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Abstract

This paper investigates the role of foreign direct investment (FDI) in accounting for the long-term trend of capital flows under demographic changes. For this purpose, we incorporate horizontal FDI under the proximity-concentration trade-off into a two-country DSGE model and conduct a quantitative analysis using long-term Japanese data for capital flows since the 1960s. The quantitative analysis finds that the transition dynamics solely driven by demographic changes well account for the long-term trend of capital flows and that multinational firms' endogenous decision on FDI in response to population aging is key to explaining the long-term trend.

Keywords: Capital flows; Demographic changes; Foreign direct investment (FDI)
JEL classification: F12, F23, F32

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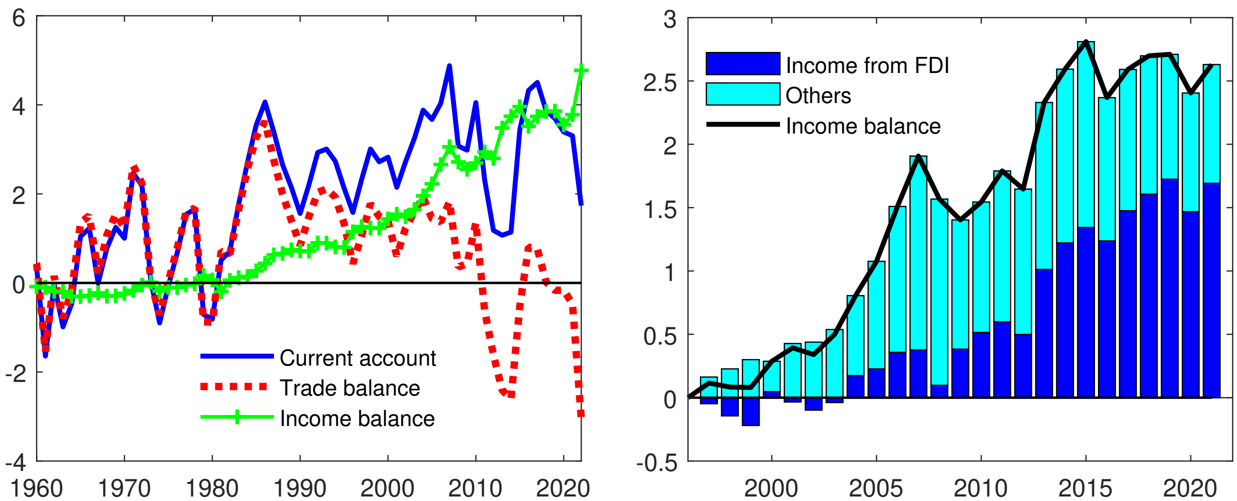
1 Introduction

Foreign direct investment (FDI) is characterized by two distinct but closely related aspects. First, FDI is a main channel of international capital flows, along with foreign portfolio investment (FPI). Particularly, FDI accounts for a substantial share of the long-term trend of capital flows in many countries. Second, on the production side, FDI is a main tool for multinational firms to capture foreign demands. These two aspects of FDI can be interpreted as two sides of the same coin, as capital flows associated with FDI aim at financing multinational firms' production in foreign countries. Hence, modeling multinational firms' decisions on FDI is key to understanding the long-term trend of international capital flows, as well as the resultant sectoral savings in the Flow of Funds.

In this paper, we investigate the role of FDI as a capital flow channel by incorporating horizontal FDI under the proximity-concentration trade-off à la Helpman et al. (2004) into a two-country DSGE model. Although the importance of FDI in accounting for capital flows has been long recognized in the empirical literature, quantitative analysis focusing on the role of FDI as a capital flow channel is novel. In the open economy macroeconomics literature, on the one hand, most previous studies do not distinguish FDI from other capital flows and discuss the dynamics of capital flows by assuming only one type of aggregate capital. On the other hand, in the international trade literature, most previous studies do not refer to FDI as a capital flow channel but investigate FDI only as multinational production. Hence, this paper's theoretical contribution is to bridge the gap between them by modeling the dual aspect of FDI, i.e., capital flows and multinational production, in a unified framework. Namely, in our model, households and firms accumulate domestic and foreign capital as in a standard open-economy macroeconomic model; however, in contrast to previous studies, the model assumes that there exist two forms of foreign assets, FPI (riskless bonds) and FDI, and that heterogeneous firms with respect to their productivity choose between exports and FDI under the proximity-concentration trade-off.

Our motivation to investigate the role of FDI as a capital flow channel is based on the Japanese experiences for the last six decades. The left panel in figure 1 shows the substantial changes in the Japanese current account and its composition, i.e., trade and income balance, since the 1960s. It indicates that the income balance surplus (the green line with x-marks) has significantly increased recently, along with the decline in trade balance

Figure 1: Current account in Japan



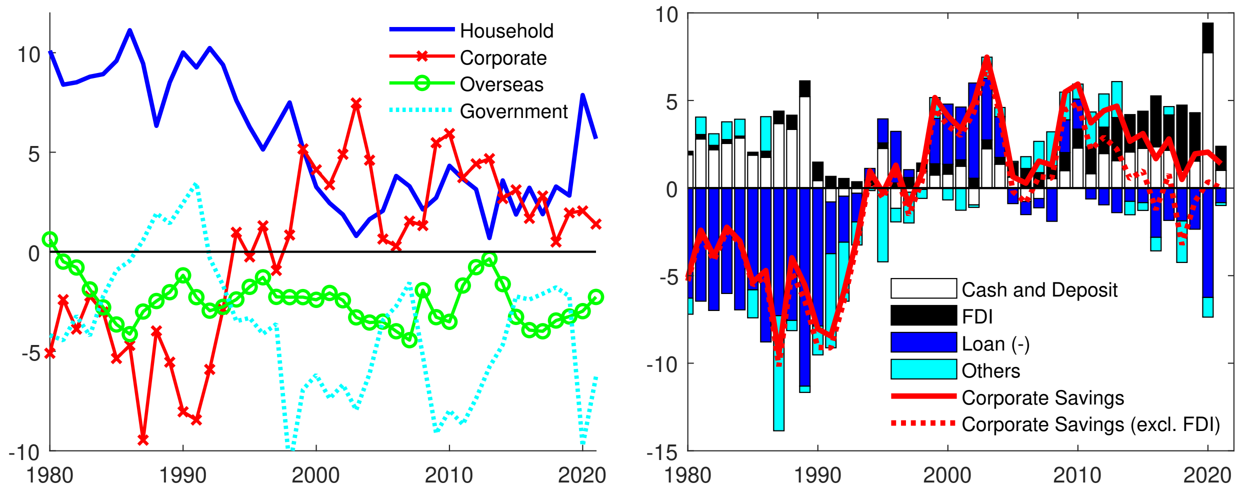
Note: The left panel shows the Japanese current account and its composition, i.e., trade and income balance, since the 1960s. The right panel shows changes in the ratios of income balance surplus to nominal GDP since 1996. The income from FPI includes those from all types of investment other than FDI. The share of the income from FDI and FPI is available only from 1996 because their definitions differ between before and after 1996.

Sources: Balance of payments statistics, Bank of Japan

surplus (the red dashed line). Furthermore, as shown in the right panel in figure 1, this recent rise in income balance surplus is mostly explained by increased income from FDI. As a result, FDI also plays a vital role in accounting for sectoral savings in the Flow of Funds. Figure 2 shows that corporate savings have been increasing since around 1990 (the red line with x-marks in the left panel) and that more than half of corporate savings since 2010 is accounted for by an increase in outward FDI (the black bars in the right panel). Specifically, corporate savings in Japan are around zero when excluding FDI from firms' financial assets.

In the quantitative analysis, we compute transition dynamics based on past and future projections of demographics in Japan and examine the role of FDI through a counterfactual simulation for FDI openness. Based on previous studies, we choose demographic changes as the sole driver for international capital flows in our quantitative analysis. The previous studies demonstrate that the long-run trend of international capital flows is primarily accounted for by demographic changes, rather than other factors such as productivity

Figure 2: Sectoral saving in Japan



Note: The left panel shows sectoral savings in the Flow of Funds in Japan since 1980. The right panel decomposes the corporate savings into FDI (the black bars) and other major components.

Source: Flow of Funds, Bank of Japan

growth or fiscal policy, and emphasize that the share of the working-age population has particularly crucial effects on capital flows through labor supply. While Japan is a leading example of such rapid demographic changes, population aging is becoming one of the most important long-term economic challenges in many advanced and Asian emerging market economies, particularly China. Hence, the Japanese experience with the effects of demographic changes on capital flows should have implications for those other countries that are expected to face such challenges in the future.

The main results of the quantitative analysis are summarized as follows. First, the long-run trend of the current account, including its composition, i.e., trade and income balance, and the composition of sectoral savings, can be fairly well accounted for solely by demographic changes. The consumption and savings behavior of households to smooth consumption is key to understanding these results. Specifically, in anticipation of population aging, households accumulate a part of their capital as foreign assets, resulting in the large trade surplus and the high household savings rate observed in Japan until the 1990s. Nevertheless, once the working-age population started to decrease in around 2000, they saved less and relied more on the returns on foreign assets, making the model consistent with the recent decrease and increase in trade and income balance surplus, as well as the decline in the household savings rate. The forecasting path based on population projection indicates that those trends will continue and that trade and income balance surplus will reach around -5% and 5% of GDP in 2050, respectively. Interestingly, those simulation results for the past and future developments in capital flows in Japan are consistent with the well-known "stages-of-the-balance-of-payments hypothesis," implying that demographic changes may be one of the driving forces to explain the hypothesis.

Second, we find that multinational firms' endogenous decisions on FDI play a crucial role in explaining the dynamics of the current account, particularly its composition, under demographic changes. In our model, a decline in the working-age population raises domestic labor costs, thus encouraging productive firms to produce more in foreign countries through FDI rather than export. Thus, due to the endogenous choice between exports and FDI, the trade balance surplus has substantially declined, while the income balance has increased. Quantitatively, the baseline simulation driven only by demographics accounts for around half of the recent rise in outward FDI in Japan. On the other hand, when we do not incorporate such an endogenous choice between exports and FDI as in a standard international trade model, productive firms would do their business abroad only through exports, even in the face of the decline in the working-age population; therefore, the model without FDI cannot replicate the rise in income balance surplus observed in Japan.

