Transmission of Fiscal Stimulus in Small Open Economies: The Role of Finance Channel[1]

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Abstract

Empirical literature documents that the size of fiscal multipliers crucially depends on country characteristics such as openness to trade, exchange rate regimes and sovereign indebtedness. We study a unified framework to explore the channels through which these characteristics shape the nature of how fiscal stimulus operates in emerging market economies. The analytical setup is a New Keynesian small open economy model with banks. Financial intermediaries make loans to both the private sector and the government, leading to financial crowding effects via the credit channel. We find that fiscal multipliers are larger under exchange rate pegs than floating regimes and financial frictions play a fundamental role in the transmission of stimulus under the two regimes.

Keywords: Fiscal multipliers, financial crowding out, monetary policy.
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1 Introduction

Ilzetzki et al. (2013) empirically document that fiscal multipliers are larger in economies that are more closed, that possess less flexible exchange rate regimes and that are less indebted. The Mundell-Fleming model explanation regarding openness goes along the line that as openness to trade increases, part of the fiscal stimulus is met by a reduction in net exports (driven by income effect on imports demand) rather than by an increase in domestic production. The Mundell-Fleming model is also useful in explaining larger multipliers under less flexible exchange rates. The argument starts with the rise in government expenditures increasing interest rates and driving capital inflows. Under predetermined exchange rate regimes, monetary authority prevents the appreciation of domestic currency by increasing money supply and accommodating the rise in aggregate demand. Hence, stimulus have expansionary effects. In sharp contrast, under flexible exchange rate regimes, monetary authority allows domestic currency to appreciate resulting a fall in net exports, which exactly offsets the expansionary impact of the stimulus. While textbook Mundell-Fleming model insights are useful in understanding the effect of openness to trade and exchange rate regime on fiscal multipliers, the ineffectiveness of fiscal policy under a sovereign debt overhang posits a relatively unexplored avenue. Ilzetzki et al. (2013) rationalize their empirical finding by referring to a Ricardian equivalence explanation. That is, fiscal multipliers might become smaller and even be negative under a sovereign debt overhang because fiscal stimulus under too much debt might trigger the expectation that future taxes will have to increase to ensure debt sustainability in the long-term.

One of the goals of this project is to provide an alternative explanation, which we refer as financial crowding out, to the empirical finding of Ilzetzki et al. (2013) that multipliers are smaller for high debt levels, rather than Ricardian equivalence. The financial crowding out effect might be defined as domestic banks holding proportionally more government debt relative to private sector credit under a sovereign debt overhang.

A recent study by Kirchner and van Wijnbergen (2016) formalizes this new crowding out channel in a New Keynesian DSGE model with banking frictions and fiscal stimulus whose financing is subject to agency costs. The authors assume that public debt is held by commercial banks who face leverage constraints as in Gertler and Kiyotaki (2011) and Gertler and Karadi (2011) and money management funds who are essentially zero cost/zero profit intermediaries between depositors and the government that face no financial friction. Consequently, as the financing of the fiscal stimulus slides towards banks, stimulus related rises in interest rates hurt banks' balance sheets and the portfolio adjustments towards government debt crowds out private credit. This causes fiscal multiplier to be small and even negative depending on the degree of financial frictions.

The work of Kirchner and van Wijnbergen (2016) abstracts from external sovereign debt and therefore provides an upper bound for the adverse implications of the financial crowding out on fiscal multipliers. Broner et al. (2014) elaborate that during tranquil episodes, sovereigns have better access to international debt markets and can build up too much debt without creating a financing burden on domestic private creditors. However, during turbulence episodes such as the recent Euro area debt crisis, foreigners stop absorbing sovereign debt as country risk increases. This results in sovereign debt to offer a higher expected return to domestic creditors relative to foreigners and induces domestic lenders to hold more government debt. Under financial frictions, private creditors cannot finance the purchase of sovereign debt by borrowing abroad and have to reduce their lending to domestic private sector, creating the financial crowding out. While Kirchner and van Wijnbergen (2016) take a passive stance on the share of sovereign debt financing by domestic lenders that face financial frictions, the analysis of Broner et al. (2014) consider spillovers (that are especially valid in an open economy setup) from sovereign risk to the composition of its financing.

Second, after measuring the extend of the financial crowding out, we use a nested framework that enables us to calculate the size of fiscal multipliers conditional on the degree of openness, monetary policy regime and sovereign indebtedness of different countries as discussed in Ilzetzki et al. (2013). The setup is a medium-scale New Keynesian small open economy model inhabited by households, banks, non-financial firms, capital producers and a government. Financial frictions define bankers as a key agent in the economy. The modeling of the banking sector follows Gertler and Kiyotaki (2011) and Mimir and Sunel (2015), with the modification that bankers extend credit to government via purchasing bonds and raise external financing from both domestic depositors and international investors. The consolidated government would make an exogenous stream of spending, borrow from both domestic banks and abroad, and determine monetary policy. The model is easily modified to represent an economy with a fixed or flexible exchange rate regime. Agency problems in the model capture both the credit discrimination and the inefficient financing of sovereign debt by domestic banks. Consequently, the model will be easily modified with regards to country characteristics (degree of openness, exchange rate regime and sovereign indebtedness) considered in the study of Ilzetzki et al. (2013) and serve as a laboratory to calculate impact and cumulative fiscal multipliers contingent on these characteristics. Corsetti and Müller (2015) carry out a similar investigation in a setup where sovereign spillovers affect asset prices held by households in a model without a financial sector and capital accumulation. Therefore, their framework is not suitable to study the impact of the financial crowding out channel.

Our preliminary results indicate that the finance channel is essential in explaining larger multipliers under pre-determined exchange rate regimes rather than floats. This finding mainly hinges on the degree of monetary accommodation in response to the fiscal spending shock. As discussed by the literature, under an inflation targeting framework, the monetary tightening in response to the increased inflation partly offsets the fiscal stimulus. In our model, the rise in real interest rates (due to the sluggish response of inflation under price stickiness) increases funding costs of banks. In addition the increased public borrowing requirement driven by the spending shock rises bank exposure to government bonds rather than private firm credit underpinning the financial crowding out. The surge in external sovereign indebtedness on the other hand, increases country risk premium as country spreads are assumed to be negatively related to the aggregate net foreign asset position. As a result, the rise in government spending is more than offset by the fall in private consumption and investment. Due to the well documented financial accelerator mechanism, credit spreads rise, asset prices fall and bank capitalization is hindered.

The transmission of the fiscal shock is considerably different under an exchange rate peg. Since the central bank has no concern for stabilizing inflation, real interest rates decline at the when the stimulus is introduced. The reduced deposit funding costs faced by banks limits the rise in their exposure to government bonds which earns a smaller return than firm credit. As a result, asset prices fall much less causing bank net worth to even rise in response to the shock. More favorable financial conditions result on smaller loan-deposit spreads and partly limits the collapse in private consumption and investment. In this sense, reducing financial crowding out helps reduce the real crowding out in the economy.

2 Model economy

The analytical framework is a medium-scale New Keynesian small open economy model inhabited by households, banks, non-financial firms, capital producers, and a government. Financial frictions define bankers as a key agent in the economy. The modeling of the banking sector follows Gertler and Kiyotaki (2011) and Mimir and Sunel (2015) with the modification that bankers extend credit to government via purchasing government bonds and make external financing from both domestic depositors and international investors, potentially bearing currency risk. The consolidated government makes an exogenous stream of spending, borrows from both domestic banks and abroad and determines monetary policy. The benchmark monetary policy regime is a Taylor rule that aims to stabilize inflation and output. Unless otherwise stated, variables denoted by upper (lower) case characters represent nominal (real) values in domestic currency. Variables that are denominated in foreign currency or related to the rest of the world are indicated by an asterisk. For brevity, we include key model equations in the main text. Interested readers might refer to Appendix A for detailed derivations of the optimization problems of agents and a definition of the competitive equilibrium.

2.1 Households

There is a large number of infinitely-lived identical households, who derive utility from consumption c_t, leisure $(1 - h_t)$, and real money balances $\frac{M_t}{P_t}$. The consumption good is a constant-elasticity-of-substitution (CES) aggregate of domestically produced and imported tradable goods as in Galí and Monacelli (2005) and Gertler et al. (2007),

$$c_t = \left[\omega^{\frac{1}{\gamma}}(c_t^H)^{\frac{\gamma-1}{\gamma}} + (1-\omega)^{\frac{1}{\gamma}}(c_t^F)^{\frac{\gamma-1}{\gamma}}\right]^{\frac{\gamma}{\gamma-1}}, \tag{1}$$

where $\gamma > 0$ is the elasticity of substitution between home and foreign goods, and $0 < \omega < 1$ is the relative weight of home goods in the consumption basket, capturing the degree of home bias in household preferences. Let P_t^H and P_t^F represent domestic currency denominated prices of home and foreign goods, which are aggregates of a continuum of differentiated home and foreign good varieties respectively. Then, the expenditure minimization problem of households subject to the consumption aggregator (1) produces the domestic consumer price index (CPI),

$$P_t = \left[\omega(P_t^H)^{1-\gamma} + (1-\omega)(P_t^F)^{1-\gamma}\right]^{\frac{1}{1-\gamma}} \tag{2}$$

and the condition that determines the optimal demand frontier for home and foreign goods,

$$\frac{c_t^H}{c_t^F} = \frac{\omega}{1-\omega}\left(\frac{P_t^H}{P_t^F}\right)^{-\gamma}. \tag{3}$$

We assume that each household is composed of a worker and a banker who perfectly insure each other. Workers consume the consumption bundle and supply labor h_t. They also save in local currency assets which are *deposited* within financial intermediaries owned by the banker members of *other* households.[1] The balance of these deposits is denoted by D_{t+1}, which promises to pay a net nominal risk-free rate r_{nt} in the next period. There are no interbank frictions so that r_{nt} coincides with the short-term policy rate of the central bank. Furthermore, the borrowing contract is *real* in the sense that the risk-free rate is determined based on the expected inflation. By assumption, households cannot directly save in productive capital, and only banker members of households and the sovereign government are able to borrow in foreign currency.

Preferences of households over consumption, leisure, and real balances are represented by the lifetime utility function

$$E_0 \sum_{t=0}^{\infty} \beta^t U\left(c_t, h_t, \frac{M_t}{P_t}\right), \tag{4}$$

where U is a CRRA type period utility function given by

$$U\left(c_t, h_t, \frac{M_t}{P_t}\right) = \left[\frac{(c_t - h_c c_{t-1})^{1-\sigma} - 1}{1-\sigma} - \frac{\chi}{1+\xi} h_t^{1+\xi} + \upsilon \, \log\left(\frac{M_t}{P_t}\right)\right]. \tag{5}$$

E_t is the mathematical expectation operator conditional on the information set available at t, $\beta \in (0,1)$ is the subjective discount factor, $\sigma > 0$ is the inverse of the intertemporal elasticity of substitution, $h_c \in [0,1)$ governs the degree of habit formation, χ is the utility weight of labor and $\xi > 0$ determines the Frisch elasticity of labor supply. We also assume that the natural logarithm of real money balances provides utility in an additively separable fashion with the utility flows scaled by υ.

[1] This assumption is useful in making the agency problem that we introduce in Section 2.2 more realistic.

Households face the flow budget constraint,

$$c_t + \frac{D_{t+1}}{P_t} + \frac{M_t}{P_t} = \frac{W_t}{P_t}h_t + \frac{(1+r_{nt-1})D_t}{P_t} + \frac{M_{t-1}}{P_t} + \Pi_t - \tau_t. \tag{6}$$

On the right hand side are the real wage income $\frac{W_t}{P_t}h_t$, real balances of the domestic currency interest bearing assets at the beginning of period t $\frac{D_t}{P_t}$, and real money balances at the beginning of period t $\frac{M_{t-1}}{P_t}$. Π_t denotes real profits remitted from firms owned by the households (banks, intermediate home goods producers and capital goods producers). τ_t stands for the real lump-sum tax collected by the government, which is defined in Section 2.5. On the left hand side are the outlays for consumption expenditures and asset demands.

