



## **ADB Working Paper Series**

### **HOW DOES POPULATION AGING AFFECT THE EFFECTIVENESS OF MONETARY AND FISCAL POLICIES?**

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We would like to thank Robert F. Engle, Peter Diamond, and John B. Shoven for their comments. This paper is based on the dinner speech delivered at the WEAI conference on 23 March 2019.

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**Abstract**

This paper studies how population aging affects macroeconomic performance and the effectiveness of macroeconomic policies. By using a new Keynesian dynamic stochastic general equilibrium model with heterogeneous households, we find that the effectiveness of monetary policy diminishes as population aging proceeds. We then examine how population aging modifies the fiscal policy effect by estimating fiscal multipliers in both aging and non-aging economies. We find that population aging weakens the effectiveness of fiscal stimulus. Our analyses suggest that neither monetary policy nor fiscal policy would be effective in aging economies, and structural reform measures would have a more important role.

**Keywords:** population aging, monetary policy, fiscal policy, DSGE, fiscal multipliers

**JEL Classification:** E52, E62, J10

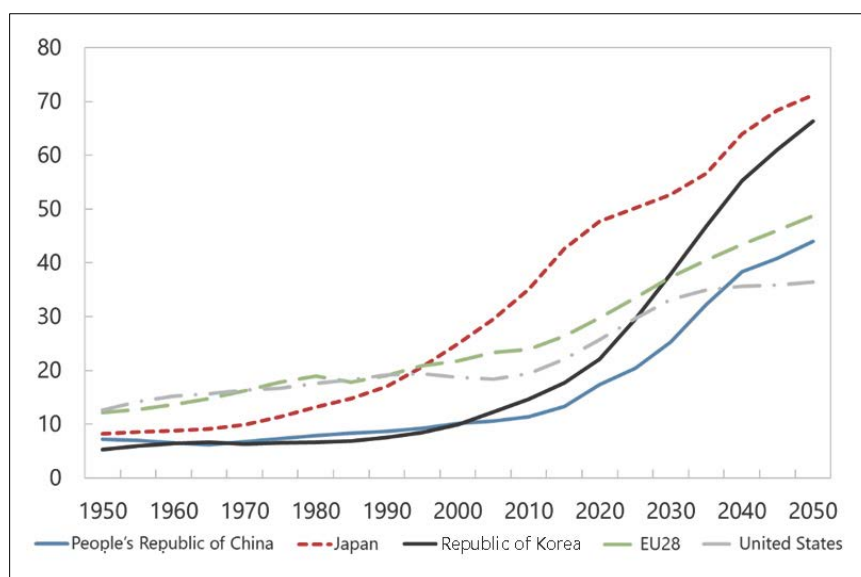
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# 1. INTRODUCTION

How does population aging affect the effects of macroeconomics policies? Due to declining fertility and rising life expectancy, many countries are facing rapid aging of their population. According to the population projection by the United Nations, the old-age dependency ratio (the proportion of people aged 65 or older in a working-age population) will be doubled by 2050 (Figure 1). These demographic changes cause qualitative and quantitative changes in the demand and supply of the entire economy. In response to population aging, research on analyzing the impact of population aging on the macro-economy is growing. However, little attention has been paid to the impact of population aging on the effectiveness of macroeconomics policies.

**Figure 1: Old-Age Dependency Ratio**  
(percent)



Source: United Nations.

The purpose of this paper is to study how population aging would affect the macroeconomics effects of monetary and fiscal policies. We first examine the effects of population aging on economic performance and the effectiveness of monetary policy by using a dynamic stochastic general equilibrium (DSGE) model with heterogeneous households (comprising young and old households).

The novelty of this study is the development of a tractable DSGE model that enables us to examine the effects of demographic changes on the economy without assuming the life-cycle of the agents. Our model shows that a decline in working population reduces aggregate output, consumption and investment by reducing total labor supply in the long run. We also find that the effectiveness of monetary policy diminishes when the working population declines. Japan is one of the most aging societies in the world, and about one-third of the population is in the aged group.

The second part of this paper examines the effect of population aging on the output effects of fiscal policy shocks by using a panel data of Organisation for Economic Co-operation and Development (OECD) countries. We identify the fiscal policy shocks as forecast errors of government spending and estimate their output effects by the local

projection method developed by Jordà (2005). We then examine how population aging modifies the output effects of fiscal policy shocks.

We find that demographic structure affects the output impact of government spending shocks. While in non-aging economies, government spending shock increases output significantly in both the short- and medium-terms, in aging economies, output responses are not statistically significant.

These results have important policy implications. Our analyses show that neither monetary policy nor fiscal policy would be effective in aging economies, and structural reform measures would have a more important role. Our model suggests that postponing retirement age by paying a productivity wage rate and asking people to work as long as possible are helpful factors. This policy recommendation would increase the labor force and reduce the burden of social security expenses. Budget deficits would decrease, and fiscal sustainability could be achieved even if the economy is faced with aging population.

Most related to this study is the work of Yoshino and Miyamoto (2017), which shows that population aging weakens the effectiveness of macroeconomic policies by using a new Keynesian DSGE model. Imam (2013) and Wong (2019) also point out that population aging would reduce the effects of monetary policy on inflation and output. Basso and Rachedi (2019) show that fiscal multipliers depend on the age structure of the population at the state level in the United States.