Literature Review In the previous literature, while the difference between FDI and FPI has been intensively examined in light of, for instance, information asymmetricity or institutions (e.g., Albuquerque, 2003; Goldstein and Razin, 2006; Daude and Fratzscher, 2008), most studies in the open economy macroeconomics literature ignore the difference between them. Notable exceptions are McGrattan and Prescott (2009, 2010) and McGrattan (2012), which distinguish FDI from other types of capital to investigate the welfare gain from FDI openness or the effects of intangible assets on FDI returns of the U.S. multinational firms. Also, Russ (2004) incorporates FDI into a two-country DSGE model with money to investigate the relationship between FDI and exchange rate volatility. Those studies, however, do not take into account the recent advances in the international trade literature, including the proximity-concentration trade-off between export and horizontal FDI as investigated in, for example, Brainard (1997), Markusen and Venables (2000) and Helpman et al. (2004). To the best of our knowledge, our paper is the first study to introduce the choice between exports and horizontal FDI by heterogeneous firms under the proximity-concentration trade-off into a DSGE model. In so doing, our paper is highly indebted to the methodology for aggregation proposed by Ghironi and Melitz (2005), which incorporates the entry decision to export markets by heterogeneous firms into a DSGE model. Our paper also contributes to the literature on the relationship between demographics and capital flows. While our quantitative result is not new but in line with previous studies emphasizing the importance of demographics, such as Domeij and Floden (2006), Krueger and Ludwig (2007), Ferrero (2010), Backus et al. (2014) and Sposi (2019), none of the previous studies focus on the role of FDI. Finally, our paper sheds new light on the literature about the rise in global corporate savings (e.g., Chen et al., 2017). While the literature points out numerous factors contributing to the recent rise in corporate savings, our quantitative exercise implies that an increase in foreign asset accumulation by non-financial firms through FDI can be added to the list of those factors, at least in Japan.

The rest of the paper is organized as follows. In Section 2, we formulate our model. Section 3 conducts a quantitative analysis focusing on the Japanese economy. Concluding remarks are given in Section 4.

2 Model

The economy consists of two countries, home and foreign. An asterisk denotes foreign variables. The model structure is a kind of mixture of standard models in open-economy macroeconomics and international trade. Namely, households accumulate domestic and foreign capital as in a standard open-economy macroeconomic model; however, in contrast to previous studies, the model assumes that there exist two forms of foreign assets, FPI (riskless bonds) and FDI, and that heterogeneous firms concerning their productivity choose between exports and FDI under the proximity-concentration trade-off as in Helpman et al. (2004). In what follows, we first describe optimization in both a final goods firm and an intermediate goods firm and then characterize the household's behavior and aggregate dynamics.

2.1 Final Goods Firm

The representative final goods firm in the home country produces the final good, Y_t, by aggregating the intermediate goods, $y_t(\omega)$, using the CES aggregator:

$$Y_t = \left(\int_{\omega \in \Omega_t} y_t(\omega)^{\frac{\theta-1}{\theta}} d\omega \right)^{\frac{\theta}{\theta-1}},$$

where θ is the elasticity of substitution and Ω_t is the set of available intermediate goods in the home country in period t. Let $p_t(\omega)$ be the price of each intermediate good. The price index in the home country, P_t, is defined as:

$$P_t = \left(\int_{\omega \in \Omega_t} p_t(\omega)^{1-\theta} d\omega \right)^{\frac{1}{1-\theta}},$$

and the demand for each intermediate good is derived as a result of profit maximization of the representative final goods firm:

$$y_t(\omega) = \left(\frac{p_t(\omega)}{P_t} \right)^{-\theta} Y_t. \tag{1}$$

The price index and the demand for each intermediate good in the foreign country, P_t^* and $y_t^*(\omega)$, are defined similarly. Note, however, that the set of available intermediate goods in the home and foreign country are not necessarily the same, i.e., $\Omega_t \neq \Omega_t^*$.

2.2 Intermediate Goods Firm in Domestic Market

There is a continuum of intermediate goods firms in each country. They are different with respect to the intermediate goods they produce, $\omega \in \Omega$, and their productivity, $z(\omega)$. In the home country, the intermediate goods firms produce using labor, l, and capital, k, according to the following Cobb–Douglas technology:

$$y_t(\omega) = z(\omega) k_t(\omega)^{\alpha} l_t(\omega)^{1-\alpha}, \tag{2}$$

where α is the capital share. We assume that the firms' idiosyncratic productivity, z, is constant over time as in Melitz (2003). The maximization problem for the intermediate goods firms is:

$$\max \ \frac{p_t(\omega)}{P_t} y_t(\omega) - w_t l_t(\omega) - r_{k,t} k_t(\omega), \tag{3}$$

subject to (1) and (2). w_t and $r_{k,t}$ are the real wage rate and the real rental rate of capital in the home country at period t. Hereafter, each firm's optimized policy is characterized as a function of idiosyncratic productivity z because the intermediate goods firms are heterogeneous with respect only to z and symmetric for all other aspects.

As a consequence of the above optimization problem, the intermediate goods firms charge a price that includes a proportional markup, $\theta/(\theta-1)$, over their effective marginal cost. Let $p_t(z)$ be the price charged by the intermediate goods firms with productivity z. Then, the intermediate goods price relative to the price index is given by:

$$\rho_t(z) \equiv \frac{p_t(z)}{P_t} = \frac{\theta}{\theta - 1} \frac{\lambda_t}{z},$$

where λ_t is the marginal cost of production, which is defined by:

$$\lambda_t \equiv \frac{r_{k,t}^{\alpha} w_t^{1-\alpha}}{\alpha^{\alpha}(1-\alpha)^{1-\alpha}}.$$

Furthermore, the demand for capital and labor is given by:

$$k_t(z) = \frac{\alpha}{r_{k,t}} \left(1 - \frac{1}{\theta}\right) \rho_t(z)^{1-\theta} Y_t$$

and

$$l_t(z) = \frac{1-\alpha}{w_t} \left(1 - \frac{1}{\theta}\right) \rho_t(z)^{1-\theta} Y_t.$$

Finally, the profit of the intermediate goods firms becomes:

$$d_t(z) = \frac{1}{\theta} \rho_t(z)^{1-\theta} Y_t.$$

The profit of the intermediate goods firms is distributed to the stockholders.

In the foreign country, we can describe the behavior of intermediate goods firms in the same manner. We can similarly derive their price, $\rho_t^*(z)$, demand for capital and labor, $k_t^*(z)$ and $l_t^*(z)$, and profit, $d_t^*(z)$.

2.3 Export and Foreign Direct Investment

The intermediate goods firms can do business in the other country in addition to their own country. In so doing, there are two ways: export or FDI. The intermediate goods firms would be involved in exporting (or FDI) if the expected profit from export (or FDI) is positive. In what follows, we will describe the entry decision for the exporting and FDI market. While we mainly focus on the decisions by intermediate goods firms in the home country, those in the foreign country are described similarly.

Export and FDI are different in terms of cost structure and hiring. When the intermediate goods firms export, they need to pay a fixed cost, f_X. The fixed cost is measured by effective labor in their own country, $w_t f_X$, in real terms. In addition, exporting their products to the other country requires an iceberg-type trade cost, τ. When the intermediate goods firms conduct FDI, on the other hand, they only need to pay a fixed cost f_I. While they do not need to pay any variable costs to carry out FDI, the fixed cost for FDI is assumed to be larger than that for exporting (i.e., $f_X < f_I$) as in Helpman et al. (2004) to capture the proximity-concentration trade-off. In addition to the difference in the cost structure, export and FDI are different in terms of labor cost. The exporting firms in the home country hire their workers in the home country, while the FDI firms in the home country hire their workers in the other country. Therefore, the FDI firms' production function is characterized by $y_t(\omega) = z k_t^{\alpha} l_t^{*1-\alpha}$, and their labor cost as well as the fixed cost are measured by the wage rate in the foreign country, w_t^*.

Under these assumptions, we can derive prices, labor demand, capital demand, and profits for the exporting and FDI firms. Hereafter, variables for the exporting and FDI firms are denoted by the subscripts X and I, respectively. Let $p_{X,t}(z)$ and $p_{I,t}(z)$ be the prices charged by the exporting and FDI firms with productivity z. Then, the prices charged by the exporting and FDI firms relative to the price index in the other country, P_t^*, are given by:

$$\rho_{X,t}(z) \equiv \frac{p_{X,t}(z)}{P_t^*} = \frac{\tau}{Q_t}\frac{\theta}{\theta-1}\frac{\lambda_{X,t}}{z} \quad \text{and} \quad \rho_{I,t}(z) \equiv \frac{p_{I,t}(z)}{P_t^*} = \frac{\theta}{\theta-1}\frac{\lambda_{I,t}}{z},$$

where Q_t is the real exchange rate based on the price indices. While the marginal cost for exporting firms is the same as that of the domestic firms (i.e., $\lambda_{X,t} = \lambda_t$), the marginal cost of FDI firms is different from that for domestic and exporting firms because they have to hire their workers in the foreign country and because the return from FDI should consider exchange rate changes. That is, the marginal cost for the FDI firm in the home country is defined by:

$$\lambda_{I,t} \equiv \frac{r_{k,I,t}^{\alpha} w_t^{*1-\alpha}}{\alpha^{\alpha}(1-\alpha)^{1-\alpha}},$$

where $r_{k,I,t}$ is the rental rate of capital for FDI firms. The capital demand of exporting and FDI firms is:

$$k_{X,t}(z) = \frac{Q_t \alpha}{r_{k,t}} \left(1 - \frac{1}{\theta}\right) \rho_{X,t}(z)^{1-\theta} Y_t^* \quad \text{and} \quad k_{I,t}(z) = \frac{\alpha}{r_{k,I,t}} \left(1 - \frac{1}{\theta}\right) \rho_{I,t}(z)^{1-\theta} Y_t^*.$$

Note that the capital demand is driven by the aggregate demand in the foreign country, Y_t^*, rather than that in the home country. As for the labor demand of exporting and FDI firms, they must hire labor for production as well as for operational fixed costs. Thus, the labor demand for exporting and FDI firms is given by:

$$l_{X,t}(z) = \frac{Q_t(1-\alpha)}{w_t} \left(1 - \frac{1}{\theta}\right) \rho_{X,t}(z)^{1-\theta} Y_t^* + f_X$$

and

$$l_{I,t}(z) = \frac{1-\alpha}{w_t^*} \left(1 - \frac{1}{\theta}\right) \rho_{I,t}(z)^{1-\theta} Y_t^* + f_I.$$

Note that the FDI firms pay their labor cost based on the foreign country's wage rate, w_t^*. Finally, the profit of the exporting and FDI firm becomes:

$$d_{X,t}(z) = \frac{Q_t}{\theta} \rho_{X,t}(z)^{1-\theta} Y_t^* - w_t f_X \quad \text{and} \quad d_{I,t}(z) = \frac{1}{\theta} \rho_{I,t}(z)^{1-\theta} Y_t^* - w_t^* f_I.$$

As mentioned before, the intermediate goods firms would enter the exporting market or the FDI market if their profit was positive. That is, the intermediate goods firms would enter: (i) the exporting market if $d_{X,t} > 0$ and $d_{X,t} > Q_t d_{I,t}$, (ii) the FDI market if $Q_t d_{I,t} > 0$ and $Q_t d_{I,t} > d_{X,t}$, and (iii) neither the exporting nor FDI market otherwise.