Households choose c_t, h_t, D_{t+1} and M_t to maximize preferences in (5) subject to (6) and standard transversality conditions imposed on asset demands D_{t+1} and M_t. The first order conditions of the utility maximization problem of the households are given by

$$\varphi_t = (c_t - h_c c_{t-1})^{-\sigma} - \beta h_c E_t \left(c_{t+1} - h_c c_t\right)^{-\sigma}, \tag{7}$$

$$\frac{W_t}{P_t} = \frac{\chi h_t^{\xi}}{\varphi_t}, \tag{8}$$

$$\varphi_t = \beta E_t \left[\varphi_{t+1}(1+r_{nt})\frac{P_t}{P_{t+1}}\right], \tag{9}$$

$$\frac{\upsilon}{M_t/P_t} = \beta E_t \left[\varphi_{t+1} r_{nt} \frac{P_t}{P_{t+1}}\right]. \tag{10}$$

Equation (7) defines the Lagrange multiplier, φ_t as the marginal utility of consuming an additional unit of income. Equation (8) equates marginal disutility of labor to the shadow value of real wages. Finally, equations (9) and (10) represent the Euler equations for deposits, the consumption-savings margin, and money demand, respectively.

The nominal exchange rate of the foreign currency in domestic currency units is denoted by S_t. Therefore, the real exchange rate of the foreign currency in terms of real home goods becomes $s_t = \frac{S_t P_t^*}{P_t}$, where foreign currency denominated CPI P_t^* is taken exogenously.

We assume that foreign goods are produced in a symmetric setup as in home goods. That is, there is a continuum of foreign intermediate goods that are bundled into a composite foreign good, whose consumption by the home country is denoted by c_t^F. We assume that the law of one price holds for the import prices of intermediate goods, that is $MC_t^F = S_t P_t^{F*}$, where MC_t^F is the marginal cost for intermediate good importers and P_t^{F*} is the foreign currency denominated price of such goods. Foreign intermediate goods producers put a markup over the marginal cost MC_t^F while setting the domestic currency denominated price of foreign goods. The small open economy also takes P_t^{F*} as given. In Section 2.4, we elaborate further on the determination of the domestic currency denominated prices of home and foreign goods P_t^H and P_t^F.

2.2 Banks

The modeling of banks closely follows Mimir and Sunel (2015), who mainly depart from Gertler and Kiyotaki (2011) by assuming that banks borrow in foreign currency from international lenders in addition to borrowing in local currency from domestic households. We further extend the model in Mimir and Sunel (2015) by assuming that banks make loans to government via purchasing government bonds as in Kirchner and van Wijnbergen (2016) in addition to financing capital expenditures of home based tradable goods producers. For tractability, we assume that banks only lend to home based production firms. In our model, the sovereign government is also able to borrow from international lenders at the country borrowing rate which we define below. For tractability, country risk is modeled in a reduced-form way so that endogenous sovereign default is excluded.

The main financial friction in this economy originates in the form of a moral hazard problem between bankers and their funders and leads to an endogenous borrowing constraint on the former. The agency problem is such that depositors (both domestic and foreign) believe that bankers might divert a certain fraction of their assets for their own benefit. Therefore, while funding their assets, banks have to satisfy an incentive compatibility constraint. This in turn restrains funds raised by bankers and limits the credit extended to nonfinancial firms and the government, leading up to nonnegative loan-deposit spreads faced by both borrowers. We formulate the diversion feature so that in equilibrium, loan rates charged by banks to firms and the government as well as the domestic/foreign bank funding rates align in the model as they do in the data.

2.2.1 Balance sheet

The period-t balance sheet of a banker j denominated in terms of the numeraire (domestic final good) reads,

$$q_t l_{jt} + b^g_{jt+1} = d_{jt+1} + b^*_{jt+1} + n_{jt}. \tag{11}$$

Banks hold two types of assets: Loans made to production firms and to the government. The former asset class is securities l_{jt} issued by nonfinancial firms against their physical capital demand and is priced at q_t, the nominal price of these claims Q_t deflated by the aggregate price index P_t. The latter class is domestic government debt, denoted by b^g_{jt+1} to represent real government bonds purchased by banker j. On the liability side, d_{jt+1} stands for real domestic deposits and $b^*_{jt+1} = \frac{S_t B^*_{jt+1}}{P_t}$ is the foreign borrowing in real domestic units. Notice that if the exogenous foreign price index P^*_t is assumed to be equal to 1 at all times, then b^*_{jt+1} incorporates the impact of the real exchange rate, $s_t = \frac{S_t}{P_t}$ on the balance sheet. n_{jt} is the real net worth of banker j.

Banker's profits from lending operations build up its net worth. Therefore, net worth evolves into the next period as,

$$n_{jt+1} = R_{kt+1} q_t l_{jt} + R_{bt+1} b^g_{jt+1} - R_{t+1} d_{jt+1} - R^*_{t+1} b^*_{jt+1}, \tag{12}$$

where R_{kt+1} denotes the state-contingent real return earned on claims against firms and R_{bt+1} denotes the real return earned from holding government bonds. R_{t+1} is the real risk-free deposit rate offered to domestic workers and R^*_{t+1} is the country borrowing rate of foreign debt, denominated in real domestic currency units. These gross real funding rates are defined as,

$$R_{t+1} = (1 + r_{nt})\frac{P_t}{P_{t+1}}$$

$$R^*_{t+1} = \Psi_t(1 + r^*_n)\frac{S_{t+1}}{S_t}\frac{P_t}{P_{t+1}} \ \ \forall t, \tag{13}$$

where r_n denotes the net nominal deposit rate as in equation (6) and r^*_n denotes the net nominal international borrowing rate. Bankers face a premium over this rate while borrowing from abroad. Following Gertler et al. (2007) and Mimir and Sunel (2015), we assume that the risk premium that banks face is an increasing function of the log deviation of the net foreign debt position of the country from its steady-state level $\widehat{nfd}_t$, where nfd_t is summation of the aggregate foreign debt of the bankers b^*_{t+1} and the aggregate foreign debt of the government b^{g*}_{jt+1} defined below. Specifically, the premium is given by the following increasing function, $\Psi_t = \exp\left[\psi\, \widehat{nfd}_t\right]$, where $\psi > 0$ is the foreign debt elasticity of country risk premium.[2] Linking this premium with total net foreign debt of the country enables us to study potential spill over effects of sovereign debt on private borrowers' (i.e. banks') balance sheet as in Corsetti and Müller (2015).

Solving for b^*_{jt+1} in equation (11), substituting it in equation (12) and re-arranging terms imply that bank's net worth evolves as,

$$n_{jt+1} = \left[R_{kt+1} - R^*_{t+1}\right] q_t l_{jt} + \left[R_{bt+1} - R^*_{t+1}\right] b^g_{jt+1} - \left[R_{t+1} - R^*_{t+1}\right] d_{jt+1} + R^*_{t+1} n_{jt}. \tag{14}$$

[2] By assuming that the cost of borrowing from international capital markets increases in the net foreign indebtedness of the aggregate economy, we ensure the stationarity of the foreign asset dynamics as in Schmitt-Grohé and Uribe (2003).

This equation illustrates that individual bankers' net worth depends positively on the premiums of the returns earned on assets over the cost of foreign debt, $R_{kt+1} - R^*_{t+1}$ and $R_{bt+1} - R^*_{t+1}$. The third term on the right-hand side shows the disadvantage of raising domestic deposits as opposed to foreign debt (provided that the former costs more). Finally, the last term highlights the contribution of internal funds, that are multiplied by R^*_{t+1}, the opportunity cost of raising one unit of external funds via foreign borrowing.

Banks would find it profitable to make loans to both non-financial firms and the government only if

$$E_t \left\{ \Lambda_{t,t+1+i} \left[R_{kt+1+i} - R^*_{t+1+i} \right] \right\} \geq 0 \text{ and } E_t \left\{ \Lambda_{t,t+1+i} \left[R_{bt+1+i} - R^*_{t+1+i} \right] \right\} \geq 0 \;\; \forall t,$$

where $\Lambda_{t,t+1+i} = \beta^{i+1} \left[\frac{U_c(t+1+i)}{U_c(t)} \right]$ denotes the $i+1$ periods-ahead stochastic discount factor of households, whose banker members operate as financial intermediaries. Notice that in the absence of financial frictions, an abundance in intermediated funds would cause R_{kt+1} and R_{bt+1} to decline until these premiums are completely eliminated by a no-arbitrage condition. In the following, we also establish that

$$E_t \left\{ \Lambda_{t,t+1+i} \left[R_{t+1+i} - R^*_{t+1+i} \right] \right\} > 0 \;\; \forall t,$$

so that the cost of domestic debt entails a positive premium over the cost of foreign debt at all times. This insight suggests a microfoundation to deviations from the uncovered interest parity (UIP for short) condition as we demonstrate below.

In order to rule out any possibility of complete self-financing, we assume that bankers have a finite life and survive to the next period only with probability $0 < \theta < 1$. At the end of each period, $1 - \theta$ measure of new bankers are born and are remitted $\frac{\epsilon^b}{1-\theta}$ fraction of the assets owned by exiting bankers in the form of start-up funds.

2.2.2 Net worth maximization

Bankers maximize expected discounted value of the terminal net worth of their financial firm V_{jt}, by choosing the amount of security claims purchased l_{jt}, the amount of government bonds purchased b^g_{jt+1} and the amount of domestic deposits d_{jt+1}. For a given level of net worth, the optimal amount of foreign debt can be solved for by using the balance sheet. Bankers solve the following value maximization problem,

$$V_{jt} = \max_{l_{jt+i}, b^g_{jt+1+i}, d_{jt+1+i}} E_t \sum_{i=0}^{\infty} (1-\theta)\theta^i \Lambda_{t,t+1+i}\, n_{jt+1+i},$$

which can be written in recursive form as,

$$V_{jt} = \max_{l_{jt}, b^g_{jt+1}, d_{jt+1}} E_t \Big\{ \Lambda_{t,t+1} \Big[(1-\theta) n_{jt+1} + \theta V_{jt+1} \Big] \Big\}. \tag{15}$$

For nonnegative premiums on credit to the non-financial firms and credit to the government, the solution to the value maximization problem of banks would lead to an unbounded magnitude of assets. In order to rule out such a scenario, we follow Gertler and Karadi (2011) and introduce an agency problem between depositors and bankers. Specifically, lenders believe that banks might divert λ fraction of their total divertable assets, where divertable assets constitute total credit extended to non-financial firms plus a fraction ω_g, of government bonds purchased minus a fraction ω_d, of domestic deposits. When lenders become aware of the potential confiscation of assets, they would initiate a bank run and lead to the liquidation of the bank altogether. In order to rule out bank runs in equilibrium, in any state of nature, bankers' optimal choices of l_{jt} and b^g_{jt+1} should be incentive compatible. Therefore, the following constraint is imposed on bankers,

$$V_{jt} \geq \lambda \Big(q_t l_{jt} + \omega_g b^g_{jt+1} - \omega_d d_{jt+1} \Big), \tag{16}$$

where λ, ω_g and ω_d are constants between zero and one. This inequality suggests that the liquidation cost of bankers from diverting funds V_{jt} should be greater than or equal to the diverted portion of assets. When this constraint binds, bankers would never choose to divert funds and lenders adjust their position and restrain their lending to bankers, accordingly.

