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Capital Controls and Macro-prudential Housing Policies in Small Open Economies

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Abstract

We evaluate the effects of capital controls and macro-prudential policies in small open economies with a housing sector that is open to foreign ownership. The work is motivated by concerns that foreign investments also respond to housing investment opportunities resulting in potential house price inflation and issues about housing affordability. Our dynamic stochastic general equilibrium model features housing as an internationally traded investment. We also consider macro-prudential policies that are combinations of monetary and fiscal instruments. We investigate whether foreign investments in the housing markets are de-stabilising and whether there are appropriate policy responses to mitigate the negative effects of foreign direct investments in housing. Our simulations suggest: 1) foreign investments in domestic housing are in general welfare-improving and do not de-stabilise house price inflation, 2) coordination between interest rate and time-varying instruments enhances social welfare and is consistent with economic stabilisation, and 3) an active stamp duty on foreign buyers helps to mitigate the welfare loss of savers through a redistribution of the tax revenue received.

Keywords: Macro-prudential policy, housing, foreign investment, dynamic stochastic general equilibrium model, small open economy
JEL classification: O18, E61, F37

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1 Introduction

In recent years, housing has increasingly become a "tradable" asset. This is because of improvements in the transfer of funds across borders as well as the growing interest of investors in buying residential properties in metropolitan cities around the world. These cities, also known as *global cities*, have high population density, but scarce residential properties. This has led to expectations of high returns from real estate, making residential properties attractive as assets to hold in the portfolios of international investors.[1]

Foreign direct investment (FDI) in housing presents challenges for policy makers. It is usually a welcomed stimulus for the local economy, as the foreign demand generates new construction activity, leading to more employment opportunities and higher income. However, while appreciating house prices generate wealth for residents, momentum effects may cause expectation-driven boom–bust housing cycles that de-link prices from economic fundamentals. The possibility of such de-stabilising speculative capital flows has become especially relevant since the onset of the global financial crisis, when investors in advanced economies, searching for higher returns, shifted their preferences towards emerging market economies and away from low interest-rate environments in advanced economies. These de-stabilising influences[2] can also exacerbate the problem of housing affordability (e.g. Favilukis and Van Nieuwerburgh, 2017). Policymakers have resorted to a number of measures, such as increased stamp duties for foreign buyers (Figure 1).

The aim of this paper is to evaluate a range of policy options in small open economies that attract FDI in domestic housing, but where macro-prudential policies are designed nationally. To this end, we propose a dynamic stochastic general equilibrium (DSGE) model for a small open economy that includes the buying/selling of domestic housing by foreigners. The model allows us to examine more closely how FDI in the housing market alters the dynamics of the economy in response to various shocks. Anticipating the results, our simulations show that FDI in housing crowds out domestic housing investments, does not cause instability in house price inflation, but can increase volatility in aggregate consumption and in the interest rate.

The model also allows us to investigate whether a range of suggested policy options are welfare-enhancing and/or stabilising/de-stabilising. Specifically, we evaluate five policy regimes for small open economies subject to FDI in housing. These policy regimes involve combinations of policy instruments such as the monetary policy instrument (the interest rate), the macro-prudential loan-to-value (LTV) ratio cap, and fiscal rules (stamp duties) that respond to housing market conditions in a counter-cyclical manner.

Our policy simulations are also conducted for cases when the price target includes/excludes asset (i.e. house) prices, as there are compelling reasons for policy makers to consider house prices. Instability in the housing market may spill over to the macroeconomy (see Iacoviello and Neri (2010)), and in general, unstable house prices create difficulty for the conduct of

[1] In the decade after the global financial crisis, there was a surge in outbound direct investment (ODI) from China, especially into real-estate sectors around the world.

[2] Using data from seven small open economies, Ng and Feng (2016) estimated that foreign housing preferences accounted for a large proportion of real house price volatility.

monetary policy, especially for central banks practising inflation targeting. Housing is also a main component of the consumer price index (CPI),[3] and housing affordability is associated with the welfare of the local residents (especially prominent in retirement plans).

Our work contributes to three strands in the literature. First, we add to the literature on capital flows and housing markets. There have been ongoing discussions on the association between current account and house prices (e.g. Matsuyama, 1990; Aizenman and Jinjarak, 2009; Ferrero, 2015), but with housing treated as a non-traded good. While it is true that houses are not physically movable across borders like consumption goods, transactions of house ownership titles between domestic and foreign entities are akin to trade in goods. Thus, subject to acknowledging the physical location of the property, the international accumulation of housing assets resembles that of an internationally traded durable good (Monacelli, 2009; Sterk, 2010; Engel and Wang, 2011). Our model allows foreigners to directly acquire housing from domestic property developers in an analogous way to international trade in consumption goods. This is preferable to a generic assumption that foreign capital flows are purely international borrowing (see Punzi, 2013; Mendicino and Punzi, 2014).

Second, following the literature on international portfolio investments (e.g. Devereux and Sutherland, 2007), we model FDI as part of the foreigners' investment portfolio. Existing models of a small open economy with a housing market usually model the demand by foreigners for domestic housing as exogenously determined or as a function of relative house prices between domestic and foreign markets (see Funke and Paetz, 2013, 2016; Ng and Feng, 2016). We treat housing as a portfolio asset and hence model the FDI as a function of the relative returns between domestic housing and the foreign riskless asset. Our model allows us to identify the effects of FDI more specifically.

Third, we contribute to the literature on the coordination of policies. In particular, while there have been studies about imposing capital controls to restrict cross-border transactions that discriminate against residency (Forbes et al., 2015), there have been no studies about targeting international flows relating to housing transactions. This is despite evidence that global cities in the world favour imposing stamp duties on foreign buyers. In our paper, we investigate the coordination between macro-prudential policies and capital controls (e.g. Kuttner and Shim, 2016; Zhang and Zoli, 2016; Korinek and Sandri, 2016; Ben Zeev, 2017; Korinek, 2018) as well as the coordination between monetary and fiscal policies (e.g. Davig and Leeper, 2011; Jarociński and Maćkowiak, 2018; Michaud and Rothert, 2018). Specifically, we consider policies that target the housing market along with some degree of capital control. These policies include stamp duties (including one exclusively on foreigners) and a ban on FDI in housing. Both are rarely discussed in the literature, except in Chao and Yu (2015).

Anticipating the results, we show that a coordinated approach to using the instruments of policies, specifically, the coordination between the monetary policy interest rate and other time-varying instruments (the LTV ratio cap and stamp duty rules), enhances the welfare of the economy. We also find that FDI and optimal policy regimes, in general, make savers worse

[3] In Singapore, Hong Kong, Australia, and Canada, housing (excluding utilities) carries a weight of 22.87%, 34.29%, 22.3%, and 22.23%, respectively. Source: CEIC Database, December 2016.

off, but the losses can be mitigated by an active stamp duty rule on foreign buyers. This is because of the redistribution of wealth from foreign buyers to domestic residents, which increases consumption and investment domestically.

The redistributional effects of the macro-prudential policies are particularly interesting. While all the policy regimes investigated improve welfare for society, the improvements, in general, favour borrowers, not savers. Recognising this non-Pareto outcome, we conducted various sensitivity analyses to ascertain whether it is possible to mitigate welfare losses for savers and/or borrowers. We find that although a Pareto improvement may be achieved in which both savers and borrowers gain, the welfare outcome for society as a whole is only marginally better than in the usual monetary regime with only a Taylor rule.

This paper is organised as follows. Section 2 introduces the DSGE model for a housing market with foreigners. Section 3 describes the model dynamics and the effects of FDI. Section 4 compares the welfare effects across optimal policy regimes. Section 5 assesses the stabilising effects of the regimes. The final section concludes.

2 Model with foreign investment in housing

The model features heterogeneous households (specifically, patient households, who are savers, and impatient households, who are borrowers) subject to the extra feature that foreigners can also buy/sell domestic housing. Figure 2 depicts the flows of funds in the model. The patient and impatient households are denoted by s and b, respectively, with the propensity to save being higher for the patient household than the impatient one, i.e. $\beta_s > \beta_b$. The impatient household borrows funds from the patient household to finance its consumption and investments, subject to a limit governed by the maximum LTV ratio ι and a nominal interest rate R set by the central bank. Patient households have access also to foreign funds at the foreign interest rate R^*; impatient households borrow only domestically. Both types of domestic household buy consumption goods and accumulate housing. Foreigners buy consumption goods (exports) and supply intermediate goods (imports), lend in the form of bonds to patient households, and buy/sell domestic housing.

The production sectors are owned by the patient household. Both the goods-producing firm and the housing developer pay for labour of the households in addition to paying for sector-specific inputs of production. The goods-producing firm purchases intermediate materials from foreigners for the production of consumption goods, while the housing developer purchases land from the government for construction of new houses. Profits from selling the goods and houses are transferred to the patient household as a source of income.

Policy makers intervene in the markets via both monetary and fiscal tools. The monetary authority sets the maximum LTV ratio and the nominal interest rate, while the fiscal authority sets the tax rates imposed on domestic households and foreigners at gross rates τ and τ^*, respectively. The government sector is assumed to run a balanced budget as tax receipts and revenue from land sales to the housing developer are transferred back to the household sector.

A novel feature of our model is that foreigners' demand for housing is not exogenous as in

the existing literature, e.g. Funke and Paetz (2013). Foreigners' decision to buy/sell housing investments depends on the relative expected return between housing investments and riskless investments in the foreign country, net of transaction taxes and depreciation of the housing stock. This specification is in line with the literature on international portfolio investment, such as Devereux and Sutherland (2007). With this setup, policy interventions in the housing market affect foreigners' demand for housing, but the extent depends on the demand elasticity of foreigners. The details of the model are described next.

2.1 Foreign sector

As in Galí and Monacelli (2005), foreigners are assumed to live in a large economy. Trade flows are defined by exports of domestic goods to foreigners and by imports of intermediate goods from foreigners. Capital flows include lending to patient households as well as flows associated with the buying/selling of houses by foreigners. In what follows, variables of the foreign sector are denoted by asterisks.

2.1.1 Goods and housing demand

Foreigners' demand for goods exported from the home country is standard in small open-economy models. See, for example, Justiniano and Preston (2010a,b), Monacelli (2005), and Kollmann (2002). The equation is given by

$$c_t^* = \left(\frac{P_{c,t}^*}{P_t^*}\right)^{-\theta_c^*} Y_t^*, \tag{1}$$

where $P_{c,t}^*$ is the price of consumption goods in the domestic, denominated in foreign currency, P_t^* is the price level in the foreign country, $\theta_c^* > 0$ is the elasticity of substitution.

Foreigners' decision to invest in housing is driven by the expected return to the investment, which includes changes in price (as in Adolfson et al. (2007)). We define foreigners' demand for domestic housing as a function of the relative return between domestic housing and foreign riskless investments:

$$I_t^* = \theta_h^* \cdot \left(\frac{R_{h,t}^* - \overline{R_h^*}}{R_t^*}\right), \tag{2}$$

where $R_{h,t}^*$ is the return to housing investment, denominated in foreign currency, R_t^* is the riskless interest rate in the foreign country, and $\theta^* > 0$ measures the response of foreign housing demand to the differential in returns. In the special case of $\theta_h^* = 0$, the foreigner does not invest in the domestic housing market. Whereas, when $\theta_h^* > 0$, the foreigner invests more in domestic housing when the return is above the steady state and/or when foreign riskless return drops. This setup facilitates the assessment of the effect of total capital control. Housing stock is accumulated as follows:

$$h_{s,t}^* = (1-\delta)\, h_{s,t-1}^* + I_{s,t}^*, \tag{3}$$

where h_t^* is the holding of housing stock by foreigners.