Because of the scale economy caused by fixed costs, f_X and f_I, only productive and large firms do business in the other country through export or FDI. Moreover, because of the assumption of $f_I > f_X$, the FDI firms are more productive and larger than the exporting firms, as in Helpman et al. (2004). Let $z_{X,t}$ and $z_{I,t}$ be the thresholds for exporting and FDI. That is, $d_X(z_{X,t}) = 0$ and $d_I(z_{I,t}) = 0$. Then, the intermediate firms' decision is summarized as follows.

$$\begin{cases} \text{Only domestic market} & \textit{if } z \leq z_X \\ \text{Domestic and exporting market} & \textit{if } z_X < z \leq z_I \\ \text{Domestic and FDI market} & \textit{if } z > z_I \end{cases}$$

2.4 Aggregation

The aggregation of the firm sector is not trivial because intermediate goods firms are heterogeneous with respect to their productivity z. Here, to make the model tractable enough to conduct a quantitative exercise, we follow Ghironi and Melitz (2005) to aggregate the firm sector. First, the productivity distribution of the intermediate goods firms is assumed to be Pareto distributed with lower bound z_{min} and shape parameter $\kappa > \theta - 1$, i.e., $G(z) = 1 - (z_{min}/z)^{\kappa}$. Let the total mass of intermediate goods firms be N_t. Then, the fraction of intermediate firms that enter the exporting market and FDI market is:

$$\frac{N_{X,t}}{N_t} = \left(\frac{z_{min}}{z_X}\right)^{\kappa} - \left(\frac{z_{min}}{z_{I,t}}\right)^{\kappa} \qquad \text{and} \qquad \frac{N_{I,t}}{N_t} = \left(\frac{z_{min}}{z_{I,t}}\right)^{\kappa},$$

where N_X and N_I are the mass of exporting and FDI firms, respectively. Next, we define a kind of average productivity, $\tilde{z}$ as follows:

$$\tilde{z} \equiv \left[\int_{z_{min}}^{\infty} z^{\theta-1} dG(z)\right]^{1/(\theta-1)} = \nu z_{min},$$

where $\nu \equiv [\kappa/(\kappa - \theta + 1)]^{1/(\theta-1)}$. Similarly, we define the average productivity for the exporting and FDI firms in period t as follows:

$$\tilde{z}_{X,t} \equiv \nu \left[z_{I,t}^{\theta-1}\left(1 - \left(\frac{z_{I,t}}{z_{X,t}}\right)^{\kappa}\right)^{-1} + z_{X,t}^{\theta-1}\left(1 - \left(\frac{z_{X,t}}{z_{I,t}}\right)^{\kappa}\right)^{-1}\right]^{\frac{1}{\theta-1}} \qquad \text{and} \qquad \tilde{z}_{I,t} \equiv \nu z_{I,t}.$$

As in Melitz (2003) and Ghironi and Melitz (2005), the average productivity is sufficient statistics that summarize all information regarding the productivity distribution. Hence, the economy can be aggregated as if there exist N_t intermediate goods firms with productivity $\tilde{z}$. Furthermore, the exporting and FDI markets can be considered as if there exist N_X firms with productivity $\tilde{z}_X$ in the exporting market and N_I firms with productivity $\tilde{z}_I$

in the FDI market, respectively. Hereafter, we denote the average for any variables, x, as follows:

$$\tilde{x}_t \equiv x_t(\tilde{z}), \quad \tilde{x}_{X,t} \equiv x_{X,t}(\tilde{z}_{X,t}) \text{ and } \tilde{x}_{I,t} \equiv x_{I,t}(\tilde{z}_{I,t}).$$

For example, the average prices are defined by: $\tilde{p}_t \equiv p_t(\tilde{z})$, $\tilde{p}_{X,t} \equiv p_X(\tilde{z}_{X,t})$ and $\tilde{p}_{I,t} \equiv p_I(\tilde{z}_{I,t})$.

Given these average productivities, the price index is redefined. It is easily shown that $P_t = \left[N_t(\tilde{p}_t)^{1-\theta} + N^*_{X,t}(\tilde{p}^*_{X,t})^{1-\theta} + N^*_{I,t}(\tilde{p}^*_{I,t})^{1-\theta}\right]^{1/(1-\theta)}$, which is equivalent to:

$$N_t(\tilde{\rho}_t)^{1-\theta} + N^*_{X,t}(\tilde{\rho}^*_{X,t})^{1-\theta} + N^*_{I,t}(\tilde{\rho}^*_{I,t})^{1-\theta} = 1. \tag{4}$$

Note that the price index in the foreign country, P^*_t, can be redefined in the same manner, and the equation corresponding to (4) holds.

Finally, the average dividend, D_t, is defined using these average productivities as:

$$D_t = \tilde{d}_t + \frac{N_{X,t}}{N_t}\tilde{d}_{X,t} + \frac{N_{I,t}}{N_t}Q_t\tilde{d}_{I,t}. \tag{5}$$

In the following subsection, the average dividend will be used for computing the firm value and for deciding whether new entrants enter the economy or not.

2.5 Entry and Exit

The intermediate goods firms actively enter and exit in every period. For their exits, we assume that an exogenous exit shock hits the intermediate goods firms with probability δ in every period. When the exit shock hits them, they let all employees go and sell all capital. For their entry, on the other hand, we assume that the potential entrants endogenously choose to enter the economy if and only if their value is larger than the entry cost. They are assumed to be identical prior to entry, and their initial productivity follows the cumulative distribution function, $G(z)$, which is the same distribution as the productivity distribution of incumbent firms. Thus, the value of new entrants, V_t, is:

$$V_t = \sum_{s=t+1}^{\infty} [\beta(1-\delta)]^{s-t}\frac{\Lambda_s}{\Lambda_t}D_s, \tag{6}$$

where D_s is the average dividend in period s, which is defined in (5), and Λ_t is the aggregate marginal utility of consumption. Note that the value of these entrants is equal to the average value of the incumbent firms because we assume that the productivity of each incumbent firm is constant after the entry. We assume that the new entrants must pay a fixed entry cost, f_E, to enter the economy. As the entry cost is also measured by an effective labor unit, the entrant must pay $w_t f_E$ in real terms to enter the economy. Thus, the new entrants enter the economy if:

$$V_t \geq w_t f_E.$$

We assume that new entry continues until this condition is satisfied with equality.

Let $N_{E,t}$ be the mass of entrants. Then, the law of motion for the mass of intermediate goods firms is:

$$N_t = (1 - \delta)(N_{t-1} + N_{E,t-1}),$$

where $(1 - \delta)$ is the survival rate. As the law of motion indicates, we assume that the exit shock hits the intermediate goods firms after the new entrants enter the economy.

2.6 Household

We assume a representative household in each of the home and foreign countries. While we will mainly describe the household decision in the home country, the same applies to that in the foreign country.

We assume a representative household that consists of M_t members. The representative household inelastically supplies L_t labor units and obtains labor income, $w_t L_t$. In our quantitative simulation, M_t and L_t correspond to the total population and working-age population, respectively. The household can invest in intermediate goods firms in the following three ways. First, the household rents the capital to firms that produce domestically (i.e., domestic or exporting firms), K_t, with a return of $(1 + r_{k,t} - \delta_K)$, where δ_K is the depreciation rate of capital. Second, the household rents the capital to FDI firms, $K_{I,t}$, with a return of $(1 + r_{k,I,t} - \delta_K)$. Investment in capital incurs an investment adjustment cost, $\Phi(K_t, K_{t-1}) \equiv \phi K_{t-1} (K_t/K_{t-1} - 1)^2$. Third, the household invests in intermediate goods firms by financing its setup and obtaining its share, X_t, whose value is V_t defined in (6). As this share of the firm gives an average dividend, D_t, in every period, the representative household obtains $X_t D_t$ dividends in every period.

The household also saves as a form of riskless bonds denominated in the home and foreign currency, B_t and $B_{*,t}$. Then, the representative household's budget constraint is:

$$\begin{aligned} & M_tC_t + K_t + Q_tK_{I,t} + \frac{X_t}{1-\delta}V_t + B_t + Q_tB_{*,t} + \frac{\eta}{2}Q_t(B_{*,t})^2 \\ = \; & w_tL_t + (1+r_{k,t}-\delta_k)K_{t-1} - \Phi(K_t, K_{t-1}) + (1+r_{k,I,t}-\delta_k)Q_tK_{I,t-1} - Q_t\Phi(K_{I,t}, K_{I,t-1}) \\ & + X_{t-1}(D_t + V_t) + (1+r_{t-1})B_{t-1} + (1+r^*_{t-1})Q_tB_{*,t-1} \end{aligned} \tag{7}$$

where r_t and r^*_t are the risk-free rates in the home and foreign countries, respectively, and Q_t is the real exchange rate. We assume that the household needs to pay a tiny cost, η, for holding the riskless foreign bonds as in Ghironi and Melitz (2005). The bond holding cost helps avoid indeterminacy for bond holdings in the steady state and captures the home bias in the household's investment behavior. We will discuss the role of home bias in more detail later.

The household maximizes the discounted sum of utility from consumption subject to the budget constraint. That is, the household's optimization problem is:

$$\max \sum_{t=0}^{\infty} \beta^t M_t \frac{C_t^{1-\gamma}}{1-\gamma}, \tag{8}$$

subject to (7). As a result of this optimization problem, we obtain five Euler equations, each of which is with respect to B_t, B^*_t, K_t, $K_{I,t}$ and X_t:

$$B_t \; : \; 1 = \beta(1+r_t)\frac{\Lambda_{t+1}}{\Lambda_t} \tag{9}$$

$$B_{*,t} \; : \; 1 + \eta B_{*,t} = \beta(1+r^*_t)\frac{\Lambda_{t+1}}{\Lambda_t}\frac{Q_{t+1}}{Q_t} \tag{10}$$

$$K_t \; : \; 1 + \Phi_1(K_t, K_{t-1}) = \beta\frac{\Lambda_{t+1}}{\Lambda_t}[1 + r_{k,t+1} - \delta_K - \Phi_2(K_t, K_{t-1})] \tag{11}$$

$$K_{I,t} \; : \; 1 + \Phi_1(K_{I,t}, K_{I,t-1}) = \beta\frac{\Lambda_{t+1}}{\Lambda_t}\frac{Q_{t+1}}{Q_t}[1 + r_{k,I,t+1} - \delta_K - \Phi_2(K_{I,t}, K_{I,t-1})] \tag{12}$$

$$X_t \; : \; V_t = \beta(1-\delta)\left[\frac{\Lambda_{t+1}}{\Lambda_t}(V_{t+1} + D_{t+1})\right], \tag{13}$$

where $\Lambda_t \equiv C_t^{-\gamma}$ is the marginal utility of consumption in period t. Note that population, M_t, does not show up in the Euler equations because we assume that the representative household maximizes the lifetime utility of the whole family rather than per capita lifetime utility, as indicated by the household preference in (8).[1]

2.7 Market Clearing Conditions

In each country, there are four markets to be cleared in the equilibrium: labor, domestic capital, FDI, and share. The market clearing conditions for these markets are:

$$\text{Labor} \;:\; L_t = N_t\tilde{l}_t + N_{X,t}\tilde{l}_{X,t} + N^*_{I,t}\tilde{l}^*_{I,t} + N_{E,t}f_E \tag{14}$$

$$\text{Domestic capital} \;:\; K_{t-1} = N_t\tilde{k}_t + N_{X,t}\tilde{k}_{X,t} \tag{15}$$

$$\text{FDI} \;:\; K_{I,t-1} = N_{I,t}\tilde{k}_{I,t} \tag{16}$$

$$\text{Share} \;:\; X_t = (1-\delta)(N_t + N_{t,E}) \tag{17}$$

These equations' left-hand sides and right-hand sides are the supply and demand for labor, domestic capital, FDI, and share, respectively. Note that the labor demand for FDI firms is that of foreign FDI firms.

