We assume, in particular, that (i) firms pay dividends equal to a constant fraction of after-tax profits net of depreciation; (ii) they issue debt to maintain a constant debt-capital ratio, and (iii) they issue new shares as the marginal source of finance. This financial behaviour is consistent with the assumptions behind the "old view" of capital taxation. The adjustment cost function is assumed to be convex in the ratio of investment (*I*) to the capital stock (*K*). We also assume that the installation costs of capital are internal to the firm. Such behaviour gives rise to a "q" investment function.

2.3. The Government

The model considers typical functions of the government as public expenditures on goods, maintenance of various transfer payments, the levying of taxes, and the issuance of debt. For a given level of spending, *G(t)*, at period *t*, the government taking in *T(t)* as tax revenue faces an intertemporal budget constraint in the form of

$$\sum_{t=1}^{\infty} T(t) d^G(t) = \sum_{t=1}^{\infty} G(t) d^G(t) + B_1^G \quad \textbf{(13)}$$

where

$$d^G(t) = \begin{cases} \prod_{s=1}^{t-1} [1 + (1-\tau_r) r(s) / (1-\tau_g)]^{-1} & \forall t > 1 \\ 1 & t = 1. \end{cases}$$

Given that the government expenditure on goods affects neither households' utility (equations 1 through 4) nor the firms' production decisions (equation 9), any cut in public expenditures will allow for an uncompensated tax cut thereby increasing the welfare. With such a structure, the model is inappropriate for studying such questions as the optimal design of expenditure programs. The changes in the level of public expenditures affect the distribution of wealth across different generations through their impact on the government debt, B^G. Since no social welfare function capable of ranking such distributions has been incorporated into the model, however, the model is also ill-equipped to study questions of optimal debt. As far as policy questions are concerned, the formulation of intertemporal budget constraint of the government could have been used for evaluating the effects of policies that can improve social welfare for given levels of public expenditure and given steady state debt. Given the emphasis placed upon the transmitted effects of demographic shocks in the EU, and Turkey's own demographic transition, the formulation is viewed as sufficiently complicated and appropriate for the purposes of this paper.

2.4. Treatment of Open Economy Features in the Model

The treatment of the country size with respect to international trade and capital flows in the model departs from the commonly-adopted small country assumption in several respects. In describing industrial economies, it appears quite unrealistic to assume that they can sell unlimited quantities of their exports at constant prices. Likewise, modelling international capital flows based on the assumption that interest rates are independent of the level of debt is hard to justify: The stylised facts of international capital markets suggest that the supply of world savings is imperfectly elastic for all but the smallest countries. Such unrealistic implications can be avoided, when the following three assumptions are adopted. First, the demand for the export good (which is also consumed by domestic households and used as an input to capital by firms) is assumed to be given by a constant elasticity function, $X_3 = X_0 P_3^{\omega}$ where X_0 is a positive constant, X_3 and P_3 are the quantity demanded of export good and the relevant foreign currency price, respectively, and ω is the elasticity parameter. Second, the net supply of savings from the rest of the world, W_{ROW}, is related to the difference between the domestic interest rate, $r(t)$, and the world interest rate, $\bar{r}$, according to the equation:

$$W_{ROW} = \bar{\bar{K}}\, sign[r(t) - \bar{r}](|r(t) - \bar{r}|)^{\omega^*}$$

where ω^* is the elasticity parameter, and $\bar{\bar{K}}$ is a non-negative constant. $\bar{\bar{K}} = 0$ represents the case of no capital mobility, but for any positive value of $\bar{\bar{K}}$, the degree of capital mobility would depend on the elasticity parameter. When $\omega^* = \infty$, the interest rate is given internationally, i.e., the small country assumption holds for capital markets. (If $\omega = \infty$, the same is true of the goods market.) $\omega^* = 0$, on the other hand, implies that there is a constant flow of capital between the domestic economy and the rest of the world which would be maintained through the adjustment of domestic interest rate. For relatively large industrial economies such as those in the EU4, it is safer to assume that the elasticity parameter would take values that are strictly between zero and infinity, implying a less than perfect mobility of capital. Finally, the third assumption fixes the foreign currency price of the imported good, which is consumed by households and used by firms in their constant coefficient production of capital, at P_2 .