We introduce two different asymmetries in financial frictions by including only ω_g fraction of government bonds into and excluding ω_d fraction of domestic deposits from diverted assets. First asymmetry of including only ω_g fraction of government bonds into the diverted assets is due to the idea that it would be more difficult to divert government bonds making them less risky compared to the security claims issued by nonfinancial firms. The second asymmetry of excluding ω_d fraction of domestic deposits from diverted assets hinges on the idea that domestic depositors would arguably have a comparative advantage over foreign depositors in recovering assets in case of a bankruptcy. Furthermore, they would also be better equipped than international lenders in monitoring domestic bankers.[3]

We log-linearly approximate the stochastic equilibrium around the deterministic steady state. Therefore, we confine our interest to cases in which the incentive constraint of banks is always binding so that (16) holds with equality at all times. We conjecture the optimal value of financial intermediaries to be a linear function of firm loans, government bonds, domestic deposits and bank capital, that is,

$$V_{jt} = \nu_t^s q_t l_{jt} + \nu_t^g b_{jt+1}^g - \nu_t^* d_{jt+1} + \nu_t n_{jt}. \tag{17}$$

Among these recursive objects ν_t^s and ν_t^g represent the expected marginal values of credit extended to nonfinancial firms and government, $-\nu_t^*$ stands for the expected excess cost of borrowing from domestic savers and ν_t denotes the expected marginal value of bank capital at the end of period t. The solution to the net worth maximization problem implies,

$$q_t l_{jt} + \omega_g b_{jt}^g - \omega_d d_{jt+1} = \frac{\nu_t}{\lambda - \nu_t^s} n_{jt} = \kappa_{jt} n_{jt}, \tag{18}$$

[3]See Mimir and Sunel (2015) for a detailed discussion of a similar type of asymmetry in the diversion of bank assets.

This endogenous constraint, which emerges from the costly enforcement problem described above, ensures that bankers' risky assets are proportional to their net worth defining bank leverage κ_{jt} endogenously. The condition further suggests that all else equal, bank leverage is decreasing with the fraction of divertable funds λ and increasing with the expected marginal value of extending credit to firms ν_t^s.

Replacing the left-hand side of (17) to verify our linear conjecture on bankers' value and using equation (14), we find that ν_t^s, ν_t^g, ν_t^* and ν_t should consecutively satisfy,

$$\nu_t^s = E_t\Big\{\Xi_{t,t+1}\left[R_{kt+1} - R_{t+1}^*\right]\Big\}, \tag{19}$$

$$\nu_t^g = E_t\Big\{\Xi_{t,t+1}\left[R_{bt+1} - R_{t+1}^*\right]\Big\}, \tag{20}$$

$$\nu_t^* = E_t\Big\{\Xi_{t,t+1}\left[R_{t+1} - R_{t+1}^*\right]\Big\}, \tag{21}$$

$$\nu_t = E_t\Big\{\Xi_{t,t+1}R_{t+1}^*\Big\}, \tag{22}$$

with $\Xi_{t,t+1} = \Lambda_{t,t+1}\Big[1 - \theta + \theta\lambda\kappa_{t+1}\Big]$ representing the augmented stochastic discount factor of bankers, which is a weighted average defined over the likelihood of survival.

Equations (19) and (20) suggest that bankers' marginal valuation of credit to nonfinancial firms and to the government are the premiums between the expected discounted credit spreads defined as respective loan rates minus the benchmark cost of foreign funds. Equation (21) demonstrates that the excess value of raising foreign debt is equal to the expected discounted value of the premium in the cost of raising domestic debt over the cost of raising foreign debt. One can show that this spread is indeed positive, that is, $\nu_t^* > 0$ by studying first order condition (A.4) in the technical appendix and observing that $\lambda, \mu, \omega_d > 0$ with μ denoting the Lagrange multiplier of bankers' problem. Finally, equation (22) shows that marginal value of net worth should be equal to the expected discounted opportunity cost of domestic funds.

The definition of the augmented pricing kernel of bankers is useful in understanding why banks shall be a veil absent financial frictions. Financial frictions would vanish when none of the assets are diverted, i.e. $\lambda = 0$ and bankers never have to exit, i.e. $\theta = 0$. Consequently, $\Xi_{t,t+1}$ simply collapses to the pricing kernel of households $\Lambda_{t,t+1}$. This case would also imply efficient intermediation of funds driving the arbitrage between the lending and deposit rates down to zero. Additionally, note here that one crucial part of our analysis is to introduce asymmetry in the diversion of asset classes by taking $0 < \omega_g < 1$. In sharp contrast to Kirchner and van Wijnbergen (2016), this allows us to differentiate equilibrium real loan rates and government bond rates as they do so in the data. The asymmetry on the funding side on the other hand $0 < \omega_d < 1$, facilitates us to match the empirical funding composition of banks as in Mimir and Sunel (2015). Since $\omega_d \neq 0$, we obtain $\nu_t^* > 0$ and the UIP breaks in the model.

2.2.3 Aggregation

All households behave symmetrically, so that we can aggregate equation (18) over j and obtain the following aggregate relationship:

$$q_t l_t + \omega_g b_{t+1}^g - \omega_d d_{t+1} = \kappa_t n_t, \tag{23}$$

where $q_t l_t$, b_{t+1}^g, d_{t+1} and n_t represent aggregate levels of their bank-specific counterparts defined above. Equation (23) shows that aggregate credit to nonfinancial firms plus divertable portion of credit to government net of nondivertable domestic deposits can only be up to an endogenous multiple of aggregate bank capital. Furthermore, fluctuations in asset prices q_t, would feed back into fluctuations in bank capital via this relationship. This would be the source of the financial accelerator mechanism in our model and would play a crucial role in the transmission of fiscal stimulus into the real economy as we demonstrate below.

The evolution of the aggregate net worth depends on that of the surviving bankers n_{et+1}, which might be obtained by substituting the aggregate bank capital constraint (23) into the net worth evolution equation (14) and adding up the start-up funds of the new entrants n_{nt+1}. The latter is equal to $\frac{\epsilon^b}{1-\theta}$ fraction of exiting banks' assets $(1-\theta)(q_t l_t + b^g_{t+1})$. Therefore,

$$n_{nt+1} = \epsilon^b (q_t l_t + b^g_{t+1}).$$

As a result, the transition for the aggregate bank capital becomes, $n_{t+1} = n_{et+1} + n_{nt+1}$.

2.3 Capital producers

Capital producers operate in a perfectly competitive market, purchase investment goods and transform them into new capital. At the end of period t, they sell both newly produced and repaired capital to the intermediate goods firms at the unit price of q_t. Fluctuations in this asset price is the main driver of the financial accelerator, which operates through bankers' endogenous borrowing limits. Intermediate goods firms use this new capital for production at time $t+1$. Capital producers are owned by households and return any earned profits to their owners. We also assume that they incur investment adjustment costs while producing new capital, given by the following quadratic function of the investment growth

$$\Phi\left(\frac{i_t}{i_{t-1}}\right) = \frac{\Psi}{2}\left[\frac{i_t}{i_{t-1}} - 1\right]^2.$$

Capital producers use an investment good that is composed of home and foreign final goods in order to repair the depreciated capital and to produce new capital goods

$$i_t = \left[\omega_i^{\frac{1}{\gamma_i}} (i_t^H)^{\frac{\gamma_i - 1}{\gamma_i}} + (1-\omega_i)^{\frac{1}{\gamma_i}} (i_t^F)^{\frac{\gamma_i - 1}{\gamma_i}}\right]^{\frac{\gamma_i}{\gamma_i - 1}},$$

where ω_i governs the relative weight of home input in the investment composite good and γ_i measures the elasticity of substitution between home and foreign inputs. Capital producers choose the optimal mix of home and foreign inputs according to the intratemporal first order condition

$$\frac{i_t^H}{i_t^F} = \frac{\omega_i}{1-\omega_i}\left(\frac{P_t^H}{P_t^F}\right)^{-\gamma_i}.$$

The resulting aggregate investment price index P_t^I, is given by

$$P_t^I = \left[\omega_i (P_t^H)^{1-\gamma_i} + (1-\omega_i)(P_t^F)^{1-\gamma_i}\right]^{\frac{1}{1-\gamma_i}}.$$

Capital producers require i_t units of investment good at a unit price of $\frac{P_t^I}{P_t}$ and incur investment adjustment costs $\Phi\left(\frac{i_t}{i_{t-1}}\right)$ per unit of investment to produce new capital goods i_t and repair the depreciated capital, which will be sold at the price q_t. Therefore, a capital producer makes an investment decision to maximize its discounted profits represented by

$$\max_{i_{t+i}} \sum_{i=0}^{\infty} E_0 \left[\Lambda_{t,t+1+i}\left(q_{t+i} i_{t+i} - \Phi\left(\frac{i_{t+i}}{i_{t+i-1}}\right) q_{t+i} i_{t+i} - \frac{P_{t+i}^I}{P_{t+i}} i_{t+i}\right)\right]. \tag{24}$$

The optimality condition with respect to i_t produces the following Q-investment relation for capital goods

$$\frac{P_t^I}{P_t} = q_t\left[1 - \Phi\left(\frac{i_t}{i_{t-1}}\right) - \Phi'\left(\frac{i_t}{i_{t-1}}\right)\frac{i_t}{i_{t-1}}\right] + E_t\left[\Lambda_{t,t+1} q_{t+1} \Phi'\left(\frac{i_{t+1}}{i_t}\right)\left(\frac{i_{t+1}}{i_t}\right)^2\right].$$

Finally, the aggregate physical capital stock of the economy evolves according to

$$k_{t+1} = (1-\delta_t)k_t + \left[1 - \Phi\left(\frac{i_t}{i_{t-1}}\right)\right] i_t, \tag{25}$$

with δ_t being the endogenous depreciation rate of capital determined by the utilization choice of intermediate goods producers.

2.4 Firms

Final and intermediate goods are produced by a representative final good producer and a continuum of intermediate goods producers that are indexed by $i \in [0,1]$ respectively. Among these, the former repackages the differentiated varieties produced by the latter and sell in the domestic market. The latter on the other hand, acquire capital and labor and operate in a monopolistically competitive market. In order to assume rigidity in price setting, we assume that intermediate goods firms face menu costs.

2.4.1 Final goods producers

Finished goods producers combine different varieties $y_t(i)$, that sell at the monopolistically determined price $P_t^H(i)$, into a final good that sell at the competitive price P_t^H, according to the constant returns-to-scale technology,

$$y_t^H = \left[\int_0^1 y_t^H(i)^{1-\frac{1}{\epsilon}} di\right]^{\frac{1}{1-\frac{1}{\epsilon}}}.$$

The profit maximization problem, combined with the zero profit condition implies that the optimal variety demand is,

$$y_t^H(i) = \left(\frac{P_t^H(i)}{P_t^H}\right)^{-\epsilon} y_t^H,$$

with, $P_t^H(i)$ and P_t^H satisfying,

$$P_t^H = \left[\int_0^1 P_t^H(i)^{1-\epsilon} di\right]^{\frac{1}{1-\epsilon}}.$$

We assume that imported intermediate good varieties are repackaged via a similar technology with the same elasticity of substitution between varieties as in domestic final good production. Therefore, $y_t^F(i) = \left(\frac{P_t^F(i)}{P_t^F}\right)^{-\epsilon} y_t^F$ and $P_t^F = \left[\int_0^1 P_t^F(i)^{1-\epsilon} di\right]^{\frac{1}{1-\epsilon}}$ hold for imported intermediate goods.

2.4.2 Intermediate goods producers

There is a large number of home-based intermediate goods producers indexed by i, who produce variety $y_t^H(i)$ using the constant returns-to-scale production technology,

$$y_t^H(i) = A\Big(u_t(i)k_t(i)\Big)^{\alpha} h_t(i)^{1-\alpha}.$$

As shown in the production function, firms choose the level of capital and labor used in production, as well as the utilization rate of the capital stock. A is the constant aggregate productivity level.

$y_t^H(i)$ stands for the part of intermediate goods sold in the domestic market in which producer i operates as a monopolistically competitor. Accordingly, the nominal sales price $P_t^H(i)$ is chosen by the firm to meet the aggregate domestic demand for its variety,

$$y_t^H(i) = \left(\frac{P_t^H(i)}{P_t^H}\right)^{-\epsilon} y_t^H,$$

which depends on the the aggregate home output y_t^H. Apart from incurring nominal marginal costs of production MC_t, these firms additionally face Rotemberg (1982)-type quadratic menu costs of price adjustment, in the form of

$$\frac{\varphi^H}{2} y_t^H(i)\left[\frac{P_t^H(i)}{P_{t-1}^H(i)\pi^H} - 1\right]^2,$$

where π^H is the steady-state gross inflation rate of home goods prices. These costs are denoted in nominal terms with φ^H capturing the intensity of the price rigidity.

