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DEMOGRAPHIC SHIFTS AND TAX BURDEN IN THE IRANIAN ECONOMY: A MACROSIMULATION APPROACH

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Abstract

Using dynamic stochastic general equilibrium (DSGE) model, this paper, addresses the effects of demographic changes on tax dynamics. In fact, the DSGE framework involves main demographic features such as working and retirement periods as well as life cycle characteristics on one hand and other special conditions of Iran's economy such as rigidities in nominal variables, distinct trait of government budget and lack of monetary and fiscal standard rules on the other. After calibration of parameters and determination of steady state values of the variables, we identified some demographic scenarios, such as reduction in the labor growth rate, increasing retirement age and improvement life expectancy and then assessed macro variables, particularly tax share, reaction to these shocks. Our results highlight that, demographic negative shocks have a significant effect on the budget deficit. A plummet (surge) in labor growth rate would increase (shrink) tax share to rebalance (smooth) a probable budget deficit(surplus). An analogous result can be attributed to the life expectancy improvement. However, any upswing (slump) in the retirement age has negative(positive) influence on the tax share. In other words, all positive demographic shocks provide opportunity to smooth tax policies and postpone revenue collection.

Keywords: Demographic Shifts, Tax Share, Macro-Simulation Approach, DSGE model.
JEL Classification: D58, E21, E50.

1. Introduction

All societies have been experiencing quite a mixed variety of changes in climate, diseases infection, environmental challenges, population shifts and a wide range of other alterations. Researchers outline that most of the mentioned evolutions stem from quite an extensive diversity of uncertain sources while the population adjustments' roots, due to their non-cryptic nature, are comparatively elucidated. (Johnson P., 1998, Saunders, 2018) Among affecting factors, precipitous slump in the fertility and mortality rates, net immigration rate, and economic environment are the main explanatory variables of population structures modifications.

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The most unambiguous aftereffect of demographic changes is replacing some older economic and social relations with some new ones. This could be because the population changes have the capability of affecting macro relations such as labor market, public finance, financial market, and ultimately the indices of real sector of economy such as income distribution and economic growth.

The demographic changes, generally, refer to the process by which pre-industrial countries involving with a higher volume of fertility and mortality rates eventually transform to developed economies with low levels of mentioned ratios. From this aspect, demographic transition is a dynamic and multi-dimensional phenomenon. Nowadays, almost all of the rich as well as pour nations have been living with demographic transition. Particularly, industrial countries have been dealt sooner than others. In fact, the global proportion of elder than 65 years of age was 4 percent in 1700, 5 percent in 1950, 7 percent in 2000, and is projected to reach 16 percent in 2050 and finally 21 percent in 2100. (Lee, 2003:168)

Analogous to all developing countries, Iran's society has been experienced two stages of demographic transition over passed times. The first stage covers from 1906 to 1991. During this period, life expectancy rose from 25 to 60 years. The second stage starts from 1992 and continues to be completed in the future. Iran's population's structure lies in "demographic dividend" or "demographic window" phase. It means that as time passes, on one hand, the proportion of young people reduces continuously and on the other the proportion of old people surges. Economists believe that this period is the best opportunity to allocate human resources to production process. (Auerbach, 2012).

As generally mentioned, the first main problem of the Iran's economy in terms of population aging is surging the seniors' share in total population, specially within two last decades. According to statistics, the average growth of aging cohort (over than 65 years) reached 3.3 percent in 2019. So that, the share of aging people escalated from 5.1 to 5.7 between 2009 and 2019. At the same time, the average growth rate of 25-55 years showed an attenuated trend. Among all cohorts, the highest growth rate could be attributed to the 55-59 cohort with 7.26 percent. The second and third ranks were occupied by 50-54 and 60-64's by 5.06 and 4.93 percent, respectively. In consequence of implied alterations, the average age of population soared from 24 to 30 years between 2000 and 2019. The second main challenge of the economy is the lower economic participation rate. Based on available data, senior cohorts have less than 20 percent participation in the economic activities. The primary causes of this predicament, spring from demographic changes as well as other structural reasons. This description outlines that, at the first, the "baby boom" effects of 1980s have abated and secondly, the structure of Iran's population will considerably have modified in coming decade.

To face up with this challenge, Iran's government has been trying to enhance the parameters of population structures by granting quite a mixture diversity of incentives since 2005. However, the fertility rate has been remained under two children for each woman since 2000. Additionally,

the population's growth rate tends to fall under 1 percent in current decade. Furthermore, the net emigration rate could be another rooting cause of structural change. This rate was zero over long term but during recent years it inclines to be positive, significantly. Iran had the highest rate of net emigration (10 emigrants per 1000 population) over Iran-Iraq's war in 1980s.

From the information supplied, it is patent that the prominent aim of this paper is to assess the deep effects of demographic changes on the tax revenues and eventually the fiscal stance of the government. Over recent decade, the share of taxes in Iran's GDP fluctuates between 5.5 and 7 percent. In the normal state this ratio is regarded trivial in comparison with the same performance in other countries. It is evident that the situation would be worse when we assume that some components such as income tax would negatively be affected by demographic changes, particularly in populous provinces such as Tehran and other industrial areas. This, in turn, would influence the budget space of the government and broaden the budget deficit.

However, above statement doesn't mean that the effects of demographic changes are similar in all economies but it depends on the transition process of each country on one hand and the level of countries integration in the world economy on the other. Having said that, this phenomenon seems to be a serious challenge and policy makers need to find solutions to mitigate negative consequences of aging population.

To shed light on the main question, second part of the paper reviews the literature of research, then we introduce our basic model and discuss about parameters which have to be calibrated. It is obvious that the mechanism of the influence of population changes would be modelled based on the theoretical background. The fourth subsection devotes to address the effects of several scenarios and shocks on steady state values of the model and the final section will be concluding remarks and policy implications of the research.