2.1.2 Return to housing investment

Foreigners are assumed to accumulate housing assets in the domestic economy as part of their investment portfolio. Housing is seen as an alternative investment to bonds in the foreign country. Thus, the expected foreign-currency-denominated return to houses purchased in the current period is a function of the expected change in the relative house price, taking into account exchange-rate movements and macro-prudential measures:

$$R_{h,t}^* = \chi \cdot \frac{(1-\delta)\, P_{h,t+1}/e_{t+1}}{\tau_t^* P_{h,t}/e_t}. \tag{4}$$

More precisely, the components are as follows:

- $\delta > 0$ is the depreciation rate of housing. A higher depreciation rate reduces the return to housing investment.
- We assume that in the steady state, $\bar{R}_h^* = \beta^{*-1}$, where β^* is the discount factor of foreigners. It follows that the coefficient $\chi = \beta^{*-1}(1-\delta)^{-1}$. The steady-state return to housing investment is equal to that of the riskless return of foreign bonds, implying foreigners' indifference between the two investment choices in the steady state.
- τ_t^* is the macro-prudential fiscal measure imposed as a gross tax/subsidy rate on purchases of houses. When $\tau_t^* > 0$, it is also known as the buyers' stamp duty; τ_t^* is set to be *above* unity when a stamp duty is imposed on buyers of the houses and *below* unity when a subsidy is provided to the buyers. In the former case, the return to housing investment is reduced.
- The nominal exchange rate e_t is defined as the price of foreign currency per unit of domestic currency, so an increase in the value of e_t represents an appreciation of the foreign currency. An expected appreciation of the foreign currency also renders investment in domestic housing by foreigners less attractive.

2.2 Domestic households

A representative patient or impatient household derives utility from consumption goods, $c_{i,t}$, and the accumulation of housing assets, $h_{i,t}$. It also derives dis-utility from supplying labour to the firms, $n_{i,t}$. The lifetime utility of the household is calculated as

$$\mathbb{E}_t \sum_{t=0}^{\infty} \beta_i^t U_{i,t}, \tag{5}$$

where the period utility is a function of the following form:

$$U_{i,t} \equiv \ln\left(c_{i,t} - \varrho c_{i,t-1}\right) + z_{h,t}\kappa_i \ln h_{i,t} - \frac{1}{1+\eta_i} n_{i,t}^{1+\eta_i}. \tag{6}$$

Here, $i = s, b$ denotes the type of household, $z_{h,t}$ is the preference shocks to housing, κ_i is the weight of housing in the utility function, and η_i is the elasticity of hours worked. Accordingly, the marginal utility of consumption and housing and the marginal dis-utility of labour are

$$U_{c,i,t} = \frac{1}{c_{i,t} - \varrho c_{i,t-1}} - \frac{\beta_i \varrho}{c_{i,t+1} - \varrho c_{i,t}} \tag{7}$$

$$U_{h,i,t} = \frac{\kappa_i z_{h,t}}{h_{i,t}} \tag{8}$$

$$U_{n,i,t} = n_{i,t}^{\eta_i}. \tag{9}$$

Since housing is a durable good, it depreciates at a rate δ and incurs an adjustment cost. The accumulation equation and cost functions are

$$I_{i,t} = h_{i,t} - (1 - \delta) h_{i,t-1} \tag{10}$$

$$\gamma_{i,t} = \frac{\gamma_h}{2} \left(\frac{h_{i,t} - h_{i,t-1}}{h_{i,t-1}} \right)^2. \tag{11}$$

2.2.1 Patient household

The expenditures of patient households include purchases of consumption goods, $c_{s,t}$, and housing, $h_{s,t}$, at prices $P_{c,t}$ and $P_{h,t}$, respectively. The sources of income include wages at W_t per hour worked, profits from the firms they own, Div_t, and transfers from the government, G_t. They also acquire bonds from abroad, b_t^*, and pay interest on the previous period's holding of foreign bonds. Furthermore, since patient households have a higher propensity to save, they also contribute to the supply of funds in the domestic loan market. Taken together, the budget constraint of a patient household is expressed as

$$P_{c,t}c_{s,t} + \tau_t P_{h,t} I_{s,t} + P_{h,t}\gamma_{s,t} + b_t + e_t \zeta_{t-1} R_{t-1}^* b_{t-1}^* = W_t n_{s,t} + R_{t-1} b_{t-1} + e_t b_t^* + Div_t + G_{s,t}. \tag{12}$$

Here, τ_t is the buyers' stamp duty and the sellers' stamp duty, respectively. To prevent unlimited borrowing from abroad, we follow Schmitt-Grohé and Uribe (2003) and model the risk premium, ζ_t, as a positive convex function that depends on the ratio of foreign debt to aggregate output:

$$\zeta_t = \exp\left[\varphi \left(\frac{e_t b_{s,t}^*}{\bar{Y}} - \frac{\bar{e}\bar{b}_s^*}{\bar{Y}} \right) \right], \tag{13}$$

where φ is the risk premium elasticity.

The patient household maximises its utility, represented by Eq. (6), subject to the budget constraint, represented by Eq. (12), by choosing the values of the variables $c_{s,t}$, $h_{s,t}$, $n_{s,t}$, $b_{s,t}$,

and $b^*_{s,t}$. The first-order conditions are

$$\lambda_{s,t} P_{c,t} = U_{c,s,t} \tag{14}$$

$$\lambda_{s,t} P_{h,t} \left[\tau_t + \frac{\partial \gamma_{s,t}}{\partial h_{s,t}} \right] = U_{h,s,t} + \beta_s \mathbb{E}_t \lambda_{s,t+1} P_{h,t+1} \left[\tau_{t+1} (1 - \delta) - \frac{\partial \gamma_{s,t+1}}{\partial h_{s,t}} \right] \tag{15}$$

$$\lambda_{s,t} W_t = U_{n,s,t} \tag{16}$$

$$\lambda_{s,t} = \beta_s \mathbb{E}_t \lambda_{s,t+1} R_t \tag{17}$$

$$\lambda_{s,t} = \beta_s \mathbb{E}_t \lambda_{s,t+1} \zeta_t R^*_t \frac{e_{t+1}}{e_t}, \tag{18}$$

where $\lambda_{s,t}$ is the Lagrangian multiplier for the budget constraint, interpreted as the increase in utility for every unit increase in the household budget.

Equation (14) equates the marginal utility of consumption goods to that of the household budget at the consumption-good price. Equation (15) shows that the marginal utility of the household budget, valued at the current house price, is the sum of the marginal utility of housing and that of the household budget valued at the expected future price of housing. From Eq. (16), the dis-utility of labour supply is equal to the utility value of the nominal wage. Equation (17) represents the Euler equation for the optimal loan provision in the domestic market, and Eq. (18) represents one for optimal foreign bond holding.

2.2.2 Impatient household

Following Funke and Paetz (2013, 2016) and Mendicino and Punzi (2014), we assume that impatient households do not have access to foreign bonds. They finance their consumption and investments via wage income and borrowing from patient households. Accordingly, the impatient household faces the following budget constraint:

$$P_{c,t} c_{b,t} + \tau_t P_{h,t} I_{b,t} + P_{h,t} \gamma_{b,t} + R_{t-1} b_{t-1} = W_t n_{b,t} + b_t + G_{b,t} \tag{19}$$

In addition, its maximum borrowing $b_{b,t}$ is given by the expected present value of its home multiplied by the time-varying LTV ratio, ι_t:

$$b_t \leq \iota_t \mathbb{E}_t \frac{P_{h,t+1} h_{b,t}}{R_t}. \tag{20}$$

As such, the impatient household maximises its utility, subject to two constraints: the budget constraint represented by Eq. (19) and the borrowing constraint represented by Eq. (20). The

choice variables are $c_{b,t}$, $h_{b,t}$, $b_{b,t}$, and $n_{b,t}$. The first-order conditions are

$$\lambda_{b,t} P_{c,t} = U_{c,b,t} \tag{21}$$

$$\lambda_{b,t} P_{h,t} \left[\tau_t + \frac{\partial \gamma_{b,t}}{\partial h_{b,t}} \right] = U_{h,b,t} + \beta_b \mathbb{E}_t \lambda_{b,t+1} P_{h,t+1} \left[\tau_{t+1} (1 - \delta) - \frac{\partial \gamma_{b,t+1}}{\partial h_{b,t}} \right] + \psi_{b,t} \iota_t \mathbb{E}_t \frac{P_{h,t+1}}{R_t} \tag{22}$$

$$\lambda_{b,t} W_t = U_{n,b,t} \tag{23}$$

$$\lambda_{b,t} = \beta_b \mathbb{E}_t \lambda_{b,t+1} R_t + \psi_{b,t}, \tag{24}$$

where $\lambda_{b,t}$ and $\psi_{b,t}$ are the Lagrange multipliers for the budget and borrowing constraints, respectively, interpreted as the marginal utilities of household budget and borrowing.

2.3 Firms

There are two production sectors in the model, the consumption-good production sector (c) and the housing development sector (h), both owned by patient households. The representative firm in each sector utilises labour supplied by domestic households and a sector-specific input for production. The outputs are sold to both domestic and foreign households.

For firm $j \in \{c, h\}$, the production function is of a Cobb–Douglas form:

$$Y_{j,t} = A_t N_{j,t}^{1-\mu_j} F_{j,t}^{\mu_j}, \tag{25}$$

where $N_{j,t}$ is the labour input and $F_{j,t}$ is the non-labour input of production. Specifically, in the consumption-good firm, $F_{c,t}$ is the imported intermediate good, K_t, while in the housing sector, $F_{h,t}$ is land, L_t. In the equation, A_t is the common productivity factor across the two sectors, and μ_j is the share of non-labour inputs of production. The economy's GDP is calculated as the aggregate value outputs from both sectors:

$$P_t Y_t = P_{h,t} Y_{h,t} + P_{c,t} Y_{c,t}. \tag{26}$$

The profit maximisation problem for the firms is given by

$$\max P_{c,t} Y_{c,t} + P_{h,t} Y_{h,t} - \left(\sum_{j \in (c,h)} W_t N_{j,t} + P_{f,j,t} F_{j,t} \right), \tag{27}$$

where $P_{f,j,t}$ is the corresponding factor price. The goods-producing firm imports materials at a given import price $P^*_{m,t}$; the housing developer "buys" land at a government-determined price $P_{l,t}$:

$$P_{f,c,t} = P_{m,t} = e_t P^*_{m,t} \tag{28}$$

$$P_{f,h,t} = P_{l,t}, \tag{29}$$

where $P^*_{m,t}$ and $P_{l,t}$ are assumed to be exogenously determined.

