Aging, Factor Prices, and Capital Movements

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Abstract

Populations in all major economies have been aging; the working age population has already started to decline in some and projections for future decades describe differential timing and extent of aging. To the extent that capital markets are integrated across regions, these different demographic trends and different fiscal responses to them will have differential implications on capital accumulation, labor supplies, and capital movements across regions.

This paper develops a general equilibrium model of the world in which overlapping generations of individuals populate three regions under perfect capital mobility. As mentioned earlier, our idea is to view our world economy as consisting of three regions that have very different demographic trends. The HI region is aging earlier and faster than the MI region, and, Japan has been aging even earlier and faster than the HI region. By isolating Japan as a separate region, our framework aims to highlight the quantitative importance of the differential aging mechanism in studying fiscal sustainability in the Japanese economy.

Keywords: Capital Flows, Demographic Trends, Factor Prices, Japan.

JEL Classification: F21, F41, J11, H55.

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1 Introduction

One of the major challenges facing all economies is the aging of the populations. In virtually all countries, fertility rates and death rates have fallen and this demographic trend has been accompanied by a secular decline in real interest rates and slow economic growth. However, the timing and the severity of these demographic trends are quite different across countries and regions of the world. Advanced economies such as United States, Japan, and those in the Eurozone have started aging much earlier and more significantly than emerging and developed countries. In order to see the differential demographic shocks in the world, consider Figure 1 which shows various aspects of the aging process and its implications in three ‘regions’, 1) ‘high-income’ (HI) region, 2) ‘middle-income’ (MI) region, and 3) Japan.\[1\]

Figure 1: Demographic Trends in the Three Regions

\[1\]The main source of demographic data is United Nation’s World Population Prospects: The 2015 Edition Revision (2015), which provides harmonized data on population, fertility and life table projections for all countries from 1950 to 2100. The division of the two regions is mainly based on the stages of overall economic growth and timing of demographic transition. The choice of countries included in the two regions is based on the size of the economy, as well as the degree of investment and financial exposure to Japan. More details are provided in section [3].
The first frame in Figure 1 shows life expectancy at birth over time in three regions. Longevity is rising in all regions but significant differences are projected to persist well into the second half of the 21st century. Furthermore, Japan has higher longevity relative to the highly advanced economies. The second frame in Figure 1 plots total fertility rates which have all come down from their earlier levels in 1960. In particular, fertility rates in HI and MI regions are projected to approximately converge (just below 2) whereas that in Japan is predicted to be significantly lower at around 1.5 for several more decades.

Given the significant fall in death and fertility rates, it is not surprising that population growth rates have fallen significantly since 1960 as the third frame in Figure 1 shows. What really stands out in this frame is that Japan’s population growth has already turned negative in mid-2000s and the decline in the Japanese population is projected to accelerate over the next few decades. According to frame (d) in Figure 1 the Japanese population in 2070 will be about the same size as that in 1950. The populations in HI and MI regions will continue to rise, at least until the 2040s.

Combined, the fall in fertility and the rise in longevity, imply significant increases in the old-age dependency ratio, defined as the ratio of individuals 65 or older to those between the ages of 20 and 64, shown in Figure 2. The dependency ratios show a gradual increase in all regions since 1950. In HI and MI regions, the main part of the increase is very recent and the projections put these ratios at about 55% and 42%, respectively. In Japan, however, the sharp rise in the dependency ratio has started in the 1990s and is projected to increase to 80% by 2070. In other words, the rise in the old-age dependency ratio in Japan has started much earlier and is predicted to reach unprecedented levels in a few decades.
These large demographic shocks and the accompanying monetary and fiscal adjustments have already started to affect capital accumulation, labor supplies and economic growth in all economies and will continue to do so in the next few decades. To the extent that capital markets are integrated across regions, different demographic trends and different fiscal responses to them will have differential implications on capital accumulation, labor supplies, and capital movements across regions. When viewed through the lens of a general equilibrium model of the world, these capital movements will have effects on the time paths of factor prices. This force is maximized in a closed economy, general equilibrium setting, with a direct link between the domestic capital labor ratio and factor rental rates. This mechanism is totally absent in a small, open economy, partial equilibrium model. Actual economies, however, are neither closed nor small, open, and depending on bilateral trade and capital flows, they may be closer to one extreme or the other.

This paper develops a general equilibrium model of the world in which overlapping generations of individuals populate three regions under perfect capital mobility. As mentioned earlier, our idea is to view our world economy as consisting of three regions that have very different demographic trends. The HI region is aging earlier and faster than the MI region, and, Japan has been aging even earlier and faster than the HI region. By isolating Japan as a separate region, our framework aims to highlight the quantitative importance of the differential aging mechanism in studying fiscal sustainability in the Japanese economy.

Each region in our model consists of overlapping generations of individuals who face complete markets except for missing annuity markets. Labor is immobile but we assume perfect capital markets in the open economy version of our model. Governments in the three regions have exogenous government expenditures and transfer payments which increase over time as the populations get older. We assume that government debt to output ratios are held constant and labor income taxes are used to achieve fiscal sustainability.

We calibrate the model under the assumption of closed regional economies using data from the World Bank, IMF, United Nations, and in the case of Japan, the Institute for Population Studies. We first compute equilibrium transitions in the three regions assuming they are closed economies and characterize the paths of equilibrium quantities such as output, capital, wages and factor prices. Second, under the same institutional settings we compute an equilibrium transition of the three region model of the world under perfect capital mobility. Our main finding is that the real interest rate falls from about 4% in 2015 to about 1% by 2080, with the capital labor ratio rising in all three regions but more significantly in the HI economies and Japan. Capital flows from MI economies to HI economies and Japan. In particular, Japan starts running current account deficits, its net foreign asset position worsens, and eventually becomes a net foreign borrower.

The paper is organized as follows. Section 2 describes the model and the economic environment. Section 3 summarizes our calibration with the details described in the Appendix. Section 4 discusses our preliminary quantitative findings and Section 5 contains our conclusions (to be completed).
Related Literature on Capital Flows Our paper follows the tradition of Auerbach and Kotlikoff (1987) type models using quantitative general equilibrium variants populated by overlapping generations, and incorporates life cycle institutions and demographic projections in detail to tease out the implications of aging on the economy. Earlier papers that studied the effects of aging on the economy focused on the effects arising from the social security budget. Our paper is related to the recent ‘secular stagnation’ papers such as Ikeda and Saito (2014), Gagnon, Johnson, and Lopez-Salido (2016), Carvalho, Ferrero, and Nechio (2016), and Eggertsson, Mehrotra, and Robbins (2017). Most of this research restricts attention to closed economy models and focus on understanding the mechanisms, including demographics, that contribute to the low real interest rates and economic growth in advanced economies.