The net supply of riskless bonds in the international bond market must be zero in the equilibrium for both currencies:

$$B_t + B^*_t = 0 \quad \text{and} \quad B_{*,t} + B^*_{*,t} = 0, \tag{18}$$

where B_t and B^*_t are the home bonds held by the home and foreign households, while $B_{*,t}$ and $B^*_{*,t}$ are the foreign bonds held by the home and foreign households.

Note that the capital stock in the home country, $\hat{K}_{t-1}$, which is defined by

$$\hat{K}_{t-1} = N_t\tilde{k}_t + N_{X,t}\tilde{k}_{X,t} + N^*_{I,t}\tilde{k}^*_{I,t}$$

is not equal to the capital owned by the household in the home country, i.e., $\hat{K}_{t-1} \neq K_{t-1} + Q_tK_{I,t-1}$. This is because the household rents the capital to the FDI firms that operate in the foreign country, and the FDI firm's capital is counted as the host country's capital stock. The goods market-clearing condition (i.e., GDP = GDE) is therefore characterized

[1] As is well known, no substantial changes exist between those two assumptions, and the latter assumption just requires some adjustments in algebra.

by using the capital stock, $\hat{K}_t$,

$$Y_t = C_t + \hat{K}_t - (1 - \delta_k)\hat{K}_{t-1}.$$

In equilibrium, the goods market-clearing condition is satisfied by Walras' Law, given the four market-clearing conditions from (14) to (17) and the balance of payments identity below.

2.8 Current Account

The current account in this model CA_t is defined as the sum of trade balance TB_t and income balance IB_t:

$$CA_t \equiv TB_t + IB_t. \tag{19}$$

The trade balance, TB_t, in this model is equal to exports minus imports:

$$TB_t \equiv Q_t N_{X,t} (\tilde{\rho}_{X,t})^{1-\theta} Y_t^* - N_{X,t}^* (\tilde{\rho}_{X,t}^*)^{1-\theta} Y_t. \tag{20}$$

The income balance, IB_t, consists of the net FDI return (= return on the outward FDI minus return on the inward FDI) and the net bond return:

$$\begin{aligned} IB_t \equiv & \underbrace{\left(Q_t r_{t-1}^* B_{*,t-1} - r_{t-1} B_{t-1}^*\right)}_{\text{Net income from foreign bond investment}} \\ & + \underbrace{\left[\tilde{d}_{I,t} Q_t N_{I,t} + (r_{k,I,t} - \delta_K) Q_t N_{I,t} \tilde{k}_{I,t}\right]}_{\text{Return on outward FDI}} - \underbrace{\left[\tilde{d}_{I,t}^* N_{I,t}^* + (r_{k,I,t}^* - \delta_K) N_{I,t}^* \tilde{k}_{I,t}^*\right]}_{\text{Return on inward FDI}} \end{aligned} \tag{21}$$

In equilibrium, changes in net foreign assets must be equal to current account. Let ΔFDI_t and ΔFDI_t^* be the outward and inward FDI flow for the home country. As they are defined in the model by:

$$\Delta FDI_t \equiv Q_t K_{I,t} - Q_t K_{I,t-1} \quad \text{and} \quad \Delta FDI_t^* \equiv K_{I,t}^* - K_{I,t-1}^*,$$

the balance of payments identity, i.e., changes in net foreign assets equal current account CA_t, is formulated by:

$$CA_t = (\Delta FDI_t - \Delta FDI_t^*) + [Q_t(B_{*,t} - B_{*,t-1}) - (B_t^* - B_{t-1}^*)], \tag{22}$$

where the right-hand side represents the change in net foreign assets and the left-hand side is the current account for the home country.

2.9 Sectoral saving

The current account dynamics are intrinsically associated with households and firms' consumption and saving behavior. Since the current account is the net accumulation of foreign assets, the current account CA_t is equal to changes in overseas savings, $-\Delta S_t^O$. Furthermore, market clearing in the savings market implies that $-\Delta S_t^O$ should be financed by household savings S_t^H or corporate savings S_t^C:

$$\begin{aligned} CA_t &= -\Delta S_t^O \\ &= \Delta S_t^H + \Delta S_t^C. \end{aligned} \tag{23}$$

There are no government savings since we do not incorporate the public sector in our model. We will discuss how we map the quantitative results in our model to data in more detail in the next section.

Household saving The household in the home country saves in the form of foreign assets including FDI in addition to domestic assets. As the budget constraint (7) indicates, the household savings ΔS_t^H can be expressed as the sum of domestic capital investment, FDI investment, and net foreign bond investment:

$$\begin{aligned} \Delta S_t^H = & \underbrace{[K_t + (N_t + N_{E,t})V_t] - [K_{t-1} + (N_{t-1} + N_{E,t-1})V_{t-1}]}_{\text{Domestic capital investment}} \\ & + \underbrace{Q_t(K_{I,t} - K_{I,t-1})}_{\Delta FDI_t} + \underbrace{Q_t(B_{*,t} - B_{*,t-1}) - (B_t^* - B_{t-1}^*)}_{\text{Net foreign bond investment}}, \end{aligned} \tag{24}$$

which implies that the household accumulates external assets not only through foreign bond investment but also through outward FDI. Therefore, given the home bias in foreign investment by the household, the outward FDI is an important channel to accumulate external assets.

Corporate saving The corporate saving S_t^C is defined by firms' financial assets minus their financial liabilities. The equations (22), (23), and (24) indicate that changes in corporate saving equal changes in domestic capital investment:

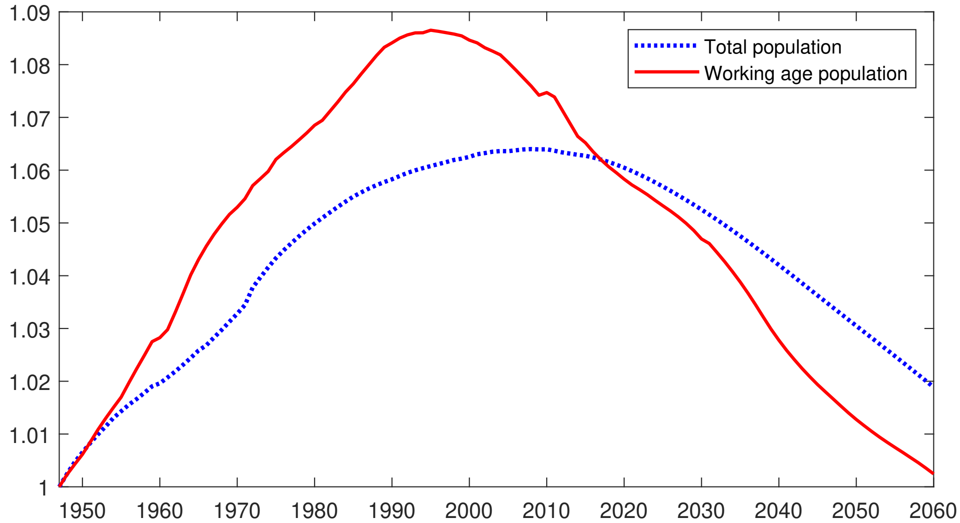
$$\Delta S_t^C = -\left[K_t + (N_t + N_{E,t})V_t + K_{I,t}^*\right] + \left[K_{t-1} + (N_{t-1} + N_{E,t-1})V_{t-1} + K_{I,t-1}^*\right]. \tag{25}$$

Even though FDI is part of corporate financial assets, this result implies that FDI flows do not show up as part of corporate savings. In our model, all financial assets of firms are FDI stocks, and all assets, including FDI stocks, are financed by financial liabilities. Hence, all changes in FDI must be associated with the same amount of changes in financial liabilities, thus making FDI flows neutral to corporate savings. On the other hand, changes in domestic capital investment influence corporate savings because they change financial liabilities without changing financial assets. However, the equation (25) does not mean that firms' FDI motive is irrelevant to corporate savings. Rather, for instance, when firms shift their foreign businesses through export to those through FDI, the equation (25) implies that corporate savings increase.

3 Quantitative Analysis: Case in Japan

This section applies our model to study long-run capital flows and sectoral savings in Japan under demographic changes. In our quantitative analysis, we compute transition dynamics based on the past, and future projections of, demographic changes in Japan and examine the role of FDI in accounting for the transition dynamics of capital flows and sectoral savings. In the transition dynamics, households and firms are assumed to make all decisions under perfect foresight, as future demographic changes are foreseeable to some extent. In the first period, all agents in the model foresee demographic changes and decide the future path of consumption and savings. Therefore, even before population

Figure 3: Total and Working-age Population in Japan (1947=1.0)



Note: The figure shows Japan's total and working-age population from 1947 to the present and their projection up to 2060. The projection is based on the 2019 projection by the National Institute of Population and Social Security Research.

aging occurs, households and firms save or borrow to smooth consumption in anticipation of population aging in the future.

When computing the transition dynamics, we refer to Japan as a home country in the model and use the working-age population as a critical variable reflecting the dramatic demographic changes in Japan. Figure 3 shows Japan's total and working-age population from 1950 to the present and their projection up to 2060. The figure indicates that Japan has faced, and will face, a considerable decrease in the working-age population relative to the total population: The number of the working-age population in Japan significantly increased and reached a level close to 10% higher than the 1950s at the peak in the 1990s, but after peaking out in the 1990s, it has been declining at an unprecedentedly rapid pace and is expected to decline until 2060. In 2060, its level is expected to return to the level in the 1950s. The total population, on the other hand, also shows similar hump-shaped dynamics. Still, the magnitude of its changes is much more moderate than that of the working-age population, implying that the working-age population ratio has considerably changed (and will change) in Japan.