Since the focus is on consumption and housing, we shall assume, without loss of generality, perfect mobility of labour and, hence, one nominal wage, W_t. Maximising profit, the firm allocates its resources according to

$$\frac{W_t N_{j,t}}{P_{f,j,t} F_{j,t}} = \frac{1-\mu_j}{\mu_j}. \tag{30}$$

The housing sector is assumed to be without nominal rigidities. The housing developer sets the price according to the marginal costs of production:

$$P_{h,t} = \left(\frac{P_{f,h,t}}{\mu_j}\right)^{\mu_h} \left(\frac{W_t}{1-\mu_h}\right)^{1-\mu_h} \frac{1}{A_t}. \tag{31}$$

Following Iacoviello and Neri (2010), we introduce price rigidity in the consumption-good sector. In each period, there is a probability $1-\xi$ that it optimises the price. We then have the following Phillips curve for the goods-producing firm:

$$\log \pi_{c,t} = \beta_s \log \pi_{c,t+1} + \frac{(1-\xi)(1-\beta_s \xi)}{\xi} \log\left(\frac{mc_t}{\overline{mc}}\right), \tag{32}$$

where mc_t denotes the real marginal cost of consumption-good production. The nominal marginal cost of consumption-good production is calculated as

$$P_{c,t} mc_t = \left(\frac{P_{f,c,t}}{\mu_c}\right)^{\mu_c} \left(\frac{W_t}{1-\mu_c}\right)^{1-\mu_c} \frac{1}{A_t}. \tag{33}$$

2.4 Government

The government is responsible for selling land to housing developers, collecting taxes from housing transactions, and transferring all revenue equally to savers and borrowers:

$$G_{s,t} = G_{b,t} = \frac{1}{2}\left[(\tau_t - 1) P_{h,t} (I_{s,t} + I_{b,t}) + (\tau^*_t - 1) P_{h,t} I^*_{s,t} + P_{l,t} L_t\right]. \tag{34}$$

2.5 Equilibrium

The goods and housing markets clear when production meets their respective demands. In the consumption-good market, the output of consumption goods equals the demand from domestic households and foreigners. Similarly, in the housing market, new housing developments in the present period equal new housing investments from domestic households and foreigners. The market clearing conditions are given as

$$Y_{c,t} = c_{s,t} + c_{b,t} + c^*_t \tag{35}$$

$$Y_{h,t} - \gamma_{s,t} - \gamma_{b,t} = I_{s,t} + I_{b,t} + I^*_{h,t}. \tag{36}$$

The clearing of the labour market is achieved by assuming homogeneous labour and perfect mobility of labour between sectors. With one nominal wage W_t, the labour market clears when

$$N_{c,t} + N_{h,t} = n_{s,t} + n_{b,t}. \tag{37}$$

Combining the budget constraints of households, firms, and the government yields the balance of payment as

$$e_t b_t^* = e_t \zeta_{t-1} R_{t-1}^* b_{t-1}^* + e_t P_{m,t}^* F_{c,t} - P_{c,t} c_t^* - \tau_t^* P_{h,t} I_t^*. \tag{38}$$

2.6 Monetary policy

In the benchmark economy, the central bank follows the conventional Taylor rule:

$$\frac{R_t}{\bar{R}} = \left(\frac{R_{t-1}}{\bar{R}}\right)^{\rho_R} \left[\left(\frac{P_{c,t}}{P_{c,t-1}}\right)^{\phi_{R,\pi}} \left(\frac{Y_t}{Y_{t-1}}\right)^{\phi_{R,g}}\right]^{1-\rho_R}, \tag{39}$$

where the coefficients $\phi_{R,\pi}$ and $\phi_{R,g}$ are the responses of interest rate to CPI inflation and GDP growth, respectively.

2.7 Exogenous shocks

The exogenous variables, $y_t = \{A_t, z_{h,t}, R_t^*, Y_t^*\}$, are assumed to follow autoregressive processes

$$\log y_t = \rho_x \log y_{t-1} + (1 - \rho_x) \log \bar{y} + \varepsilon_{y,t} \tag{40}$$

$$\varepsilon_{y,t} \sim N\left(0, \sigma_y^2\right). \tag{41}$$

We use positive shocks in productivity, housing preferences, and foreign demand, and an expansionary foreign interest-rate shock, to simulate scenarios in which house price inflation increases.

2.8 Parameterisation

Without any specific economy in mind, we set the parameter values to be in the common ranges seen in the literature. These parameter values are summarised in Table 1. Most of the parameters follow Iacoviello and Neri (2010) except the following. The housing preference parameters, κ_s and κ_b, are calibrated to be 0.5, such that the steady-state housing output is about 20% of the GDP. This is true for small open economies in which the housing sectors are more attractive to foreign investors, for example, Hong Kong and Singapore. The elasticity of demand in housing by foreigners is set to a lower value at 0.5 as compared to the foreign goods demand at 3.0. We also assume that in steady state, no stamp duty is imposed, and the LTV ratio cap is 0.85.

We assume some interactions among the shocks. Standard deviations of the shocks are set to be 0.005, 0.05, 0.000625, and 0.05 for productivity, housing preference, foreign interest rate,

and foreign demand, respectively. To reflect the association between the exogenous shocks, we assume the correlation between the foreign shocks to be 0.5 and that between the domestic housing preference and the foreign demand to be 0.2.

3 Model dynamics with a tradable housing sector

Our concern is whether FDI in housing exacerbates the volatility in house price inflation and, consequently, real activity and CPI inflation. To understand the effect of FDI, we compare the case where there is no FDI with the case where there is limited participation in the domestic housing market by foreigners.

Holding all other parameters at their calibrated values, we simulate the former case by setting the parameter θ_h^* to 0. According to Eq. (2), FDI in the housing market is 0 and is invariant. We then increase the value of θ_h^* to 0.5 to mimic the case where FDI is time-varying, with the relative movements between housing investment return $R_{h,t}^*$ and foreign riskless return R_t^*. This value of θ_h^* delivers a standard deviation of housing stock held by foreign entities that equals 3% of the GDP.[4]

In these comparative simulations, monetary policy is set at its simplest form, excluding any macro-prudential considerations. The simulations are for two domestic shocks (productivity and housing preference) and for two foreign shocks (foreign demand and foreign interest rate).

Table 2 presents the variance decompositions for key variables for the case without FDI and the case with FDI (the latter in parentheses). The variables are GDP, consumption, CPI inflation, domestic housing investment, house price inflation, and policy interest rate.

In Panel A, we compare the standard deviations of these variables, expressed as percentages of their respective steady states. The effects of FDI, under the simplest form of monetary policy, are more volatile GDP, consumption, and policy interest rate, and more stable CPI inflation, housing investment, and house price inflation.

In Panel B, we compare the variance decompositions between these two cases. This panel reveals the following general observations. First, the contribution of productivity shocks, as expected, dominates the variance decompositions. Second, overall volatility in the variables can be attributed, to a large extent, to foreign shocks. This is especially so for GDP, the policy interest rate, and house price inflation. Third, shocks to the demand factors, namely, the domestic housing preference and foreign demand, are the most important contributors to volatility in house price inflation.

A closer comparison of the variance decompositions for the simulations with/without FDI shows that the presence of foreign investment in domestic housing has an important effect on domestic housing investment and house price inflation. The importance of the foreign shocks in explaining domestic housing investments increases from 4.8% to 10.5% for foreign demand. Correspondingly, the importance of productivity drops from 76.0% to 71.1%. For house price inflation, the importance of foreign interest rate increases slightly. The variance decompositions

[4] According to Singapore's data, around 16% of the residential properties are owned by foreigners. This proportion translates to 3% of the GDP in our model economy.

for the other variables appear to be similar and, thus, are barely affected by the presence/absence of FDI.

To obtain further insights into the differences in the contributions of the shocks, we compare the impulse responses of key macroeconomic variables to a foreign demand shock and a domestic housing preference shock. In Fig. 3a, we show the impulse responses to a foreign demand shock for the cases without/with FDI in the housing market. The former is represented as blue dashed lines and the latter as red solid lines. The immediate effect of an increase in foreign demand in the consumption-good sector (blue dashed lines) is the higher volume of exports and hence the higher profits for the savers who own the firms. Both savers and borrowers consume less as foreigners consume more. The higher profits from the production sector cause a surge in housing investments by the savers, which crowds out the borrowers'. Fewer loans are available as savers invest more. Housing output responds to the aggregate housing demand with an initial oversupply followed by a contraction. The resultant levels of the real house price inflation are therefore first below the steady state and then above it.

When FDI is present in the housing market, the differences show up mainly in the housing sector. As the red solid lines show, the domestic house buyers invest less in housing as foreigners invest more. The crowding-out effect of the FDI has moderated housing investment from the savers. The resultant aggregate demand from the savers, the borrowers, and the foreigners is lower than in the case without FDI. The housing output responds to the aggregate demand with a decline and gradual movement back to its steady state. Because of the less volatile movements in the demand and supply in the housing market, the real house price inflation also exhibits smaller fluctuations. The responses of GDP and CPI inflation do not vary differently across these two cases.

In contrast to the effects of foreign shocks, the impulse responses for domestic shocks are not as distinguishable between the cases with/without FDI in the housing market. The impulse responses are depicted in Fig. 3b. A housing preference shock causes the demand for housing to increase. The effect is immediate for the borrowers. The savers respond with an initial dip, followed by higher housing investment. Real house price inflation is higher because of the increased demand. At the same time, housing output drops as the increase in house price inflation compensates for the profit from housing development. Comparing the cases without and with FDI in the housing market, we find the most obvious differences to be in the housing investments by the savers and the borrowers.

Overall, foreign participation in domestic housing is modelled here as being driven by portfolio considerations about returns. This implies that foreigners enter the domestic housing market when prices are high (returns to housing exceed returns to foreign bonds) and exit when house prices are low (relative returns are not favourable to housing). This helps to smooth out some of the fluctuations in the domestic housing market, and thus, overall foreign shocks become less important as sources of fluctuations in housing market dynamics and, by extension, of fluctuations in overall real activity (GDP) and CPI inflation.

We also examined impulse responses to the productivity and the foreign interest-rate shocks.

To keep this paper concise, these figures are not presented here, but are available from the corresponding author on request. The impulses are consistent with the findings given here.

4 Policies and welfare

We have seen how FDI affects the dynamics of the model economy. We now discuss how policies should be designed to achieve better welfare for a society. The welfare criterion adopted is widely used in the literature, for example, Faia and Monacelli (2007), Schmitt-Grohé and Uribe (2007), and Erceg et al. (2000). Specifically, the welfare of each household type is computed as the conditional expectation of the lifetime utility at time t:

$$V_{i,t} = U_{i,t} + \beta_i V_{i,t+1}, \tag{42}$$

where i denotes the household type. It follows that the society's welfare is calculated as the weighted average of the welfare of the two types of household:

$$\tilde{V}_t \equiv (1-\beta_s)\, V_{s,t} + (1-\beta_b)\, V_{b,t}. \tag{43}$$

Higher values of the welfare measures correspond to improvements in welfare. The values of the welfare measures are obtained as the unconditional means of $V_{s,t}$, $V_{b,t}$, and $\tilde{V}_t$. In the simulations, the DSGE model is solved at the second order.

Given the form of the utility function, the difference in welfare between a base case and under an alternative policy rule can also be presented as the change in consumption units required for households under the baseline policy to achieve the same level of welfare under the alternative rule. This consumption-equivalent welfare effect is calculated as

$$\exp\left[(1-\beta_i)\left(V_i^1 - V_i^0\right)\right] - 1, \tag{44}$$

where V_i^1 is the lifetime utility of household type i under the alternative policy, and V_i^0 is the lifetime utility under the baseline policy. Accordingly, the consumption-equivalent welfare effect for the society is calculated as

$$\exp\left[\left(\tilde{V}^1 - \tilde{V}^0\right)\right] - 1. \tag{45}$$

In obtaining the optimal policy regimes, we assume that the policy maker's objective is to achieve the highest level of welfare, $\tilde{V}$, by adopting a reaction function that links a policy instrument to changes in economic conditions. We consider a number of policy options that are combinations of simple rules describing the responses of policy instruments. The policy instruments involve both monetary and fiscal tools, namely, the interest rate, the LTV ratio cap, and the stamp duty. The policy interest rate responds to changing economic conditions as reflected in GDP growth, CPI inflation, and optionally, real house price inflation. The LTV ratio cap may be fixed or time-varying in response to domestic loans or real house price inflation.