This paper is more closely related to the work by Attanasio, Kitao, and Violante (2006), Domeij and Floden (2006), Börsch-Supan, Ludwig, and Winter (2006), Attanasio, Kitao, and Violante (2007), Krueger and Ludwig (2007), Backus, Cooley, and Henriksen (2014) and Lisack, Sajedi, and Thwaites (2017) that analyze the effects of demographic changes in open economies. This research exploits the differential timing and nature of aging and different ways of dealing with pension programs in large, open economy models. The general finding is that capital flows from the ‘North’ to the ‘South’ as aging is earlier and higher in high income countries relative to that in less developed economies.

When an economy ages faster than others, then the rise in capital labor ratio will be larger than others and as a result the fall in the return to capital will be bigger. If capital is allowed to flow among economies, the fall in the return to capital in an aging economy will be accompanied by an outflow of capital seeking higher returns elsewhere. This is the simple mechanism that determines capital flows in this quantitative literature.

In addition to this mechanism, there is also differential growth rates in total factor productivity that lead to differences in returns to capital among economies. It is also possible that tax treatment of capital income is different or pension institutions have different sustainability issues that may influence the return to capital in these economies. With these and other ‘moving parts’ in large scale, quantitative general equilibrium mod-

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2See, for example, Huang, İmrohoroğlu, and Sargent (1997), De Nardi, İmrohoroğlu, and Sargent (1999).
3For example, Eggertsson, Mehrotra, and Robbins (2017) build a three-period New Keynesian model to highlight the various mechanisms of their model (shocks to collateral constraints, demographics, zero lower bound, debt to GDP ratio, relative price of investment goods, labor share, nominal rigidities, productivity growth, hystereses) to create secular stagnation and negative natural interest rates for the United States between 1970 and 2015, with projections to 2030. For Japan, their numerical example using a 3-period OG model under a closed economy setup delivers persistent low growth, low inflation and low real interest rates in the 1070-2013.
4? develop a two-country open economy, representative agent model and study the effects of productivity, tax, and population growth rate differences on capital flows between the U.S. and the rest of the world (RoW). They argue that the factor that seem to have driven the capital to flow into the U.S. in the 1960-2004 period is faster productivity growth in the U.S.
els populated with overlapping generations, it becomes necessary to conduct numerical experiments to isolate some of these effects in an attempt to quantify their contributions to the overall results. We address these issues in the section on Alternative Computations.

2 The Model

2.1 Economic Environment

Preliminaries: Our model consists of Japan (J) and two regions; High-income (H) and Middle-income (M) regions. The two regions and Japan differ in their demographic trends, total factor productivity, and fiscal institutions. Our approach is to calculate a perfect foresight equilibrium transition path for the world economy from 2015 to a distant future steady state. Let $t$ denote time, $j$ a household’s age, and $r$ the regions, with $r = J, H, M$.

Technology: In each region $r$, a constant returns to scale, aggregate production function $F(Z^r_t, K^r_t, N^r_t)$ produces output of a final good $Y^r_t$ which can be used for consumption $C^r_t$ or investment $I^r_t$. Among the arguments of the production function, $Z^r_t$ denotes the total factor productivity level in region $r$ at time $t$, $N^r_t$ is the aggregate labor supply in efficiency units, and $K^r_t$ is the aggregate stock of physical capital used in production. Physical capital depreciates at the same rate $\delta$ each period in all regions. The level of technology in region $r$ grows exogenously at rate $\lambda^r_t$ between $t$ and $t+1$. The growth rates differ across regions during the transition, but in the long-run all regions grow at the same constant rate $\lambda$.

Demographics: Each region in the economy is populated by overlapping generations of ex-ante identical households who become active economically at age $j = 1$ and may live for a maximum of $J$ periods. For households born in region $r$, $s^r_{j,t}$ denotes the probability of survival until age $j$ at time $t$, conditional on being alive at time $t-1$. Hence, in region $r$, the unconditional probability of surviving $j$ periods up to time $t$ is given by

$$S^r_{j,t} = \prod_{k=1}^{j} s^r_{k,t+(k-j)},$$

where $S^r_{1,t} = s^r_{1,t} \equiv 1$ for all $t$ by definition. We denote by $\mu^r_{j,t}$ the size of the population of age $j$ at time $t$ in region $r$.

Household Preferences: Households of age $j$ at time $t$ in region $r$ make consumption allocation decisions based on the instantaneous utility function

$$u(c_{j,t}) = \frac{c_{j,t}^{1-\theta}}{1-\theta}. \quad (1)$$
where \( c_{j,t} \) denotes consumption of a household of age \( j \) at time \( t \). The intertemporal preference ordering for households born at adult-age \( j = 1 \) at time \( t \) is given by

\[
U^r = \sum_{j=1}^{J} \beta^{j-1} S^r_{j,t+j-1} \frac{c_{j,t+j-1}^{1-\theta}}{1-\theta},
\]  

(2)

where \( \beta \) is the subjective discount factor. There is no explicit bequest motive driven by altruism. Accidental bequests left by the deceased are distributed as a lump-sum transfer, denoted as \( b_t^r \).

**Household Endowments:** Households exogenously supply labor and derive no utility from leisure. At age \( J_R^r \), households are subject to compulsory retirement from any working activity. Households of age \( j \) at time \( t \) in region \( r \) are endowed with \( \varepsilon_{r,t}^j \) efficiency units of labor for each unit of time worked in the market. Finally, we assume that the initial asset holdings of each household is zero, i.e. \( a_{1,t}^r = 0 \) for any \( t \) in both regions.

**Household Budget Constraint:** Let \( a_{j,t}^r \) be the net asset holding of a household \( j \) at time \( t \) in region \( r \).

\[
(1 + \tau_{c,t}^r) c_{j,t}^r + a_{j+1,t+1}^r = y_{j,t}^r + [1 + (1 - \tau_{a,t}^r) r_t] (a_{j,t}^r + b_t^r) + p_{j,t}^r.
\]  

(3)

We require households to die with non-negative wealth once they reach age \( J \), but otherwise impose no borrowing constraint during their life. Net earnings \( y_{j,t}^r \) accruing to households of age \( j \) in region \( r \) at time \( t \) are defined as

\[
y_{j,t}^r = \begin{cases} 
(1 - \tau_{w,t}^r) w_t^r \varepsilon_{j,t}^r = (1 - \tau_{w,t}^r) \tilde{y}_{j,t}^r & \text{if } j < J_R^r, \\
0 & \text{if } j \geq J_R^r,
\end{cases}
\]  

(4)

where \( w_t^r \) is the market wage rate, \( \varepsilon_{j,t}^r \) is the efficiency units of labor of a household of age \( j \), and \( \tilde{y}_{j,t}^r \) is the before-tax labor income. \( p_{j,t}^r \) is pension income and takes a positive value for eligible individuals at and above social security’s retirement age \( j \geq J_{SS}^r \) and zero otherwise.