2. Literature Review

As mentioned above, it could be expected that the demographic change would affect economy through several direct and indirect channels. Main paths which these effects can be effective on the government revenues are labor, financial as well as goods markets which we introduce some theoretical points related to each of them below. It is worth noting that the certain effects of demographic changes on tax revenues are somehow nebulous in literature and depend on several conditions (or assumptions) which could be important in these channels.

According to the related literature, structural changes of population which arise from low fertility and mortality rates, immigrations, long term care improvements and so on, have a vast effect on macroeconomic variables and markets such as labor market(through participation rates, retirement age, productivity rate, income distribution and immigration channels), goods market(through consumption), financial markets(through savings, capital formation and creation new financial institutions based on population arrangements) and specially public finance(through

government revenues and expenditures). (Zhang et al., 2020; Saunders, 2018; Connors et al., 2019)

Among multifaceted effects of population aging, some economists, such as Yoshino et al. (2019), Nartey (2019), Tine et al. (2020), concentrate on the tax influence of demographic transition. The compelling reason behind this focusing markedly lies on the importance of fiscal sustainability in economy. Along with this line, we apply a small-scale macroeconomic model involving all important parts of markets. Since, as mentioned, our main question is about effectiveness of aging population on government revenues or tax burden, in this section we will theoretically emphasized on the response of public finance variables against demographic shocks.

Before focusing on the effects of demographic changes on the tax revenues, a glance on the effects of mentioned variable on public finance would be helpful in revealing the controversial aspects of the issue. It is evident that the effects of aging population on public finance can be followed in two sides. The first one is its effects on the government expenditure and the second one is reaction of tax revenues. The former has the clearest response against structural change of population. Because the expanding reaction of the social security's expenditure on the one hand and ascending health care costs on the other, are in entire congruence of economists. (Auerbach, 2012; Kudrna, et al. 2014; Van Ewijk et al. 2006) However, regarding to the later, despite the relative convergence on the extension of effects of demographic modifications in recent line of research, the literature was witnessing some dissonance in opinions over pre-assumptions. We discus all chain of points as follows.

In their research, Goudswaard & Kar. (1994, p:52-53) put forward an argument that population aging has two contradictory effects on tax revenues. According to their debate, on the one hand aging people increase tax revenues through expanding the variety of their revenues and on the other hand accretion of over 65 old years' share in total population's composition could be immediate reason for tax revenues decline. In other words, at the first, age-earnings have positive effects on the tax collecting and then accumulating of population in older cohorts would cause negative impact and stymies the revenues expansion. In this point of view, the net outcome would be based on some structural parameters and empirical assessment.

Auerbach et al. (1998) believe that the demographic uncertainties which are likely effective on tax revenues stem from life horizons of individuals. Also, Auerbach (2012) emphasize that the macroeconomic effects of population changes can be divided onto cyclical and long-run effects which should be separated from each other. Cyclical effects can be attributed to variables such as tax revenues as well as government expenditures and long run effects can be assigned to economic growth.

King and Jackson (2000, p:8) develop the claim that the demographic adjustments influence tax revenues through two channels: the first one is the supply side of economy and the second is the saving-investment behavior of economic agents. However, the size and direction of these effects are desperately uncertain.

Manzi et al. (2005) discusses that because of high benefices which older groups receives from government, their effective payments rate (tax rate) is very low. So, aging can decrease effective tax rate significantly.

Carone et al. (2007) develop the claim that the demographic revolutions can potentially eliminate some tax bases and expand or create others. According them, in result of demographic developments, tax burden will be shifted from mobile into immobile bases. So, tax on personal income in aging society cannot be reliable source to finance government's social expenditures.

Sjoquist et al. (2007) emphasize on capital income tax and payroll tax shares in whole tax revenues. Since, older age groups mainly receive capital income so tax system should be modified to contain more this type of taxation. Otherwise, aging population lead tax tumble.

According to Fisher (2008), the effects of population aging on tax revenues depend on the relation of income variation and aging on one hand and variation of marginal and average propensity to consumption on the other. In this case, older age groups possibly allocate main part of their income to health expenditures which are exempted from taxing. So, if the variation of income is low and consumption composition is aging-based then sale and value added tax revenues might be plunged.

Kenneth et al. (2011) assert that whenever economy is under aging pressure it will be desirable to change the tax system from direct – base into indirect – base. Since, tax on personal income will likely be reduced.

Dolls et al. (2017) findings in 27 EU countries lend support to the discussion that the effect of demographic alteration on tax revenues would not be so sever but retirement age extension could be effective in budget balancing in the long-term.

Nartey (2019) puts forward an argument that the old-age dependency ratio picks up property and corporate income taxes while has diminishing effect on individual income tax, other tax (taxes on motor vehicle licenses), charges (tolls on highway, tuition paid to state universities etc.), and all other revenue.

Using an overlapping generation model, Tine et al. (2020) highlight that the precipitous plummet in tax revenues, considerably due to consumption tax drop, is an immediate result of population aging.

In general, in spite of a variety of disputes among researchers, most of mentioned theoretical points imply that if the participation, productivity and effective tax rates remain unchanged, demographic changes (say fertility shrink) can slump tax revenues. In addition, factors such as skyrocketing share of older generations in total population, low capital tax rate in comparison with labor income tax rate, meltdown or fixed wage rate and abated share of age-based incomes have similar (decreasing) effect on tax revenue. These hypotheses have been examined in several empirical studies which Table 1 summarizes main findings of some prominent research around the world.