3. PARAMETRISATION

Even though utility and production function parameters are likely to differ across EU4 and Turkey in reality, the unavailability in the literature of any precise information on the magnitude of the actual differences makes parametrisation difficult. In order not to rely on a rather sketchy notion of these differences, the model is implemented under the simplifying assumption that they are identical. Likewise, same levels of productivity over the life-cycle, and same patterns of government spending by age groups are assumed, but various tax and growth parameters are allowed to differ across countries. The differences with respect to size and structure of the economies under consideration are reflected by taking the values of such variables as capital and labour stocks, and the levels of savings as country specific.

Table 1 summarises the utility and production function parameters which were selected by drawing on a large number of empirical studies as indicated in the following subsections.

Table 1. BASELINE PARAMETRISATION

Utility Function Parameters		
Parameter	Equation	Value
Subjective discount rate	1	0.025
Elasticity of intertemporal substitution	1	0.900
Consumption-leisure elasticity of substitution	2	1.100
Tradable-non-tradable elasticity of substitution	3	1.200
Elasticity of substitution between tradables	4	0.800
Bequest preference parameter	1	0.500
Maximum life-span, *n*, for EU4	1	80
Maximum life-span, *n*, for Turkey	1	75
Industry Parameters		
Production elasticity (nontraded)	9	0.71
Production elasticity (export good)	9	0.92
Adjustment cost parameter, κ	10	0.05
Adjustment cost parameter, ξ	10	20
Depreciation rate, d	-	0.75
Capital-output ratio	-	3.00

3.1. Household Parameters

Estimated values for the intertemporal elasticity of substitution in the literature typically lie either within a low range of 0.2 to 0.4 –see Hall (1988) and Bayoumi (1990) for estimates based on US and UK time series data, respectively, or Patterson and Pesaran (1992) based on quarterly time series data from both

US and UK, or within a high range of 1.0 to 1.3 –see Mankiw, Rotemberg and Summers (1985) and Lawrance (1991) for US estimates from quarterly time series and panel data, respectively. With somewhat more faith placed in microeconomic estimates, this elasticity is taken here as equal to 0.9.

Of the other utility function parameters, the consumption-leisure elasticity of substitution is set at 1.1. This yields an uncompensated wage elasticity of labour supply of 0.2 that appears to be a sensible figure for the combined labour supply of a husband and wife couple. Empirical support for such a value may be found in various studies surveyed by Hum and Simpson (1994).

The bequest preference parameter and the bequest substitution elasticity are hard to choose. The values are taken as 0.5 and 0.9, respectively, and imply reasonable ratios of bequests to peak savings. These values are generally consistent with the levels estimated by Kotlikoff and Summers (1981).

In accordance with the findings of Kotlikoff and Gokhale (1992), Davies (1992) and Gottschalk and Joyce (1992), the wage-age profile used is hump-shaped. Kotlikoff and Gokhale (1992), in particular, argue that productivity peaks at around age 45 and declines thereafter. Productivity at age 65 is less than one-third of the peak. Both Davies (1992) and Gottschalk and Joyce (1992) find using cross-country data that the ratios of mean earnings for 40-49-year-old men to mean earnings for 25-29-year-old men are in the range of 1.08 to 1.30. Finally, the subjective discount rate, δ and the consumption-leisure parameter, α_L , were determined in the model calibration.