In the quantitative analysis, we input the past, and future projection of, the number of working-age population into the model as an exogenous path of labor endowment L_t and compute the transition dynamics under the perfect foresight assumption. We choose demographics as the sole driver of capital flows in our quantitative exercise because several previous studies that we mention in the introduction demonstrate that the long-run trend of international capital flows is primarily accounted for by demographics rather than other factors, including productivity growth or fiscal policy. In particular, Krueger and Ludwig (2007) uses an overlapping generations model and shows that changes in the working-age population, rather than the total population, strongly influence capital flows through the effects on labor supply.[2] Hence, in our baseline quantitative analysis, we use the working-age population in Japan as a sole driver of capital flows and keep other possibly relevant variables constant throughout the sample periods.[3] Given that it is not feasible for our model to take into account the whole age structure due in part to the complicated model structure with firm heterogeneity, our quantitative approach using the working-age population as an exogenous change in labor endowment is a parsimonious way to capture the essential economic consequences of population aging.

In the following quantitative exercise, we investigate whether the model quantitatively accounts for capital flows in Japan and what the model predicts about the future path of capital flows based on the current projection of population aging. To examine the role of FDI, we compare the simulation results using a baseline model with FDI to those using a model *without* FDI as in a standard open-macroeconomics model. Finally, we touch on the model prediction about sectoral savings in Japan. In what follows, we first calibrate the model parameters and then compute the transition dynamics of capital flows in the face of demographic changes in Japan.

Table 1: Calibration by standard values

Parameter		Value
Discount factor	β	0.96
Elasticity of intertemporal substitution	γ	2.0
Capital share for production	α	0.36
Depreciation rate for capital	δ_k	0.1
Exit rate	δ	0.1
Degree of substitution for goods	θ	4.0
Shape of productivity distribution	κ	4.25
Iceberg cost for exports	τ	1.3

3.1 Calibration

For quantitative analysis, we first calibrate the model parameters. First, we calibrate most parameter values to standard ones. One period in the model is assumed to equal one year, and the discount rate β is then set to 0.96. The parameter for the elasticity of intertemporal substitution γ is set to 2.0. The capital share, the depreciation rate for capital, and the entry rate are set to standard values, $\alpha = 0.36$, $\delta_k = 0.1$, and $\delta = 0.1$, respectively. The parameters for the degree of substitution and the shape of productivity distribution, θ and κ, are set to 4.0 and 4.25 according to Melitz and Redding (2013). As for the trade costs, the iceberg cost for exports is assumed and set to 30%, i.e., $\tau = 1.3$, as in other studies in the international trade literature. Finally, given that the equilibrium does not depend on the values of fixed costs for exports and FDI but on the ratios of those fixed costs to the entry cost, the entry cost, f_E and f_E^*, is normalized to one. Those calibration results are summarized in table 1.

Second, we use indirect inference to calibrate the remaining five parameters, namely, the cost for bond holdings, η, the fixed cost for export in the home and the foreign country, f_X and f_X^*, and the fixed cost for FDI in the home and the foreign country, f_I and f_I^*. Specifically, first, we assume the trade cost is the same in the home and foreign countries,

[2] Imrohoroglu et al. (2006) argue that demographics have little effect on the Japanese savings rate, based on their analysis using a neoclassical growth model. However, given that they incorporate changes in the total population rather than the working-age population, their analysis ignores the age structure and the effects of population aging on labor supply.

[3] In a robustness check in Appendix A, we use total population in Japan and total and working-age population in the U.S. as a proxy for exogenous changes in M_t, L_t^* and M_t^* in the model, and obtain similar results to the baseline case.

Table 2: Calibration by indirect inference

Parameter		With FDI	w/o FDI
Fixed cost for outward FDI	f_I	18.8	N.A.
Fixed cost for inward FDI	f_I^*	324.8	N.A.
Fixed cost for exports	f_X, f_X^*	.636	2.428
Adjustment cost for FPI	η	.0474	.0599

i.e., $f_X = f_X^*$. Then, those key parameters are calibrated to minimize the loss function based on the absolute distance between data and the model-implied values for the current account, trade balance, income balance, and outward and inward FDI stocks relative to GDP in Japan. The loss function for estimation is defined as,

$$\sum_{X_t} \sum_{t=1955}^{2020} \frac{|X_t^{\text{data}} - X_t^{\text{model}}|}{|X_t^{\text{data}}|} \text{ where } X_t \in \left\{ CA_t, TB_t, IB_t, \frac{FDI_t}{Y_t}, \frac{FDI_t^*}{Y_t} \right\}, \tag{26}$$

and we compute f_X, f_I, f_I^*, and η to minimize the loss function in the model with and without FDI. In so doing, we repeatedly compute the model-implied values and minimize the loss function using a standard hill-climbing algorithm.

Table 2 shows that the loss function is minimized by $f_X = .636$, $f_I = 18.8$, $f_I^* = 324.8$ and $\eta = .0474$ for the model with FDI, and $f_X = 2.428$ and $\eta = .0599$ for the model without FDI. There are some notable features. First, the fixed cost for FDI f_I is almost thirty times larger than for exports f_X. While they seem too different at first glance, it is not surprising given that FDI needs tremendous costs for operating businesses in foreign countries. Second, the cost for inward FDI f_I^* is more than ten times larger than that for outward FDI f_I. The very high cost of inward FDI reflects the extremely low level of inward FDI in Japan, as shown later. Third, there is a nontrivial cost for foreign bond holdings η, which implies the existence of home bias in financial investment by households. Moreover, the cost for bond holdings and the fixed cost for export are higher in the model without FDI, as bond investment and export are the only ways to accumulate external assets and do foreign business in the model without FDI, respectively. Even with FDI, since FDI is a restrictive channel for capital flows, the value of η substantially affects the shape of the current account and its components. In particular, as η becomes larger, the economy approaches financial autarky with balanced trade.

4 Simulation Results

This section gives the simulation results of the quantitative exercise. As discussed in more detail below, we obtain the following two takeaways. First, the simulation paths in response to demographic changes can reasonably account for the long-run trend of current account dynamics and its composition, as well as FDI dynamics, in Japan. Second, FDI plays a crucial role in explaining the long-run trend of the current account in Japan, particularly the dynamics of its composition. In what follows, we show our quantitative results in more detail and discuss economic intuitions behind the above two main results.

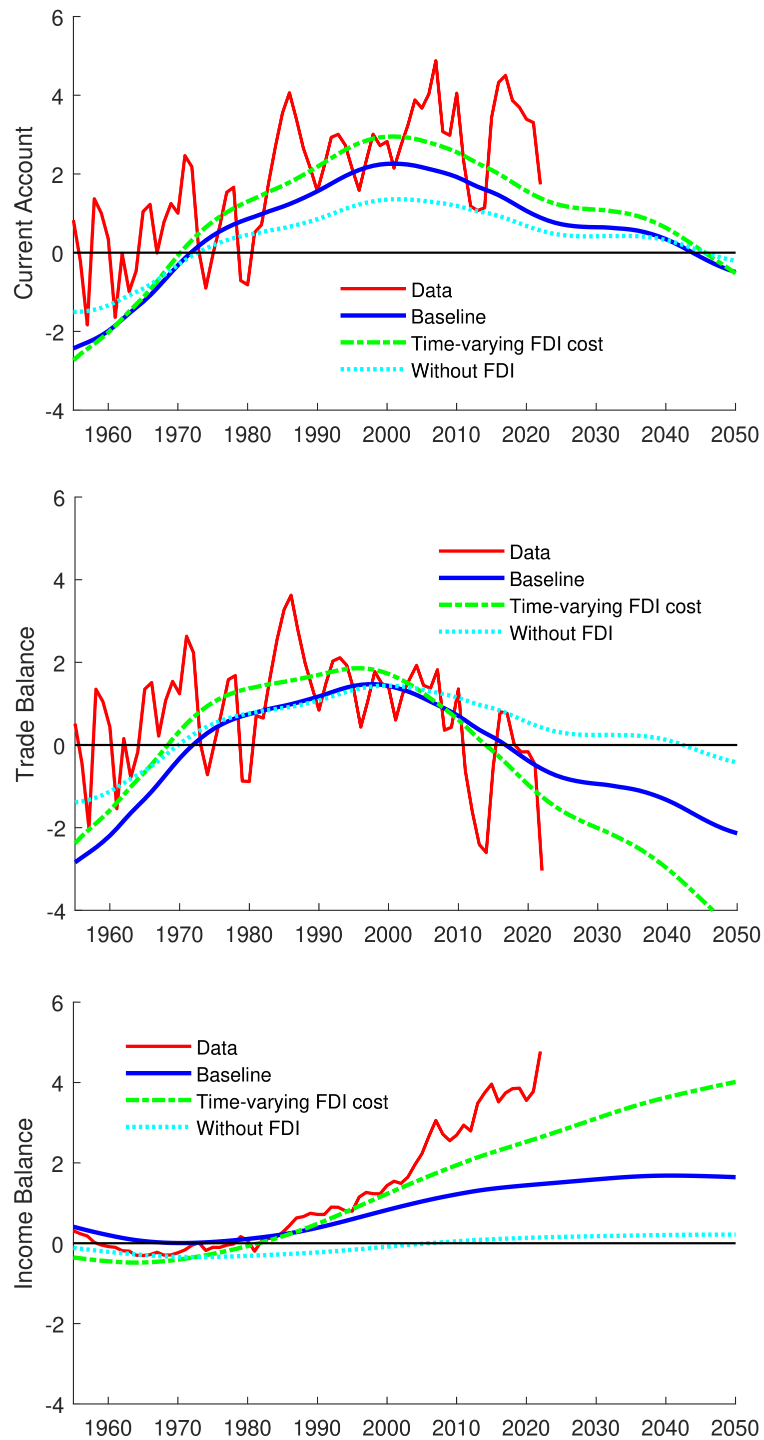
4.1 Long-run Trend of Capital Flows and FDI

Figure 4 displays the simulation results for the current account and its composition (the blue bold lines), along with data in Japan (the thin red lines). The simulation results imply that demographics alone can reasonably account for the long-run trend of the Japanese current account and its composition.[4] In particular, the baseline simulation is consistent with the significant decrease in trade balance surplus along with the increase in income balance surplus, which we have observed in Japan in the last several decades.

The household's consumption and savings behavior for consumption smoothing is key to replicating the long-term current account dynamics in Japan. Until the 1970s, the Japanese working-age population was expected to grow in the future, resulting in a current account deficit and an increase in external debt, as seen in most emerging market economies. From the 1970s to around 2000, as the working-age population increased, the current account recorded a surplus due to a large trade balance surplus. The substantial trade balance surplus until around 2000 can be interpreted as a consequence of consumption smoothing. That is, since households knew that the working-age population would decrease in the future, they saved in part as a form of external assets. Finally, as the working-age population started to decline in the 2000s, the trade balance surplus began

[4] It is not surprising that the model simulation replicates the *average level of* current account surplus and its compositions, as we use those data as calibration targets in the loss function (26). However, it is obviously impossible to match their dynamics by only adjusting parameters in indirect inference.