Domestic intermediate goods producers choose their nominal price level to maximize the present discounted real profits. We confine our interest to symmetric equilibrium, in which all intermediate producers choose the same price level that is, $P_t^H(i) = P_t^H \ \ \forall i$. Imposing this condition to the first order condition of the profit maximization problem and using the definitions $rmc_t = \frac{MC_t}{P_t}$, $\pi_t^H = \frac{P_t^H}{P_{t-1}^H}$, and $p_t^H = \frac{P_t^H}{P_t}$ yield

$$\epsilon - 1 = \frac{\epsilon \, rmc_t}{p_t^H} - \varphi^H \left[\frac{\pi_t^H}{\pi^H} - 1 \right] \frac{\pi_t^H}{\pi^H} + \varphi^H E_t \left\{ \Lambda_{t,t+1} \left[\frac{\pi_{t+1}^H}{\pi^H} - 1 \right] \frac{\pi_{t+1}^H}{\pi^H} \frac{y_{t+1}^H}{y_t^H} \right\}. \tag{26}$$

Notice that even if prices are flexible, that is $\varphi^H = 0$, the monopolistic nature of the intermediate goods market implies that the optimal sales price reflects a markup over the marginal cost that is, $P_t^H = \frac{\epsilon}{\epsilon - 1} MC_t$.

The remaining part of the intermediate goods is exported as $c_t^{H*}(i)$ in the foreign market, where the producer is a price taker. To capture the foreign demand, we follow Gertler et al. (2007) and Aoki et al. (2016) and impose an autoregressive exogenous export demand function in the form of

$$c_t^{H*} = \left[\left(\frac{S_t P_t^*}{P_t} \right)^{-\Gamma} y^* \right]^{\nu^H} (c_{t-1}^{H*})^{1-\nu^H},$$

which positively depends on foreign output which is assumed to be constant since we are only interested in domestic fiscal spending shocks.

Imported intermediate goods are purchased by a continuum of producers that are analogous to the domestic producers except that these firms face exogenous import prices as their marginal cost. In other words, the law of one price holds for the import prices, so that $MC_t^F = S_t P_t^{F*}$. Since these firms also face quadratic price adjustment costs, the domestic price of imported intermediate goods is determined as,

$$\epsilon - 1 = \frac{\epsilon \, s_t}{p_t^F} - \varphi^F \left[\frac{\pi_t^F}{\pi^F} - 1 \right] \frac{\pi_t^F}{\pi^F} + \varphi^F E_t \left\{ \Lambda_{t,t+1} \left[\frac{\pi_{t+1}^F}{\pi^F} - 1 \right] \frac{\pi_{t+1}^F}{\pi^F} \frac{y_{t+1}^F}{y_t^F} \right\}. \tag{27}$$

with $p_t^F = \frac{P_t^F}{P_t}$, $s_t = \frac{S_t P_t^{F*}}{P_t}$, and $P_t^{F*} = 1 \; \forall t$ is taken exogenously by the small open economy.

For a given sales price, optimal factor demands and utilization of capital are determined by the solution to a symmetric cost minimization problem, where the cost function shall reflect the capital gains from market valuation of firm capital and resources that are devoted to the repair of the worn out part of it. Consequently, firms minimize

$$\min_{u_t,k_t,h_t} q_{t-1}r_{kt}k_t - (q_t - q_{t-1})k_t + p_t^I\delta(u_t)k_t + w_th_t + rmc_t\Big[y_t^H - A_t\Big(u_tk_t\Big)^{\alpha}h_t^{1-\alpha}\Big] \tag{28}$$

subject to the endogenous depreciation rate function,

$$\delta(u_t) = \delta + \frac{d}{1+\varrho}u_t^{1+\varrho}, \tag{29}$$

with $\delta, d, \varrho > 0$. The first order conditions to this problem govern factor demands and the optimal utilization choice as,

$$p_t^I\delta'(u_t)k_t = \alpha\Big(\frac{y_t^H}{u_t}\Big)rmc_t, \tag{30}$$

$$R_{kt} = \frac{\alpha\Big(\frac{y_t^H}{k_t}\Big)rmc_t - p_t^I\delta(u_t) + q_t}{q_{t-1}}, \tag{31}$$

and

$$w_t = (1-\alpha)\Big(\frac{y_t^H}{h_t}\Big)rmc_t. \tag{32}$$

2.5 Monetary authority and the government

Under a floating exchange rate regime, we consider a conventional Taylor type interest rate rule that allows responses to inflation and output gap,

$$\log\left(\frac{1+r_{nt}}{1+\overline{r_n}}\right) = \rho_{r_n}\log\left(\frac{1+r_{nt-1}}{1+\overline{r_n}}\right) + (1-\rho_{r_n})\left[\varphi_\pi\log\Big(\frac{\pi_t}{\overline{\pi}}\Big) + \varphi_y\log\left(\frac{y_t^H}{\overline{y^H}}\right)\right], \tag{33}$$

where r_{nt} is the short-term policy rate, π_t is the gross CPI inflation rate, y_t^H is domestic output, variables with bars denote respective steady-state values that are targeted by the central bank. To be general, we also allow for interest rate smoothing in the monetary policy rule so that $0 \leq |\rho_{r_n}| < 1$. In our experiments, we set $\rho_{r_n} = 0.8$, $\varphi_\pi = 1.5$ and $\varphi_y = 0.125$.

Under a pre-determined exchange rate regime, the interest rate rule takes the form,

$$\log\left(\frac{1+r_{nt}}{1+\overline{r_n}}\right) = \rho_{r_n}\log\left(\frac{1+r_{nt-1}}{1+\overline{r_n}}\right) + (1-\rho_{r_n})\left[\varphi_S \log\left(\frac{S_t}{\bar{S}}\right)\right], \tag{34}$$

where $\bar{S}$ is the steady-state level of nominal exchange rate. Adolfson et al. (2008) shows that (in a specification with $\rho_{r_n} = 0$) an arbitrarily large nominal exchange response of the policy interest rate acts as a fixed exchange rate regime arrangement. Corsetti and Müller (2015) further argue that using a positive value for φ_S is enough to produce the dynamics under a peg. In our quantitative exercises, we take $\rho_{r_n} = 0.8$ and $\varphi_S = 75$.

Money supply in this economy is demand determined and compensates for the cash demand of workers. Consequently, the money market clearing condition is given by

$$M_{0t} = M_t,$$

where M_{0t} denotes the supply of monetary base at period t.

Government consumption g_t^H falls on final home goods and satisfies an autoregressive exogenous process

$$\ln(g_{t+1}^H) = (1-\rho^{g^H})\ln \bar{g}^H + \rho^{g^H}\ln(g_t^H) + \epsilon_{t+1}^{g^H}, \tag{35}$$

where $\epsilon_{t+1}^{g^H}$ is a Gaussian process with zero mean and constant variance. Fiscal shock is the only source of uncertainty in our model using which we study the magnitude of fiscal multipliers in different economic settings.

As in Kirchner and van Wijnbergen (2016), we assume that government bonds that are held by domestic banks and foreign lenders follow the following laws of motion:

$$b_{t+1}^g = \zeta\left[p_t^H g_t^H - \left(\frac{M_t - M_{t-1}}{P_t}\right) - \tau_t\right] + R_{bt} b_t^g, \tag{36}$$

$$b^{g*}_{t+1} = (1-\zeta)\left[p^H_t g^H_t - \left(\frac{M_t - M_{t-1}}{P_t}\right) - \tau_t\right] + R^*_t b^{g*}_t. \quad (37)$$

The parameter ζ is the share of primary deficit that adds up to the stock of domestic government bonds while debt is rolled over. Different from Kirchner and van Wijnbergen (2016), instead of using arbitrary values to explore the impact of financial crowding out, we calibrate this parameter to the data by imposing steady state on equation (37) and using macroeconomic steady state ratios. For simplicity, we assume that foreign investors earn the same rate of return R^*_t from lending their money to domestic banks or to the government.

The last fiscal element of the model is a rule that pins down lump-sum real taxes. We assume that taxes are determined by the following fiscal rule,

$$\tau_t = \Psi^\tau (b^g_t + b^{g*}_t),$$

where Ψ^τ is the reaction parameter of lump-taxes to total government debt. Using a large enough Ψ ensures that debt dynamics do not diverge (see Born et al. (2013)). The resource constraints and the definition of competitive equilibrium are included in Appendix A.

3 Quantitative analysis

This section analyzes the quantitative predictions of the model by studying the results of numerical simulations of an economy calibrated to an emerging market such as Turkey, for which financial frictions in the banking sector and monetary policy arrangements as well as public spending/borrowing characteristics analyzed here are particularly relevant. To investigate the dynamics of the model and carry out welfare calculations, we compute a first-order approximation to the equilibrium conditions. All computations are conducted using the open source packages Dynare and Octave.

3.1 Model parametrization and calibration

Table 1 lists the parameter values used for the quantitative analysis of the model economy. The reference period for the long-run ratios implied by the Turkish data is 2002-2014. The data sources for empirical targets are the Central Bank of the Republic of Turkey and the Banking Regulation and Supervision Agency. The preference and production parameters are standard in the business cycle literature. Starting with the former, we set the quarterly discount factor $\beta = 0.9821$ to match the average annualised real deposit rate of 7.48% observed in Turkey. The relative risk aversion $\sigma = 2$ is taken from the literature. We calibrate the relative utility weight of labor $\chi = 199.348$ in order to fix hours worked in the steady state at 0.3333. The Frisch elasticity of labor supply parameter $\xi = 3$ and the habit persistence parameter $h_c = 0.7$ are set to values commonly used in the literature. The relative utility weight of money $v = 0.0634$ is chosen to match 2.25 as the quarterly output velocity of M2. Following the discussion in Faia and Monacelli (2007), we set the intratemporal elasticity of substitution for the consumption composite $\gamma = 0.5$ to retain constrained efficiency. The intratemporal elasticity of substitution for the investment composite good $\gamma_i = 0.25$ is chosen as in Gertler et al. (2007). The share of domestic goods in the consumption composite $\omega = 0.62$ is set to match the long-run consumption-to-output ratio of 0.57.

We calibrate the financial sector parameters to match some long-run means of financial variables for the 2002-2014 period. Specifically, the fraction of assets that can be diverted $\lambda = 0.65$, the proportional transfer to newly entering bankers $\epsilon^b = 0.00195$, and the fraction of domestic deposits that cannot be diverted $\omega_l = 0.81$ are jointly calibrated to match the following three targets: an average domestic credit spread of 34 basis points, which is the difference between the quarterly commercial loan rate and the domestic deposit rate, an average bank leverage of 7.94, and the share of foreign funds in total bank liabilities, which is around 40% for commercial banks in Turkey. We also pick the survival probability of bankers θ as 0.925, which implies an average survival rate of bankers of nearly three and a half years.

Regarding the technology parameters, the share of capital in the production function $\alpha = 0.4$ is set to match the labor share of income in Turkey. We pick the share of domestic goods in the investment composite $\omega_i = 0.87$ to match the long-run mean of investment-to-output ratio of 15%. The steady-state utilization rate is normalised at one and the quarterly depreciation rate of capital $\delta = 3.5\%$ is chosen to match the average annual investment-to-capital ratio. The elasticity of marginal depreciation with respect to the utilization rate $\varrho = 1$ is set as in Gertler et al. (2007). The investment adjustment cost parameter $\psi = 5$ is calibrated to a value in line with the literature. We set the elasticity of substitution between varieties in final output $\epsilon = 11$ to have a steady-state mark-up value of 1.1. Rotemberg price adjustment cost parameters in domestic and foreign intermediate goods production $\varphi_H = \varphi_F = 113.88$ are chosen to imply a probability of 0.75 of not changing prices in both sectors. We pick the elasticity of export demand with respect to foreign prices $\Gamma = 1$ and the foreign output share parameter $\nu^F = 0.25$ as in Gertler et al. (2007). Given these parameters, the mean of foreign output $\bar{y}^* = 0.16$ is chosen to match the long-run mean of exports-to-output ratio of 18%.