Table 1: Main Results of More Related Research Line

Author	Country or Religion	Effects of Demographic Changes
Calahorrano et al. (2019)	Germany	Population aging will intensify tax expenditure
Beznoska and Hentze (2017)	Germany	Germany will annually lose 7 billion Euros due to demographic changes
Sagiri (2015)	Japan	Tax rate on labor income and consumption tax rate should be increased at least 13.5 and14.3 percent, respectively.
Kudrna et al. (2014)	Australia	T/GDP will increase during 2015-2050.
Felix and Kate (2013)	United States	Reduces per capita Tax revenues.
Miles (1999)	Britain	Budget Deficit will be resulted, so tax revenues should be increased over time.
Auerbach et al. (1989)	US, Japan, Sweden and Germany	Tax rate should increase to cover budget deficits.

As Table 1 represents after demographic changes, tax revenues have to soar to keep the balance of government budget. It's worth mentioning that those studies which don't use the budget balance in their framework, such as Felix and Kate (2013), only captures tax revenue dwindle after demographic changes and these studies don't be able to show how mechanism works.

3. Empirical Assessment: The Simulated Model

In the light of previous sections debates, we would be able to build a specific model revealing some important features. First, the model should be able to capture the life cycle behavior of individuals. Second, some special characteristics of Iranian economy such as rigidities, oil revenue shocks, and lack of standard rules for monetary and fiscal policies, should be identified as specific equations in the model. Third, beyond overlapping generation's growth model, our framework should aggregate some macroeconomic variables such as wealth and consumption related to either workers or retirees.

To present a model with mentioned traits, we use tractable DSGE-Life Cycle model which its initial parts already presented by Gertler (1999) and Kilponen et al. (2006). Gertler modified Blanchard (1985)/Weil (1989) framework to allow for life-cycle behavior in overlapping generations model, that is to say his framework introduces random transition from work to retirement, and then from retirement to death. In addition to these adjusts, DSGE structure helps us to consider specific conditions of the Iranian economy.

The model has several remarkable features: dynamics of population, retiree's behavior, workers' behavior, and Government sector. All these facets are explained below, respectively.

3.1 Dynamics of Population

In this segment, it's said that, each individual is born as a worker. Conditional on being a worker in the current period, the probability of remaining this person in the next period as a worker is ω

. Otherwise, the probability of retiring is $1-\omega$. The average time to be in the labor force for an individual is thus $\frac{1}{1-\omega}$. Once retirement time comes, the probability of surviving to the next time is γ and, conversely, the probability of death in the next period is $1-\gamma$. The average retirement period is thus $\frac{1}{1-\gamma}$.

Let N_t denote the stock of workers at time t. It's assumed that $(1-\omega+n)N_t$ new workers are born in $t+1$, implying that the workforce grows at the gross rate $(1+n)$:

$$N_{t+1} = (1-\omega+n)N_t + \omega N_t = (1+n)N_t \tag{1}$$

Given that the number of people in each cohort is large, in the stationary equilibrium the number of retirees is $\left(\frac{1-\omega}{1+n-\gamma}\right)N_t$. The ratio of retirees to workers is thus:

$$\psi \equiv \frac{1-\omega}{1+n-\gamma} \tag{2}$$

Since this ratio is fixed, both the work force and the number of retirees grow at the gross rate of $1+n$.

3.2 Retiree Behavior

The representative retiree (with index j) maximizes in period t the objective (Z):

$$Z_t^{rj} = [[(c_t^{rj})^{s1}(m_t^{rj})^{s2}(1-l_t^{rj})^{s3}]^{\rho} + \beta\gamma_t[Z_{t+1}^{rj}]^{\rho}]^{1/\rho} \tag{3}$$

Subject to the flow budget constraint

$$c_t^{rj} + \frac{i_t}{1+i_t}m_t^{rj} + A_t^{rj} = \frac{1+r_{t-1}}{\gamma_{t-1}}A_{t-1}^{rj} + \xi w_t l_t^{rj} + e_t^j \tag{4}$$

Where A_{t-1}^{rj} denotes stock of monetary-physical wealth of retiree. He receives pensions e_t^{rj} and faces an effective wage rate ξw_t. The parameter $\xi \in (0,1)$ captures labor efficiency of retirees with respect to workers. With i_t denoting the nominal interest rate, the term $\frac{i_t}{1=i_t}m_t^{rj}$ describes the using level of real balances, reflecting those real balances are dominated in return by interest-bearing assets. We suppose that: $s3 = 1-s2-s1$.

Following Gertler (1999), taking first order conditions with respect to consumption, leisure and real balances gives:

$$\frac{c_{t+1}^{rj}}{c_t^{rj}} = [\beta(1+r_t)(\frac{1+i_{t+1}}{i_{t+1}}\frac{i_t}{1+i_t})^{s2\rho}(\frac{w_t}{w_{t+1}})^{s3\rho}]^{\sigma} \tag{5}$$

$$1-l_t^{rj} = \frac{s3}{s1}\frac{c_t^{rj}}{\xi w_t} \tag{6}$$

$$m_t^{rj} = \frac{s2}{s1}\frac{1+i_t}{i_t}c_t^{rj} \tag{7}$$

In addition, suppose $\varepsilon_t\pi_t$ is retiree marginal propensity to consume out of wealth. Moreover, d_t^{rj} and h_t^{rj} denoting the disposable income and human capital of retiree, respectively, consider the recursive law of motion for human capital as:

$$h_t^{rj} = d_t^{rj} + \frac{\gamma_t}{1+r_t}h_{t+1}^{rj} \quad (8) \text{ and} \quad d_t^{rj} = \xi w_t l_t^{rj} + e_t^j \quad (9)$$