Households pay proportional taxes at the rate of \( \tau_{c,t}^r \) on consumption, \( \tau_{a,t}^r \) on capital income, and \( \tau_{w,t}^r \) on labor income. Residents of region \( r \) pay capital income taxes in region \( r \), independently of where capital was invested. Social security benefits are given by the formula

\[
p_{j,t}^r = \kappa_t^r \frac{W_{j,t}^r}{J_{SS}^r - 1},
\]

where \( \kappa_t^r \) is the replacement ratio of average past earnings. Cumulated past gross earnings \( W_{j,t}^r \) are defined recursively as

\[
W_{j,t}^r = \begin{cases} 
\tilde{y}_{j,t}^r & \text{if } j = 1, \\
\tilde{y}_{j,t}^r + W_{j-1,t-1}^r & \text{if } 1 < j < J_{SS}^r, \\
W_{j-1,t-1}^r & \text{if } j \geq J_{SS}^r.
\end{cases}
\]  

(5)
**Government Budget Constraint:** In each region \( r \), public expenditures and social security program are administered by the government under a unique consolidated intertemporal budget constraint. The government can raise revenues through its fiscal instruments: taxes on consumption, labor income, and capital income, and can issue one-period risk-free debt, \( B^r_t \). Government borrowing and tax revenues finance a stream of expenditures \( G^r_t \) and the PAYG social-security program described above. The consolidated government budget constraint reads as

\[
G^r_t + (1 + r^t) B^r_t + \sum_{j=J^r} p^j_t \mu^j_t = \\
\tau^r w^t \sum_{j=J^r} \mu^j_t c^r_{j,t} + \sum_{j=J^r} \mu^j_t \tau^a_t (a^r_{j,t} + b^r_t) + \sum_{j=J^r} \mu^j_t \tau^c_t c^r_{j,t} + B^r_{t+1}.
\]

**Market Structure:** There are three goods in the world economy: a final good which can be used either for consumption or investment, the services of labor and the services of capital. The price of the final good (homogeneous across the three regions) is used as the world numeraire. Labor is immobile, thus wages are determined independently in regional labor markets.

In the open economy, we assume that physical capital is perfectly mobile across the three regions, so there is one world market for capital. Let \( X^r_t \) denote the external wealth of region \( r \) at time \( t \), that is, the stock of capital used in production in other regions and owned by households of region \( r \). A negative value indicates ownership of capital used for production in the region but owned by households of other regions. The sum of positive and negative external wealth across regions is zero in equilibrium, satisfying the condition \( \sum_r X^r_t = 0 \) at any time \( t \). The markets where these goods and assets are traded are perfectly competitive. An intuitive no-arbitrage condition between assets and the absence of aggregate uncertainty imply that the return on both regional bonds is equal to the return on physical capital, as we have already implicitly assumed when we wrote the budget constraints of the government and households.

### 2.2 Equilibrium

Before stating the definition of equilibrium, it is useful to point out that, without further restrictions, the equilibrium path of the fiscal variables \( \{G^r_t, \kappa^r_t, \tau^a_t, \tau^c_t, B^r_t\}_{t=1}^\infty \) is indeterminate, as there is only one budget constraint we can operate on. In what follows, we define an equilibrium for the case where the paths of all fiscal variables are given, except for \( \{\tau^r_{w,t}\}_{t=1}^\infty \). It is straightforward to extend this definition to the case where the path of a different set of government policies is given exogenously. Finally, for brevity we omit the definition of the closed-economy equilibrium and state directly the equilibrium conditions for the open economy.

A *Competitive Equilibrium of the Multi-Region Economy*, for a given sequence of region-specific demographics, TFP levels \( \{Z^r_t\}_{t=1}^\infty \), and fiscal variables \( \{G^r_t, \kappa^r_t, \tau^a_t, \tau^c_t, B^r_t\}_{t=1}^\infty \),
is a sequence of: (i) households’ choices \( \{(c^r_j,t, a^r_j,t)\}_{j=1}^{J} \), (ii) labor income tax rates \( \{\tau^r_{w,t}\}_{t=1}^{\infty} \), (iii) wage rates \( \{w^r_t\}_{t=1}^{\infty} \), (iv) aggregate variables \( \{K^r_t, N^r_t, I^r_t, C^r_t\}_{t=1}^{\infty} \) in each region \( r \), (v) world interest rates \( \{r_t\}_{t=1}^{\infty} \), and (vi) external wealth positions \( \{X^r_t\}_{t=1}^{\infty} \) such that:

1. Households choose optimally consumption and wealth sequences \( \{(c^r_j,t, a^r_j,t)\}_{j=1}^{J} \), maximizing the objective function in (2) subject to the budget constraint (3), and the income process (4), and the time allocation constraint.

2. Firms in each region maximize profits by setting the marginal product of each input equal to its price, i.e.
   \[
   w^r_t = F_N(Z^r_t, K^r_t, N^r_t), \quad \text{for all } r, \tag{7}
   \]
   \[
   r_t + \delta = F_K(Z^r_t, K^r_t, N^r_t). \tag{8}
   \]

3. The lump-sum transfer of accidental bequests equals the amount of assets left by the deceased, distributed equally to all households of the region.
   \[
   b^r_t = \frac{\sum_{j=1}^{J-1} a^r_{j,t} (1 - s^r_{j+1,t}) \mu^r_{j,t-1}}{\sum_{j=1}^{J} \mu^r_{j,t}}.
   \]

4. The regional labor markets clear at wage \( w^r_t \) and aggregate labor supply in each region is given by
   \[
   N^r_t = \sum_{j=1}^{J_k-1} \mu^r_{j,t} \varepsilon^r_{j,t}. \tag{9}
   \]

5. The regional bond markets and the world capital market clear at the world interest rate \( r_t \), and the aggregate stocks of capital in the two regions satisfy
   \[
   K^r_t + X^r_t + B^r_t = \sum_{j=2}^{J} \mu^r_{j-1,t-1} a^r_{j,t}, \tag{10}
   \]
   where
   \[
   K^r_t = \sum_{j=1}^{J} \mu^r_{j,t} (a^r_{j,t} + b^r_t). \tag{11}
   \]

6. The tax rates \( \{\tau^r_{w,t}\}_{t=1}^{\infty} \) satisfy the consolidated budget constraint (6) in each region.

7. The allocations are feasible in each region, i.e., they satisfy the regional aggregate resource constraints
   \[
   K^r_{t+1} - (1 - \delta) K^r_t + X^r_{t+1} - (1 + r_t) X^r_t = F(Z^r_t, K^r_t, N^r_t) - C^r_t - G^r_t. \tag{12}
   \]
Before concluding, it is useful to recall that aggregate gross investments in region \( r \) are given by
\[
I^r_t = K^r_{t+1} - (1 - \delta) K^r_t, \tag{13}
\]
whereas aggregate (private plus public) savings in the three regions are, respectively,
\[
S^r_t = F(Z^r_t, K^r_t, N^r_t) + r_t X^r_t - C^r_t - G^r_t. \tag{14}
\]
As a result, the current account balances of the three regions equal their respective net asset positions, and, are given by,
\[
S^r_t - I^r_t = CA^r_t = X^r_{t+1} - X^r_t. \tag{15}
\]
The sum of these current account balances is zero.