We use the estimated interest rate rule persistence $\rho_{r_n} = 0.89$ and inflation response $\varphi_\pi = 2.17$ parameters (for the 2003:Q1-2014:Q4 period) in the approximation of the decentralised equilibrium around a zero inflation non-stochastic steady-state.[4] The long-run value of required reserves ratio $\bar{rr} = 0.09$ is set to its empirical counterpart for the period 1996-2015. The steady state government expenditures-to-output ratio $\bar{g^H} = 10\%$ reflects the value implied by the Turkish data for the 2002-2014 period.

Finally, we estimate three independent AR(1) processes for the share of public demand for home goods g_t^H, country risk premium Ψ_{t+1} and the US interest rate R^*_{nt+1}, where $\epsilon^{g^H}_{t+1}$, ϵ^{Ψ}_{t+1}, and $\epsilon^{R^*_n}_{t+1}$ are i.i.d. Gaussian shocks. The resulting estimated persistence parameters

[4]These values naturally change when we analyze the dynamics of the optimal simple and implementable monetary policy rule economies.

are $\rho^{g^H} = 0.457$, $\rho^{\Psi} = 0.963$, and $\rho^{R_n^*} = 0.977$. The estimated standard deviations are $\sigma^{g^H} = 0.04$, $\sigma^{\Psi} = 0.0032$, and $\sigma^{R_n^*} = 0.001$. The long-run mean of quarterly foreign real interest rate is set to 64 basis points to match quarterly real interest rate in the U.S. for the period 2002-2014 and the long-run foreign inflation rate is set to zero. The foreign debt elasticity of risk premium is set to $\psi_1 = 0.015$. Parameters underlying the TFP shock are taken from Bahadir and Gumus (2014), who estimate an AR(1) process for the Solow residuals coming from tradable output in Turkey for the 1999:Q1-2010:Q1 period. Their estimates for the persistence and volatility of the tradable TFP emerge as $\rho^A = 0.662$ and $\sigma^A = 0.0283$. Finally, we calibrate the export demand shock process under all shocks to match both the persistence and the volatility of euro area GDP, which are 0.31 and 0.48% respectively. The implied persistence and volatility parameters are $\rho^{y^*} = 0.977$ and $\sigma^{y^*} = 0.0048$.

3.2 Transmission of fiscal stimulus under a floating exchange rate regime

In this section we consider the role of alternative exchange rate regimes on the transmission of fiscal stimulus shocks as well the actual size of the fiscal multiplier. To that end, we shock the model with a positive perturbation in the fiscal spending process (35) under a floating exchange rate regime and a peg, respectively. The size of the shock is adjusted so that the rise in government spending amounts to 1 percent of deterministic steady-state output. The first 20 quarters of the endogenous responses of model to the fiscal impulse (straight lines) are presented in Figure 1.

Under a floating exchange rate regime, central bank follows a typical inflation targeting rule which responds to deviations of inflation from its respective steady state with a coefficient of $\varphi_{\pi} = 1.5$. The interest rate policy also displays substantial persistence (with $\rho_{r_n} = 0.8$) to obtain hump-shaped interest rate trajectories. We find that the impact response of GDP to the fiscal spending shock is 0.83 percent under a floating regime. Since the shock is defined relative to steady state GDP, this impact response is also the impact fiscal multiplier (defined as level deviation in GDP per level deviation in government spending as in Ilzetzki et al. (2013). The model is consistent with the VAR evidence documented in the literature that the government spending shock drives and appreciation in the domestic currency (second row of the figure). As is typical of New Keynesian models, the stimulus is inflationary and central bank responds by raising policy rates as inflation gap increases. Note however, because of menu costs, prices do not adjust fully so that real interest rate increases and real exchange rate appreciates.

We observe that while stimulating GDP, the fiscal shock crowds out private consumption and investment response is very muted compared to the ultimate response of GDP. Additionally, as documented by Born et al. (2013) and Ilzetzki et al. (2013), the real appreciation drives a deterioration in net exports, which however is less emphasized than suggested by the Mundell-Fleming insight. In accordance with the fall in net exports, current account-to-GDP ratio rises in response to the shock. One intriguing finding is that although there is real appreciation, banks fund their assets relatively less by foreign debt as illustrated by the decline in foreign currency share of external bank liabilities (the far right plot in the middle row).

Model dynamics are understood better if the *financial transmission* of the shock is elaborated in greater detail. Banks are affected adversely from the shock for two reasons. First, the (subsequent) rise in real interest rates increases the cost of domestic deposits by bankers. Second, the increase in public borrowing requirement increases banks' exposure to government bonds (the far right-middle plot) which earn a smaller return than loans extended to firms. Therefore, as far as different asset classes are concerned, we observe that public debt limits the rise in private credit leading banks to lend more intensively to the government.[5] Additionally, since government debt held by foreigners increases as well (first plot in the bottom panel), country risk premium rises due to the rise in net foreign indebtedness. This is why bankers reduce their foreign currency funding as a

[5] This aspects mainly relates our work to Broner et al. (2014) and Kirchner and van Wijnbergen (2016).

result of the shock. The middle-panel demonstrates that due to the financial crowding out effect, bankers increase their total credit by only 0.05% so that their exposure to public debt increases as they increase their loans to the government proportionally more (about 0.8%). Since banks are adversely affected both on the assets and the liability side, the rise in bank net worth is muted as well. As a result of the financial amplification, credit spreads faced by both the government as well as firms increase (see the dynamics of interest rates in the bottom panel).

3.3 Transmission of fiscal stimulus under an exchange rate peg

This section explains the stark differences in the transmission of the fiscal stimulus brought by a positive public spending shock illustrated by the dashed plots in Figure 1. With an exchange rate parameter of $\varphi_s = 10,000$, we achieve perfect stabilization of the nominal exchange rate in response to the fiscal shock.[6] We find that fiscal multiplier is larger under a peg (1.11). A few important observations with regards to the monetary policy response to the shock are in order. Recall that in the floating economy, fiscal stimulus appreciates the exchange rate. Therefore, exchange rate stabilization under the peg is achieved by reducing the policy rate sharply. This allows inflation to increase much more under a peg than a float suggesting that monetary policy is accommodating the fiscal stimulus. As a result, real interest rate declines on impact in response to the shock, consistent with the VAR findings of Born et al. (2013) and real appreciation is less intense than the case of a float. Most remarkably, private consumption is now even stimulated and investment displays a much stronger positive amplification leading to a more emphasized deterioration in net exports relative to the floating exchange rate regime economy.

We show that the impact differences of the fiscal stimulus rely profoundly on the financial transmission of the shock. First and foremost, the decline in real interest rates is welcome for banks as cost of deposits declines. As illustrated in the middle panel,

[6] Model dynamics other than the exchange rate are not sensitive to this response coefficient.

in Figure 1, financial crowding out is less severe due to this reason so that bank credit increases by about 3%. This pushes up asset prices under a peg and bank net worth expands by more than 15% via the financial accelerator mechanism that operates through the endogenous leverage condition faced by banks. This explains why investment rises more under a peg. The monetary accommodation introduced by the fall in real interest rates ultimately facilitates an easing in all credit spreads (the differential between firm loan R_k and government bond R_b rates over the benchmark external finance cost of R^*).

3.4 The size of fiscal multipliers

In this section, we run a number of exercises to uncover the effect of key country characteristics on the size of fiscal multipliers. By running a cross-country structural VAR, Ilzetzki et al. (2013) show that fiscal multipliers are larger in economies that are less industrialized, closer, less indebted (in terms of sovereign borrowing) and that employ pre-determined exchange rate regimes rather than a floating exchange rate regime. The findings of Born et al. (2013) focus on the exchange rate dimension and are in tandem with those highlighted by the previous study.

Our methodology of assessing the role of these characteristics is to compare the difference between multipliers implied by the peg and the floating regime under the benchmark and alternative specifications, in which we change one feature at a time. Our preliminary results are reported in Table 2. Columns 1 and 2 report impact and cumulative multipliers under a float and a peg, within each specification. Impact multipliers are defined as $\frac{\Delta y_1}{\Delta g_1}$ where Δx_1 denotes level deviation in variable x (driven by the fiscal impulse) from its non-stochastic steady state value. Cumulative multipliers are then defined as $\frac{\sum_{t=1}^{1000} \beta^{t-1} \Delta y_t}{\sum_{t=1}^{1000} \beta^{t-1} \Delta g_t}$ where β is the household discount factor. Following this definition, a multiplier of 0.90 would mean that a 1 dollar increase in government spending increases GDP by 90 cents. Column 3, provides the excess stimulus provided by the peg in each case by reporting the difference in multipliers reported in the previous two columns.

We find that domestic and external public debt act as a substitute to each other in terms of their impact on fiscal multipliers. Notice that both types of debt have a negative effect on fiscal stimulus; domestic public debt crowds out credit to production firms and accordingly investment. Whereas, external public debt increases the country risk premium and curbs commercial banks' access to foreign debt. Therefore, when only one of these public debt instruments are eliminated, multipliers emerge similar to those in the benchmark model.[7]

We consider an increased degree of openness in the fourth panel. A higher degree of openness (defined as a greater trade volume-to-GDP ratio) is achieved by reducing the home bias parameter in the consumption and investment aggregators of households and firms. In line with the empirical findings in the literature, we find that fiscal multipliers get smaller under both exchange rate regimes when the economy is more open. As we define in Table 3, the stronger trade channel calls for a more emphasized deepening in trade deficits in response to the fiscal shock. This is because currency appreciates as a result of the fiscal stimulus. The increased deterioration in trade balance is also evident in the impulse responses analysis depicted in Figure 4, where the lighter straight and dashed plot represent the peg and float economies under more openness.

Finally, we consider a case in which financial frictions are less severe (the bottom panel of Table 2 and Figure 5). We achieve lower frictions by eliminating the spread between loan and domestic deposit rates. Since the financial amplification is more predominant in the case of a peg, as we discussed previously, we find that fiscal multiplier gets larger under a peg when financial frictions are reduced. In contrast, financial aspects are fairly neutral under the floating regime. Note also that cumulative multiplier increases to 3.74 under a peg relative to a benchmark value of 0.57.[8]

[7]The lighter straight and dashed plots in Figures 2 and 3 demonstrate the impulse responses of selected model variables to the fiscal shock when domestic and foreign public debt are eliminated one at a time, respectively.

[8]The excessive volatility of bank capital is expected in this case because under reduced financial frictions bank capital is almost eliminated in the model.

4 Conclusion

This study explores the nature of fiscal multipliers in small open economies depending on certain key country characteristics. We find that the exchange rate regimes play a profound role in the transmission of fiscal shocks. This is because fiscal policy is inflationary and an inflation targeting regime calls for a tightening in financial conditions in response to the stimulus. In sharp contrast, an exchange rate peg accommodates the expansionary fiscal shock as it calls for a reduction in interest rates in the face of capital inflows following the stimulus.

The effectiveness of fiscal policy in relation to the exchange rate regimes was well documented in the previous literature. However, previous contributions do not provide a unified framework, which is analytically able to identify the key mechanisms that provide the foundation to the sizable differences in fiscal multipliers under alternative exchange rate regimes. Our work is an effort toward filling this gap by showing that for alternating degrees of openness, public debt composition or financial frictions, floating exchange rate regimes are robustly found to offset expansionary fiscal policy. On the other hand, the increased performance of fiscal policy under a peg is further amplified when the economy is more closed and financial frictions are lower. Our results suggest important testable hypotheses on the relative impact of monetary policy arrangements on the effectiveness of expansionary fiscal policy in emerging market economies.