Then, in combination with the budget constraint, one can establish the consumption function and the law of motion for $\varepsilon_t\pi_t$ satisfy the relationships

$$c_t^{rj} + \frac{i_t}{1+i_t}m_t^{rj} = c_t^{rj}(1+\frac{s2}{s1}) = \varepsilon_t\pi_t(\frac{1+r_{t-1}}{\gamma_{t-1}}A_{t-1}^{rj} + h_t^{rj}) \tag{10}$$

$$\varepsilon_t\pi_t = 1-[(\frac{1+i_{t+1}}{i_{t+1}}\frac{i_t}{1+i_t})^{s2\rho}(\frac{w_t}{w_{t+1}})^{s3\rho}]^{\sigma}\beta^{\sigma}(1+r_t)^{\sigma-1}\gamma_t\frac{\varepsilon_t\pi_t}{\varepsilon_{t+1}\pi_{t+1}} \tag{11}$$

3.3 Worker Behavior

Similarly, the representative worker maximizes in period t the objective;

$$Z_t^{wj} = [[(c_t^{wj})^{s1}(m_t^{wj})^{s2}(1-l_t^{wj})^{s3}]^{\rho} + \beta[\omega_t Z_{t+1}^{wj} + (1-\omega_t Z_{t+1}^{rj}]^{\rho}]^{1/\rho} \tag{12}$$

s.t.
$$c_t^{wj} + \frac{i_t}{1+i_t}m_t^{wj} + A_t^{wj} = (1+r_{t-1})A_{t-1}^{wj} + w_t l_t^{wj} + f_t^{\,j} - \tau_t^{\,j} \tag{13}$$

The representative worker faces the full wage rate w_t, receives profits $f_t^{\,j}$ and pays lump-sum taxes, $\tau_t^{\,j}$. Again, three F.O. conditions are

$$\omega_t c_{t+1}^{wj} + (1-\omega_t)(\varepsilon_{t+1})^{\sigma/\sigma-1}(1/\xi)^{s3}c_{t+1}^{rj} = [\beta(1+r_t)\mathrm{H}_{t+1}(\frac{1+i_{t+1}}{i_{t+1}}\frac{i_t}{1+i_t})^{s2\rho}(\frac{w_t}{w_{t+1}})^{s3\rho}]^{\sigma}c_t^{wj} \tag{14}$$

$$\mathrm{H}_{t+1} = \omega_t + (1-\omega_t)\varepsilon_{t+1}^{1/1-\sigma}(1/\xi)^{s3} \tag{15}$$

$$1-l_t^{wj} = \frac{s3}{s1}\frac{c_t^{wj}}{\xi w_t} \quad (16), \qquad m_t^{wj} = \frac{s2}{s1}\frac{1+i_t}{i_t}c_t^{wj} \quad (17)$$

And, disposable income of a worker which earns in rigid wages condition is;

$$d_t^{wj} = w_t l_t^{wj} + f_t^j - \tau_t^j \tag{18}$$

Where
$$w_t = A_1 w_{t+1} + A_2 w_{t-1} + A_3 \overline{w} \tag{19}$$

determine from overlapping contracts and A_i's are given by;

$$A_1 = \frac{(1-q)\beta\widehat{w}}{(1+\beta(1-q)^2\widehat{w}^2} \quad (20), \qquad A_2 = \frac{(1-q)\widehat{w}}{(1+\beta(1-q)^2\widehat{w}^2} \quad (21), \qquad A_3 = \frac{q(1-(1-q)\beta\widehat{w}}{(1+\beta(1-q)^2\widehat{w}^2} \quad (22)$$

Where q is the fraction of workers that can reset their wages and 1-q fraction of work force which their wages remain unchanged. Also, worker's stock of human capital, along with marginal propensity to consumption, π_t, are;

$$h_t^{wj} = d_t^{wj} + \frac{\omega_t}{\Omega_{t+1}}\frac{1}{1+r_t}h_{t+1}^{wj} + (1-\frac{\omega_t}{\Omega_{t+1}})\frac{1}{1+r_t}h_{t+1}^{rj} \tag{23}$$

$$c_t^{wj} + \frac{i_t}{1+i_t}m_t^{wj} = c_t^{wj}(1+\frac{s2}{s1}) = \pi_t((1+r_{t-1})A_{t-1}^{wj} + h_t^{wj}) \tag{24}$$

$$\pi_t = 1 - [(\frac{1+i_{t+1}}{i_{t+1}}\frac{i_t}{1+i_t})^{s2\rho}(\frac{w_t}{w_{t+1}})^{s3\rho}]^{\sigma}\beta^{\sigma}((1+r_t)(\mathrm{H}_{t+1})^{\sigma-1}\frac{\pi_t}{\pi_{t+1}} \tag{25}$$

3.4 Aggregation Over the Two Groups

As the final step in setting retiree and worker behavior, using total number of retirees and workers in period t being given by N_t^r and N_t^w, all of mentioned endogenous variables i.e. aggregate labor supply and demand, human capital, disposable income, consumption functions of retiree and worker groups, and distribution of wealth have been aggregated. For example;

$$l_t^w = N_t^w l_t^{wj} \qquad , l_t^r = N_t^r l_t^{rj}, l_t = l_t^w + \xi_t^r$$

$d_t^r = d_t^j N_t^r$, $d_t^r = d_t^{rj} N_t^r$, $d_t^w = d_t^{wj} N_t^w$ and so on.

3.5 Firm Behavior

Firms produce goods and services in a New Keynesian (NK) market structure which involves some imperfections. Wage and price rigidities are main features of this structure. According the NK structure, in order to produce final goods, firms should take some intermediate and capital goods from related sectors.