The remainder of the paper is organized as follows. In section 2, we develop a New Keynesian DSGE model with heterogeneous households. In Section 3, we calibrate the model parameters. Section 4 examines how population aging affects the performance of the economy and the effectiveness of monetary policy. Section 5 examines the effect of population aging on fiscal policy effects. Finally, section 6 concludes and draws out the policy implications.

## 2. THE MODEL

Our model is based on the work of Yoshino and Miyamoto (2017). We consider a New Keynesian DSGE model with two types of households: working populations and retired groups. The model also includes a continuum of firms producing differentiated intermediate goods, a perfectly competitive final good firm, and a government in charge of monetary and fiscal policies. Except for the presence of heterogeneous households, our model structure is similar to a standard DSGE model with staggered price setting à la Calvo (1983). In the following, we briefly explain our DSGE model.<sup>1</sup>

### 2.1 Household's Problem

There are two types of infinitely-lived households. A fraction  $\phi$  of households are working populations, which provide labor services and earns wages. Besides providing their labor services, workers buy and sell physical capital and government bonds. The remaining fraction  $1-\phi$  of households are retirees who do not provide any labor services, but obtain social security benefits from the government. We assume that workers maximize their intertemporal utility function subject to a lifetime budget constraint, while retirees consume all resources in each period of time.

---

<sup>1</sup> A detailed explanation of our mathematical model can be seen in Yoshino and Miyamoto (2017).

### 2.1.1 Worker's Utility Maximization and the Retiree's Problem

The expected lifetime utility function of a worker is given by:

$$E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{1}{1-\sigma} \left[ \left\{ \omega c_{w,t}^{\frac{\zeta-1}{\zeta}} + (1-\omega) g_t^{\frac{\zeta-1}{\zeta}} \right\}^{\frac{\zeta}{\zeta-1}} \right]^{1-\sigma} - \frac{h_{w,t}^{1+\mu}}{1+\mu} \right\}, \quad (1)$$

where  $\beta \in (0,1)$  is an individual's subjective discount factor,  $c_{w,t}$  is a worker's consumption,  $g_t$  is government consumption, and  $h_{w,t}$  is hours of work. The parameter  $\mu$  is the inverse of the Frisch elasticity of labor supply, and  $1/\sigma$  is intertemporal elasticity of substitution. The parameter  $\zeta$  is the elasticity of substitution between private and government consumption, and the share parameter  $\omega$  determines how much government consumption affects utility.

The worker chooses consumption  $c_{w,t}$ , physical capital  $k_{w,t}$ , and government bonds  $b_{w,t}$  to maximize the expected lifetime utility function above, subject to the budget constraint:

$$c_{w,t} + k_{w,t} + b_{w,t} = w_t h_{w,t} + r_{k,t} k_{w,t-1} + (1-\delta) k_{w,t-1} + R_{t-1} \frac{b_{w,t-1}}{\pi_t} + d_{w,t} - \tau_{w,t}, \quad (2)$$

where  $w_t$  is real wages,  $r_{k,t}$  is the real rental rate of capital,  $R_t$  is the nominal interest rate,  $d_{w,t}$  is the dividend that the worker receives from the firm sector,  $\tau_{w,t}$  is the lump-sum tax, and  $\pi_t \equiv P_t/P_{t-1}$  is the gross inflation rate where  $P_t$  is the nominal price level.

The evolution of physical capital stock is given by:

$$k_{w,t} = (1-\delta) k_{w,t-1} + i_{w,t} \quad (3)$$

where  $\delta$  is the depreciation rate and  $i_{w,t}$  is investment.

The remaining measure of  $1-\phi$  consumers is retired. The lifetime utility function of a retiree is given by:

$$E_0 \sum_{t=0}^{\infty} \beta^t \frac{1}{1-\sigma} \left[ \left\{ \omega c_{r,t}^{\frac{\zeta-1}{\zeta}} + (1-\omega) g_t^{\frac{\zeta-1}{\zeta}} \right\}^{\frac{\zeta}{\zeta-1}} \right]^{1-\sigma}, \quad (4)$$

where  $c_{r,t}$  is a retiree's consumption.

It is assumed that a retiree does not maximize consumption intertemporally and simply consumes her income each period.<sup>2</sup> Her income consists of pension benefits and interest from financial assets. For simplicity, it is assumed that the retiree does not operate financial assets, and rather, receives interest income from wealth that she receives at the time of her retirement. Thus, the consumption of a retiree  $c_{r,t}$  is:

$$c_{r,t} = s + R_t \overline{W}_r, \quad (5)$$

where  $s$  is the social security benefit in the real term, and  $\overline{W}_r$  is wealth of the retiree.

<sup>2</sup> Instead of assuming that retirees only consume social security benefits each period, we may assume that they have initial wealth and have decisions of saving. However, this does not change our main results.

## 2.2 Firm's Problem (The Final Good Producer and the Intermediate Good Producer)

There are two types of firms: a perfectly competitive final good firm and monopolistically competitive intermediate goods firms, indexed by  $j \in [0,1]$ .