Figure 4: Data and model generated path: Current account in Japan



Note: The figure displays the simulated path by the model versus the data on the current account, trade balance, and income balance. In each panel of the figure, the thin red line and the bold blue line show the data and the transition dynamics of the baseline simulation. Also, the light blue dotted line and the green dashed line represent the simulation results for the hypothetical case where FDI is unavailable and those with a time-varying FDI cost, respectively.

to decrease as well. On the other hand, the income balance started to run a surplus due to income from external assets accumulated through the past trade balance surplus.

The model-generated paths can also account for the long-run trend of FDI dynamics. The first two panels in Figure 5 show the model-generated paths for outward and inward FDI stocks relative to GDP (the blue bold lines), along with the data (the red thin lines). The figure highlights two notable features. First, inward FDI has been very low compared to outward FDI. As discussed in calibration, the exceptionally low level of inward FDI in Japan leads to an asymmetrically high cost for inward FDI in our calibration (See Table 2). Second, and more importantly, outward FDI stocks have been dramatically increasing and have almost quadrupled since 2000 in the data. While the model-generated path, driven only by demographics, cannot completely track such a dramatic increase in outward FDI, it replicates the increasing trend since around 2000. More specifically, the outward FDI ratio in the model has almost doubled since 2000, implying that demographics can account for around half of the recent rise in outward FDI in Japan. As discussed below, the increase in FDI stocks driven by factor price changes under demographic changes is key to replicating the dynamics of the current account and its composition.

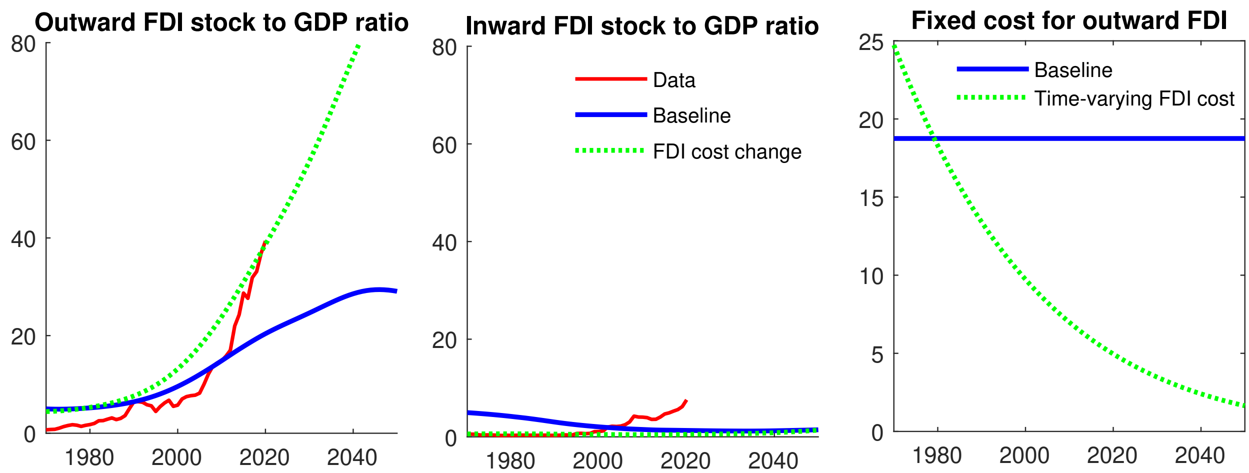
4.2 Role of FDI as a Capital Flow Channel

In this subsection, we examine the role of FDI in accounting for capital flows in Japan. As discussed below, we find that FDI plays a crucial role in explaining the dynamics of the current account, particularly the developments in income balance. In what follows, we first examine the role of FDI by comparing the baseline simulation with the counterfactual simulation *without* FDI. Then, we introduce a time-varying FDI cost to improve the model fit, further indicating the importance of FDI in explaining capital flows.

4.2.1 Counterfactual Simulation without FDI

To examine the role of FDI in accounting for the trend of current account in Japan, we conduct a counterfactual simulation where FDI is unavailable. The model without FDI differs from the baseline model with FDI mainly in the following two aspects, which reflect the dual aspects of FDI in our model. First, since firms cannot produce and sell their products in foreign countries through FDI, they can access foreign markets only

Figure 5: Data and model generated path: FDI stocks in Japan



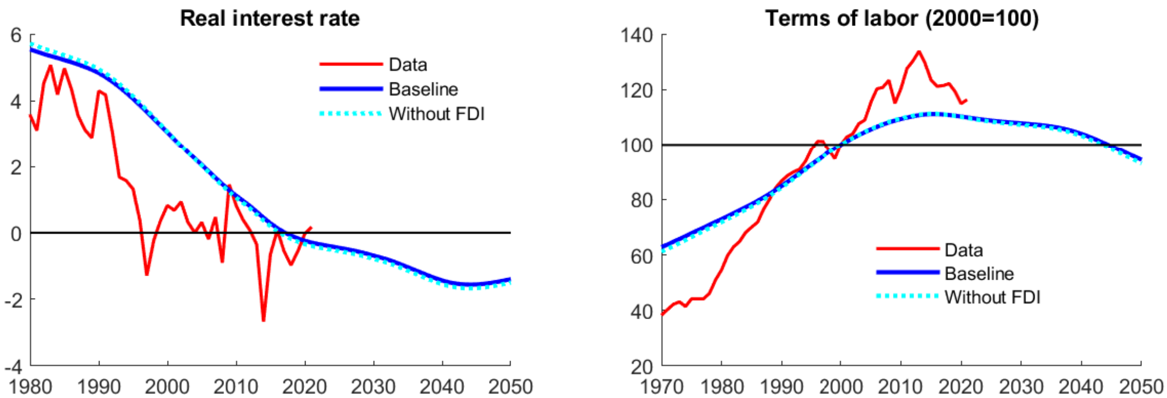
Note: The first two panels show the data and the model-generated paths for outward and inward FDI stocks relative to GDP. The thin red lines show data, while the thick blue lines and the green dashed lines show model outputs with a constant and time-varying FDI cost, respectively. The last panel shows the fixed operational cost for FDI in the baseline and the simulation with a time-varying cost of FDI.

through exports. Second, since firms cannot accumulate foreign assets through FDI, households' investment in riskless bonds (FPI) would be the only channel to accumulate external assets.[5] Those two differences imply that the model without FDI is close to a standard open-economy macroeconomic model with heterogeneous firms such as Ghironi and Melitz (2005).

In each panel of figure 4, the light-blue dotted line labeled "without FDI" shows the transition dynamics in the hypothetical case where FDI is unavailable. The figure indicates that the model without FDI cannot well account for the long-run trend of the current account, particularly its composition. More specifically, the counterfactual simulation where FDI is unavailable displays: (i) the income balance (the bottom panel) is almost zero even in the face of population aging and thus cannot replicate its dramatic increase since the 1990s, and (ii) the decrease in trade balance surplus (the middle panel) is much more moderate than the baseline case and data.

[5] While we assume that households cannot hold equity of foreign firms directly, this assumption has little effect on our quantitative results because foreign households can borrow from abroad by riskless bonds and invest in equity.

Figure 6: Real Interest Rate and Terms of Labor



Note: The figure shows the developments in real interest rates (the left panel) and the terms of labor (the right panel). In both panels, the bold blue lines and the dashed light blue lines represent the simulation results for the case with and without FDI, while the thin red lines show actual data. The real interest rate in the data is calculated by subtracting the inflation rate from the short-term interbank market rate. The terms of labor are calculated by relative wages across the two countries adjusted by real exchange rates, $w_t/(Q_t w_t^*)$, as in Ghironi and Melitz (2005), while those in data use the PPP-adjusted wages in Japan relative to the U.S. Sources: Ministry of Health, Labour and Welfare; Ministry of Internal Affairs and Communication; Bank of Japan; FRED; World Bank.

The developments in factor prices are crucial to understanding the role of FDI, as firms endogenously choose between exports and FDI in response to their changes. Figure 6 illustrates the developments in real interest rates (the left panel) and the terms of labor (the right panel). In both panels, the bold blue lines and the dashed light blue lines represent the simulation results for the case with and without FDI, while the thin red lines show actual data.[6] The figure indicates that the model-implied real interest rates and terms of labor are quantitatively consistent with actual data in Japan, even though they are not targeted in calibration at all. Specifically, the model simulation implies that (i) real interest rates have declined since the 1980s and are expected to decline further, and (ii) the terms of labor had increased until around 2010 and started to decrease. Given that any dynamics in our simulation are driven only by demographics, the figure implies that the decline in the working-age population since the 1990s, as well as the rise in household savings in anticipating population aging, makes the labor force scarce relative to capital, thus

[6] The terms of labor in the model are calculated by relative wages across the two countries adjusted by real exchange rates, $w_t/(Q_t w_t^*)$, according to Ghironi and Melitz (2005), while those in the data use PPP-adjusted wages in Japan relative to the U.S.

increasing labor costs and decreasing capital costs in Japan.

While the factor price changes in Figure 6 are almost identical in the economy with and without FDI, the endogenous response by firms to those changes is in contrast between them, resulting in significantly different current account dynamics. In the economy with FDI, i.e., the baseline simulation, the rise in labor costs and the decline in capital costs encourage productive firms in Japan to produce more in foreign countries through FDI rather than produce in Japan and export. Thus, due to the endogenous choice between exports and FDI, the trade balance surplus has declined since the 1990s, while the income balance has increased since then. On the other hand, when we do not incorporate FDI as in a standard international finance or trade model, productive firms would do their business abroad only through exports, even in the face of the decline in the working-age population. Therefore, the model without FDI predicts a milder decline in the trade balance surplus and a smaller increase in the income balance surplus, making the model unable to replicate the current account dynamics in Japan, particularly since the 1990s.

While such international relocation through FDI is often considered negative for domestic workers, the model simulation implies that households benefit from it by obtaining higher returns on FDI as stockholders. According to the relationship in (24), households indirectly hold external assets through FDI when Japanese firms invest abroad through FDI. Of course, in reality, households who lose their jobs due to the increase in outward FDI may not be the same as those who benefit from it as stockholders of multinational firms. While the representative household assumption in our model is too simple to analyze such an issue associated with heterogeneity among households, it is an interesting issue to be explored in future work.