Intermediate capital and final goods technologies are as follows, respectively:

$$y_t(z) = (X_t l_t(z))^{\alpha} k_t(z)^{1-\alpha} \tag{26}$$

$$k_{t+1}(u) = \phi(\frac{i_t^k(u)}{k_t(u)})k_t(u) + (1-\delta)k_t(u) \tag{27}$$

$$y_t = [\int_0^1 y_t(z)^{\theta-1/\theta}\, dz]^{\theta/\theta-1} \tag{28}$$

$z \in [0,1]$ and $u \in (0,1)$ represent intermediate and capital goods chain. Also, $i^k(u)/k(u)$ denotes the investment-capital ratio at the firm level and q represents the price elasticity of demand. Profits of representative firm are given by

$$f_t(z) = (\frac{P_t(z)}{P_t} - mc_t)y_t(z) \tag{29}$$

Where mc_t, $P_t(z)$ and P_t denote the real marginal costs, the price of good z and the average price level of intermediate goods, respectively. According with Calvo (1983), in each period only a fraction $1-\zeta$ of firms can reset its price optimally, while for a fraction ζ of firms the price remains unchanged. Let $P_t^*(z)$ denote the optimally changed price in period t by a firm which can change its price. Reflecting the forward-looking dimension of the price-setting decision under the Calvo-constraint, $P_t^*(z)/P_t$ evolves over time according to;

$$\frac{P_t^*(z)}{P_t} = \frac{\theta}{\theta-1}\frac{E_t\sum_{i=0}^{\infty}(\zeta\beta)^i(\frac{1}{P_{t+i}})^{1-\theta}y_{t+i}mc_{t+i}\frac{P_{t+i}}{P_t}}{E_t\sum_{i=0}^{\infty}(\zeta\beta)^i(\frac{1}{P_{t+i}})^{1-\theta}y_{t+i}}$$

Or

$$P_t = (\zeta P_{t-1}^{1-\theta} + (1-\zeta)P_t^{*1-\theta})^{\frac{1}{1-\theta}} \tag{30}$$

Finally, the aggregate resource constraint of economy is given by;

$$y_t + oil_t = c_t + g_t + i_t^k \tag{31}$$

Where *oil* denotes the oil revenue of the economy.

3.6 The Government

The nominal budget constraint of the government supposed to be as follows;

$$M_t + Oil_t + T_t + B_t = M_{t-1} + (1 + i_{t-1})B_{t-1} + G_t + E_t \tag{32}$$

The reason for why oil and M introduced in the equation is the Iranian government finances its budget deficit from new money printing and oil revenues during year.

Applying;

$$(1 + i_t) = (1 + r_t)(P_{t+1} / P_t) \tag{33}$$

term the real budget constraint will be;

$$\tau_t = (1 + r_{t-1})(b_{t-1} + \frac{1}{1 + i_{t-1}} m_{t-1}) + g_t + e_t - m_t - oil_t. \tag{34}$$

It must be noted that due to the lack of the government debt data, most of studies about the Iranian economy eliminate B from models, since in DSGE models we needn't time series of this variable and its initial value, which is guessable from other proxies, we keep this important variable in model. In addition, the budget constraint involves benefits (E_t) which its path must be clarified in the model.

The aggregate path of real benefits determined by the replacement rate of benefits and wages, μ_t , could be expressed as follows;

$$\mu_t = \frac{e_t^j}{w_t} \Rightarrow e_t = e_t^j N_t^r = \mu_t w_t N_t^r \tag{35}$$

According the Iranian economy's stylized facts [1], the policy rules of government could be specified as follows;

$$\frac{\tau_t}{y_t} = \tau^* + \gamma_1(\frac{A_t - A_{t-1}}{y_t}) + \gamma_2(\frac{oil_t}{y_t} - \bar{oil}) \tag{36}$$

$$\eta_m = \rho_m \eta_{m,t-1} + (1 - \rho_m)\bar{\eta} + \rho_\eta \varepsilon_{oil} + \varepsilon_\eta \tag{37}$$

$$oil_t = \rho_{oil} oil_{t-1} + (1 - \rho_{oil}) oilbar + \varepsilon_t^{oil} \tag{38}$$

Equations (36) and (37) represent main role of oil revenue in fiscal and monetary policies and explain how oil revenue determines policy rules. Equation (38) illustrates how oil shocks affect the whole system.

1 Several studies show that there is positive relation between tax and oil revenues. Whenever oil revenue tails off tax revenue almost behaves alike.

Where $t^*, \eta_m, \rho_m, \varepsilon_m, \varepsilon_{oil}$ represent long-term tax ratio, money growth coefficient, monetary and oil shocks respectively.[2] and,

$$A_t = p_t^k k_t + b_t + \frac{m_t}{1+i_t}$$

3.7 Equilibrium

In equilibrium, behavior of agents (retirees, workers, firms and government) should be consistent at the aggregate levels. In other words, in the equilibrium, the endogenous system of equations which specified in Table 2 must be satisfied. It has to be noticed that before introducing variables in the system we detrended some of them through appropriate measure. (For example; $y_t = Y_t \big/ N_t^w X_t$ where X is the productivity of the labor.)

Table 2: Endogenous Variables and Parameter Definitions

Variable Definition	Symbol	Variable Definition	Symbol
Retiree's human capital	h^r	Physical-monetary wealth	A_t
Worker's disposable income	d^w	Real production	y_t
Retiree's disposable income	d^r	Total consumption	c_t
Marginal propensity to consumption(retiree)	$\varepsilon_t \pi_t$	Retiree consumption	c^r
Marginal propensity to consumption(workers)	π_t	Worker consumption	c^w
Old-age dependency ratio	ψ_t	Worker's Human Capital	h^w
Probability of living of retirees	γ_t	Total number of workers	N^w
Employment probability of workers	ω_t	Total number of retirees	N^r
Price of capital goods	p_t^k	Relative discount term	H_t
Real money	m_t	Wealth distribution	λ_t
Labor supply by retirees	l^r	Total Labor supply	l
Capital stock	k	labor supply (Workers)	l^w
Real wage rate	w_t	Real Interest rate	r_t