The final good  $Y_t$  is produced by combining a continuum of differentiated intermediate goods  $y_{j,t}$  produced by the firm  $j$ . The production function of the final good producer is given by:

$$Y_t = \left( \int_0^1 y_{j,t}^{\frac{\epsilon-1}{\epsilon}} dj \right)^{\frac{\epsilon}{\epsilon-1}}, \quad (6)$$

where  $\epsilon$  governs the degree of substitution between different inputs.

The production function of intermediate goods firm  $j$  is given by:

$$y_{j,t} = (k_{j,t}^d)^\alpha (h_{j,t}^d)^{1-\alpha} k_{g,t}^{\alpha_g}, \quad 0 < \alpha < 1, \alpha_g > 0, \quad (7)$$

where  $k_{j,t}^d$  and  $h_{j,t}^d$  represent capital and labor services hired by firm  $j$ , and  $k_{g,t}$  is aggregate public capital.

## 2.3 Aggregation

The aggregate level of any consumer-specific variables  $x_{i,t}$  where  $i \in [w, r]$  is given by  $x_t = \int_0^1 x_{i,t} di = \phi x_{w,t} + (1 - \phi) x_{r,t}$ , as consumers in each of the two groups are identical. Hence, aggregate consumption  $c_t$  is given by:

$$c_t = \phi c_{w,t} + (1 - \phi) c_{r,t}. \quad (8)$$

Since only workers provide labor services and accumulate physical capital, total hours of work  $h_t$ , total capital stock  $k_{t-1}$ , and total investment  $i_t$  are given by:

$$h_t = \phi h_{w,t}, \quad (9)$$

$$k_{t-1} = \phi k_{w,t-1}, \quad (10)$$

$$i_t = \phi i_{w,t}, \quad (11)$$

Similarly, only workers hold government bonds and receive dividends from firms and pay the lump-sum tax. Thus, we have government bonds  $b_{w,t}$  held by workers, the amount of dividends that the worker receives from the firm sector,  $d_{w,t}$  and the lump-sum tax levy  $\tau_{w,t}$  as follows.

$$b_t = \phi b_{w,t}, \quad (12)$$

$$d_t = \phi d_{w,t}, \quad (13)$$

$$\tau_t = \phi \tau_{w,t}, \quad (14)$$



## 2.4 Monetary and Fiscal Authorities

The government purchases goods for consumption  $g_t$  and investment purpose  $i_{g,t}$  and pays social security benefits  $s(1 - \phi)$ . It finances them by levying the lump-sum tax and issuing government bonds. Hence, the government budget constraint in real terms is given by:

$$b_t + \tau_t = g_t + i_{g,t} + R_{t-1} \frac{b_{t-1}}{\pi_t} + s(1 - \phi). \quad (15)$$

The law of motion for public capital is:

$$k_{g,t} = (1 - \delta_g)k_{g,t-1} + i_{g,t} \quad (16)$$

where  $\delta_g$  is the depreciation rate for public capital.

We allow for debt financing, but assume that there exists a tax rule to keep the level of real debt constant in the long run. Thus, the tax rule is:

$$\frac{\tau_t}{\tau} = \left( \frac{b_{t-1}}{b} \right)^\psi, \quad (17)$$

where  $\psi$  is the feedback parameter from debt to taxes which insures determinacy.

Monetary policy follows a Taylor rule:

$$\frac{R_t}{R} = \left( \frac{\pi_t}{\pi} \right)^{\varphi_\pi} \left( \frac{Y_t}{Y} \right)^{\varphi_Y} \exp(v_t), \quad (18)$$

where any variable without the time subscript denotes the corresponding steady-state value of the variable,  $\varphi_\pi$  indicates how strongly the monetary authority responds to deviations of inflation from the target,  $\varphi_Y$  is the response to the output gap, and  $v_t$  is a random error term.

## 2.5 Market Clearing Conditions for Labor, Capital, and Final Goods

The labor market is in equilibrium when the labor demand by the intermediate goods firms  $h_t^d \equiv \int_0^1 h_{j,t}^d dj$  is equal to the labor services supplied by workers. Similarly, the capital rental market is in equilibrium when the demand for capital by the intermediate goods firms  $k_t^d \equiv \int_0^1 k_{j,t}^d dj$  equals the capital supplied by consumers. The interest rate is determined by the monetary policy rule. In order to maintain the money market equilibrium, the money supply adjusts endogenously to meet the money demand at those interest rates. The final goods market is in equilibrium when the supply by the final goods firms (equation (15)) equals the demand by consumers and the government:

$$Y_t = c_t + i_t + g_t + i_{g,t}. \quad (19)$$

## 3. CALIBRATION

As it is not possible to solve our model analytically, we solve the model using a numerical method. We calibrate the model to match several dimensions of the Japanese economy.

We chose the Japanese economy as our target as Japan is a front-runner of population aging.

We choose the model period to be one quarter and set the subjective discount factor at  $\beta=0.99$ , implying a steady-state real interest rate of 4% per year.