3.2. Firm Parameters

Estimates of the elasticity of substitution between labour and capital range between 0.45 and 0.9. The values found by Boskin (1978), Feldstein (1982) and Artus (1984), all using US annual time series, are 0.45, 0.9 and 0.50, respectively. Artus (1984) also obtained an estimate of 0.85 for Canada. As for European countries, Törmä, Rutherford and Vaittinen (1995) made an attempt to estimate the Finnish production function parameters in traded and nontraded industries. At 0.915 and 0.703 for traded and nontraded industries, respectively, their estimates are in the range of US and Canadian ones. In the simulations, these values estimated from Finnish data are used for two reasons: i) they are more likely to be relevant for the European countries we are studying and ii) the estimates reported are for traded and nontraded industries and hence, fit well to the commodity aggregation scheme employed here.

Equation (10) clearly shows the importance of adjustment cost parameters (ξ, κ) as determinants of the economy's dynamics following shocks. The values picked for these parameters are similar to those chosen by Summers (1981).

3.3. Rest of the World Parameters

The rest of the world elasticities of export demand and savings supply, ω and ω^* were set at -1.2 and 5 as in Perraudin and Pujol (1991). The constant in the savings supply function was chosen in such a way that a 1% deviation from world interest rates elicited a change in world savings supply equal to 10% of GDP.

3.4. Tax Rates and Pension Parameters

Wherever feasible, the tax rates employed are average and marginal income tax rates for married couples with two children. Wage income tax rates come from three different OECD publications (1993, 1992, and 1991a). Average and marginal social security contribution rates come from OECD (1991a), while marginal rates are taken from OECD (1993) and (1992a). The savings tax rates employed are for taxes on interest income as in OECD (1991b). Finally, VAT rates are taken from various issues of *OECD Economic Surveys* of individual member countries.

Like the tax rates, information on pension schemes and the contribution rates used in model implementation are taken from OECD sources, Van der Noord and Herd (1993) and Foster (1994). In terms of pension benefits, each country has a basic statutory pension arrangement plus supplementary pension plans. The supplementary arrangements are organized either as occupational or as private pension schemes (see Foster, 1994 and OECD, 1992b). Since private pension plans often constitute parts of complicated implicit labour contracts, and they are rather difficult to analyze, our model considered only the public schemes.

4. SIMULATION RESULTS

We now consider the effects of the demographic shock transmitted from the EU4 onto Turkish economy. In order to gauge these transmission effects on Turkey's output, capital stock and income distribution, simulation results are compared across two experiments, each conducted by feeding a different set of exogenous values for world prices of tradables and the world interest rate to the Turkish economy model. The first simulation scenario is meant to capture the effects resulting from Turkey's own demographic transition when the country faces a given set of world prices and interest rate. In the second scenario, on the other hand, the world prices and interest rates facing Turkey change, along with the changes in EU4 over the period under consideration. To conduct this experiment, we first simulate the model for EU4 and obtain relevant prices that prevail in the presence of the demographic shock in Europe. We then treat these as the world prices facing Turkey and plug them into the Turkish economy simulation. A comparison of the results across scenarios allows for an observation of differential effects resulting from the transmission of the effects of the demographic shock in EU4 onto Turkey, through the channels described above.

Both simulations consider the period from the year 1990 until the end of model horizon. 1990 is chosen to represent the current situation. As an alternative, one could consider 1950 as the starting period, the beginning of demographic shock in Europe. However, this would have caused a shift of focus away from the periods we particularly want to consider, i.e., 1990 onwards. The model horizon is taken to be 71 periods of five years each. The seventy-first period is the steady state when various growth rates and the population share of each age cohort become equal to calibrated values.

4.1. The Nature of Demographic Transitions

The demographic shock in Europe gives way to a different demographic transition in the EU4 than the one that would have been experienced by these countries in its absence. Through its effect on dependency ratios, this affects consumption and savings patterns, as well as the composition of government spending by age groups, causing, in turn, changes in prices. For this reason, the nature of demographic transitions facing the EU4 and Turkey must separately be captured first. To do that population profiles showing the shares of population by age cohorts over time are needed for both EU4 and Turkey. Consistently with the balanced growth path condition, these are derived by assuming stationarity at the beginning (1990) and at the end (from 2050 until the end of model horizon). This section describes the demographic transitions in EU4 and Turkey by summarising the projected demographic transitions in each. Table 2 reports the fractions of the population in different age groups starting from 1950, and Figure 1 on the next page shows the dependency ratios for EU4 and Turkey, starting from 1990. Both the historically observed values and the projections into the year 2050 are taken from United Nations sources.