2 We took monetary growth equation from Shahmoradi, & Ebrahimi, (2010).

Real return of capital	r^k	Marginal cost	mc_t
Tax rate	t_t	Price index	P_t
Real profits of firms	f_t	Real Benefits ratio	e_t
Types of shocks	ε_{it}	Nominal interest rate	i_t
The growth rate of workers	nw	Investment	i^k
Probability of living of retirees	$\overline{\gamma}$	The growth rate of retirees	nr
Productivity growth rate	x	Probability of death of retirees	$1-\gamma$
Employment probability of workers	ω	Life expectancy (in 1395(2015))	T
Old-age dependency ratio	ψ	Retirement probability of workers	$1-\omega$
Average Retirement period	T^r	Average working period	T^w
Intertemporal elasticity of substitution	σ	Discount factor	β
Depreciation rate	δ	Risk aversion parameter	ρ
Preference parameter:money	$s2$	Preference parameter: consumption	$s1$
Elasticity of Demand (intermediate goods)	θ	Preference parameter: leisure	$s3$
Relative productivity of retirees	ξ	Oil revenue share(long-run)	$\overline{oil}$
Firms mark up	ζ	Share of labor	α

3.8 Calibration

After de-trending the system of defined equations and obtaining steady state version of the model, we calibrate the model to match key features of the Iranian economy's data. Tables 3 to 5 delineate the demographic, structural and policy parameters values. In addition, Table 6 sketches some estimated coefficients for some equations.

Table 3: Demographic Parameters

Calibration method	Parameter value	Parameter name	Calibration method	Parameter value	Parameter name
$\omega = 1 - \frac{1}{T^w} = 1 - \frac{1}{50} = 0.98$	0.98	ω	United Nations data (1970-2016)	0.0279	nw

$1-\omega=0.02$	0.02	$1-\omega$	United Nations data (1970-2016)	0.0279	nr
$\psi=\frac{1-\omega}{1-nw+\gamma}$	$\psi=\frac{1-\omega}{1-nw+\gamma}$	ψ	$\gamma=1-\frac{1}{T^r}=0.888$	0.888	γ
Iran's Labor code	50	T^w	$1-\gamma=1-0.888$ $=0.112$	0.112	$1-\gamma$
Difference between retirement age and life expectancy	8.9	T^r	$X_t=(\frac{y_t}{l_t^{\alpha}k_t^{1-\alpha}})^{\frac{1}{\alpha}}$	0.038	x
			United Nations data	73.9	T

Table 4: Structural Parameters

Calibration method	Parameter value	Parameter name	Calibration method	Parameter value	Parameter name
Based on steady state version of model	0.14	$s3$	Rezaei(2010)	0.98	β
Shahmoradi-Ebrahimi(2010)	4.33	θ	Cointegration approach: $s=\frac{d\ln(\frac{c_t}{c_{t+1}})}{d\ln(\frac{p_{t+1}}{p_t})}$	0.67	σ
Based on data(1970-2010)	0.096	$oi\bar{l}$	Cointegration approch	$\rho=1-\frac{1}{\sigma}$	$\overline{\rho}$
Getler(1999)	0.01	ξ	Shahmoradi-Ebrahimi (2010)	0.042	δ
Rezaei(2010)	0.58	α	Based on steady state version of model	0.81	$s1$
Shahmoradi-Ebrahimi(2010)	0.30	ζ	Based on steady state version of model	0.03	$s2$

Table 5: Policy Rules Coefficients

Coefficient definition	Coefficient name	Coefficient definition	Coefficient name
Coefficient of money growth equation	ρ_m	Coefficient of oil equation	ρ_{oil}
Coefficient of oil revenue in tax rule equation	$\gamma 2$	Direct tax coefficient in tax rule equation	$\gamma 1$
		Coefficient of oil shock on money level	ρ_{η}

Table 6: Exogenous Variables (Shocks)

Variable(shock) Definition	Variable(shock) name	Variable(shock) Definition	Variable(shock) name
Life expectancy shock	ε_T	Productivity shock	ε_x
Retirement probability shock	ε_ω	Average of working period shock	ε_{Tw}
Living probability shock	ε_γ	Average of retiree period shock	ε_{Tr}
Monetary shock	ε_η	Oil revenue shock	ε_{oil}

When above parameters and coefficients used in the steady state equations system, the steady state values of endogenous variables have been calculated which some of them are reported in Table 7.

Table 7: Some Endogenous Variables

Moments of simulated data		Moments of data		
Standard deviation	Mean	Standard deviation	Mean	
0.001	0.070	0.065	0.071	$\frac{\tau}{y}$
0.012	0.59	0.017	0.58	$\frac{c}{y}$
0.053	3.48	0.076	3.60	$\frac{k}{y}$

According Table 7, values of endogenous variables in the steady state are very close to their values in the actual position. So, the result indicates that the model will be able to capture the effects of demographic changes scenarios on endogenous variables, particularly on the tax burden.

3.9 Simulation [3]

In this section, main questions of present study could be replied by using the simulation approach. Scenarios I to VI along with figures 1to 5 illustrate the effects of various demographic shocks on t-share (t/y), c-share(c/y) and ca-share (capital/y) variables. These scenarios will respectively be elucidated, in the rest of the paper.

3.9.1 Scenarios I and II: Negative and Positive Shocks on Labor Force Growth Rate

According to the figure 1, one percentage point of standard deviation as negative shock on labor growth force increases t-share to rebalance budget deficit arising from demographic change.

3 The simulation has been performed by Dynare software.

According theoretical points, any reduction in labor force increases government expenditure and the government has to finance this change by increasing tax burden. In contrary, a positive shock on labor growth affects budget constraint in opposite line. Figure 2, reveals the reverse of mentioned process in the Figure 1.