We calibrate the parameters related to the consumer's utility function based on existing studies. The risk aversion parameter  $\sigma$  is set to 1. We choose  $\mu=2.0$  or the Frisch elasticity is  $1/\mu=0.5$ , which is consistent with the micro-evidence that Frisch elasticity is less than one.<sup>3</sup> Based on Kato and Miyamoto (2013), we set the share parameter at  $\omega=0.6$  and the elasticity of substitution between private and government consumption at  $\zeta=0.4$ .

In the production function, we set  $\alpha=1/3$  to target the capital share. We normalize the technology level to  $A=1$  without loss of generality. Based on Yoshino and Nakajima (1999), we set the elasticity of output with respect to public capital at  $\alpha_g = 0.129$ . Following Esteban-Pretel et al. (2011), we set the depreciation rate at  $\delta=0.028$ . We assume that the depreciation rates are the same between the private and public sectors. Thus,  $\delta_g = \delta$ .

Based on existing studies, we calibrate the parameters related to nominal rigidities. The elasticity of demand is set to  $\varepsilon=11$ , which implies a steady-state markup of 10%.<sup>4</sup> Estimates of the Calvo parameter for price in Japan are in the range of 0.72–0.88 (Iiboshi et al. 2015; Sugo and Ueda 2008; Ichiue and others 2013; Kuo and Miyamoto 2016). Given this, we set the Calvo parameter to  $\xi=0.8$ , which implies that the average contract duration of price setting is about 5 quarters.

We choose the value of the fraction of workers  $\phi$  based on the ratio for the population aged 20–64 to the population aged 20 or older. According to the National Institute of Population and Social Security Research, over the period of 1970–2000, the mean value of the ratio is about 0.85. Thus, for the benchmark case, we set  $\phi = 0.85$ .

We now turn to the policy parameters. For the Taylor rule, in order to maintain comparability with existing studies (Clarida et al. 1998; Fujiwara et al. 2007; Fujiwara et al. 2008), we set  $\varphi_\pi = 1.5$  and  $\varphi_Y = 0.1$ . For the feedback parameter from debt to taxes in the tax rule, we set  $\psi=0.1$ . This value is also used by Mayer and others et al. (2010). The value of social security benefits  $s$  is pinned down by targeting the ratio of the average social benefits to the average wages.<sup>5</sup>

Based on the data, we set the steady-state value for government spending to output ratio  $g/Y=0.16$ , the steady-state value for government investment expenditure to output ratio  $i_g/Y=0.06$ , and the steady-state value for debt to output ratio  $b/Y=1.7$ . Following Kato and Miyamoto (2013), we also set the value for the government spending autoregressive parameters at  $\rho_g = \rho_i = 0.9$ . Finally, following Gali (2008), we consider a moderately persistent monetary shock, and we set  $\rho_v = 0.5$ .

**Table 1: Parameter Values**

<sup>3</sup> Our parameter value is also consistent with the evidence that the Frisch elasticity for males in Japan is in the range of 0.2–0.7 (Kuroda and Yamamoto 2008).

<sup>4</sup> This is the conventional value in the literature.

<sup>5</sup> Based on surveys (Explanation of the Statistical Survey of Actual Status for Salary in the Private Sector conducted by the National Tax Agency) and the annual report on the public pension system conducted by the Ministry of Health, Labour and Welfare, the ratio of the average monthly pension benefits to the average monthly salary is about 0.4. We therefore calibrate  $s$  by targeting this.

| Parameter     | Description                                         | Value | Source/Target                |
|---------------|-----------------------------------------------------|-------|------------------------------|
| $\beta$       | Discount factor                                     | 0.99  | Data                         |
| $\sigma$      | Relative risk aversion parameter                    | 1.0   | See text                     |
| $\mu$         | The inverse of Frisch elasticity                    | 2.0   | Kuroda and Yamamoto (2008)   |
| $\omega$      | Share parameter                                     | 0.6   | See text                     |
| $\zeta$       | Elasticity of utility function                      | 0.4   | See text                     |
| $\alpha$      | Capital share                                       | 1/3   | Data                         |
| $\alpha_g$    | Elasticity of output with respect to public capital | 0.129 | Yoshino and Nakajima (1999)  |
| $A$           | Aggregate productivity                              | 1.0   | Normalization                |
| $\delta$      | Depreciation rate                                   | 0.028 | Esteban-Pretel et al. (2010) |
| $\delta_g$    | Depreciation rate                                   | 0.028 | $\delta = \delta_g$          |
| $\epsilon$    | Electricity of demand                               | 11    | See text                     |
| $\xi$         | Calvo parameter                                     | 0.8   | See text                     |
| $\phi$        | Fraction of workers                                 | 0.85  | Data                         |
| $\varphi_\pi$ | Taylor-rule coefficient for inflation               | 1.5   | See text                     |
| $\varphi_Y$   | Taylor-rule coefficient for output                  | 0.1   | See text                     |
| $\psi$        | Feedback parameter in the tax rule                  | 0.1   | See text                     |
| $s$           | Social security benefits                            | 0.900 | See text                     |
| $\rho_g$      | Persistency of the gov. consumption shock           | 0.9   | Data                         |
| $\rho_i$      | Persistency of the gov. investment shock            | 0.9   | Data                         |
| $\rho_v$      | Persistency of the monetary policy shock            | 0.5   | See text                     |