Similarly, the stamp duty may be fixed or time-varying in response to real house price inflation. Additionally, the stamp duty may be differentiated according to the nationality of the buyers, allowing greater flexibility in enhancing welfare.

We compute the welfare effects under alternative rules and present the consumption-equivalent welfare effects from the various alternative rules. In the following simulations, the baseline case is the one with the ad hoc Taylor rule and no FDI in the domestic housing market described in section 3. The coefficients of the optimal policy rules and their respective welfare outcomes are summarised in Table 3. Numbers in parentheses correspond to the case with FDI.

4.1 Welfare effects of FDI

Before examining optimal policy regimes, we first look at the welfare effects of having FDI under the ad hoc regime. The first column in Table 3 provides the coefficients in the ad hoc regime and the welfare effect with respect to the baseline case. As per the design of our experiment, the only source of the differences in welfare is the change in the parameter value of θ_h^*. At the society level, welfare improves. This is because FDI increases the income flows to the domestic economy, and hence, aggregate consumption is likely to be higher when compared with the case without FDI.

However, we also note that this is not a Pareto improvement in welfare. Although society's welfare improves, it is at the expense of the savers. The welfare of savers is negatively affected, but overall, society's welfare is dominated by the positive effect on the welfare of borrowers. As will be discussed later in section 5, the welfare losses incurred by savers, due to FDI, are associated with more volatile interest returns, causing increased uncertainty in the income of savers.

4.2 Alternative optimal policy rules

All rules in the remaining columns in Table 3 are optimal policy rules. For each policy option, we search over commonly accepted ranges for parameters governing the responses of the policy instruments, to identify the optimal set of values that will deliver the highest welfare. As in column 1, the welfare effects are with respect to the baseline scenario (ad hoc policy rule and no FDI).[5]

We discuss five sets of optimal policies. The first is the optimised Taylor rule regime (TR). The second is an extension of TR to include consideration of house price inflation (augmented TR, or ATR). The third alternative is to complement TR with a time-varying LTV ratio cap that responds to selected variables (the TR+LTV policy regime). The fourth alternative is the addition of a fiscal rule, or a time-varying stamp duty, to the TR (the TR+FR policy regime). The final alternative scenario is the consideration of a policy setting with all policy instruments in effect (TR+LTV+FR). Note that the three alternatives that involve the use of

[5]For the optimal Taylor rule regime, the ranges of parameters over which our grid search is conducted are $[1, 10]$ and $[0, 10]$ for $\phi_{R,\pi}$ and $\phi_{R,g}$, respectively, and $[0, 0.9]$ for the smoothing parameter ρ_R. The grid step for each parameter is 0.1. The set of parameters corresponding to the highest mean value of $\tilde{V}$ then forms the optimal policy rule.

macro-prudential tools (LTV and/or FR) are alternatives to the ATR case (which targets house price inflation directly).

All alternative policy options considered are also linear additions to TR. Since TR is always in operation alongside the alternative policy specifications, we hold the optimised coefficients in Eq. (39) unchanged when searching for the additional optimal policy coefficients and smoothing parameters introduced in the alternative policies. This approach allows us to analyse the change in effects between TR and the alternative policies as any changes in economic dynamics or welfare reflect the additional responses introduced in the alternative policy rules.[6] Accordingly, should the alternative specifications not deliver better welfare than TR, the coefficients in the alternative specifications remain at 0.

In what follows, we assess the welfare effects of the optimal regimes in two ways. First, we analyse the change in welfare due to an inflow of FDI into domestic housing. This is done by comparing, under the same policy regime, the cases without and with FDI. Second, we analyse the welfare effects relative to the TR regime by comparing the cases with/without FDI under each regime with the same case under TR (see Fig. 4 for a visual comparison).

4.2.1 Interest-rate regimes

As seen from columns 2 and 3 in Table 3, the TR regime features larger response to CPI inflation, smaller response to GDP , and slightly higher smoothing than in the ad hoc policy regime case. The coefficients for the with/without FDI are very similar. Taking into account the smoothing coefficient, TR in both cases features active responses to CPI inflation ($\phi_{R,\pi} > 1$).

The transition from the ad hoc regime to the TR policy regime shows substantial welfare improvement. This is, however, not a Pareto improvement, because savers experience lower welfare while borrowers experience higher welfare. This is because of the more active responses to CPI inflation under the optimised TR regime, which lead to greater movements in the interest rate and, hence, greater volatility in the income savers receive from their domestic lending. The situation is, moreover, worse in the presence of FDI. Despite the improvement in overall social welfare, the welfare of savers falls in the case without FDI (compare this (column 2) with the case with FDI (column 3)).

The first alternative rule we consider is whether the interest-rate rule should also include targeting conditions in the housing market. We do this by evaluating the welfare implications of an interest-rate rule that includes reactions to changes in real house price inflation. We call this ATR (augmented Taylor rule) because it is simply an extension of the conventional Taylor rule. The ATR regime can be written as

$$\frac{R_t}{\bar{R}} = \left(\frac{R_{t-1}}{\bar{R}}\right)^{\rho_R} \left[\left(\frac{P_t}{P_{t-1}}\right)^{\phi_{R,\pi}} \left(\frac{Y_t}{Y_{t-1}}\right)^{\phi_{R,g}} \left(\frac{P^r_{h,t}}{P^r_{h,t-1}}\right)^{\phi_{R,\pi_h}}\right]^{1-\rho_R}, \tag{46}$$

[6] Less computing power is also needed in finding the optimal parameters. Time needed for the grid search increases exponentially with the number of parameters. Searching among subsets of the parameters helps to reduce computing time.

where $P^r_{h,t}$ denotes the relative (real) price of housing to that of consumption goods. When $\phi_{R,\pi_h} = 0$, ATR collapses to the TR case. Where $\phi_{R,\pi_h} > 0$, the interest rate moves counter-cyclically with real house price inflation. It is designed to curb housing investment by increasing the cost of borrowing as real house inflation accelerates.[7] As columns 4 and 5 in Table 3 show, the ATR features passive responses to real house price inflation after taking into account the smoothing parameter.

There are two potential side-effects associated with this policy regime. First, the additional target introduces additional uncertainty to the interest income of the savers. Second, as is evident from the uncovered interest-rate parity relationship, there will be greater exchange-rate uncertainty, which in turn creates greater uncertainty in the profits of firms from exports. Savers are thus likely to be at a disadvantage under this regime. From columns 4 and 5 in Table 3, despite higher welfare to society, when compared with TR, the welfare of savers is lower regardless of the absence/presence of FDI in the domestic housing market.

Comparing across the cases with and without FDI, we find similar welfare implications for savers, borrowers, and society. Specifically, savers suffer from lower welfare, while borrowers gain in welfare, when there is FDI in the domestic housing market. The overall aggregate effect of FDI on society is slightly higher.

We show in Fig. 4a the welfare effect of ATR as the response of interest rate to real house price inflation increases from 0 to 5 in the case with FDI. Note that when $\phi_{R,\pi_h} = 0$, the regime is the same as TR, and hence, no welfare effect is observed. These plots show that the savers' welfare deteriorates in the positive range of ϕ_{R,π_h}, while the borrowers' welfare becomes worse at values greater than 5. Society gains in welfare when $\phi_{R,\phi_h} < 2.3$.

Rather than target house price inflation, we next investigate alternative instruments of macro-prudential policies. Specifically, we consider the welfare outcomes from implementing a TR interest-rate regime in conjunction with the use of other time-varying instruments such as the macro-prudential tool, the LTV ratio, and/or the fiscal tool of stamp duties.

4.2.2 Dynamic LTV ratio cap

We consider a dynamic LTV ratio cap (TR+LTV), which varies in a counter-cyclical manner around the steady state, $\bar{\iota}$. The counter-cyclical LTV ratio rule is described as follows:

$$\frac{\iota_t}{\bar{\iota}} = \left(\frac{\iota_{t-1}}{\bar{\iota}}\right)^{\rho_\iota} \left(\frac{x_t}{x_{t-1}}\right)^{-\phi_{\iota,x}(1-\rho_\iota)}, \tag{47}$$

where $x_t = \left\{P^r_{h,t}, b_t\right\}$. The LTV ratio cap, ι_t, may be fixed or time-varying, depending on the coefficient $\phi_{\iota,x}$. When $\phi_{\iota,x} = 0$, the LTV ratio cap is fixed at $\bar{\iota}$ as in Table 1. In this scenario, when real house price inflation increases or domestic loans expand, loans available to the borrowers also increase, potentially posing higher systemic risk to the economy. In contrast, when $\phi_{\iota,x} > 0$, the time-varying LTV ratio cap changes — falls with increases in real house

[7] After coefficients in the TR are determined, the additional coefficient, ϕ_{R,π_h}, in ATR is found by searching over the range $[0, 5]$, also in steps of 0.1.

price inflation or expansion of domestic loans — so the growth in loans available to borrowers is moderated. Following Mendicino and Punzi (2014), we assume that the LTV ratio cap may respond to only one variable at a time. The time-varying feature in the LTV ratio cap is expected to lead to smoother payment schedules for borrowers, although it also implies less interest income for savers.

The optimal coefficients for TR+LTV are presented in columns 6 to 9 in Table 3. We present the optimal responses of the LTV ratio cap to real house price inflation in columns 6 and 8, and the optimal responses to growth in domestic loans in columns 7 and 9. Although the optimal LTV ratio cap responds to real house price inflation or domestic loans in a fairly active manner, the autoregressive coefficient of 0.9 helps to smooth the changes, resulting in less than proportionate responses. The responses in the case without FDI (columns 6 and 7) are slightly larger than, but comparable with, those in the case with FDI (columns 8 and 9).

In contrast to the ATR regime discussed earlier, FDI under a TR+LTV policy regime does not lead to a clear improvement in the overall welfare of society. Comparing columns 6 and 8 (when the LTV ratio cap is set to respond to house price inflation), we see that the welfare of borrowers remains about the same, but the welfare of savers is lower. The increase in the volatility of domestic housing demand associated with the introduction of FDI has not been sufficiently moderated by the LTV ratio cap rule. Hence, the interest income of savers is affected negatively by greater uncertainty in the provision of loans, which translates into a deterioration in the welfare of savers. When the LTV ratio cap is set to respond to the growth in home loans, there is a marginal improvement in welfare when FDI is present.

We show in Fig. 4b the welfare effects relative to TR in the case with FDI for a range of reaction coefficients. The red solid lines are for the case when the LTV ratio cap responds to real house price inflation; the blue dashed lines are for the case when the LTV ratio cap responds to domestic loan growth. It is clear that an LTV ratio cap responding to real house price inflation delivers higher social welfare than one responding to domestic loan growth, but, similar to ATR, the welfare of savers is lower compared to TR in the positive range of ϕ_{ι,π_h}. Despite the lower social welfare gain shown by the blue dashed lines, it is interesting to find that the savers may gain from an LTV ratio cap responding to domestic loan growth at a value of $\phi_{\iota,b}$ that is large enough. It is even possible to achieve a small Pareto improvement when $\phi_{\iota,b}$ is between 4 and 6. However, because of the marginal improvement in welfare, we shall focus our discussion on the TR+LTV regime that responds to real house price inflation only.