Figure 1: Negative Shock on Labor Force Growth Rate

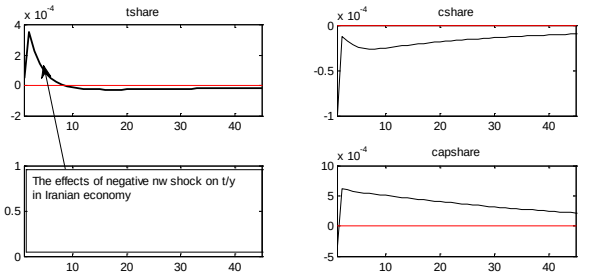
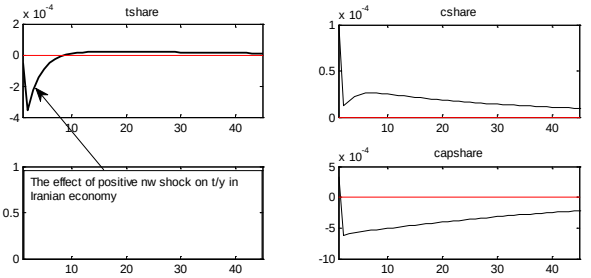


Figure 2: Positive Shock on Labor Force Growth Rate



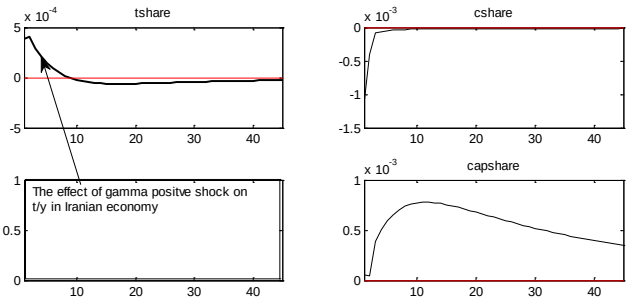
A practical application of pointed result in the figure 1 is that when labor growth rate is reduced about one percentage point, tax policy maker has a 10-year period opportunity to increase tax-share (0.22 percent [4]) to prevent large fiscal deficits.

3.9.2 Scenario III: Increasing Life Expectancy

Based on Life cycle theory, it's expected that increasing in life expectancy affects the government expenditure through its welfare programs on aging people. In order to implement these programs, the government has to increase tax rates to cover the budget deficit. As we can see in figure 3 after one percentage point of positive expectancy shocks (i.e., increasing 2.8 year in life expectancy until 2030 in the Iranian's demographic structure based on the United Nations prediction) tax – share in GDP (t-share) picks up almost 0.28 percent to reduce the budget deficit.

4 This value and values reported in other scenarios, calculated based on predicted and stochastic simulated data.

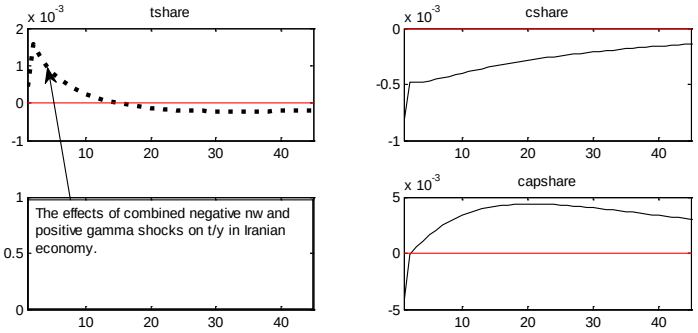
Figure 3: Positive Shock on Life Expectancy



3.9.3 Scenario IV: Increasing Life Expectancy and Decreasing Labor Growth Rate

Opposite movements of the life expectancy and labor growth rate have a same effect on the government budget constraint. Because, conditional on the fixed productivity growth, both of them reduce tax revenue and increase expenditures. So, the government has to increase the tax burden (through increasing tax rate) to rebalance the budget constraint. The government response is represented in figure 4. As it can be seen in t-share panel, in order to eliminate the budget gap, the government should increase t-share in GDP about 0.61percent during 10 years.

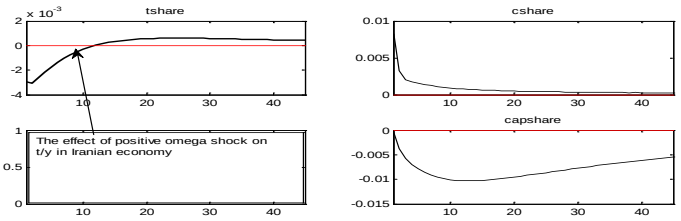
Figure 4: Positive Shock on Life Expectancy and Reducing Labor Growth Rate



3.9.4 Scenario V: Increasing Retirement Age

Increasing retirement age is a usual policy in population aging economies. This policy postpones expenditure changes and keeps labor force for some additional years in the labor market. So, it provides opportunity to the government to smooth its tax policy by possibly decreasing of tax rates. Figure 5 displays the decreasing response of t-share against increasing retirement age by 2 years.