Table 2. 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

[Insert Figure 1 Approximately Here !]

In producing Figure 1, we 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.

Both Figure 1 and Table 2 show that not only the size but also the timing of demographic transitions differ considerably for Turkey and EU4. Turkey always has a relatively younger population as compared to the largest four European countries as it has a higher population growth rate. It is particularly evident from Figure 1 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. The decline (in young age dependency ratio) is even more drastic for Turkey because of the birth rates that have slumped drastically since the 1970s in this country. Also shown in Figure 1 is the ratio of people over 65 to those in the working age (the 'old-age dependency ratio') which rises steadily for a few decades after 1990 in both the EU4 and Turkey, and stabilizes just above 25% after 2060 in the EU4, and just above 35% after 2110 in Turkey. Thus, the population gradually becomes older in the EU4 starting from the 1990s whereas Turkey begins to experience population ageing following the period after 2020.

In simulating the model, we adopt the simplifying assumption that net immigration is zero, since treating immigration explicitly would complicate our projections considerably. In reality, immigration has affected the age profile of the Turkish population at various points in time. In the 1960s and in the second half of the 1970s, in particular, there was significant immigration to other European countries, and especially to Germany. Yet, with the restrictions imposed upon the inflow of Turkish labour into the EU in the last two decades, the assumption has become increasingly realistic. Given the likelihood that these restrictions are to be maintained into the foreseeable future, the assumption may be viewed as sufficiently realistic.[4]

[4] Although it has not become the official position of the country yet, Turkey is currently considering to sacrifice the right of Turkish workers to freely seek employment anywhere within the EU as a concession to support its bid for full-membership. So, in all likelihood, the movement of Turkish labour into the EU will continue to be

In addition, the assumption that agents live for a fixed period of 75 years (80 for EU4) is maintained in the simulations. Since actual mortality rates are falling in Turkey as well as in other OECD countries, this is a convenient assumption for the present study where the focus is on the effects of Turkey's demographic transition and of demographic transmission on Turkey. The choice of such a long period of life can further be justified by noting that the prospective rise in old-age dependency ratios is due largely to the demographic shock rather than the rise in life expectancy.

4.2. Transmitted Effects of the Demographic Shock in the EU4

The discussion on the effects of demographic changes on the economy in this section begins with a description of the so called first round effects on factor supplies. The first round effects are those that would have been observed in the course of the country's own demographic transition (i.e., in the absence of the effects transmitted from Europe), if factor prices and incomes could be held constant. These effects arise due to the changes in the age composition of the population over time as the composition has a direct bearing on the supply of labour and capital (savings) to the economy. Additional changes are introduced to the time paths of factor supplies and other variables, as factor prices and incomes are allowed to vary along with the changes in the age composition of the country (second round price effects or general equilibrium effects). Since the transmission of the effects of the demographic shock in Europe through price and interest rate channels are also expected to alter the time paths of economic variables in Turkey, we may compare the time paths with and without the demographic developments in Europe taken into account.

To consider the first round effects, we first construct an index of effective labour input available to the Turkish economy with 1990 taken as the base year. Figure 2 plots this index that is calculated by weighting the labour supply of different age groups in the initial steady state by the numbers of households in the corresponding age groups at later points in time and summing over. As can be seen from Figure 2, the labour supply is strongly affected by the demographic transition, rising over 26% above trend around the year 1990 before beginning to fall substantially after 2020. Similarly, one can calculate the `first round' impact of the population dynamics on the capital stock by weighting the savings held by households at different ages in the initial steady state by the number of households of those ages at subsequent points in time. Again, an index based on this calculation is shown in Figure 2 with 1990=100. The path of labour supply is more or less mirrored by that of capital although the initial rise is somewhat quicker and the magnitude of the fluctuation is significantly larger.