4.2.3 Dynamic fiscal rules

The second time-varying instrument we investigate, together with a Taylor rule, is a fiscal rule (FR), or as it is more commonly known, stamp duties on housing transactions. It is important to note that this fiscal instrument has symmetric effects — it can be a tax or a subsidy imposed on participants in the market. Taxes increase transaction costs and curb housing demand, while subsidies offset changes in house price, delivering smoother transaction price movements (especially useful to support affordable housing during periods of house price hikes).

In practice, policy makers tend to be sensitive to the nationality of the house buyers and will implement discriminatory fiscal measures. In other words, domestic and foreign buyers will be subject to different rates of stamp duties/subsidies:

$$\frac{\tau_t}{\bar{\tau}} = \left(\frac{\tau_{t-1}}{\bar{\tau}}\right)^{\rho_\tau} \left(\frac{P^r_{h,t}}{P^r_{h,t-1}}\right)^{\phi_{\tau,\pi_h}(1-\rho_\tau)} \tag{48}$$

$$\frac{\tau^*_t}{\bar{\tau}^*} = \left(\frac{\tau^*_{t-1}}{\bar{\tau}^*}\right)^{\rho^*_\tau} \left(\frac{P^r_{h,t}}{P^r_{h,t-1}}\right)^{\phi^*_{\tau,\pi_h}(1-\rho^*_\tau)}, \tag{49}$$

where τ and τ^* correspond to fiscal rules imposed on the local and the foreign buyers, respectively. They can be interpreted as stamp duties if the values are greater than unity and subsidies if the values are less than unity. Similar to the LTV ratio cap, the stamp duty or subsidy can be fixed or time-varying, depending on the values of the coefficients ϕ_{τ,π_h} and ϕ^*_{τ,π_h}. In the case of a dynamic stamp duty (subsidy) rule, the buyers are taxed (subsidised) more when real house price is higher.

Coefficients for the TR+FR policy regime are presented in columns 10 to 12 in Table 3. In the case without FDI, no foreign buyers can participate in the domestic housing market. Hence, the TR+FR regime does not include the coefficient $\phi^*_{\tau,\pi}$. When FDI is present in domestic housing, policy makers have the option to tax foreign buyers (to include or to exclude Eq. (49) alongside Eq. (48)).

Our experiment here is to identify the welfare effects of a stamp duty on foreign buyers. For the case with FDI, we run a simulation assuming Eq. (49) is not in action (column 11) and compare it with a simulation when Eq. (49) is implemented.

The optimal rules in the TR+FR regime are interpreted as stamp duties (instead of subsidies, given the positive coefficients). These rules indicate active and persistent responses of the stamp duty to real house price inflation. As such, following an increase in real house price inflation, there is a redistribution of wealth from house buyers back to patient and impatient households. The redistribution of income may boost domestic consumption as well as mitigate the distortionary impact of taxes on consumption and investment decisions.

The fact that domestic and foreign buyers can be subject to different stamp duties implies greater flexibility in pursuing policies to enhance social welfare. Without imposing a stamp duty on foreign buyers, the welfare effect of FDI under TR+FR is similar to TR+LTV. Borrowers gain while savers lose, leading to an overall loss in social welfare (columns 10 and 11). However, if we compare the welfare effects in columns 11 and 12, we can see that the welfare of society is improved when there is an additional stamp duty rule on foreign buyers. The welfare loss to savers is also smaller when compared with the case without FDI. TR+FR with a stamp duty on foreign buyers enhances the income-redistributing effect at the expense of foreign buyers, mitigating the welfare loss to savers.

It is important to note that the stamp duty rules for local residents and for foreigners need to work together to achieve the best welfare outcome. We show the welfare effect of TR+FR relative to TR in Fig. 4c. Each stamp duty rule may improve social welfare when working

independently, but will lead to steep welfare loss for savers, especially when the stamp duty is imposed on only local residents. The loss-mitigating effect from the foreigners' stamp duty kicks in at only the moderate range of ϕ_{τ,π_h}. As such, both stamp duty rules are needed to achieve the highest social welfare or the least welfare loss to savers. Nevertheless, the savers' loss is unlikely to be mitigated within the reasonable ranges of ϕ_{τ,π_h} and ϕ^*_{τ,π_h}.

4.2.4 A combined monetary–fiscal strategy

The final policy regime investigated is one with a Taylor rule, a dynamic LTV ratio cap, and a fiscal rule (TR+LTV+FR). The optimal policy parameters are not restricted, and we find that this regime delivers a better welfare outcome that all the other options discussed. It turns out that, in the case without FDI, TR+LTV+FR produces outcomes similar to the TR+LTV case, implying that the FR component is redundant. However, in the case with FDI, a coordinated use of these three policy instruments yields the best welfare (column 13 in Table 3) (but only slightly better than under TR+FR). Similarly, borrowers gain and savers lose as compared with TR, but the redistribution of stamp duties collected partially mitigates the loss to savers.

4.2.5 Discussion

The simulations were designed to consider the effects of five policy regimes on welfare. The base case is the traditional Taylor rule (TR), where the interest rate is formulated to maintain stability in goods price inflation. The first point to note is that allowing the interest rate to also react to changes in real house price inflation is not necessarily better at improving welfare than the adoption of alternative macro-prudential tools (such as the LTV ratio cap and stamp duties).

Second, although ATR, TR+LTV, TR+FR, and TR+LTV+FR all deliver higher social welfare than TR, the welfare of savers falls in all scenarios. This is because the additional target or policy instruments introduce greater uncertainty in the interest income of savers. This effect is exacerbated when the housing market is open to FDI.

Third, our welfare comparison across the policy regimes shows that TR+LTV delivers the best welfare outcome under the condition that FDI in the domestic housing market is not allowed. However, this may not be a realistic scenario for global cities in small open economies. We find instead that coordination between monetary and fiscal rules — the TR+LTV+FR regime — delivers the next best welfare outcome for society.

Rather than ban FDI altogether, the imposition of stamp duties on foreign investment in domestic housing can serve two purposes. On the one hand, it discourages excessive foreign demand if the housing market is overheated, and on the other hand, the income generated can be redistributed to local residents, thereby increasing consumption and investments domestically. If operated optimally, the TR+FR regime is capable of mitigating the welfare losses of savers and at the same time maintaining the welfare-improving feature of FDI.

5 Stabilising effects of policies

To round off the analysis, we present results about the stabilising/de-stabilising effects of FDI under alternative optimal policy regimes. These effects may differ from those reported in section 3, because alternative policy reaction functions can change the nature of responses in housing market conditions. For completeness, the volatility comparisons are presented in two tables — one to show the effect of FDI and another to show the effect of the policy regime.

We list in Table 4 the changes in standard deviations, allowing for FDI in domestic housing under different optimal policy regimes. The values presented are ratios of standard deviations, calculated relative to the base case without FDI, in each policy regime. A value greater than unity indicates greater volatility, and vice versa.

In Table 5, we present the standard deviations under respective regimes relative to the TR regime. In this comparison, we also distinguish between the case without and with FDI (the latter in parentheses). If the ratio of standard deviations is greater than unity, it indicates larger volatility relative to the TR case, and vice versa.

Note first the higher volatility in policy interest rates across all regimes. This reflects either the introduction of the additional house price inflation target or the more variable demand and supply of loans.

The lower volatility in house price inflation is also notable.[8] This result reflects the portfolio balancing behaviour of foreign buyers as FDI in domestic housing equalises the expected return from housing investment with the return on a riskless foreign asset. This effect will moderate the volatility of house price inflation, as long as international returns remain stable.

In contrast to the more stable house price inflation, domestic housing investments appear to be more volatile under the multi-instrument regimes. Note that under the fiscal rules (TR+FR and TR+LTV+FR), the de-stabilising effect of FDI is most obvious. This is jointly due to the crowding-out of domestic housing investments by FDI and the stamp duty that directly distorts households' consumption and investment decisions.

The effects of FDI on the other macroeconomic variables are mixed. In general, FDI leads to more volatile aggregate consumption and CPI inflation. Volatility in GDP is more stable under TR+FR and TR+LTV+FR and is almost unaffected under TR, ATR, and TR+LTV.

When FDI is not present in domestic housing, the alternative regimes (relative to TR), in general, deliver more stable macroeconomic variables. GDP, housing investments, and house price inflation are all more stable under TR+FR. Consumption is most stable under ATR. CPI inflation and policy interest rate are most stable under TR+LTV. We also see a correspondence between the welfare-based optimal policy and the stabilisation objective of the policy makers.

When FDI is present in domestic housing, the stabilisation effects are slightly different. This difference arises from the volatility of housing investments, which becomes higher than in the TR case under the alternative regimes: ATR, TR+LTV, TR+FR, and TR+LTV+FR. The volatility in housing investment is highest in TR+LTV+FR. However, house price inflation is best stabilised with TR+FR and TR+LTV+FR. This result shows that the welfare maximisa-

[8] Lower volatility in house price inflation was also evident in section 3.

tion objective and the stabilisation of house price inflation are also consistent in the case when FDI is present in domestic housing.

We plot in Fig. 5 the impulse responses to foreign demand shock and domestic housing preference shock in the case with FDI. It appears that FDI leads to greater crowding-out effects in domestic housing investments, but smaller drops in consumption under the FR regimes with foreign demand shock (Fig. 5a). Under a domestic housing preference shock, the FR regimes help to curb the demand from FDI, to prevent overheating of the domestic housing market (Fig. 5b).

In sum, FDI in domestic housing is not always de-stabilising. The de-stabilising effects are more likely with the macroeconomic variables such as consumption, CPI inflation, and interest rate, rather than with variables in the housing sector such as house price inflation. Furthermore, the effects are regime-dependent. Regimes involving coordination between monetary and fiscal instruments are more likely to be associated with larger stabilising or de-stabilising effects of FDI. Among the five regimes, the stabilising effect of FDI on house price inflation is most prominent under the TR+LTV+FR policy regime.

6 Conclusion

Housing has become more tradable with the ease of international fund transfers and travelling. In global cities where population density is high, housing is seen as an attractive investment vehicle for buyers around the world. Policy makers thus face the challenge of balancing the benefits and costs of FDI in the housing sector. In this paper, we examine the implications of a "tradable" housing sector for the design of macro-prudential policies in small open economies.

We propose a model that allows for foreign investment in domestic housing. The model is simulated to yield insights about the importance of FDI in housing as well as to provide some understanding about the welfare and volatility implications of various policy regimes. The policy regimes examined include the adoption of a Taylor rule in conjunction with the implementation of time-varying LTV ratio caps and stamp duty rules on housing transactions by foreigners. We also considered the adoption of a Taylor rule that includes reacting to house price inflation.

Our findings are as follows. First, FDI in domestic housing is, in general, welfare-improving and does not de-stabilise house price inflation. The former result is due to the additional income that foreign entities bring to the economy, analogous to exports purchased; the latter result is due to the portfolio balancing behaviour of the foreign investors. Second, coordination in the use of instruments such as the interest rate and other time-varying instruments (the LTV ratio cap and stamp duty rules) enhances the welfare of the economy. Finally, FDI and optimal policy regimes, in general, make savers worse off, but the losses can be mitigated by an active stamp duty rule on foreign buyers. This is because of the redistribution of wealth from foreign buyers to the domestic residents, which increases consumption and investment domestically.