3 Calibration

We calibrate the initial steady-state using demographic and economic variables for the period 1990-2015 in the three regions. We assume that demographic parameters and TFP growth rates in the three regions converge to the same values in the very long run, by 2200, and all regions eventually reach a balanced growth path some time after 2200. We then let our world economy transit between the two steady-states. The model’s period is set to 5 years. Appendix \[B\] provides more details of the calibration, including description of various database used to compute statistics across regions.

The Three Regions: As discussed above, there are three regions in the model, Japan, High-income and Middle-income regions. For High-income region, we include North America (United States and Canada), Europe, Australia, and New Zealand. For Europe, we include 28 countries that are members of European Union.

Middle-income region includes countries in Asia (China, Hong Kong, Taiwan, Korea, Singapore, Thailand, Indonesia, Malaysia, Philippines, Viet Nam, and India), Mexico, Brazil, Russia, Saudi Arabia, U.A.E., South Africa, and Turkey.

Technological Parameters: We assume a constant returns to scale production function
\[
F(Z^r_t, K^r_t, N^r_t) = Z^r_t (K^r_t)^\alpha (N^r_t)^{1-\alpha},
\]
with capital share \( \alpha = 0.35 \) in three regions, following Holmes, McGrattan, and Prescott (2015). Based on the World Bank’s World Development Indicators (WDI), we obtain growth rates of output per capita in the three regions from 1990-2015, which stand at

\[5\]

The calibration strategy is to match a set of moments in the data with the model’s counterparts in the closed economy equilibrium.

\[6\]

We selected countries that have at least 100 billion yen of either foreign direct investment or portfolio investment according to the breakdown of Japanese foreign assets as of 2015 reported by the Bank of Japan. We exclude Cayman Islands from the list and also add Turkey to Middle-income region.
1.1% in Japan, 1.4% in High-income region and 3.9% in Middle-income region. The growth rate of TFP $\lambda$ in each region is set so that the region achieves the target average per-capita output growth rate during the same period.

After 2015, we let $\lambda_t^r$ of all regions converge smoothly to the common long-run growth rate of TFP, which we set to 1%. We set the initial value of the Japanese TFP, $Z_0^J$, in order to normalize income per capita in Japan to 1 in 2015. Based upon the WDI, income per capita in High-income and Middle-income region in 2015 were 1.11 ($45,373) and 0.31 ($12,696) of that of Japan ($40,763), respectively, and we set $Z_0^H$ and $Z_0^M$ to match these ratios. The depreciation rate of capital is set to 6% per year.

**Demographic Parameters:** The population data is based on the estimates of the United Nations (2015) for the High-income and Middle-income regions and on the data and projections of the National Institute of Population and Social Security Research (IPSS) (2017) for Japan. The population in 1990, the initial year of the transition, is 122 million in Japan, 178 million in High-income region, 2,976 million in Middle-income regions. The survival probabilities are computed based on the population data and projections by age for each region. The population dynamics thereafter follow the projections of the United Nations and the IPSS.

Each model-period corresponds to five years, we let households enter the economy at age $j = 1$, which corresponds to 22 years old (age 20-24), and live up to the maximum age of $J = 16$, or for the maximum of 80 years, up to age 97 (95-99 years old). We set the age to exit the labor force $J^r_R$ at 10, which corresponds to 67 years old (65-69).

**Preferences and endowments parameters:** Preferences are common across regions. We set $\theta = 2$ based on the estimates in the literature (for a survey, see Attañasio, 1999). We set the subjective discount factor $\beta = 1.0552$ to match the target interest rate of 4% in Japan on an annual basis in 1990, the initial year of the transition.

The calibration of the age profile of efficiency units is done separately for each region. The age-efficiency profile for Japan is based on the earnings data from the BSWS in 2010. For High-income region, we use weekly wage data from the Consumer Expenditure Survey (CEX) for the period 1982-1999. For Middle-income region, we use estimates used in Attañasio, Kitao, and Violante (2007), an age-efficiency profile on Mexican data—precisely from the Encuesta Nacional de Ingreso y Gasto de los Hogares (ENIGH), which is the equivalent of the U.S. CEX, using the 1989, 1992, 1994, 1996, 1998, and 2000 waves.

**Government Debt to GDP Ratios:** Government debt and expenditures as a frac-

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7We assume that the growth rate of Middle-income region converges over the next 30 years, by 2045, and those of Japan and High-income region by 2100. The TFP level in the long-run will differ across regions and the levels of Japan and Middle-income region will be around 0.75 of that of the High-income region. We simulate the model under alternative assumptions about the future growth of TFP across regions in section XX.

8Note that the age to exit the labor force $J^r_R$, which is assumed to be exogenous in the model, can be different from the retirement age for the purpose of the social system. The latter is a policy parameter. We set the two at the same age in Japan and High-income region, but the retirement age is lower in Middle-income region as discussed below.
tion of GDP for High and Middle-income regions are computed from the IMF’s World Economic Outlook database (WEO, 2017) as time-averages over the period 1990-2015.

The WEO data yield a ratio of government expenditures to GDP at 35%, 41% and 25% for Japan, High-income and Middle-income regions, respectively, in 1990-2015. These expenditures contain all expenditures including interest payments on the government debt and transfers such as social security benefits. We calibrate the ratio of the government expenditures in our model, \( G_r \), to GDP to match these data and they turn out to be 26% in Japan, 33% in High-income and 21% in Middle-income region. The ratio of government debt \( B_r \) to GDP in 1990-2015 was 51% and 31% in High-income and Middle-income regions, respectively, based on the WEO database. The debt level of the Japanese government greatly fluctuated during the period and rose from 14% of GDP in 1990-1995 to approximately 120% in 2010-2015 and we set the ratio to 100%.

**Public Pension Replacement Rates:** Pension replacement rates for the three regions are calculated using OECD Pensions at a Glance (2014). In particular, we compute ‘coverage adjusted’ net replacement rates (NRRs) by multiplying NRRs by active coverage (defined as total number of contributors divided by labor force), available from the World Bank Pensions database (2014). The GDP (current PPP) weighted, coverage adjusted NRRs are 47.8%, 26.8%, and 38.5% for High and Middle-income regions and Japan, respectively.

The statutory retirement age is 65, 66 and 56 in Japan, High-income and Middle-income regions, respectively, based on the population-weighted average of the World Bank’s database. Based on these, in the model, the retirement age \( J_{SS} \) in Japan and High-income region is set at 10, which corresponds to 67 years old (65-69) and that of Middle-income region at 8, corresponding to 57 years old (55-59).