4.2.2 Time Varying FDI Cost

While our quantitative exercise indicates that FDI plays an important role in accounting for the trend of capital flows, figure 5 shows that the baseline simulation (the blue bold lines) obviously underestimates the recent rise in FDI stocks. Specifically, (i) outward FDI has doubled since the 2000s in the simulation while it has become more than quadrupled in data, and (ii) inward FDI has remained at a very low level while it has increased since the 2000s in data. In fact, the underestimation of the increase in FDI stocks leads to the underestimation of the recent rise in income balance surplus in figure 4. While our simulation assumes a constant FDI cost, f_I and f_I^*, throughout the simulation periods, the underestimation of FDI stocks implies that the FDI cost has probably decreased under globalization in the last half-century.

In this subsection, we conduct an additional simulation assuming a time-varying and declining cost of FDI to account for Japan's recent rise in FDI stocks. Specifically, we assume that the fixed operational cost for outward and inward FDI has proportionally dropped until 2020 from $100f_I$ to gf_I and from $100f_I^*$ to $g^*f_I^*$, where f_I and f_I^* are the baseline calibration values. To fit the data of FDI stocks, we pick $g = 0.07$ and $g^* = 0.01$, respectively. That is, we assume that the fixed cost of FDI has become less than 0.1% during the last half century, as shown in the right panel in figure 5.

The green dashed lines in figures 4 and 5 show the simulation results with the time-varying FDI cost. First, with the time-varying FDI cost, the model can account for the dramatic rise in FDI stocks since the 2000s (figure 5). This result is mechanical because we pick the values of g and g^* to fit the data of FDI stocks. Second and more importantly, with the rise in FDI stocks, the model replicates a dramatic increase in income balance surplus in data. The bottom panel of figure 4 shows that the income balance surplus has increased since the 2000s more substantially than the baseline and consequently fits the Japanese data better. Furthermore, the model fit for the current account and trade balance is almost the same or slightly better than the baseline simulation.

Overall, assuming the time-varying and decreasing FDI cost significantly improves the model fit, particularly for income balance. Hence, while the quantitative exercise here takes the decline in the FDI cost as exogenously given, it further endorses the importance of FDI in explaining the current account dynamics. Exploring what drives the decline in the FDI cost in Japan should be a fruitful future research agenda.

4.3 Model Forecasts and the Stages of the Balance of Payments

What does the model predict about the current account in the future? Since demographics are foreseeable to some extent, our simulation should provide reasonable forecasting paths for the current account and its composition in the next several decades under the ongoing trend of population aging.

Figure 4 shows the forecasting path of the Japanese current account and its composition until 2050. The baseline simulation (the blue bold lines) indicates that (i) the current account surplus will continue to decrease and will be around zero in 2050, (ii) the trade balance surplus will continue to decrease and reach around -2 percent of GDP in 2050, and (iii) the income balance surplus will continue to increase. While the model with time-varying FDI cost (the green dashed lines) gives a similar prediction, it predicts a more substantial decrease and increase in a trade and income balance surplus, respectively, than the baseline (-5 and 5 percent of GDP in 2050). The declining FDI cost leads to a more significant decrease in trade balance surplus, as well as a more substantial increase in an income balance surplus, because it accelerates the Japanese firms' transition from exports to FDI under population aging. Thus, the model forecasts imply that the Japanese economy will face a more significant decrease and increase in trade and income surplus in the future if the current declining trend in FDI costs continues.

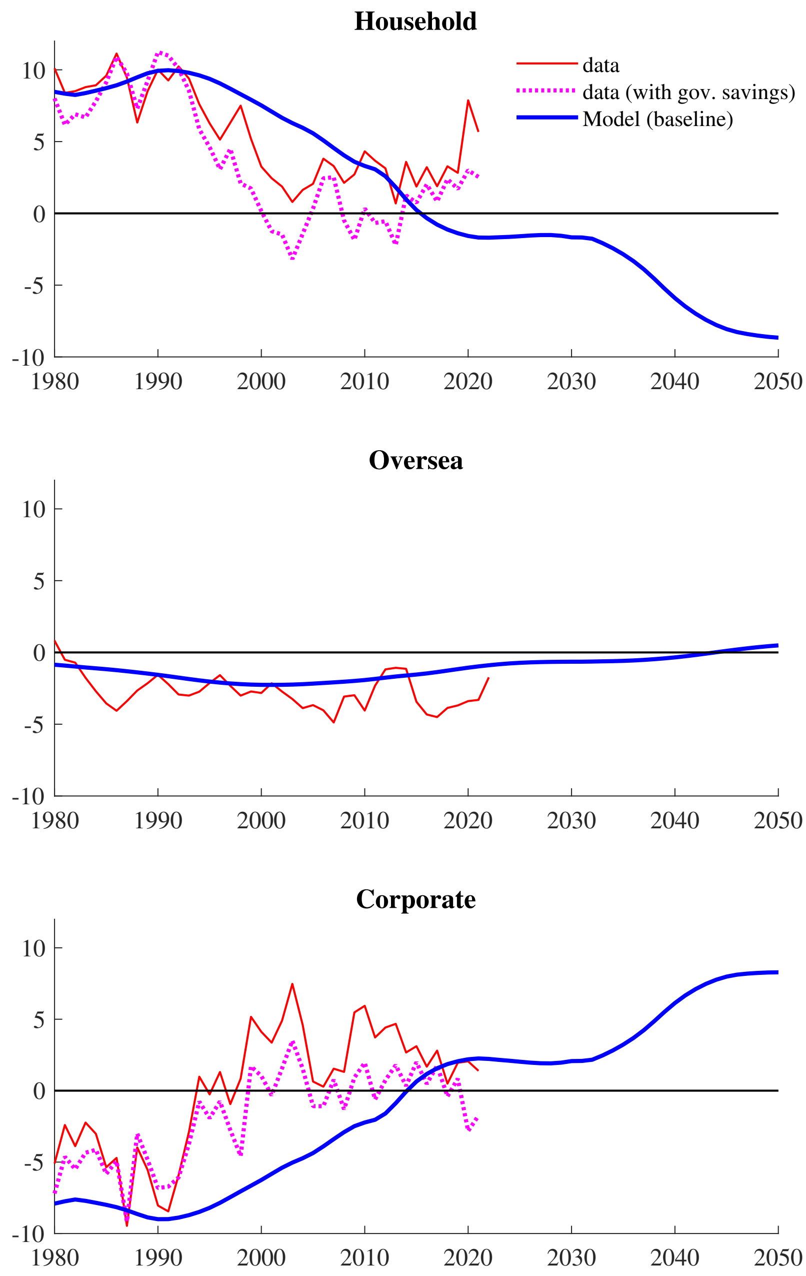
Interestingly, those simulation results for the past and future developments in capital flows in Japan are consistent with the well-known "stages-of-the-balance-of-payments hypothesis" by Geoffrey Crowther.[7] According to this hypothesis, a typical classification defines four stages: (i) a young and growing debtor (trade and income balance deficit), (ii) a mature debtor (trade balance surplus and income balance deficit), (iii) a young creditor (trade and income balance surplus), and (iv) a mature creditor (trade balance deficit and income balance surplus). According to this classification, the current account deficit from the 1960s to the 1980s implies that Japan was at stages (i) and (ii). Since the 1990s, as trade and income balance ran a surplus, Japan has been at the stage of (iii). Since the mid-2000s, however, the trade balance surplus has decreased while the income balance surplus has increased. The forecasting path suggests that in line with the hypothesis, Japan is transiting to a "mature creditor," i.e., stage (iv), characterized by a trade balance deficit and income balance surplus. Since our exercise uses demographics as the sole driver of current account dynamics, the quantitative result implies that demographic changes may be a driving force to explain the hypothesis.

4.4 Sectoral Savings in Japan

In this subsection, we investigate the dynamics of sectoral savings under demographic changes in Japan. The sectoral composition of savings in Japan has dramatically shifted

[7] For more details about this hypothesis, see, for example, Fischer and Frenkel (1974) and Lane and Milesi-Ferretti (2002).

Figure 7: Data and model generated path: Sectoral saving in Japan



Note: The figure illustrates the model's simulation path and the sectoral savings data in Japan. There are two data sequences, namely, (i) the data where the government savings are divided in half and added to the household and corporate savings (the pink dashed lines), and (ii) the data ignoring the government savings (the red lines).

in the last three decades, as shown in figure 2 in the introduction. In particular, the figure indicates that corporate savings have increased since around 1990, as household savings have decreased. Since we can define sectoral savings in the model as consistent with data, it is worthwhile to examine whether the transition dynamics under demographic changes in our model account for the recent developments in sectoral savings and what drives the dynamics of sectoral savings.

Figure 7 illustrates the model-generated paths and the data of sectoral savings in Japan. The figure demonstrates that the model (the blue bold lines) can fairly well account for the long-run trend of sectoral savings in Japan (the thin red lines) since the 1980s. Specifically, the simulated path explains: (i) the household saving rate has been decreasing since around 1990, (ii) the corporate saving rate has been increasing since around 1990, and (iii) the financial surplus of the overseas sector continues to record deficit. According to the model prediction, such a shift in sectoral savings in Japan will continue due to the decrease in the working-age population.

Population aging has generated a shift in sectoral savings through the following two mechanisms. First, the decline in the working-age population has decreased the household savings rate since the 1990s as a result of the household's consumption smoothing. At the same time, given that most household savings take the form of domestic physical investment, the decline in household savings has decreased the financial liabilities in the corporate sector and thus raised corporate savings. Second, population aging has further increased corporate savings by encouraging large firms to shift from exports to FDI, as explained in the previous subsection. Hence, since the 1990s, corporate savings have increased in exchange for declining overseas savings. The second mechanism is consistent with the fact that more than half of corporate savings since 2010 can be accounted for by an increase in outward FDI in Japan (the right panel in figure 2).

While the model dynamics under demographic changes can account for the long-term trend in Japanese sectoral savings, they are subject to some caveats. First, since our model does not have a public sector, government savings do not exist in the model. The pink dashed lines in figure 7 show the case where government savings are divided in half and added to the household and corporate savings to maintain consistency with data. Compared with the data ignoring government savings (the red lines), while those two data sequences exhibit some gaps by construction, these gaps do not substantially affect our quantitative assessment. Second, our simulation results underestimate the rise in corporate savings in around 2000. However, this is unsurprising because we do not model other relevant factors contributing to the increase in corporate savings, including the firm's precautionary motive for cash holdings.

In sum, our quantitative exercise shows that demographic changes can broadly account for a long-run trend of sectoral savings in Japan, including the recent rise in corporate savings. Note that our quantitative exercise does not argue that an increase in FDI by non-financial firms under population aging is the main factor of corporate savings. Rather, while the previous literature points out numerous factors contributing to the recent surge in global corporate savings, our exercise implies that outward FDI under population aging can be added to the list of those factors at least in Japan. Hence, while the recent increase in corporate savings in Japan is driven by many factors including the lack of Japanese firms' risk-taking or strengthening corporate governance, there is also a secular trend driven by population aging.