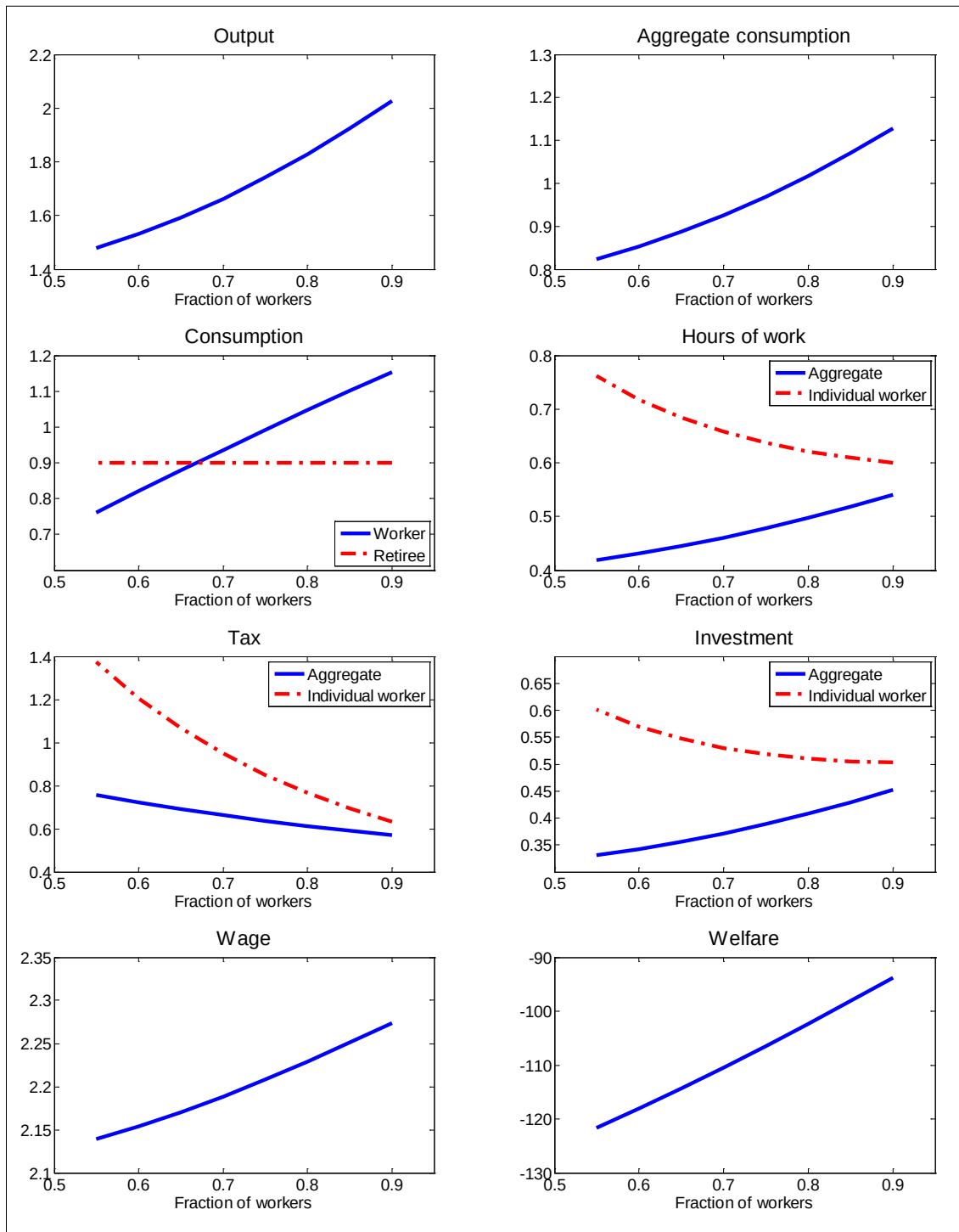
## 4. QUANTITATIVE ANALYSIS

This section examines how a demographic change influences the economy. We first examine the long-term effects of a change in the proportion of the working population on the aggregate economy. We then investigate how a change of demographic structure alters the effectiveness of monetary and fiscal policies in the short run.<sup>6</sup>

### 4.1 The Long-Term Effect of Population Aging

We first examine the long-term effects of a demographic structure change on the economy by calculating the steady-state response to an increase in the proportion of workers. The results are shown in Figure 2.

<sup>6</sup> We solve the model by approximating the equilibrium conditions around a non-stochastic steady state. We then examine the dynamic responses of the economy to macroeconomic policy shocks.

**Figure 2: The Long-term Effects of a Change in Labor Participation**

An increase in the proportion of workers caused by making retired people return to the labor force increases output, aggregate consumption, aggregate investment, and total labor input. These responses can be understood by examining the response of taxes paid by workers. In the economy, the pension benefits are transfers from tax payments by workers to retirees. Since the amount of pension benefits per retiree is fixed, an increase in the proportion of the working population reduces each worker's tax burden. As a retired person receives a fixed amount of pension benefits and consumes all of it in

each period, consumption of retirees does not change. In contrast, worker consumption increases due to the reduction of tax. This leads to a higher aggregate consumption.