**Tax Rates:** Tax rates on consumption and assets are computed using the revenue data from the OECD Revenue Statistics, OECD National Accounts Statistics and UN National Account Statistics, following the method of Mendoza, Razin, and Tesar (1994). \( \tau_a \) is set at 34.7%, 34.1% and 18.8% in Japan, High-income and Middle-income regions, respectively. Consumption tax rates are 10.9% and 12.7% for High-income and Middle income regions. The Japanese consumption tax rate had been zero until 1989, when it was set to 3% and raised to 5% in 1997 and 8% in 2014. We let \( \tau_{c,t} \) increase accordingly and assume that it stays constant after 2015. We adjust labor income tax rates \( \tau_w \) to satisfy the government budget constraint in each period and region. The paths of endogenously determined labor income tax rates are reported in section XX.

### Table 1: Demographic Parameters

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<th>Parameter and description</th>
<th>Value, source</th>
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<tr>
<td>( s_{jt} )</td>
<td>Survival rates</td>
</tr>
<tr>
<td>( n_{jt} )</td>
<td>Cohort growth rates</td>
</tr>
<tr>
<td>( J_{R} )</td>
<td>Age to retire from the labor force</td>
</tr>
<tr>
<td>( J )</td>
<td>Maximum age</td>
</tr>
</tbody>
</table>
Table 2: Calibrated Parameters

<table>
<thead>
<tr>
<th>Parameter and description</th>
<th>Value</th>
<th>Target, source</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta$ Subj. discount factor</td>
<td>1.055</td>
<td>Interest rate in Japan in 1990</td>
</tr>
<tr>
<td>$\theta$ Risk aversion</td>
<td>2.0</td>
<td>Attanasio (1999)</td>
</tr>
<tr>
<td>$\varepsilon_j$ Wage profile</td>
<td>–</td>
<td>see text</td>
</tr>
<tr>
<td>$\alpha$ Capital share</td>
<td>0.35</td>
<td>Holmes, McGrattan, and Prescott (2015)</td>
</tr>
<tr>
<td>$\delta$ Depreciation rate</td>
<td>0.06</td>
<td>Holmes, McGrattan, and Prescott (2015)</td>
</tr>
</tbody>
</table>

**Government**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Target, source</th>
</tr>
</thead>
<tbody>
<tr>
<td>$D_t/Y_t$ Debt to GDP ratio</td>
<td></td>
<td>IMF World Economic Outlook (2017)</td>
</tr>
<tr>
<td>$G_t/Y_t$ Gov. purch. to GDP ratio</td>
<td></td>
<td>IMF World Economic Outlook (2017)</td>
</tr>
<tr>
<td>$\kappa^r_t$ Pension replacement rate</td>
<td></td>
<td>OECD Pension at a Glance (2014)</td>
</tr>
<tr>
<td>$J^r_{sa}$ Pension retirement age e</td>
<td></td>
<td>10 (65-69 yrs) in J and H, 8 (55-59 yrs) in M</td>
</tr>
<tr>
<td>$\tau^c_{e,t}$ Consumption tax</td>
<td></td>
<td>World Bank Pensions database</td>
</tr>
<tr>
<td>$\tau^r_{a,t}$ Capital income tax</td>
<td></td>
<td>OECD Revenue Stat., OECD/National Acct. Stat.,</td>
</tr>
<tr>
<td>$\tau^r_{w,t}$ Labor income tax</td>
<td></td>
<td>Mendoza, et al (1994)</td>
</tr>
</tbody>
</table>

Note: values are on an annual basis.

Table 3: Growth rate and level of TFP

<table>
<thead>
<tr>
<th>Region</th>
<th>GDP per capita growth, WDI (1990-2015), target</th>
<th>TFP growth rate $\lambda_r^r(1990-2015)$ calibrated</th>
<th>GDP per capita level, WDI 2015, target</th>
<th>Initial TFP level $Z^r_0$ calibrated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>1.1%</td>
<td>0.72%</td>
<td>$40,763 (1.00)</td>
<td>1.12</td>
</tr>
<tr>
<td>High Income</td>
<td>1.4%</td>
<td>0.82%</td>
<td>$45,373 (1.11)</td>
<td>1.38</td>
</tr>
<tr>
<td>Middle Income</td>
<td>3.9%</td>
<td>2.07%</td>
<td>$12,696 (0.31)</td>
<td>0.60</td>
</tr>
</tbody>
</table>

**Capital Flows** In our calibration, we did not target the net foreign asset position of Japan. Before we show the model’s projections on the net foreign asset positions of the three regions, it will be useful to show how our model performs in the 1990-2015 period for which we have data. Figure 3 plots the model’s net foreign asset position for Japan against two data versions of the same object. The first data counterpart comes form the Ministry of Finance measurements and the second one follows the procedure in Hayashi and Prescott (2002).

The Ministry of Finance publishes the Net International Investment Position of Japan as the difference between Japan’s Total Assets and Total Liabilities, and we used the Gross Domestic Product (GDP) in
The model comes reasonably close to this particular moment even though it was not targeted. As a result, we have some confidence about the projections going forward.

4 Numerical Findings

In this section, we present our numerical findings that characterize equilibrium transition paths from the initial steady state that represents the period 1990-2015 to a final steady state in 2200. These equilibrium paths are computed under the 'perfect foresight' assumption and are therefore deterministic. All individuals and firms have perfect information on factor prices and fiscal policy parameters (tax rates, benefits, etc.) and make optimal decisions under new demographic variables and fiscal parameters and associated (endogenous) factor prices, given their asset holdings in the initial steady state. In other words, cohorts that survive to 2015 re-optimize given their new demographic and policy environments. Along the transition, like in the initial and final steady states, it is assumed that the labor income tax rate adjusts in each time period to satisfy the government’s budget, given a constant debt to output ratio. These computations form our baseline results below.

Japan to calculate the ratio of Japan’s net foreign asset position to output. Hayashi and Prescott (2002) method makes adjustments to measured Gross National Product (GNP) and the Capital Stock to arrive at the Net Foreign Capital Holdings of Japan. In particular, the Current Account Balance over the years is added to measured GNP and its accumulated value is added to measured domestic capital stock as the foreign capital stock owned by the Japanese economy.
In most of the figures below, we will show the equilibrium transition paths under two separate assumptions on the closeness of the economies. First, we compute the transitions under the assumption that each region has been a closed economy in the initial steady state and will remain closed along the transition path to the final steady state. Alternatively, in the open economy computations, we assume that there are three regions in the initial steady state and the transition path such that labor is immobile but capital is perfectly mobile across regions and there is one international capital market that helps determine the world interest rate.

### 4.1 Baseline Transitions

We begin with the projected populations in the three regions in Figure ???. In the high income region, the total population is predicted to decline gradually and then stabilize around 2050. In the middle income region, there is a significant increase from 2015 to 2035 but then an equally significant drop after 2045. In Japan, however, there is a monotonic decline throughout and by 2070 the population is projected to drop by 45%.