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References

Adolfson, M., S. Laséen, J. Lindé, and M. Villani (2007, July). Bayesian estimation of an open economy DSGE model with incomplete pass-through. *Journal of International Economics 72*(2), 481–511.

Aizenman, J. and Y. Jinjarak (2009, September). Current account patterns and national real estate markets. *Journal of Urban Economics 66*(2), 75–89.

Ben Zeev, N. (2017, November). Capital controls as shock absorbers. *Journal of International Economics 109*, 43–67.

Chao, C.-C. and E. S. H. Yu (2015). Housing Markets with Foreign Buyers. *The Journal of Real Estate Finance and Economics 50*(2), 207–218.

Davig, T. and E. M. Leeper (2011, February). Monetary–fiscal policy interactions and fiscal stimulus. *European Economic Review 55*(2), 211–227.

Devereux, M. B. and A. Sutherland (2007, April). Monetary Policy and Portfolio Choice in an Open Economy Macro Model. *Journal of the European Economic Association 5*(2/3), 491–499.

Engel, C. and J. Wang (2011, January). International trade in durable goods: Understanding volatility, cyclicality, and elasticities. *Journal of International Economics 83*(1), 37–52.

Erceg, C. J., D. W. Henderson, and A. T. Levin (2000, October). Optimal monetary policy with staggered wage and price contracts. *Journal of Monetary Economics 46*(2), 281–313.

Faia, E. and T. Monacelli (2007, October). Optimal interest rate rules, asset prices, and credit frictions. *Journal of Economic Dynamics and Control 31*(10), 3228–3254.

Favilukis, J. and S. Van Nieuwerburgh (2017, June). Out-of-town Home Buyers and City Welfare.

Ferrero, A. (2015). House Price Booms, Current Account Deficits, and Low Interest Rates. *Journal of Money, Credit and Banking 47*(S1), 261–293.

Forbes, K., M. Fratzscher, and R. Straub (2015, July). Capital-flow management measures: What are they good for? *Journal of International Economics 96*, S76–S97.

Funke, M. and M. Paetz (2013, March). Housing prices and the business cycle: An empirical application to Hong Kong. *Journal of Housing Economics 22*(1), 62–76.

Funke, M. and M. Paetz (2016, January). Dynamic Stochastic General Equilibrium - Based Assessment of Nonlinear Macroprudential Policies: Evidence from Hong Kong. *Pacific Economic Review*, n/a–n/a.

Galí, J. and T. Monacelli (2005, July). Monetary Policy and Exchange Rate Volatility in a Small Open Economy. *The Review of Economic Studies 72*(3), 707–734.

Iacoviello, M. and S. Neri (2010). Housing Market Spillovers: Evidence from an Estimated DSGE Model. *American Economic Journal: Macroeconomics 2*(2), 125–64.

Jarociński, M. and B. Maćkowiak (2018, May). Monetary-fiscal interactions and the euro area's malaise. *Journal of International Economics 112*, 251–266.

Justiniano, A. and B. Preston (2010a, May). Can structural small open-economy models account for the influence of foreign disturbances? *Journal of International Economics 81*(1), 61–74.

Justiniano, A. and B. Preston (2010b, January). Monetary policy and uncertainty in an empirical small open-economy model. *Journal of Applied Econometrics 25*(1), 93–128.

Kollmann, R. (2002, July). Monetary policy rules in the open economy: effects on welfare and business cycles. *Journal of Monetary Economics 49*(5), 989–1015.

Korinek, A. (2018, March). Regulating capital flows to emerging markets: An externality view. *Journal of International Economics 111*, 61–80.

Korinek, A. and D. Sandri (2016, March). Capital controls or macroprudential regulation? *Journal of International Economics 99, Supplement 1*, S27–S42.

Kuttner, K. N. and I. Shim (2016, October). Can non-interest rate policies stabilize housing markets? Evidence from a panel of 57 economies. *Journal of Financial Stability 26*, 31–44.

Matsuyama, K. (1990, February). Residential investment and the current account. *Journal of International Economics 28*(1), 137–153.

Mendicino, C. and M. T. Punzi (2014, December). House prices, capital inflows and macroprudential policy. *Journal of Banking & Finance 49*, 337–355.

Michaud, A. and J. Rothert (2018, May). Redistributive fiscal policies and business cycles in emerging economies. *Journal of International Economics 112*, 123–133.

Monacelli, T. (2005, December). Monetary Policy in a Low Pass-Through Environment. *Journal of Money, Credit & Banking (Ohio State University Press) 37*(6), 1047–1066.

Monacelli, T. (2009, March). New Keynesian models, durable goods, and collateral constraints. *Journal of Monetary Economics 56*(2), 242–254.

Ng, E. C. and N. Feng (2016, May). Housing market dynamics in a small open economy: Do external and news shocks matter? *Journal of International Money and Finance 63*, 64–88.

Punzi, M. T. (2013, September). Housing Market and Current Account Imbalances in the International Economy. *Review of International Economics 21*(4), 601–613.

Schmitt-Grohé, S. and M. Uribe (2003, October). Closing small open economy models. *Journal of International Economics 61*(1), 163–185.

Schmitt-Grohé, S. and M. Uribe (2007, September). Optimal simple and implementable monetary and fiscal rules. *Journal of Monetary Economics 54*(6), 1702–1725.

Sterk, V. (2010, March). Credit frictions and the comovement between durable and non-durable consumption. *Journal of Monetary Economics 57*(2), 217–225.

Zhang, L. and E. Zoli (2016, February). Leaning against the wind: Macroprudential policy in Asia. *Journal of Asian Economics 42*, 33–52.

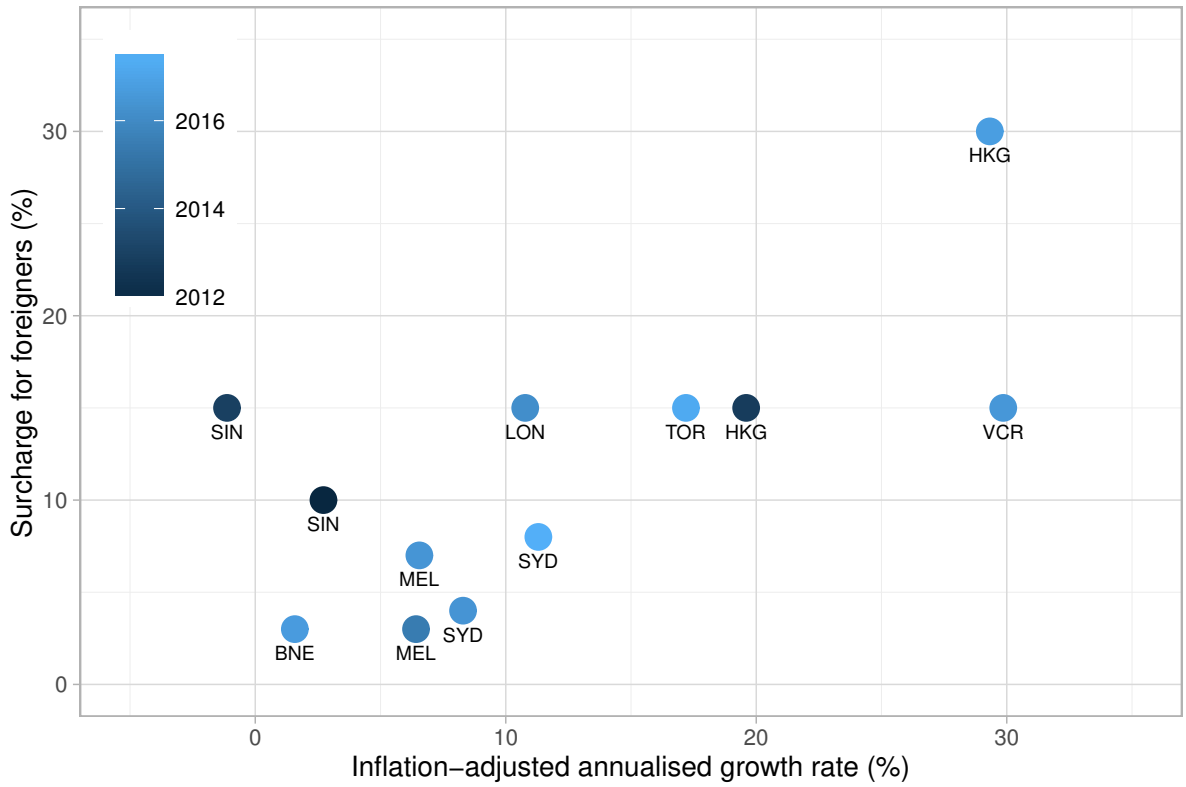


Figure 1: Surcharges on foreign buyers versus annualised growth rates of real house prices. The annualised growth rates are computed as the average of the current and past three observations of annualised real house price growth rates. Quarterly data are used for Singapore (SIN), Sydney (SYD), Melbourne (MEL), Brisbane (BNE), and London (LON), monthly data for Hong Kong (HKG), Vancouver (VCR), and Toronto (TOR). Sources: CEIC Database, Teranet.