The positive disposable income effect caused by a reduction of taxes also reduces the labor supply of each worker. However, an increase in the working population caused by making retired people return to the labor force pushes up the total labor supply, leading to higher output. The decrease in the proportion of retirees reduces the amount of investment of each worker. However, aggregate investment increases due to the increase in the working population.

Interestingly, wages rise as labor participation increases. This is because the increase in the working population increases the capital–labor ratio. Since an increase in the working population increases workers' consumption, welfare increases as labor participation increases.<sup>7</sup>

## 4.2 Dynamics of Aging Population in Relation to Monetary Policy

We now examine the dynamic responses of the economy to a monetary policy shock and how population aging affects the effectiveness of monetary policy.

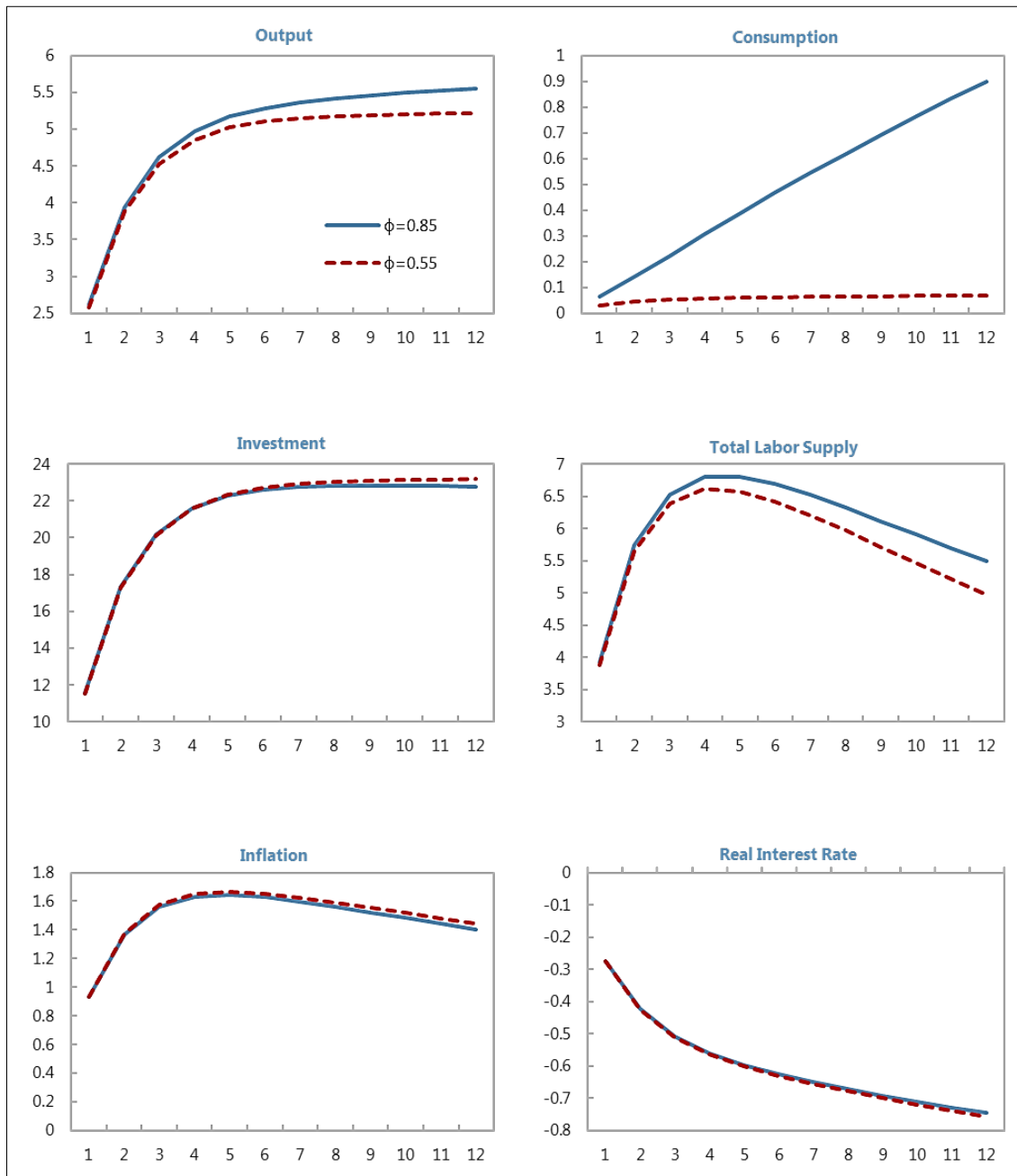
Figure 3 shows the effect of an expansionary monetary policy shock on the economy. Lowering the interest rate increases inflation. In turn, the resulting decrease in the real interest rate boosts consumption and investment. Increased demand puts upward pressure on the process of production factors, leading to higher wages and increased working hours.

Figure 3 also illustrates the dynamic effects of an expansionary monetary policy shock in an economy with a lower proportion of workers. A change in the demographic structure does not affect the qualitative responses of the economy to the monetary policy shock. However, it does affect the quantitative responses of endogenous variables to the shock.