5 References

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Table 1: Model parameters

Description	Parameter	Value	Target
Preferences			
Quarterly discount factor	β	0.978	Annualised real deposit rate of 9%
Relative risk aversion	σ	2	Literature
Scaling parameter for labor	χ	123.03	Steady state hours worked of 0.33
Labor supply elasticity	ξ	3	Literature
Habit persistence	h_c	0.7	Literature
Scaling parameter for money	υ	0.0095	$Y/M1 = 5.51$
Elasticity of substitution for consumption composite	γ	0.5	Faia and Monacelli (2007)
Elasticity of substitution for investment composite	γ_i	0.25	Gertler et al. (2007)
Share of domestic consumption goods	ω	0.62	$C/Y = 0.57$
Financial Intermediaries			
Fraction of diverted bank loans	λ	0.6556	Domestic credit spread = 34 bp.
Proportional transfer to the entering bankers	ϵ^b	0.00179	Commercial bank leverage = 7.58
Fraction of non-diverted domestic deposits	ω_l	0.7976	Banks' foreign debt share = 40.83%
Fraction of diverted government bonds	ω_g	0.2991	$R_b - R$ spread of -355 bs. pt. per annum
Survival probability of bankers	θ^b	0.915	Survival duration of 2.94 years for bankers
Firms			
Share of capital in output	α	0.4	Labor share of output = 0.60
Share of domestic goods in the investment composite	ω_i	0.87	$I/Y = 0.15$
Steady-state utilization rate	$\overline{u}$	1	Literature
Depreciation rate of capital	δ	0.035	$I/K = 14.8\%$
Utilization elasticity of marginal depreciation rate	ϱ	1	Gertler et al. (2007)
Investment adjustment cost parameter	ψ	5	Literature
Elasticity of substitution between varieties	ϵ	11	Steady state mark-up of 1.1
Menu cost parameter for domestic intermediate goods	φ_H	112.57	Price inertia likelihood = 0.75
Menu cost parameter for foreign intermediate goods	φ_F	112.57	Price inertia likelihood = 0.75
Foreign price elasticity of export demand	Γ	1	Literature
Share of foreign output in export demand	ν^F	0.25	Gertler et al. (2007)
Average foreign output	$\bar{y^*}$	1.8322	$X/Y = 0.17.64$
Monetary Authority and Government			
Policy rate persistence	ρ_{r_n}	0.80	Literature
Policy rate inflation response	φ_π	1.5	Literature
Policy rate output response	φ_y	0.125	Literature
Policy rate exchange rate response	φ_S	75	Literature
Steady state government expenditure to home output ratio	$\bar{g^H}$	0.939	$G/Y = 9.39\%$
Fraction of primary deficit financed by domestic public debt	ζ	0.8702	Prim.Surp./GDP = 4.58%, $\frac{\bar{b_g^*}}{\bar{y}} = 18.35\%$
Fiscal rule response to debt	Ψ^τ	0.05	$\frac{\overline{b_g + b_g^*}}{y} = 61.44\%$
Shock Processes			
Persistence of government spending shocks	ρ^{g^H}	0.457	Estimated for 2002-2014
Standard deviation of government spending shocks	σ^{g^H}	0.04	Estimated for 2002-2014

Table 2: Fiscal multipliers under alternative specifications

	(1) Float	(2) Peg	(3) (Peg-Float)
Benchmark			
Impact	0.83	1.11	0.28
Cumulative	0.65	0.57	-0.08
Domestic government debt ($b_g = 0$)			
Impact	0.76	1.14	0.38
Cumulative	0.57	0.16	-0.41
Sovereign indebtedness ($b_g^* = 0$)			
Impact	0.82	1.18	0.36
Cumulative	0.65	0.49	-0.16
Openness (*More open*)			
Impact	0.64	0.96	0.32
Cumulative	0.81	0.92	0.11
Financial Frictions (*Low ss spreads*)			
Impact	0.83	1.22	0.39
Cumulative	0.65	3.74	3.09

Impact multipliers are defined as $\frac{\Delta y_1}{\Delta g_1}$ where Δx_1 denotes level deviation in variable x (driven by the fiscal impulse) from its non-stochastic steady state value. Cumulative multipliers are then defined as $\frac{\sum_{t=1}^{1000} \beta^{t-1} \Delta y_t}{\sum_{t=1}^{1000} \beta^{t-1} \Delta g_t}$ where β is the household discount factor.

Table 3: The effects of different channels on fiscal multipliers under alternative scenarios

- **Private expenditure channel:** Higher government spending raises inflation as firms adjust prices upward in the face of higher public demand. Central bank increases the nominal policy rate more than one-for-one with an increase in inflation under Taylor rule. The short-term real interest rate rises, leading to a decline in private expenditures such as consumption and investment.

- **Trade channel:** The increased activity due to higher government spending puts upward pressure on interest rates, triggering capital inflows and an appreciation of the currency. This, in turn, crowds out net exports and eventually offsets the effect of increased public spending on the demand for domestic goods.

- **Financial crowing out channel:** Fiscal expansion financed banks with leverage constraints leads to reduced private access to credit and to an economy-wide increase in credit spreads for the private sector (as higher government budget deficits tighten intermediary balance sheet constraints. The rise in spreads lowers non-financial investment which can offset the output gain of a demand stimulus.

- **Sovereign risk channel:** When fiscal expansion is financed via foreign government debt, it might lead to an increase in the risk premium required by international investors. A hike in risk premia in turn is passed through into higher cost of foreign borrowing by the banking sector. This can lead to a fall in their credit extension to both private sector and government, reducing the positive effects of a fiscal stimulus.

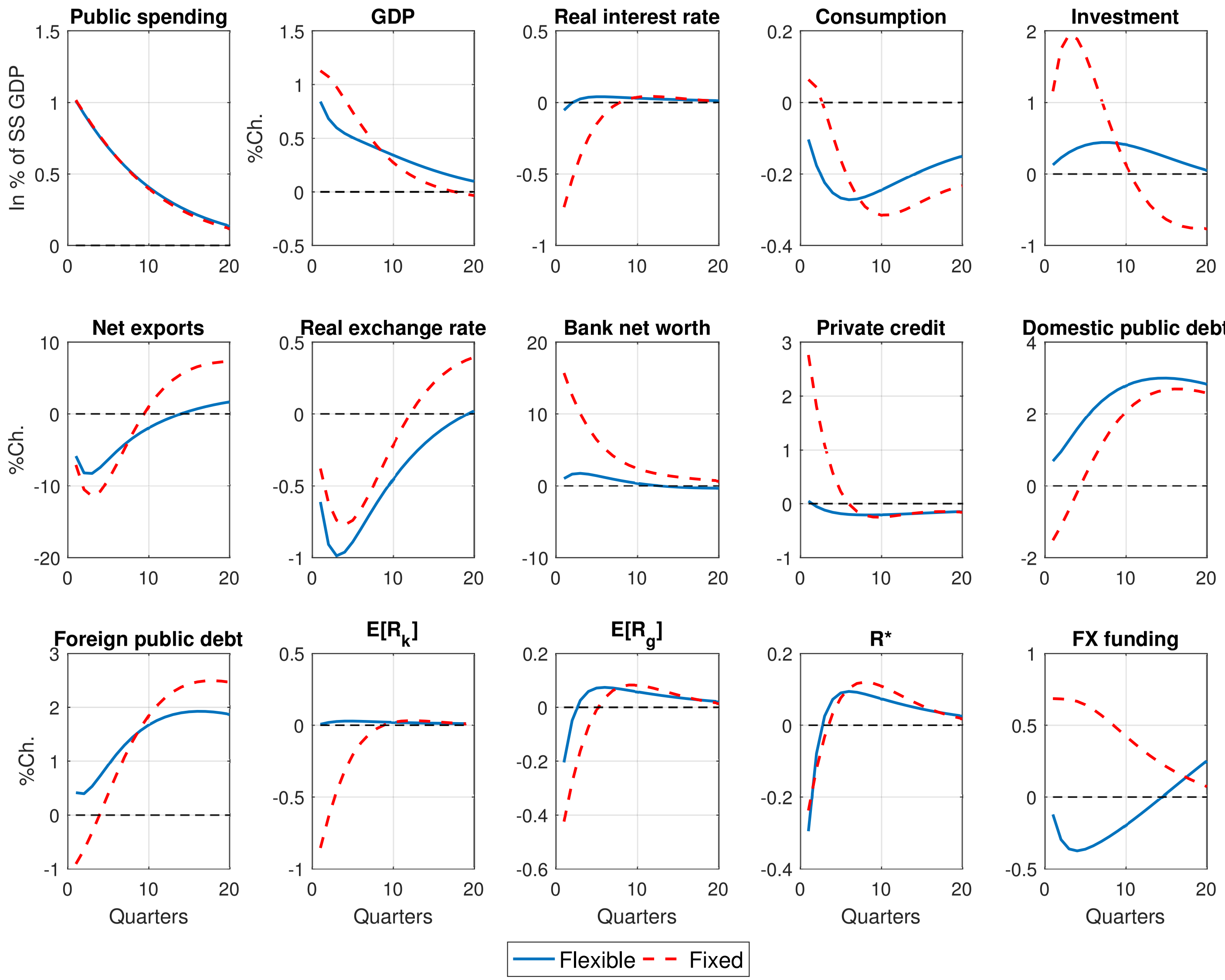

Figure 1: Fiscal stimulus and exchange rate regimes. Float (line) vs. peg (dashed).

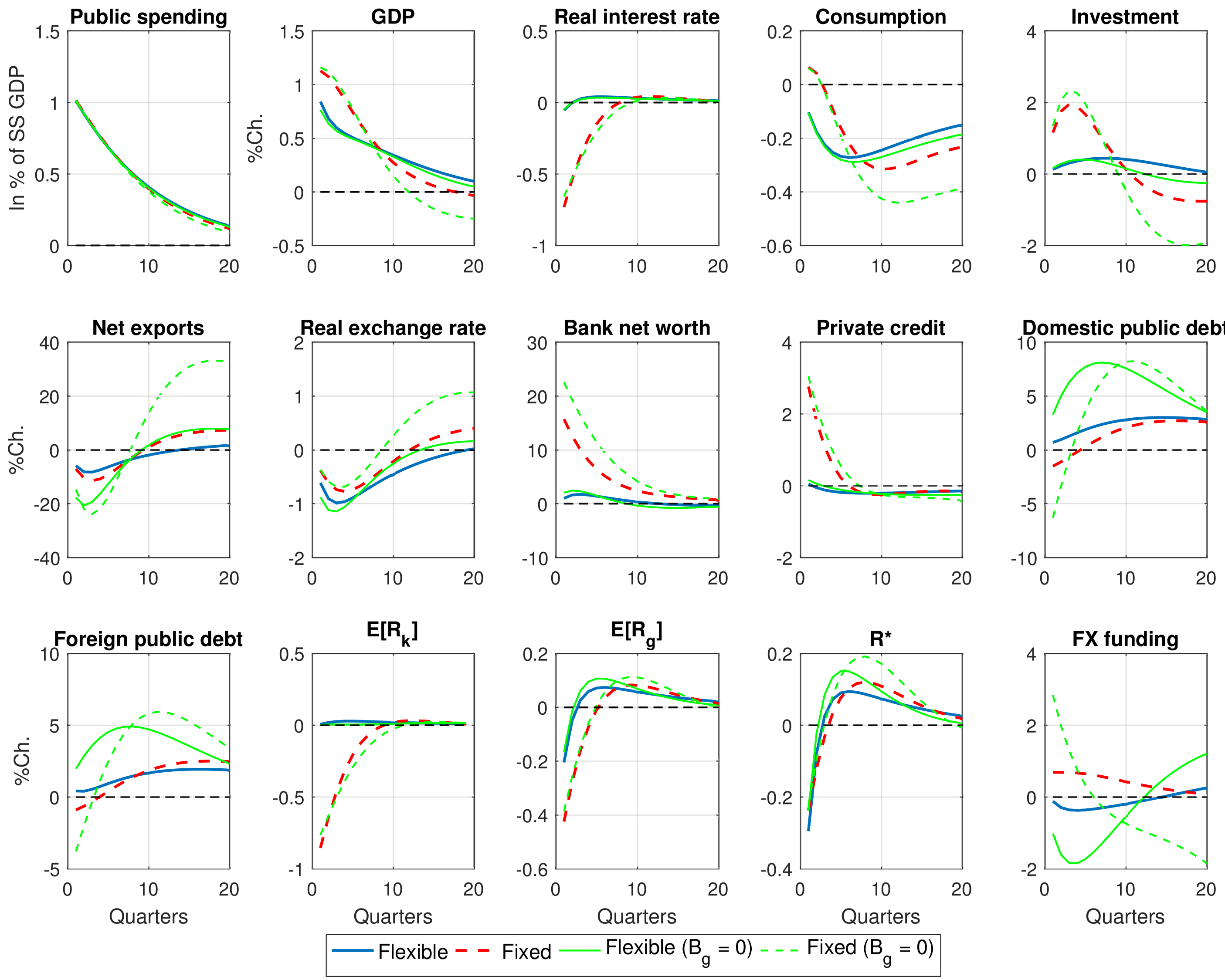

Figure 2: Fiscal stimulus and exchange rate regimes. Float (line) vs. peg (dashed). Green colored counterparts correspond to $b_g = 0$.