We now turn to general equilibrium effects (price effects) of the demographic shocks in the EU4 and in Turkey. To distinguish the effects transmitted onto Turkish economy from the effects of Turkey's own demographic transition, we simulate the Turkish economy model with and without feeding the tradable prices and interest rates obtained from the EU4 simulation. Some of the results are presented in Table 3 below.

restricted even if Turkey is admitted into the Union, implying that the assumption will remain as realistic, at least to a degree to justify the treatment within the present context.

Table 3. SUMMARY SIMULATION RESULTS
ON THE IMPACTS OF DEMOGRAPHIC TRANSITION IN TURKEY
WITH AND WITHOUT TRANSMISSION EFFECT
(% Deviations from Trend Values)

	Without Transmission Effects				With Transmission Effects			
Variables	1990	2040	2090	2140	1990	2040	2090	2140
Capital Stock	-4.164	10.629	-3.749	-3.095	-5.205	13.286	-4.869	-3.869
Investment	-7.360	17.041	-10.606	-3.325	14.725	-12.167	-13.258	-4.156
Household Savings	64.431	-56.283	-18.737	-3.565	80.539	-70.354	-23.422	-4.456
Consumption	-4.026	2.987	-5.073	-3.148	-5.032	3.734	-6.341	-3.936
National Output	-2.987	2.144	-5.364	-3.159	-3.734	2.680	-6.705	-3.949
Interest Rate	3.565	-10.642	3.394	0.127	5.348	-15.963	5.092	0.190
Exchange Rate	22.109	-9.803	-8.906	-0.149	33.164	-14.704	-13.359	-0.223
Tradable Price	1.222	-2.439	-0.338	0.007	1.832	-3.659	-0.507	0.010
Wage Rate	-0.499	1.094	0.305	0.015	-0.748	1.641	0.458	0.023
Labour Supply	-1.310	-0.807	-6.119	-3.183	-1.637	-1.009	-7.648	-3.978

[Insert Figure 2 Approximately Here !]

These results indicate that substantial fluctuations must be expected in real and nominal macroeconomic variables as the profile of Turkish population with respect to the age composition changes during the country's own demographic transition even without the transmission effects. For example, between 1990 and 2060, the real output is expected to fluctuate between levels that are about 6% below and 18% above its trend value (Figure 4), and the fluctuations for such variables as consumption, household savings and investment are larger (Figures 3 and 4). When its effects are transmitted through price and interest rate channels, the demographic shock in Europe is expected to magnify these effects. The transmission effects are visible on the values over time of all variables including investment, household savings, consumption and labour supply, as well as the exchange rate, wage rate and interest rate. It is clear from the results in Table 3 that savings (nominal) and investment in Turkish economy are expected to be increased initially (until 2010) but lowered later on (between 2020 and 2150) by the transmitted effects of the demographic shock in the EU. Real consumption and output are also expected to follow the same pattern of transition. In other words, the growth rate of national output would be increased initially until 2010, but lowered between 2020 and 2150 –that is, lowered more with transmission effects than it would by the slow down resulting from population ageing in Turkey in the course of the country's own demographic transition.

As for the implications of the European demographic shock for the labour market in Turkey, the results suggest that the increase in the wage rate between 2010 and 2150 would be magnified by the transmission of the demographic shock effects from Europe as compared to the case where the profile of the Turkish population followed its own course of transition. As can be observed from the relevant row of the table, this would speed up the reduction in the labour supply that is naturally expected to occur due to the changing age composition of Turkish population on the country's demographic transition path.

To allow for observation of the effects over a longer time horizon, the time paths that various variables follow are given in Figures 3 through 5. The figures showing percentage deviations from trend values generally indicate that transmission of demographic shocks generate significant output, consumption and savings effects.