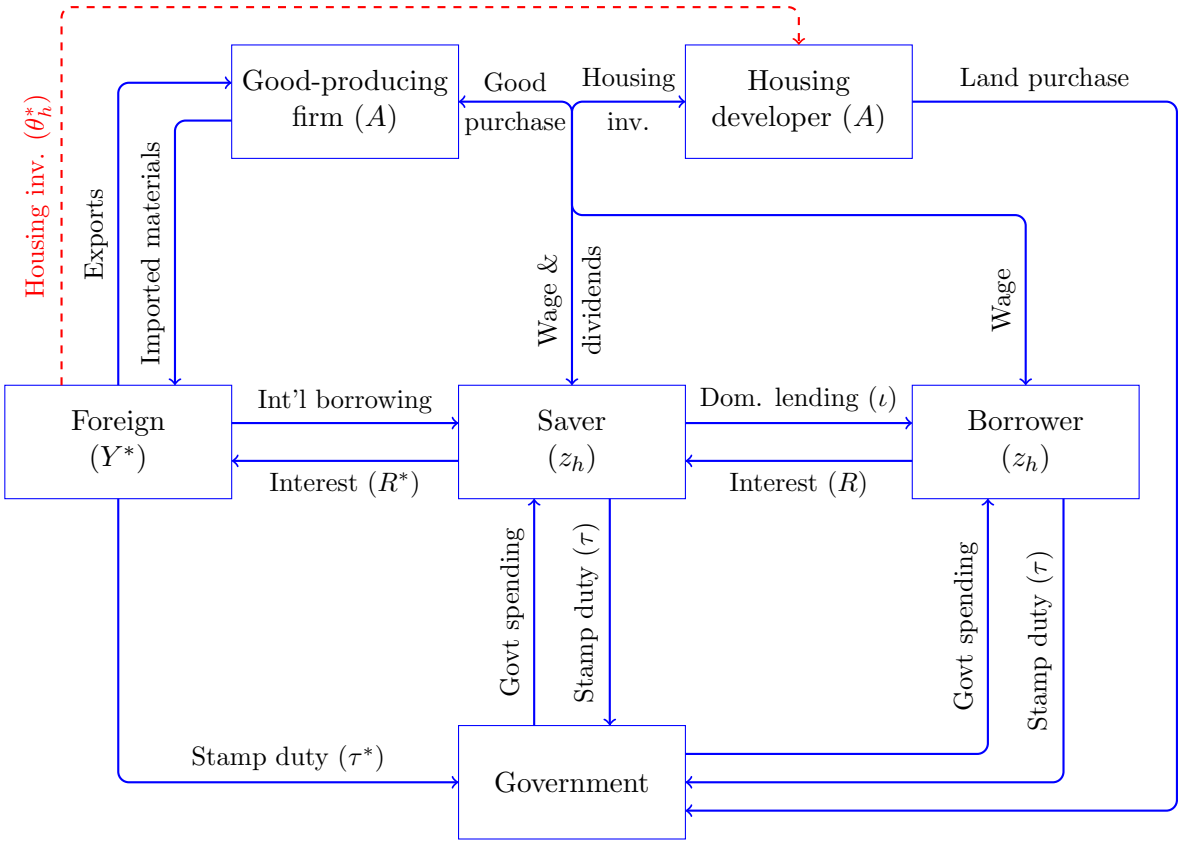
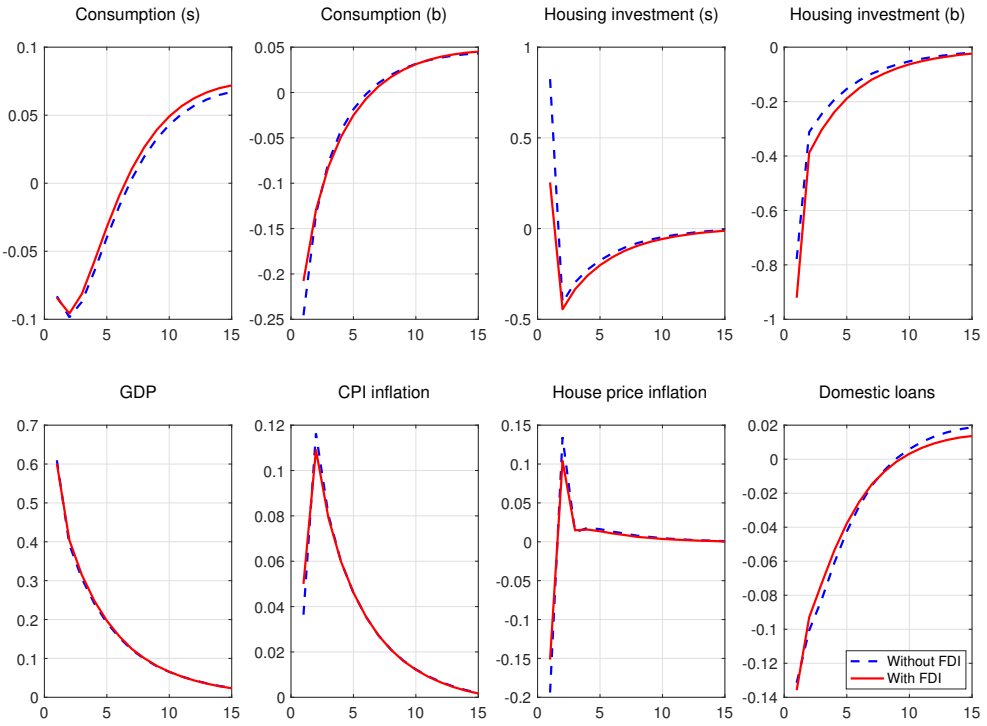
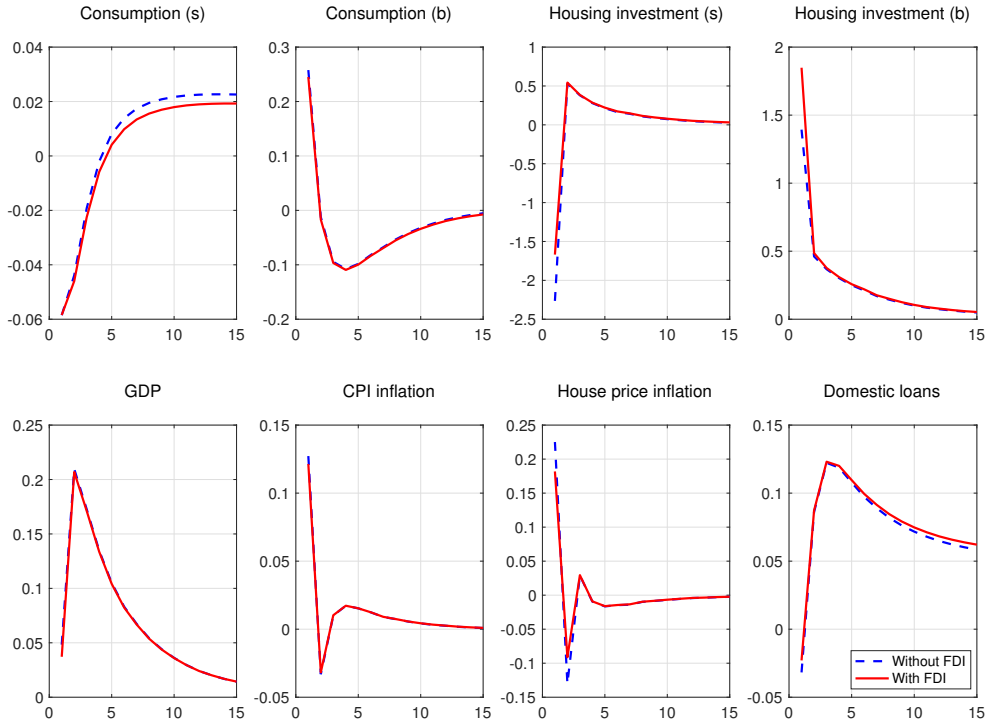


Figure 2: Flows of funds. Foreign household participation in the domestic housing market is governed by θ_h^*. Exogenous shocks in the model are foreign demand Y^*, foreign interest rate R^*, domestic housing preference shock z_h to both saver and borrower, and domestic productivity shock A to both the goods-producing firm and the housing developer. The policy instruments available are the interest rate R, LTV ratio ι, and fiscal tools τ and τ^*.

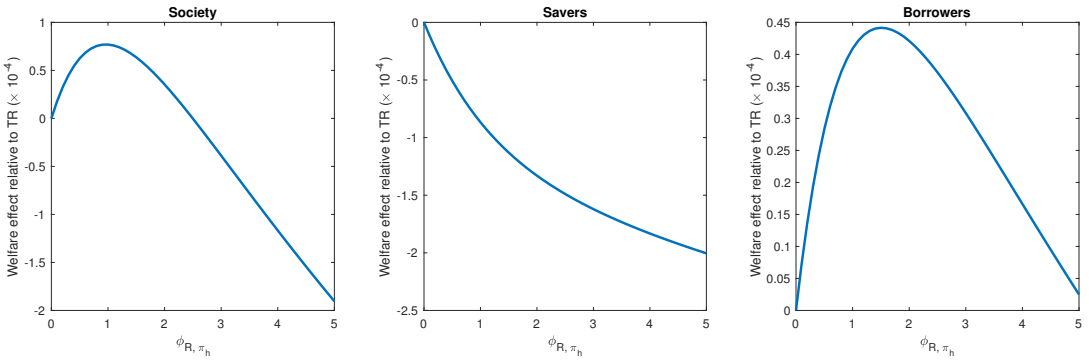


(a) Foreign demand shock.

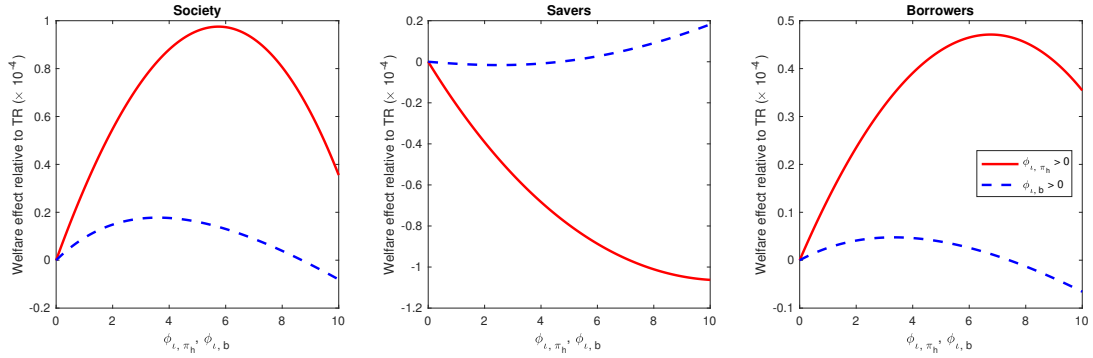


(b) Housing preference shock.

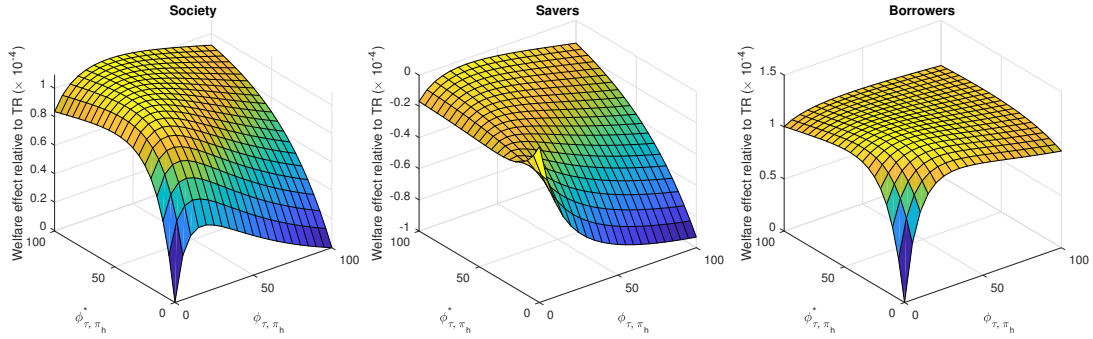
Figure 3: Impulse responses with and without FDI in domestic housing (b, borrowers; s, savers).



(a) Welfare effect of interest-rate response to π_h.

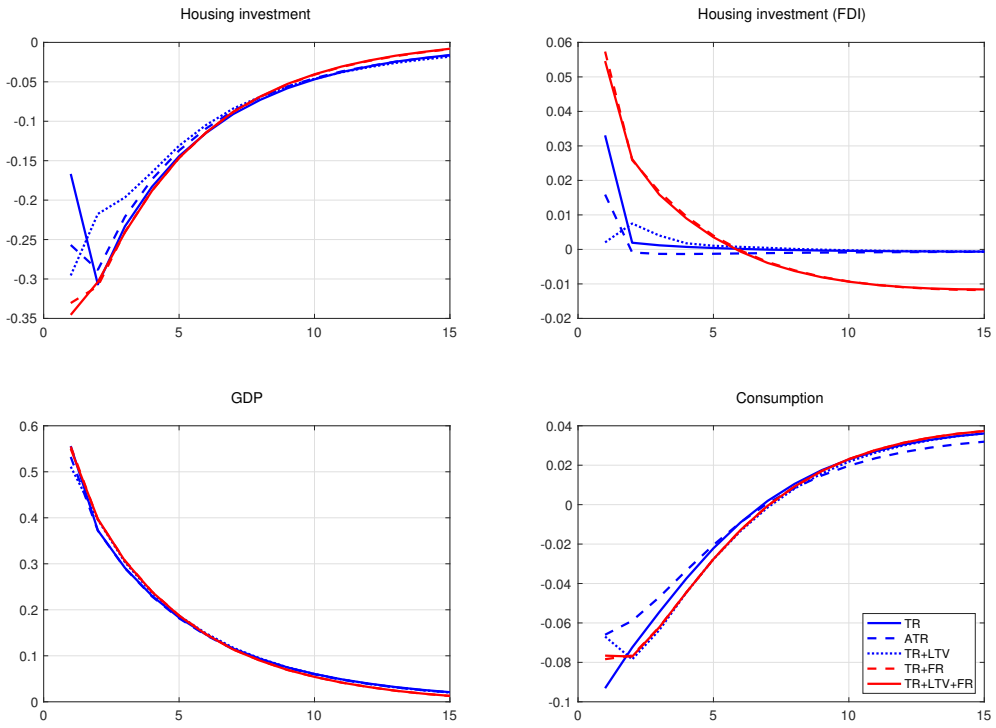


(b) Welfare effect of LTV ratio cap response to house price inflation and loan growth.