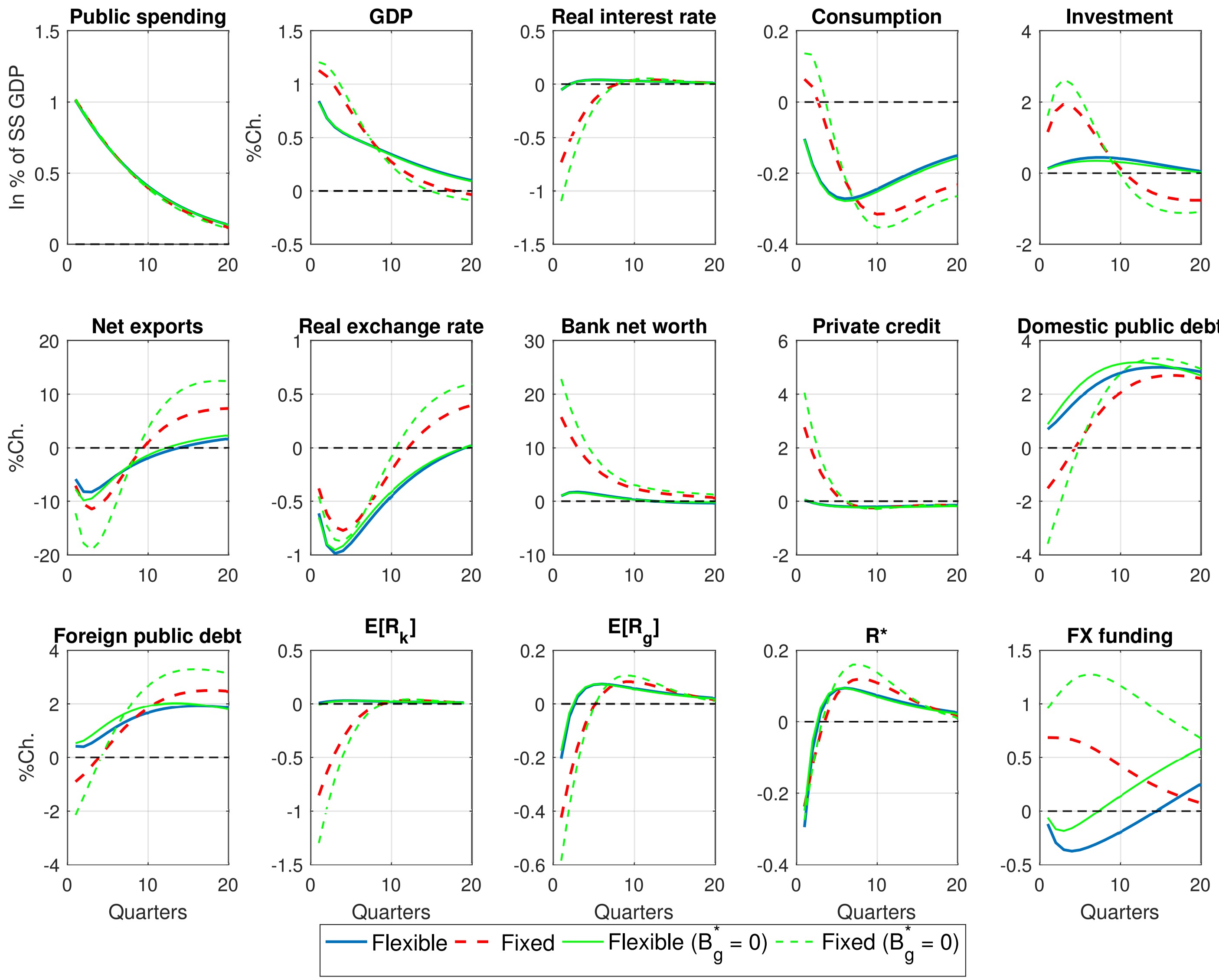

Figure 3: Fiscal stimulus and exchange rate regimes. Float (line) vs. peg (dashed). Green colored counterparts correspond to $b_g^* = 0$.

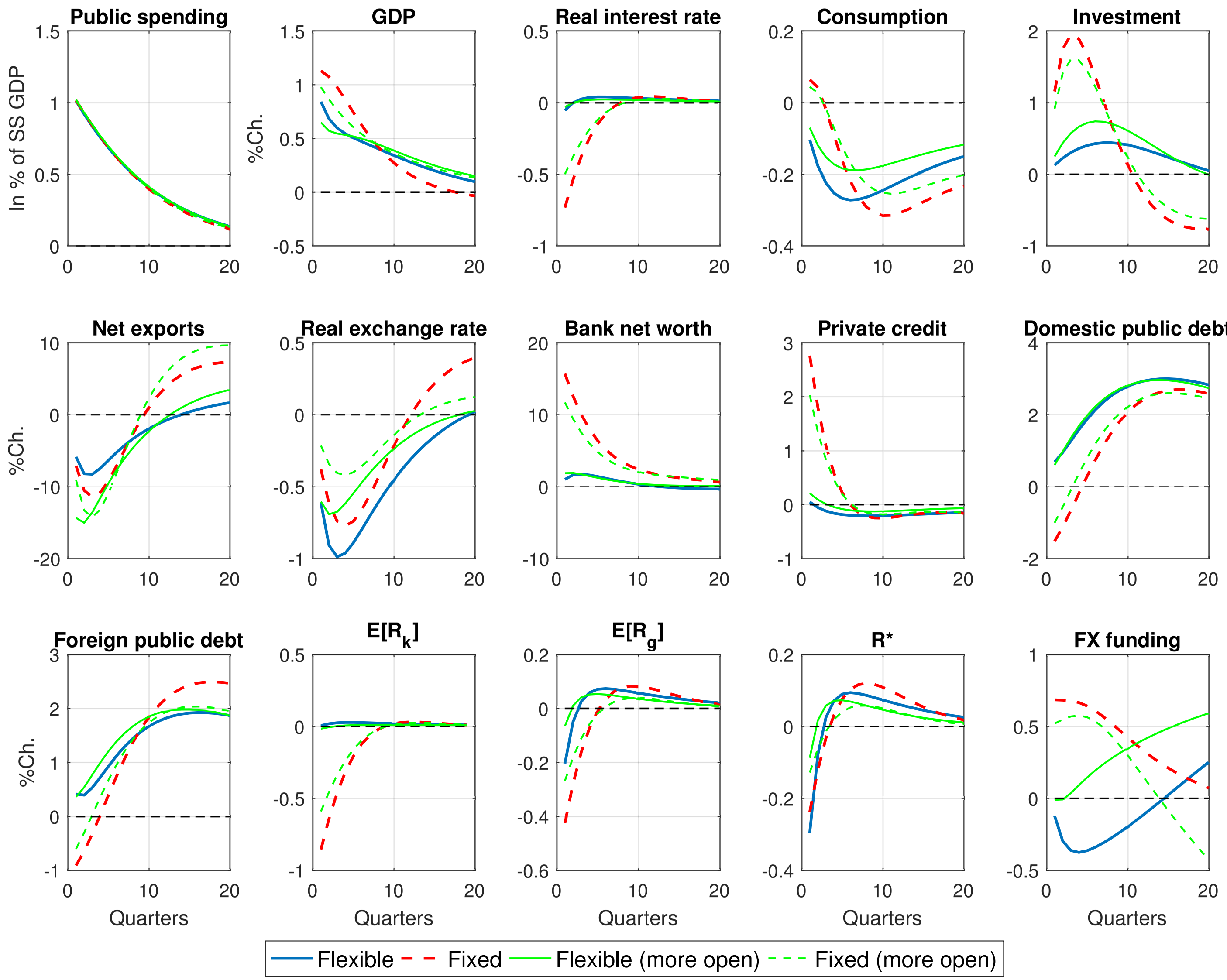

Figure 4: Fiscal stimulus and exchange rate regimes. Float (line) vs. peg (dashed). Green colored counterparts correspond to smaller home bias.

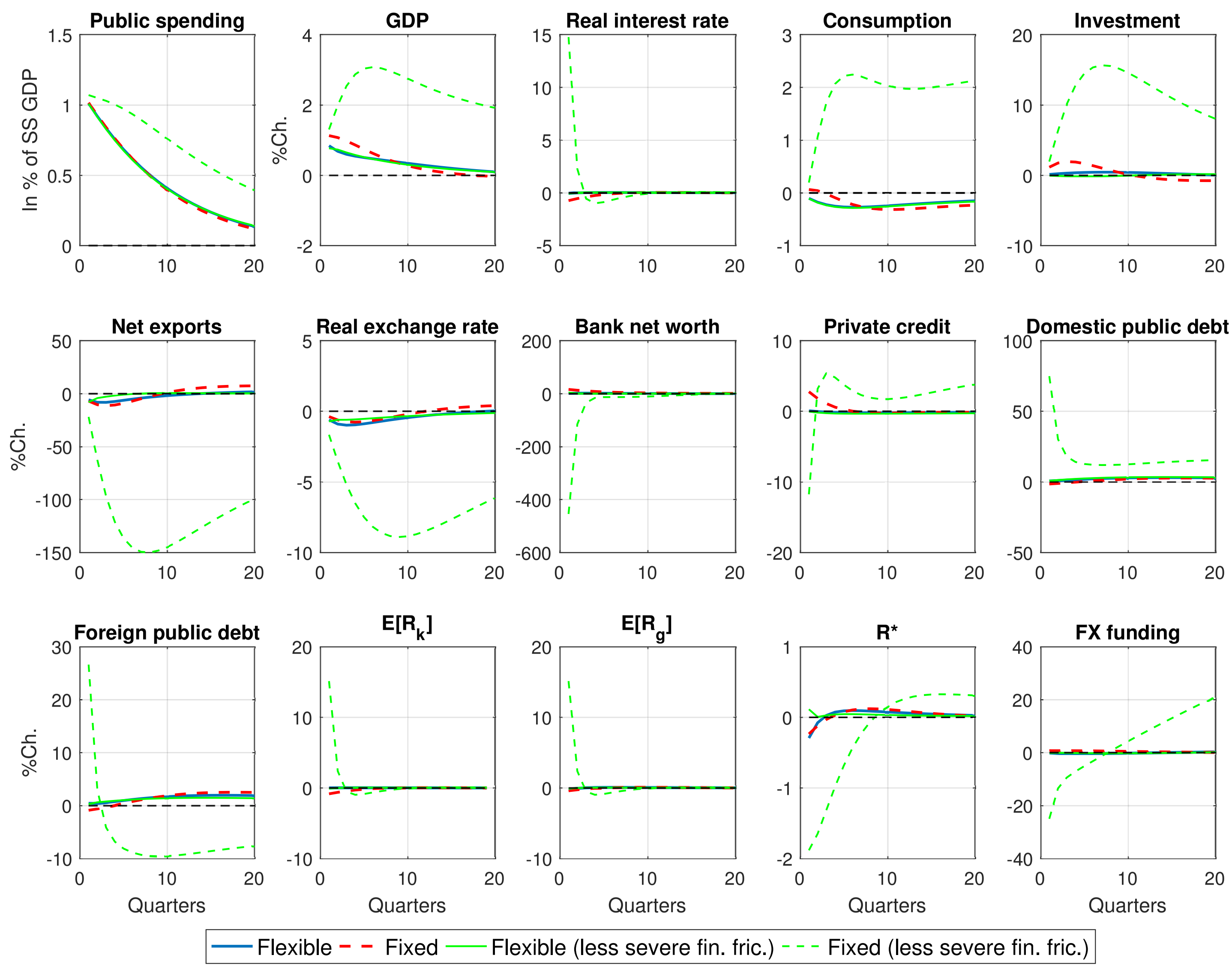

Figure 5: Fiscal stimulus and exchange rate regimes. Float (line) vs. peg (dashed). Green colored counterparts correspond to lower steady state spreads.