[Insert Figures 3 to 5 Approximately Here !]

5. CONCLUSIONS

Demographic projections for industrial countries including most of the European Union area indicate that the fraction of the population over 65 will increase considerably in the next few decades, primarily due to the fertility shock of the late 1940s and the 1950s. The growth in the population share of elderly is becoming increasingly evident in many countries as the generations born during these decades (i.e., baby boomers) keep getting older. The already visible increase in dependency ratios resulting from the baby boom shock points to potential changes in such macroeconomic variables as national savings and investment and requires changes in the levels and/or the composition of government expenditures. Such macroeconomic changes are likely to generate microeconomic consequences as they will affect relative prices of consumption and investment goods, as well as tradables and non-tradables. In the light of the fact that small countries outside the European Union or North America trade intensively with the industrial countries currently experiencing population ageing mainly at these countries' prices, trade must be expected to act as a channel for transmission of the effects of demographic shocks onto small countries. Similarly, the changes in interest rates in major suppliers of foreign capital to the rest of the world are likely to serve to the transmission of demographic effects to other countries. While the implications for countries which experienced the demographic shocks themselves have been investigated somewhat thoroughly in the literature, the potential for the transmission of these effects onto other countries has been overlooked so far.

In order to contribute to the filling of this gap in the literature, this paper addressed the issue by considering the effects likely to be transmitted from four major nations of the European Union (EU4) onto Turkey, a small, middle income country that heavily trades with them. The magnitude and the direction of these effects upon Turkish economy were investigated within a dynamic, overlapping generations general equilibrium framework. Despite its complexity, the flexibility of the modelling framework enabled us to capture the differing nature of the demographic transition in EU4 and Turkey, and to separately analyze the effects of Turkey's own, shock-free demographic transition with and without allowing for the transmission effects. The model employed here was noted to extend past work in various directions. Salient features of the model included the use of an open economy set up with variable terms of trade and an imperfectly elastic supply of foreign savings where both the EU4 and Turkey were assumed to face a finite supply of savings from the rest of the world. This treatment was argued to be particularly suitable for industrial economies of the EU as well as a middle income economy like Turkey, despite the small size of the Turkish economy with respect to international trade flows, and was defended in the light of the work of Feldstein and Horioka (1980) and others on the limited degree of international capital market diversification.

Simulation results reported in the paper suggest that the demographic developments leading to population ageing and changes in age composition of the population are likely to affect the time paths of major macroeconomic variables significantly. Furthermore, the demographic shock in Europe is expected to magnify these effects visibly and will therefore have implications for such variables as consumption, savings, investment, output and labour supply in Turkey, as well as the wage, exchange and interest rates in the country. While the impact on welfare of the transmitted effects is expected to be negative, per capita welfare will be affected much less than aggregate output. Welfare calculations indicate that the maximum impact of the shock on the utility of individual households is less than 1.2 % of their lifetime endowment.

The discussion in the paper so far has tried to shed some light on the possible effects of demographic developments in Europe on Turkey, but the results have implications also for other countries. The increasing degree of openness of small countries, the process of globalization and the associated increases in the volumes of international commodity and factor flows should be expected to facilitate the transmission of demographic shock effects even further as they make small countries increasingly susceptible to changes in the terms of trade, interest and exchange rates in large countries. Coupled with the results presented here, this observation clearly points to a need on the part of all small developing or middle income countries that consider alternative growth strategies for the long run. In addition to taking the implications of ageing of their own population into account, they need to start watching the demographic developments and transition in large industrial nations with which they have strong economic ties. The issue studied in this paper is at least as relevant to countries such as Mexico, a NAFTA member, and other Latin American countries as it is to Turkey that is in a Customs Union with the EU. It should also be a matter of concern for Asian countries that heavily trade with Japan and other industrial countries, as well as attract sizable amounts of foreign capital from these countries.

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