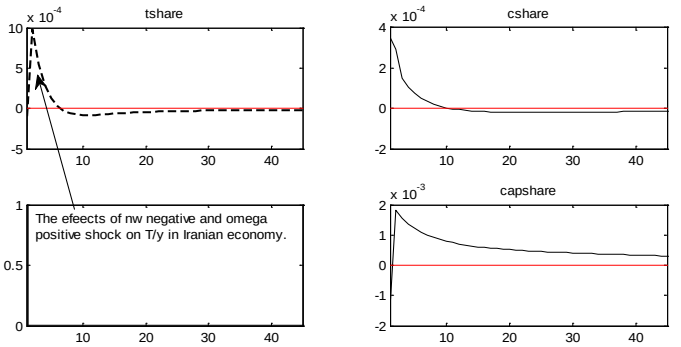
Figure 5: Increasing Retirement Age and Response of T-Share



3.9.5 Scenario VI: Increasing Retirement Age and Decreasing Labor Growth Rate

As a final scenario we performed simultaneous demographic alteration, i.e., enlargement in working period and reduction of labor growth rate, to analyze t-share response. As previously noted, the former improves tax revenues while the latter impairs them. Therefore, the net effect of these opposite direction shocks will be depended on the relative effectiveness of the two demographic changes. According figure 6, the effectiveness of the labor growth rate wanes the enlargement of working period and increased the tax rate to rebalance the budget constraint. In other words, policy maker should increase t-share at least 0.82 percent to deal with this composite demographic change.

Figure 6: Increasing Retirement Age and Decreasing Labor Growth Rate



4. Discussion

A glance at the latest trend of demographic alteration in Iran's society discloses that the population measures have dramatically changed since recent two decades. While the mortality rate was 50 in 1000 new born babies in 1990s it plunged to 22 in 1000 within 2011-2018. In addition, the fertility rate dropped from more than 6 babies in terms of each woman from four decades ago to less than 2 babies in recent years. This sharp slump has been changing the structure of Iran's population.

Besides boosting health and medical standards, other policies such as Iran's government programs in controlling population growth and continuous sever economic situations were behind this demographic adjustment. Although it could be mentioned that the government programs were not so effective as factors affecting smart demand for children such as urbanism (rising from 30 to 70 percent in four decades) as well as surging the literacy rate among parents. These factors besides improving other indices like life expectancy (73 years for women and 72 years for men) and net positive emigration have shifted the situation of Iran's population's structure in recent period. Furthermore, adding elderly people dependency soaring, up to 6 percent, would complicate the status of policy making in Iran's economy.

In the context of the mentioned movements what was the main question of our research was the impact of this trend on the tax revenues and budget structure of Iran's state. It was obvious that the effect of population change on the tax revenues is more and less ineluctable, the prominent issue is, however, the role of other modifiers such as technology progress and production factors productivity which can potentially alleviate the negative impacts of demographic alterations. We assumed these mitigating determinants as varying factors, in several scenarios, to measure the effects of generation changes. In this regard, our results were consistent with the theoretical predictions that the government has to concentrate on some alternatives to compensate the ramifications of the challenge. Now, to what extent the government would be able to follow these not-so-simple policies absolutely depends on the package of smart actions. As time being and based on our model output, due to the low-flowing and sticky nature of factors such as productivity and technology, particularly in developing countries like Iran, the easily available policy is setting the tax rates.

5. Concluding Remarks

Demographic structure as one of the important elements of socio-economic factors is at the core attention of policy makers and researchers. In fact, its importance springs from position of this variable in economic growth theories. Nowadays, most of the developing and developed countries around the world are experiencing demographic transition and population aging. This statement involves Iran's economy, too, which its situation is not better, if not actually worse than, other countries. But, the principal difference among Iran and other countries is in the timing of transition. So that, developed countries dealt with this problem after industrialization and development stage but Iran has been dealing in early years of its developing stage. So, several demographic-based research and assessments in various fields should be provided to prepare Iran's economy against demographic challenges. Therefore, this study concentrating on the tax revenue effects of demographic transition, tries to analyze several dimensions of potential changes in public finance. Therefore, main findings can be summarized as follows;

1. In order to eliminate the effects of exogenous variables, such as oil revenue, during demographic transition period, our macroeconomic framework supposed that, any budget

deficit could be financed by tax rate changes. Such that if budget constraint was unbalanced due to demographic metamorphosis, then the government was able to change tax rates to cover related fiscal gap.

2. A plunge in the labor growth rate, which had been assessed by reducing one percent of its long-term growth rate (from 0.0279 to 0.0179) and one percentage point of its standard deviation, had same effect on the budget constraint and justified increasing of tax rate to overcome the deficit problem. Although the size(amount) of the reaction was small it was statistically significant.

3. According predictions of international institutions, such as the United Nations, the life expectancy of Iran's people will be constantly increasing in the coming future. Our results showed that this demographic shift would affect the budget constraint through two tax and expenditure channels. So, to compensate these undesirable effects, the government should improve tax share in GDP through hiking 1.5 percent in the average tax rate.

4. Combined effect of reduction in labor growth rate and increasing in the life expectancy can be compensated by increasing 1.65 percent of the average tax rate. However, it should be noted that the tax rate upswings have enormous adverse effect in terms of tax burden on one hand and deteriorating behavior of agents on the other, governments, therefore, have to incline towards "tax base expansion" instead of emphasizing on the tax rate ascending.

5. Combined effect of depletion in the labor growth rate and accrual in the retirement age, as an opposite direction demographic changes, can be managed by increasing at least 1.6 percent of the average tax rate.

6. According to the mentioned results, shifting from labor-based tax system towards capital and wealth-based framework could be an important alternative for Iran's policy-makers to mitigate adverse effects of demographic changes. It has to be clarified that in case of implementing "comprehensive(global) tax system" they should focus more on the capital and wealth bases instead of labor-based system.

7. In order to keep sustainability in the government budget, an imperative action is taking a dynamic optimal taxing approach in appropriate pace with any changes in structural parameters of demographic modifications. This means that the parliament might not be able to determine some targets for revenue collection, as it was traditionally done, before considering the possible impacts of population changes.

As a whole, all of demographic changes, specifically labor growth rate, had a significant effect on the tax revenue in Iran's economy. At the same time, it's worth noting that their effects not being so considerable, provide remarkable opportunity to appropriate response by the policy maker. However, it has to be regarded as a serious future problem in the horizon of Iran's public finance.

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