Population aging weakens the effectiveness of monetary policy on the economy. In particular, the positive impact of the monetary policy shock on consumption is weakened in an aging economy. This is because the proportion of the working population who are positively affected by the expansionary monetary policy shock decreases. Given the fact that consumption accounts for about 60% of gross domestic product (GDP) in the Japanese economy, the reduction of total consumption brings about a significant negative impact on the economy. While the monetary policy has had less of an impact on investment in recent years, as shown in the work of Yoshino and others (2017), our result implies that the effects of monetary policy are weakened in an aging economy.

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<sup>7</sup> We define the welfare function as  $W = \phi W_w + (1 - \phi) W_r$ , where  $W_w$  and  $W_r$  are the utility of workers and retirees, respectively.

**Figure 3: The Effects of an Expansionary Monetary Shock**

Note: The solid lines labeled " $\phi=0.85$ " plot the cumulative impulse responses obtained in the model with higher labor participation. The dashed lines labeled " $\phi=0.55$ " plot the cumulative impulse responses obtained in the model with lower labor participation. The horizontal axis represents quarters after the shock.

## 5. EFFECTIVENESS OF FISCAL POLICY AND POPULATION AGING

We now turn to examining how population aging affects the output effects of a government spending shock. The government spending shock is identified by a forecast error, and its output effects are estimated by using the local projection method. We find

that the output effect of fiscal policy is more likely to be smaller in countries where population aging occurs.

## 5.1 Methodology

We estimate the impact of a government spending shock on output by using the local projection method developed by Jordà (2005) in a panel setting. The government spending shock is identified by employing the approach of Auerbach and Gorodnichenko (2012, 2013). In this approach, government spending shocks are identified as forecast errors of government spending. Thus,

$$Shock_{i,t} = \Delta \ln g_{i,t} - \Delta \ln g_{i,t}^E.$$

where  $Shock_{i,t}$  is the government spending shock of country  $i$  in year  $t$ ,  $\Delta \ln g_{i,t}$  is the growth rate of the actual government consumption, and  $\Delta \ln g_{i,t}^E$  is the growth rate of the forecast. Forecasts are taken from the fall issue of the OECD's *Economic Outlook*.

With the identified government spending shocks, we use two econometric specifications to estimate fiscal multipliers. The first specification estimates the average impact of government spending shocks on output. The second specification examines how population aging affects the fiscal multiplier.

The first regression specification is:

$$y_{i,t+h} - y_{i,t-1} = \alpha_i^h + \gamma_t^h + \beta^h shock_{i,t} + X_{i,t} + \varepsilon_{i,t}^h \quad (1)$$

where  $y$  is log of real GDP,  $\alpha$  is the country fixed effect,  $\gamma$  is the time fixed effect,  $shock$  is the identified government spending shock, and  $X_{i,t}$  is a set of control variables. Control variables are two lags of government spending shocks and two lags of GDP growth. Note that all coefficients vary with the horizon  $h$ . Thus, a separate regression is estimated for each horizon. We estimate equation (1) for each  $h=0, \dots, 4$ , where  $h=0$  is the year when the government spending shock occurs. We compute the impulse response function of output by using the estimated  $\beta^h$ . The confidence intervals associated with the impulse response functions are obtained by the estimated standard errors of the coefficient  $\beta^h$ , based on clustered robust standard errors.

The second specification allows the response of output to vary with the degree of population aging. As discussed in the work of Auerbach and Gorodnichenko (2013), the local projection method can easily adapt non-linearity and thus estimate a state-dependent model. The second regression model is:

$$y_{i,t+h} - y_{i,t-1} = \alpha_i^h + \gamma_t^h + \beta_1^h G(z_{i,t}) shock_{i,t} + \beta_2^h (1 - G(z_{i,t})) shock_{i,t} + \theta^h X_{i,t} + \varepsilon_{i,t}^h \quad (2)$$

with:

$$G(z_{i,t}) = \frac{\exp(-\delta z_{i,t})}{1 + \exp(-\delta z_{i,t})}, \delta > 0$$

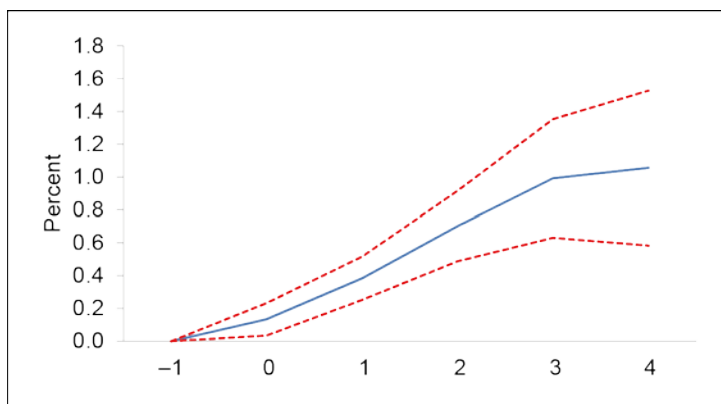
where  $G(\cdot)$  is the transition function and  $z$  is an indicator of population aging. As in the work of Abiad and others (2016), we set  $\delta = 1$ . We use the share of youth aged 20–29 in the total population as the measure of population aging.