![Figure 4: Labor Supply](image)

Given these exogenous demographic effects on labor supply, the paths for capital labor ratios will be determined by what happens to saving behavior and capital accumulation in the three regions.
Figure 5 depicts endogenous capital accumulation behavior in response to demographics and also the particular fiscal policy of raising the labor income tax rates in the three regions to satisfy the respective governments’ budget constraints (and keeping the debt to output ratios unchanged from their 2015 levels). Under the closed economy case, capital rises only in the middle income region, at a rate very similar to that under the open economy assumption. In the high income region, the capital stock slowly rises until about 2025 but then declines through 2070, in the closed economy case. When an open, large economy model is used, however, the capital stock continues to rise in the high income region from 2015 to 2070.

In Japan, capital falls under both closed and open economy cases. However, the rate of decline is much smaller in the open economy case. The increase in longevity increase the life cycle saving motive to provide old age consumption for a longer period of retirement. The sharp decline in the fraction of working age population, on the other hand, decreases the relative share of ‘savers’ and as a result capital decumulates throughout the 2015-2070 period.
When there two secular trends are combined in the capital out ratio, the differences in capital accumulation between the closed versus open economy cases translate into sharp differences in the transition paths in the capital labor ratios. Figure 6 shows that the capital labor ratios are predicted to rise in all regions in the open economy case.

When we view these three regions using a closed economy model, we see a similar pattern for the middle income region, but very different paths for the high income region and Japan. In particular, the capital labor ratio falls in the HI region around 2030 and in Japan around 2040. Clearly, the impact on factor prices in the open economy case will be different than those in the closed economy case.
Figure 7 shows the returns to capital in the three regions in the closed and open economy cases. In the HI region under the closed economy assumption, the interest rate is fairly flat; it starts at about 3.3%, declines very slightly and then gradually goes up to a similar level in 2070 at 3.2%. In the MI region in the closed economy case, the interest rate monotonically falls from 5.1% in 2015 to 0.8% in 2070. In Japan, the closed economy interest rate is rather flat, similar to that in the HI region, but at a much lower level; it starts at 1.6% and ends at 1.8%. In the open economy case, the world interest rate starts at 4.2% and falls monotonically to 1.3% by 2070.
Figure 8 shows the wage rates in the three regions under closed and open economy transition paths. In the closed economy transitions, the only region that enjoys rising wages is the MI region. Wages are flat for about 15 years in the HI region until 2030 and then they fall throughout the prediction period. In Japan, wages are falling continually from 2015 to 2070. In open economy transition, wages are rising, although at different rates, in all three regions, similar to the uniform increase in the capital labor ratio in the three regions.

We now look at the magnitude of adjustments undertaken in these three regions to maintain fiscal sustainability in the future. In our baseline results, we assumed that the labor income tax is used to satisfy government budgets, holding the initial debt to output ratios constant. Figure 9 shows the time paths of labor income tax rates that maintain fiscal sustainability in these regions in the closed and open economy transitions.
In the MI region, there seems to be little difference in this tax rate between the closed and open economy transitions. The maximal tax rate is about 51.5% (in 2125, not shown in the figure) in either case.

For the HI region and Japan, however, the tax rate is different between the closed and open economy scenarios. In particular, the fiscal adjustment as measured by the labor income tax rate is smaller, by about 5.5 percentage points, in the open economy transition compared to the tax rate in the closed economy scenario. This is true for both HI and Japan and it is a result of having a relatively much larger tax base in the open economy transition.
In our open economy transitions, capital is freely mobile across regions and facilitate the smoothing of lifetime consumption of individuals in national economies or regions. Figure 10 shows the time paths of current accounts in the three regions in the open economy transition. The transition is characterized with persistent current account surpluses in the middle income region where as in the high income region and Japan there are current account deficits. Put differently, capital flows from Japan and high income region to the economies in the middle income region. The main drivers seem to be the higher TFP growth rate in the middle income economies and the relatively faster aging in Japan and the high income region that contribute to the capital flows to the middle income region.

In order to understand the sources of the trends in the current account balances, consider the time paths of domestic investment and national saving in Japan.
Figure 11: Investment and Saving in Japan (Closed)

Figure 11 shows the time path of national saving and domestic investment in Japan in the closed economy transition. As they are equal in a closed economy, the curves coincide with the current account at zero by construction. Note that national saving falls throughout the 2015-2100 period. There are two main reasons for this. First, the increase in the labor income tax rate to achieve fiscal sustainability forces individuals of all ages to consume and save less over time. As a result, total national saving falls over time.
Figure 12 shows the paths of national saving and investment as a share of output in the open economy transition. National saving declines similar to the case of the closed economy but the fall in domestic investment is slower as foreign capital starts to flow in.
Figure 13 combines the saving and investment behavior as a percentage of GDP. According to our numerical results, Japan will soon start running current account deficits primarily due to the decline in national saving.

Figure 14: External Wealth

Figure 14 shows the time path of external wealth owned by these regions. Given the time path of current account or capital flows, net foreign ownership of capital changes ‘regions’ around 2040. The HI region starts as a net lender region but becomes a net borrower region prior to 2040, with the MI region changing from a net borrower to a net lender region. Japan, on the other hand, gradually reduces its foreign wealth and eventually turns into a net borrower.
Figure 15 displays output in Japan in the closed and open economy transitions. Although output (measured as GDP) falls in both cases, the decrease is slower in the open economy case because capital inflows help produce more output than otherwise.
Figure 16 shows the age-asset profile in Japan for a few selected years. With the decline in the working age population and higher taxation to achieve fiscal sustainability, our model predicts a shrinkage of the asset holdings profiles for future cohorts.

This reduction in asset holdings over the life cycle is still present in the open economy transition but as Figure 17 shows the scale of the profiles is much higher in the case. This is in part due to the higher capital stock due to openness and in part due to the higher world interest rates compared to the very low rates in the closed economy transition. Note that even the 2045 profile in the open economy case is higher than the 2015 under the closed economy transition.
Figure 18 shows output per person in the three regions under the closed and economy transitions. Typically interpreted as an indicator for living standards, output per person seems to start lower in the open economy transition for the HI region and Japan but it increases from 2015 to 2070, whereas it seems to decline in the closed economy transition. This is especially true for Japan where living standards monotonically fall in the closed economy transition but rise in the open economy transition. The main reason for this is the capital inflows and the corresponding increase in output in Japan.
Figure 19 shows data on Japan’s current account balance as a percentage of GDP during 1980-2015 and the model’s estimates for the same period, as well as model’s projections after 2015. Two version of the current account balance are shown for the 1980-2015 period, one uses the data from the Ministry of Finance and the other relies on the national product account data and implements the Hayashi-Prescott approach. According to Figure 19, Japan’s current account turns negative in 2020 and capital flows are reversed for several decades into the 21st century. This CA balance improves and becomes zero at the end of the century. The main reason for this behavior is the large decline is Japanese national saving starting from 2020 through 2050 while domestic investment peaks in 2050 and is substantially above national saving at this date.\footnote{See Figure 13}
Japan is currently a significant net lender to the rest of the world, with its 2015 net foreign asset position at about 70-80% of GDP, depending on whether you use data from the Ministry of Finance or Japan’s national accounts. The earlier onset of aging and the magnitude of aging in Japan lead to a large decline in national saving and our model predicts a shift in the flow of net assets. The decline in this net foreign asset position starts in 2020 and Japan becomes a net international borrower in 2075 according to our quantitative results.