5 Concluding Remarks and Policy Implications

This paper investigates the role of FDI in accounting for the long-term trend of capital flows under demographic changes. For this purpose, we incorporate horizontal FDI under the proximity-concentration trade-off à la Helpman, Melitz, and Yeaple (2004) into a two-country DSGE model and conduct a quantitative analysis using long-term Japanese data since the 1960s. The quantitative analysis finds that the trend of the current account, including its composition and dynamics of sectoral savings in Japan, can be well accounted for solely by demographic changes. Our simulation implies that multinational firms' endogenous choice between exports and FDI in the face of factor price changes driven by demographics is key to explaining those trends.

The quantitative analysis has some policy implications for the Japanese economy. First, the simulation exercise implies that the recent decline in a trade balance surplus and the recent increase in corporate savings in Japan can be accounted for by demographic changes at least in the long run. In other words, they do not necessarily reflect, for instance, a loss of competitiveness of Japanese firms or a passive risk-taking attitude of Japanese firms. Second, the simulation results indicate that the decreasing trend of trade balance surplus and the increasing trend of corporate savings will continue for the next several decades, as population aging continues. Furthermore, given the crucial role of FDI in accounting for the long-run trend of capital flows, greater FDI openness in the future, if any, will reinforce those trends. Hence, Japanese policymakers should take into account those trends as given when they develop their policies and strategies for international finance.

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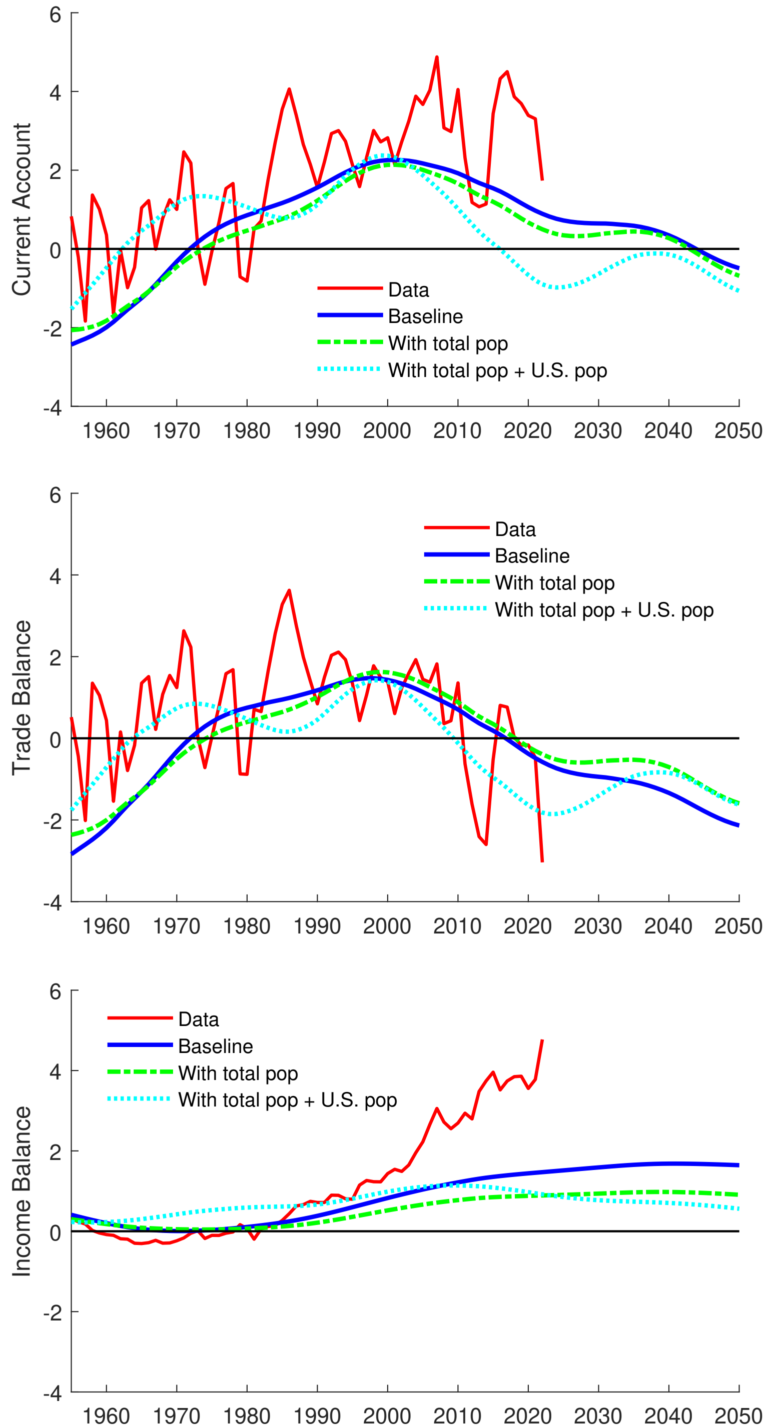
Appendix A. Robustness Checks

In the appendix, we conduct the following four additional simulation exercises as robustness checks. First, we take into account changes in the total population in addition to the working-age population (the blue dotted lines in figure 3) as exogenous changes in M_t. Second, we take into account not only the total population and working-age population in Japan but also demographics in foreign countries. As a proxy for demographics in foreign countries, we use changes in the U.S. working-age population as exogenous changes in L_t^*, given that the U.S. has been the most important counterpart for Japan in trade and FDI. Third, we take into account the fact that some older people continue to work in Japan. Based on the latest male and female labor force participation rate for 65 or older people, we use the sum of the working-age population and old workers as a proxy for the labor supply, L_t. Fourth, we use the number of labor forces rather than the working-age population as a proxy for L_t to consider the recent rise in labor participation rate particularly among female workers.[8]

Figure 8 shows the simulation results for the first and second robustness checks. First, the simulation paths, which take into account the total population (the green dashed lines), are very close to the baseline case. The small effect of the total population is consistent with the previous papers such as Imrohoroglu et al. (2006), and implies that considering the developments in the working-age population rather than the total population is necessary to capture the effects of demographics on capital flows. Second, the simulation paths that take into account the U.S. demographics (the dotted light blue lines) are also close to the baseline case, while they fluctuate more than the baseline due to demographic changes in the U.S. Similarly, figure 9 shows the simulation results for the third and fourth robustness checks. In both robustness checks, the current account surplus is somewhat smaller than in the baseline case. This is because households have less incentive to save than the baseline, as the adverse effects of population aging are mitigated by working in old age. Nonetheless, the simulation paths are close to the baseline and do not substantially change the quantitative assessments.

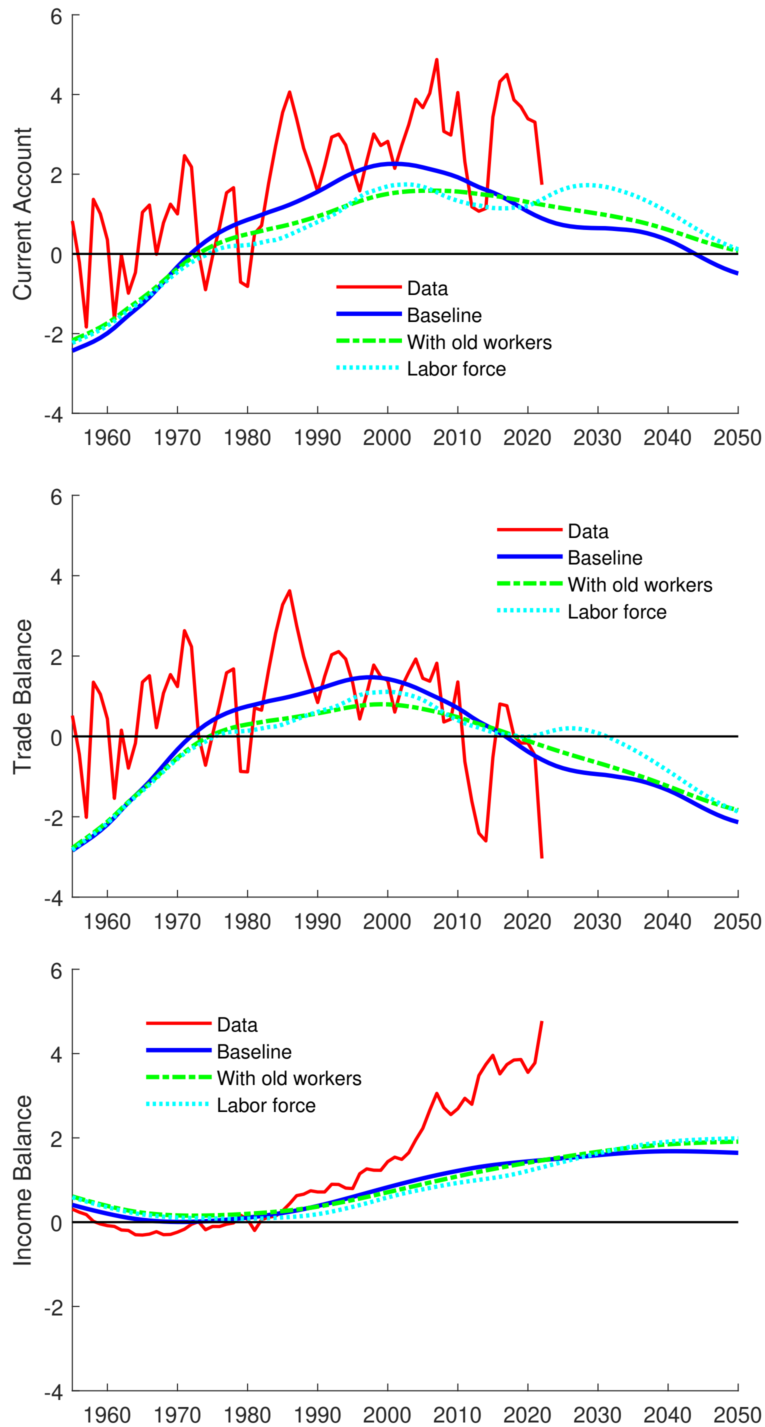
[8] In this exercise, the future path of labor forces is assumed to be constant at the level in 2020.

Figure 8: Data and model generated path: Current account in Japan



Note: The figure displays the simulated path by the model on the current account, trade balance, and income balance. In each panel of the figure, the thin red line and the bold blue line show the data and the transition dynamics of the baseline simulation. Also, the green dashed line represents the simulation results which take into account total population changes, and the light blue line represents those which take into account changes in both the total population in Japan and the U.S. population.

Figure 9: Data and model generated path: Current account in Japan



Note: The figure displays the simulated path by the model on the current account, trade balance, and income balance. In each panel of the figure, the thin red line and the bold blue line show the data and the transition dynamics of the baseline simulation. Also, the green dashed line represents the simulation results, which consider workers over 65 years old, and the light blue line represents those that use the labor force instead of the working-age population as a measure of labor endowment, L_t.