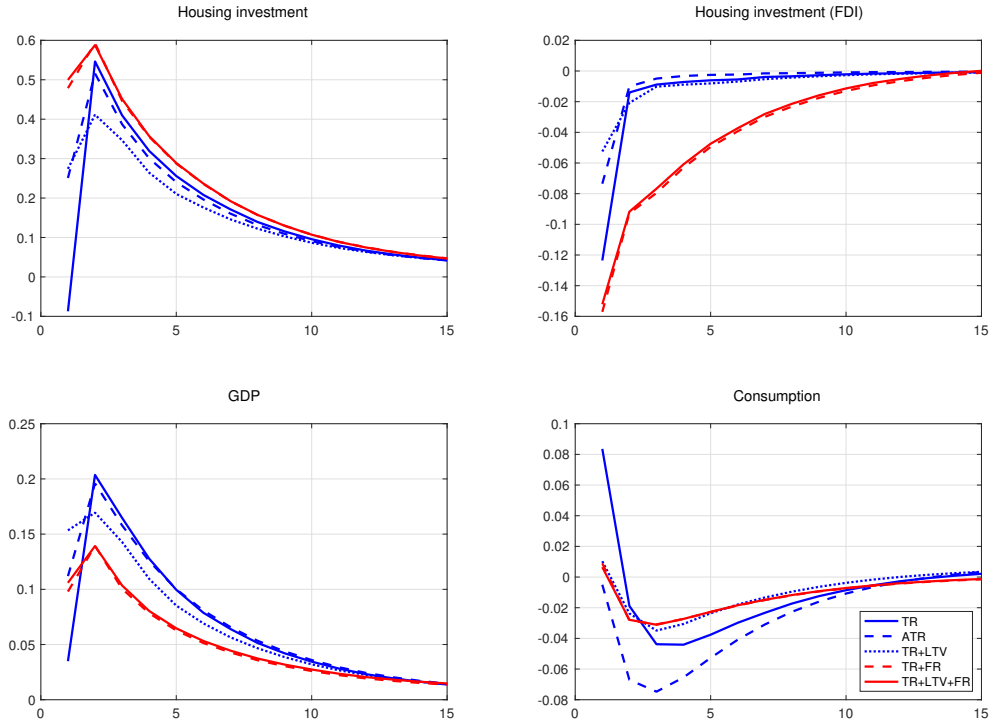


(c) Welfare effect of stamp duty response to house price inflation.

Figure 4: Welfare effects of response coefficients.



(a) Foreign demand shock.



(b) Housing preference shock.

Figure 5: Impulse responses under optimal regimes. The optimal coefficients are from Table 3. TR+LTV corresponds to column 8. TR+FR corresponds to column 12.

Table 1: Calibrated parameter values.

Parameter	Value	Description
β_s	0.993	Discount factor (s)
κ_s	0.500	Housing preference (s)
η_s	0.500	Inverse Frisch (s)
β_b	0.970	Discount factor (b)
κ_b	0.500	Housing preference (b)
η_b	0.500	Inverse Frisch (b)
δ	0.010	Housing depreciation
φ	0.001	Coefficient of risk premium
μ_c	0.300	Proportion of capital input in goods production
μ_h	0.300	Proportion of land input in housing development
θ_h^*	0.500	Foreign housing demand elasticity
θ_c^*	3.000	Foreign goods demand elasticity
ϱ	0.500	Habit formation
γ_h	8.000	Housing adjustment cost
ξ	0.500	Price stickiness
ρ_{A_c}	0.900	Autoregressive coefficient of productivity
ρ_{z_h}	0.800	Autoregressive coefficient of housing preference
ρ_π^*	0.800	Autoregressive coefficient of foreign inflation
ρ_R^*	0.800	Autoregressive coefficient of foreign interest rate
ρ_c^*	0.800	Autoregressive coefficient of exports
ρ_R	0.500	Smoothing parameter of stamp duty for interest rate
$\phi_{R,g}$	0.500	Response of interest rate to GDP growth
$\phi_{R,\pi}$	1.500	Response of interest rate to goods price inflation

Table 2: Volatility and variance decompositions with and without FDI in housing.

	A. Volatility		B. Variance decompositions							
	(% of s.s.)		Productivity		Housing preference		Foreign interest rate		Foreign demand	
GDP	1.684	(1.699)	59.6	(59.9)	4.4	(4.2)	8.9	(8.9)	27.1	(27.1)
Consumption	1.115	(1.132)	75.5	(76.0)	1.9	(1.7)	9.6	(9.4)	13.0	(12.9)
CPI inflation	0.356	(0.344)	55.6	(53.5)	14.3	(14.0)	6.6	(7.8)	23.6	(24.7)
Domestic housing investment	2.699	(2.180)	76.0	(71.1)	16.0	(15.5)	3.1	(2.9)	4.8	(10.5)
House price inflation	0.440	(0.349)	28.2	(25.0)	34.4	(34.0)	9.2	(13.6)	28.2	(27.4)
Policy interest rate	0.326	(0.326)	7.1	(5.6)	16.9	(15.4)	8.5	(8.3)	67.6	(70.7)

Notes: Simulations are conducted under the ad hoc policy regime with $\rho_R = 0.5$, $\phi_{R,\pi} = 1.5$, and $\phi_{R,g} = 0.5$; θ_h^* is set to 0 for the case without FDI and 0.5 for the case with FDI. Panel A summarises the standard deviations as percentages of steady states (s.s.). Variance decompositions in Panel B are the percentages of variations explained by respective shocks. The values for the case with FDI are in parentheses.

Table 3: Optimal policy regimes and welfare effects.

	Ad hoc	TR		ATR		TR+LTV				TR+FR			TR+LTV+FR
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
A. Optimal coefficients													
ρ_R	0.5	0.6	(0.5)	0.6	(0.5)	0.6	0.6	(0.5)	(0.5)	0.6	(0.5)	(0.5)	(0.5)
$\phi_{R,\pi}$	1.5	2.8	(2.1)	2.8	(2.1)	2.8	2.8	(2.1)	(2.1)	2.8	(2.1)	(2.1)	(2.1)
$\phi_{R,g}$	0.5	0.4	(0.3)	0.4	(0.3)	0.4	0.4	(0.3)	(0.3)	0.4	(0.3)	(0.3)	(0.3)
ϕ_{R,π_h}				1.3	(1.0)								
ρ_ι						0.9	0.9	(0.9)	(0.9)				(0.9)
$\phi_{\iota,\pi}$						6.2		(5.7)					(2.9)
$\phi_{\iota,b}$							5.6		(3.6)				
ρ_τ										0.9	(0.9)	(0.9)	(0.9)
$\phi_{\tau,\pi}$										26.2	(17.2)	(22.1)	(12.8)
ρ^*_τ												(0.9)	(0.9)
$\phi^*_{\tau,\pi}$												(64.3)	(45.9)
B. Consumption-equivalent welfare effects ($\times 10^{-4}$)													
Society	(0.718)	2.846	(2.943)	3.732	(3.712)	4.063	3.029	(3.918)	(3.120)	3.454	(3.412)	(4.037)	(4.049)
Saver	−(0.558)	−0.408	−(0.531)	−1.268	−(1.398)	−1.255	−0.367	−(1.393)	−(0.543)	−0.991	−(1.069)	−(0.627)	−(0.770)
Borrower	(1.276)	3.254	(3.474)	5.001	(5.111)	5.319	3.396	(5.311)	(3.664)	4.446	(4.481)	(4.664)	(4.819)

Notes: The optimal parameters are obtained from grid searching in steps of 0.1. The ranges of parameters are: $\phi_{R,\pi} \in [1,5]$, $\phi_{R,g} \in [0,1]$, $\phi_{R,\pi_h} \in [0,5]$, $\phi_{\iota,\pi} \in [0,10]$, $\phi_{\iota,b} \in [0,10]$, $\phi_{\tau,\pi} \in [-100,100]$, $\phi^*_{\tau,\pi} \in [0,100]$, and $[0,1]$ for all smoothing parameters. The welfare effects are interpreted as the units of consumption goods required for a household under the baseline policy regime to achieve the same level of welfare under an alternative policy regime. The ad hoc Taylor rule with capital control (no FDI in the domestic housing market) is used as the baseline policy regime. Values for the case with FDI are in parentheses. Best and worst welfare outcomes are in blue and red, respectively.

Table 4: Changes in volatility due to FDI

	TR	ATR	TR+LTV	TR+FR	TR+LTV+FR
GDP	1.004	1.005	1.002	0.991	0.982
Consumption	1.042	1.020	1.041	1.018	1.031
CPI inflation	1.115	1.181	1.193	1.207	1.313
Domestic housing investment	0.939	0.978	0.986	1.333	1.262
House price inflation	0.854	0.914	0.942	0.581	0.319
Policy interest rate	1.182	1.150	1.224	1.250	1.256

Notes: Values indicate standard deviations relative to the case without FDI under the respective regimes. Values greater than unity refer to higher standard deviations than without FDI. The lowest standard deviation for each variable is shown in blue, while the highest is in red. Where there is more than one possible specification under the same regime, the following columns from Table 3 are used to compute the relative standard deviations: columns 6 and 8 for TR+LTV and columns 10 and 12 for TR+FR; for TR+LTV+FR, columns 6 and 13 are used.

Table 5: Changes in volatility due to regime shifts.

	ATR		TR+LTV		TR+FR		TR+LTV+FR
	(4)	(5)	(6)	(8)	(10)	(12)	(13)
GDP	0.996	(0.997)	0.997	(0.995)	0.986	(0.973)	(0.975)
Consumption	0.969	(0.948)	0.994	(0.993)	1.007	(0.983)	(0.983)
CPI inflation	0.921	(0.975)	0.834	(0.893)	0.923	(0.999)	(0.983)
Domestic housing investment	1.003	(1.044)	0.949	(0.997)	0.896	(1.271)	(1.276)
House price inflation	0.629	(0.673)	0.856	(0.944)	0.351	(0.239)	(0.320)
Policy interest rate	0.986	(0.959)	0.919	(0.951)	0.927	(0.980)	(0.975)

Notes: Values indicate standard deviations relative to TR for cases without and with FDI (the latter in parentheses). Values greater than unity refer to higher standard deviations than TR. The lowest standard deviations for each variable are shown in blue, while the highest are in red. Where there is more than one possible specification under the same regime, the following columns from Table 3 are used to compute the relative standard deviations: columns 6 and 8 for TR+LTV and columns 10 and 12 for TR+FR.