4.2 Alternative Computations (to be continued)

In this subsection, we will compute equilibrium transition paths under different fiscal policies or counterfactual projections to identify the sources of contributions to our quantitative findings. In particular, we conduct a series of alternative calculations as described below:

- Use a higher consumption tax to achieve fiscal sustainability,
- Conduct a sensitivity analysis regarding the projected fertility and mortality rates in the three regions,
- Assume identical growth in all three regions to isolate the effects of differential aging.
5 Conclusion

TO BE WRITTEN

References


## Computation of the Equilibrium

We describe the computation of the equilibrium in an open economy, where the labor income tax rate in each period is adjusted to achieve the government budget balance. All the other policy variables either remain fixed throughout the transition or move deterministically.

**Step 1:** Compute the initial and final steady-states of the model. Let the transition between the two steady states take $T$ periods, long enough so the economy converges smoothly to the final steady state.

**Step 2:** Guess three $T$-dimensional vectors for the world interest rate, the labor income tax rate, and accidental bequests in each region. The first and last entry of these vectors are the initial and final stationary equilibrium values computed in Step 1.

Given the path for the interest rates, using the property of the constant returns to scale technology and the optimization conditions for the firm, sequences of wages in each region can be derived. the problem of the households can be solved in each region.

**Step 3:** Given prices and the sequence of tax rates and accidental bequests obtained in Step 2, solve households’ problem. Recall the budget constraint of the household at time $t$:

$$(1 + \tau^r_{c,t}) c^r_{j,t} + a^j_{j+1,t+1} = y^r_{j,t} + [1 + (1 - \tau^r_{a,t}) r_t] (a^r_{j,t} + b^r_{j,t}) + p^r_{j,t}. $$

Denote net-of-tax gross interest rate as $$ R^r_t \equiv 1 + (1 - \tau^r_{a,t}) r_t. $$

From the first order condition with respect to asset holdings next period, we obtain

$$ \frac{c_{j+1,t+1}}{c_{j,t}} = \left[ \beta s^r_{j+1,t+1} \frac{1 + \tau^r_{c,t}}{1 + \tau^r_{c,t+1}} R^r_{t+1} \right]^{\frac{1}{\theta}} \equiv g^c_{j+1,t+1}, $$

which is the optimal growth rate of consumption between age $j$ and $j+1$ and between time $t$ and $t+1$. Iterating backward over \ref{eq:16}, we obtain that

$$ c_{j+1,t+j} = c_{1,t} \prod_{k=1}^{j} g^c_{k+1,t+k}. $$

The discounted present value of the total (gross of taxes) lifetime consumption expenditures of the household of age 1 at time $t$ is given as

$$ \bar{c}_{1,t} = c_{1,t} \left[ (1 + \tau^r_{c,t}) + \sum_{j=1}^{J-1} (1 + \tau^r_{c,t+j}) \prod_{k=1}^{j} \frac{s^r_{k+1,t+k+1}}{R^r_{t+k}} g^c_{k+1,t+k+1} \right]. $$

31
In general, the discounted present value of the total (gross of taxes) lifetime consumption expenditures of the household of age \( j^* \) at time \( t \) is

\[
\bar{c}_{j^*,t} = c_{j^*,t} \left[ (1 + \tau_{c,t}) + \sum_{i=j^*}^{J-1} (1 + \tau_{c,t+(i-j^*)+1}) \prod_{k=j^*}^{i} \frac{s_{k+1,t+(k-j^*)+1}}{R_{t+(k-j^*)+1}} y_{k+1,t+(k-j^*)+1} \right].
\]

(18)

Define a variable \( x_{j,t}^r \), as a sum of earnings, pensions and a bequest transfer net of taxes:

\[
x_{j,t}^r = y_{j,t}^r + p_{j,t}^r + R_t b_t^r.
\]

(19)

The discounted present value of the total (net of taxes) lifetime earnings and bequest transfers of a household of age 1 at time \( t \) is:

\[
\bar{x}_{1,t} = x_{1,t}^r + \sum_{j=1}^{J-1} \left( \prod_{k=1}^{j} \frac{s_{k+1,t+k}}{R_{t+k}} \right) x_{j+1,t+j}^r.
\]

(20)

where we are implicitly imposing the initial condition \( a_1 = 0 \). The discounted present value of the total (net of taxes) lifetime earnings of a household of age \( i^* \) at time \( t \) is:

\[
\bar{x}_{i^*,t} = x_{i^*,t}^r + \sum_{j=i^*}^{J-1} \left( \prod_{k=i^*}^{j} \frac{s_{k+1,t+(k-i^*)+1}}{R_{t+(k-i^*)+1}} \right) x_{j+1,t+(j-i^*)+1}^r + R_t a_{i^*,t}.
\]

(21)

Since individual optimization requires \( \bar{c}_{j^*,t} = \bar{x}_{j^*,t} \) for each age \( j^* \) and time \( t \), from (18) and (21), we obtain \( c_{j^*,t} \) as

\[
c_{j^*,t} = \frac{\bar{x}_{j^*,t}}{\left[ (1 + \tau_{c,t}) + \sum_{i=j^*}^{J-1} (1 + \tau_{c,t+(i-j^*)+1}) \prod_{k=j^*}^{i} \frac{s_{k+1,t+(k-j^*)+1}}{R_{t+(k-j^*)+1}} y_{k+1,t+(k-j^*)+1} \right]}.
\]

Note that \( a_{j^*,t} \) in equation (21) is computed residually from \( c_{j^*-1,t-1} \) and the budget constraint (3):

\[
a_{j^*,t} = x_{j^*-1,t-1}^r + R_{t-1} a_{j^*-1,t-1} - (1 + \tau_{c,t-1}) c_{j^*-1,t-1}.
\]

Step 4: Aggregating asset holdings of all age groups and using equation (10) for each region, we obtain the implied sequence for external wealth of the region \( X_t^r \). Together with the world capital market clearing condition (3), we arrive at a new guess for the sequence of the world interest rate. We use the government budget constraints (6) in each region with price sequences to update our guess for the tax rate. From the life-cycle asset decisions, we compute the accidental bequests left by the deceased in each region to update the guess for the bequests in the next iteration. If convergence is not reached, we restart from Step 3 with the new vector of guesses.
## B Summary of calibration targets

This section provides further details on the data used in the model calibration. Table B.1 reports a summary by region of the indicators used as targets in calibrating the model. Table B.2 presents a description of the macro data used and a short explanation of how calibration targets were computed; the sample period over which the statistics are calculated is also reported.