We obtain the data used in the analysis from the OECD's Statistics and Projections Database. In order to construct government spending shocks, we use the forecast of government spending reported in the fall issue of the OECD's *Economic Outlook* for the same year.<sup>8</sup> Our dataset covers an unbalanced sample of 43 countries over the period of 1996–2017.

## 5.2 Empirical Results

This section presents our empirical results. We first examine the average effect of the government spending shock by estimating equation (1). Figure 4 displays the impulse responses to an increase of government consumption by 1%. In this and subsequent figures, the horizontal axis measures years, while vertical axis measures the deviation from pre-shock in percent for output. Dashed lines indicate 90% confidence bounds. An expansionary government spending shock increases output by about 0.1% in the same year. Using the sample average of government spending as a share of GDP, this implies a short-term fiscal multiplier of 0.7. The government spending shock also has long-lasting effects on output. Output increases by about 1.1% four years after the shock.

**Figure 4: Output Effects of an Expansionary Government Spending Shock**

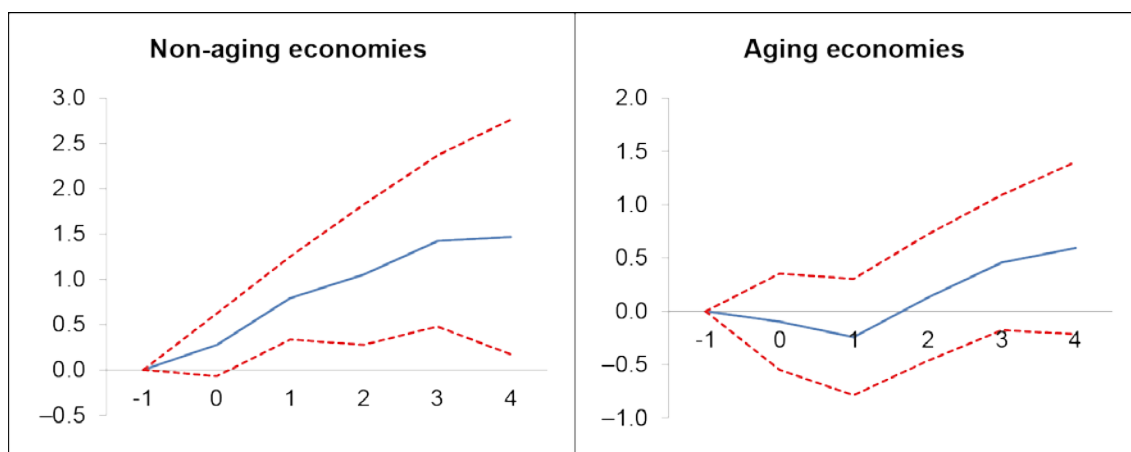


Note:  $t=0$  is the year of the shock. Solid and dashed lines denote the point estimates and 90% confidence bands, respectively.

We now turn to examining how population aging affects the output impact of the government spending shock by estimating equation (2). Figure 5 shows the results. The output effects of government spending shocks differ between countries with a high share of youth population (non-aging economies) and countries with a low share of youth population (aging economy). In non-aging economies, the positive government spending shock increases output by about 0.3% in the same year and about 1.5% in the medium term. The implied short-term fiscal multiplier is 1.46. In contrast, in aging economies, the response of output is not statistically significant. This result is consistent with the prediction of Yoshino and Miyamoto (2017). They show that macroeconomic impacts of fiscal policy shocks are weakened when population aging occurs by using a new Keynesian DSGE model with heterogeneous households.

<sup>8</sup> As a robustness check, we also use the forecasts of the fall issue of the previous year and find that results remain unchanged.



**Figure 5: Population Aging and Output Effects of Government Spending Shocks**

Note:  $t=0$  is the year of the shock. Solid and dashed lines denote the point estimates and 90% confidence bands, respectively.

## 6. CONCLUSION

The world is in the midst of a demographic change toward population aging. Population aging can have significant effects on the macro-economy. This paper studies how population aging affects the effectiveness of monetary and fiscal policies. By using the DSGM model and panel data analysis, we find that population aging weakens the output effect of monetary and fiscal policies.

We can draw out important policy implications from our analyses. As neither monetary policy nor fiscal policy would be effective in aging economies, structural reform measures would have a more important role.

Let now us consider the case of Japan, which has the world's most aged population. Japan's economy continues to suffer from long-term stagnation that dates back to its bubble-bursting three decades ago. Monetary and fiscal policies have been implemented to recover the Japanese economy. Although these macroeconomic policies have brought temporary relief, a number of studies show that the effectiveness of monetary and fiscal policies has diminished (Nakahigashi and Yoshino 2016; Yoshino et al. 2017). This is consistent with results of our analyses.

Our analyses suggest the following policy recommendations to Japan: (1) postpone the retirement age and ask people to work as long as possible; and (2) the wage rate must be based on productivity rather than following a seniority-based wage rate. These two recommendations will increase the labor force and reduce the burden of social security expanses. Budget deficits will decline, and fiscal sustainability could be achieved even if the economy is faced with an aging population.

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