### Table B.1: Summary of calibration targets

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Target</th>
<th>Period</th>
<th>Value by region</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Preferences and endowments</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta$</td>
<td>Subj. discount factor</td>
<td>Interest rate in Japan, %</td>
<td>1990</td>
<td>4</td>
</tr>
<tr>
<td><strong>Production technology</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$Z_0^p$</td>
<td>TFP level (initial)</td>
<td>GDP per capita level, $</td>
<td>2015</td>
<td>40,763 45,373 12,696</td>
</tr>
<tr>
<td>$\lambda_t^p$</td>
<td>TFP growth rate</td>
<td>GDP per capita growth, %</td>
<td>1990-2015</td>
<td>1.1 1.4 3.9</td>
</tr>
<tr>
<td><strong>Government</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$D_t/Y_t$</td>
<td>Debt to GDP ratio</td>
<td>General gov. net debt to GDP, %</td>
<td>1990-2015</td>
<td>100a 50.9 30.7</td>
</tr>
<tr>
<td>$G_t/Y_t$</td>
<td>Gov. purch. to GDP ratio</td>
<td>General gov. total expenditure to GDP, %</td>
<td>1990-2015</td>
<td>34.9 41.5 25.2</td>
</tr>
<tr>
<td>$\kappa_t^r$</td>
<td>Pension replacement rate</td>
<td>Net replacement rate, coverage adjusted</td>
<td>2014</td>
<td>38.5 47.8 26.8</td>
</tr>
<tr>
<td>$\tau_a^c$</td>
<td>Capital income tax</td>
<td>Avg. eff. capital income tax, %</td>
<td>2000-2014</td>
<td>34.7 34.1 18.8</td>
</tr>
<tr>
<td>$\tau_c^t$</td>
<td>Consumption tax</td>
<td>Avg. eff. consumption tax, %</td>
<td>2000-2014</td>
<td>3 – 8b 10.9 12.7</td>
</tr>
</tbody>
</table>

Notes:  
- a,b See text for details on how targets were set;  
- c High Income (HI): United States, Canada, Europe (UE 28), Australia, New Zealand; Middle Income (MI): China, Hong-Kong, Taiwan, South Korea, Singapore, Thailand, Indonesia, Malaysia, Philippines, Vietnam, India, Saudi Arabia, United Arab Emirates, Turkey, Russia and South Africa.
<table>
<thead>
<tr>
<th>Indicator</th>
<th>Period</th>
<th>Description</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP per-capita (PPP, current international $)</td>
<td>2015</td>
<td>Gross domestic product divided by midyear population and converted to international dollars using purchasing power parity exchange rates. The target indicator by region is computed as a cross-country weighted mean, using GDP at current PPPs for weighting.</td>
<td>World Bank World Development Indicators (2017)</td>
</tr>
<tr>
<td>GDP per-capita growth (%)</td>
<td>1990-2015</td>
<td>The annual growth rate of GDP per-capita is calculated from GDP per-capita measured in constant local currency. The target indicator by region is a time average of the cross-country weighted mean. GDP at constant 2010 US$ is used for weighting.</td>
<td>World Bank World Development Indicators (2017)</td>
</tr>
<tr>
<td>General government total expenditure (% GDP)</td>
<td>1990-2015</td>
<td>Total spending of general government includes expenditures incurred by the central, state and local government, and social security funds. Total expenditure comprises current outlays, including interest payments on government debt and social transfers, and net investment in non-financial assets. The target total expenditure to GDP ratio by region is a time average of the cross-country weighted mean. GDP at constant 2010 US$ is used for within-region weighting.</td>
<td>IMF World Economic Outlook (2017)</td>
</tr>
<tr>
<td>General government net debt (% GDP)</td>
<td>1990-2015</td>
<td>Net debt of general government is given by gross debt minus financial assets corresponding to debt instruments (monetary gold and SDRs, currency and deposits, etc.). The target net debt to GDP ratio by region is a time average of the cross-country weighted mean. GDP at constant 2010 US$ is used for within-region weighting.</td>
<td>IMF World Economic Outlook (2017)</td>
</tr>
<tr>
<td>Capital income tax rate (%)</td>
<td>2000-2014</td>
<td>Average effective tax rate computed following the method by Mendoza, Razin and Tesar (1994). Tax revenue data and national account aggregates available from various sources. The target indicator by region is a time average of the cross-country weighted mean. GDP at constant 2010 US$ is used for within-region weighting.</td>
<td>OECD Revenue Statistics (2017), OECD National Accounts Statistics (2017), UN National Accounts Statistics (2017)</td>
</tr>
<tr>
<td>Consumption tax rate (%)</td>
<td>2000-2014</td>
<td>Average effective tax rate computed following the method by Mendoza, Razin and Tesar (1994). Tax revenue data and national account aggregates available from various sources. The target indicator by region is a time average of the cross-country weighted mean. GDP at constant 2010 US$ is used for within-region weighting.</td>
<td>OECD Revenue Statistics (2017), OECD National Accounts Statistics (2017), UN National Accounts Statistics (2017)</td>
</tr>
<tr>
<td>Net replacement rate, coverage adjusted (%)</td>
<td>2014</td>
<td>The net replacement rate (NRR) is given by net pension entitlements divided by net pre-retirement lifetime earnings, thus accounting for individual income tax and social contributions (for a mean male earner). The adjustment for coverage is done by multiplying the NRR by active coverage (defined as the number of contributors to the social security system divided by labor force). GDP at current PPPs is used for within-region weighting.</td>
<td>OECD Pensions at a Glance (2014), World Bank Pensions Database (2014)</td>
</tr>
<tr>
<td>Pension retirement age</td>
<td>2013</td>
<td>It is the statutory retirement age (mean of females and males if they differ) at which people eligible to old-age pension start receiving benefits. Total population is used for within-region weighting.</td>
<td>World Bank Pensions Database (2014)</td>
</tr>
<tr>
<td>Indicator</td>
<td>Period</td>
<td>Description</td>
<td>Sources</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>----------------------------------------------</td>
</tr>
<tr>
<td>Total population by age groups</td>
<td>1990-2100</td>
<td>Historical data and projections (medium variant). Total population is used for within region weighting.</td>
<td>UN World Population Prospects (Rev. 2015)</td>
</tr>
<tr>
<td>Age-specific fertility rate</td>
<td>1990-2100</td>
<td>The age-specific fertility rate is the number of births to women in a particular age group divided by the number of women in that group. Historical data and projections (medium variant). Total population is used for within-region weighting.</td>
<td>UN World Population Prospects (Rev. 2015)</td>
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