A Technical Appendix - Model derivations

A.1 Households

The expenditure minimization problem of households

$$\min_{c_t^H, c_t^F} P_t c_t - P_t^H c_t^H - P_t^F c_t^F$$

subject to (1) yields the demand curves $c_t^H = \omega \left(\frac{P_t^H}{P_t}\right)^{-\gamma} c_t$ and $c_t^F = (1-\omega)\left(\frac{P_t^F}{P_t}\right)^{-\gamma} c_t$, for home and foreign goods, respectively.

The final demand for home consumption good c_t^H, is an aggregate of a continuum of varieties of intermediate home goods along the [0,1] interval. That is, $c_t^H = \left[\int_0^1 (c_{it}^H)^{1-\frac{1}{\epsilon}} di\right]^{\frac{1}{1-\frac{1}{\epsilon}}}$, where each variety is indexed by i, and ϵ is the elasticity of substitution between these varieties. For any given level of demand for the composite home good c_t^H, the demand for each variety i solves the problem of minimising total home goods expenditures, $\int_0^1 P_{it}^H c_{it}^H di$ subject to the aggregation constraint, where P_{it}^H is the nominal price of variety i. The solution to this problem yields the optimal demand for c_{it}^H, which satisfies

$$c_{it}^H = \left(\frac{P_{it}^H}{P_t^H}\right)^{-\epsilon} c_t^H,$$

with the aggregate home good price index P_t^H being

$$P_t^H = \left[\int_0^1 (P_{it}^H)^{1-\epsilon} di\right]^{\frac{1}{1-\epsilon}}.$$

First order conditions (7) and (9) that come out of the utility maximization problem can be combined to obtain the consumption-savings optimality condition,

$$(c_t - h_c c_{t-1})^{-\sigma} - \beta h_c E_t (c_{t+1} - h_c c_t)^{-\sigma} = \beta E_t \left[\left\{(c_{t+1} - h_c c_t)^{-\sigma} - \beta h_c (c_{t+2} - h_c c_{t+1})^{-\sigma}\right\} \frac{(1 + r_{nt+1}) P_t}{P_{t+1}}\right]$$

The consumption-money optimality condition,

$$\frac{v/m_t}{\varphi_t} = \frac{r_{nt}}{1+r_{nt}}.$$

on the other hand, might be derived by combining first order conditions (9) and (10) with m_t denoting real balances held by consumers.

A.2 Banks' net worth maximization

Bankers solve the following value maximization problem,

$$V_{jt} = \max_{s_{jt+i}, b^g_{jt+i}, b^*_{jt+1+i}} E_t \sum_{i=0}^{\infty} (1-\theta)\theta^i \Lambda_{t,t+1+i}\, n_{jt+1+i}$$

$$= \max_{s_{jt+i}, b^g_{jt+i}, b^*_{jt+1+i}} E_t \sum_{i=0}^{\infty} (1-\theta)\theta^i \Lambda_{t,t+1+i} \Big([R_{kt+1+i} - R_{t+1+i}]\, q_{t+i} s_{jt+i}$$

$$+ [R_{bt+1+i} - R_{t+1+i}]\, b^g_{jt+i} + \left[R_{t+1+i} - R^*_{t+1+i}\right] b^*_{jt+1+i} + R_{t+1+i} n_{jt+i} \Big).$$

subject to the constraint (16). Since,

$$V_{jt} = \max_{s_{jt+i}, b^g_{jt+i}, b^*_{jt+1+i}} E_t \sum_{i=0}^{\infty} (1-\theta)\theta^i \Lambda_{t,t+1+i}\, n_{jt+1+i}$$

$$= \max_{s_{jt+i}, b^g_{jt+i}, b^*_{jt+1+i}} E_t \left[(1-\theta)\Lambda_{t,t+1} n_{jt+1} + \sum_{i=1}^{\infty} (1-\theta)\theta^i \Lambda_{t,t+1+i}\, n_{jt+1+i} \right],$$

we have

$$V_{jt} = \max_{s_{jt}, b^g_{jt}, b^*_{jt+1}} E_t \Big\{ \Lambda_{t,t+1} [(1-\theta) n_{jt+1} + \theta V_{jt+1}] \Big\}.$$

The Lagrangian which solves the bankers' profit maximization problem reads,

$$\max_{s_{jt}, b^g_{jt}, b^*_{jt+1}} L = \nu^s_t q_t s_{jt} + \nu^g_t b^g_t + \nu^*_t b^*_{jt+1} + \nu_t n_{jt} \tag{A.1}$$

$$+\mu_t \left[\nu^s_t q_t s_{jt} + \nu^g_t b^g_{jt} + \nu^*_t b^*_{jt+1} + \nu_t n_{jt} - \lambda \left(q_t s_{jt} + \omega_g b^g_{jt} - \omega_d \left[q_t s_{jt} + b^g_{jt} - b^*_{jt+1} - n_{jt} \right] \right) \right],$$

where the term in square brackets represents the incentive compatibility constraint, (16) combined with the balance sheet (11), to eliminate d_{jt+1}. The first-order conditions for $s_{jt}, b^g_{jt}, b^*_{jt+1}$, and the Lagrange multiplier μ_t are:

$$\nu^s_t(1+\mu_t) = \lambda\mu_t\Big(1-\omega_d\Big), \tag{A.2}$$

$$\nu^g_t(1+\mu_t) = \lambda\mu_t\Big(\omega_g-\omega_d\Big), \tag{A.3}$$

$$\nu^*_t(1+\mu_t) = \lambda\mu_t\omega_d \tag{A.4}$$

and

$$\nu^s_t q_t s_{jt} + \nu^g_t b^g_{jt} + \nu^*_t\Big[q_t s_{jt} + b^g_{jt} - b^*_{jt+1} - n_{jt}\Big] + \nu_t n_{jt} - \lambda(q_t s_{jt} + \omega_g b^g_{jt} - \omega_d d_{jt+1}) \geq 0 \tag{A.5}$$

respectively. We are interested in cases in which the incentive constraint of banks is always binding, which implies that $\mu_t > 0$ and (A.5) holds with equality.

Combining (A.2) and (A.3) yields,

$$\frac{\nu^s_t}{\nu^g_t} = \frac{(1-\omega_d)}{(\omega_g-\omega_d)}.$$

Combining (A.2) and (A.4) yields,

$$\frac{\nu^s_t}{\nu^*_t} = \frac{(1-\omega_d)}{\omega_d}.$$

Re-arranging the binding version of (A.5) leads to equation (18).

We replace V_{jt+1} in equation (15) by imposing our linear conjecture in equation (17) and the borrowing constraint (18) to obtain,

$$\tilde{V}_{jt} = E_t\Big\{\Xi_{t,t+1} n_{jt+1}\Big\}, \tag{A.6}$$

where $\tilde{V}_{jt}$ stands for the optimised value.

Replacing the left-hand side to verify our linear conjecture on bankers' value (17) and using equation (14), we obtain the definition of the augmented stochastic discount factor $\Xi_{t,t+1} = \Lambda_{t,t+1}\Big[1 - \theta + \theta\lambda\kappa_{t+1}\Big]$ and find that ν_t^l, ν_t^g, ν_t^*, and ν_t should consecutively satisfy equations (19), (20), (21), and (22) in the main text.

Surviving bankers' net worth n_{et+1} is derived as described in the main text and is equal to

$$n_{et+1} = \theta\Big\{[(R_{kt+1} - R^*_{t+1})\kappa_t + R^*_{t+1}]n_t + [(R_{bt+1} - R^*_{t+1}) - (R_{kt+1} - R^*_{t+1})\omega_g]b_t^g + [(R_{kt+1} - R^*_{t+1})\omega_d - (R_{t+1} - R^*_{t+1})]d_{t+1}\Big\}. \quad \text{(A.7)}$$

A.3 Final goods producers

The profit maximization problem of final goods producers are represented by

$$\max_{y_t^H(i)} \; P_t^H \left[\int_0^1 y_t^H(i)^{1-\frac{1}{\epsilon}} di\right]^{\frac{1}{1-\frac{1}{\epsilon}}} - \left[\int_0^1 P_t^H(i) y_t^H(i) di\right]. \quad \text{(A.8)}$$

A.4 Intermediate goods producers

Domestic intermediate goods producers' profit maximization problem can be represented as follows:

$$\max_{P_t^H(i)} E_t \sum_{j=0}^{\infty} \Lambda_{t,t+j} \left[\frac{D_{t+j}^H(i)}{P_{t+j}}\right] \quad \text{(A.9)}$$

subject to the nominal profit function

$$D_{t+j}^H(i) = P_{t+j}^H(i) y_{t+j}^H(i) + S_{t+j} P_{t+j}^{H*} c_{t+j}^{H*}(i) - MC_{t+j} y_{t+j}(i) - P_{t+j}\frac{\varphi^H}{2}\left[\frac{P_{t+j}^H(i)}{P_{t+j-1}^H(i)} - 1\right]^2, \quad \text{(A.10)}$$

and the demand function $y_t^H(i) = \left(\frac{P_t^H(i)}{P_t^H}\right)^{-\epsilon} y_t^H$. Since households own these firms, any profits are remitted to consumers and future streams of real profits are discounted by the stochastic discount factor of consumers, accordingly. Notice that the sequences of the nominal exchange rate and export prices in foreign currency $\{S_{t+j}, P^{H*}_{t+j}\}_{j=0}^{\infty}$ are taken exogenously by the firm, since it acts as a price taker in the export market. The first-order condition to this problem becomes,

$$(\epsilon-1)\left(\frac{P^H_t(i)}{P^H_t}\right)^{-\epsilon}\frac{y^H_t}{P_t}=\epsilon\left(\frac{P^H_t(i)}{P^H_t}\right)^{-\epsilon-1}MC_t\frac{y^H_t}{P_tP^H_t}-\varphi^H\left[\frac{P^H_t(i)}{P^H_{t-1}(i)}-1\right]\frac{1}{P^H_{t-1}(i)}$$

$$+\varphi^H E_t\left\{\Lambda_{t,t+1}\left[\frac{P^H_{t+1}(i)}{P^H_t(i)}-1\right]\frac{P^H_{t+1}(i)}{P^H_t(i)^2}\right\}. \tag{A.11}$$

A.5 Resource constraints

The resource constraint for home goods equates domestic production to the sum of domestic and external demand for home goods and the real domestic price adjustment costs, so that

$$y^H_t=c^H_t+\frac{c^{H*}_t}{p^H_t}+i^H_t+g^H_t+\frac{\varphi^H}{2}y^H_t\left[\frac{\pi^H_t}{\pi^H}-1\right]^2. \tag{A.12}$$

A similar market clearing condition holds for the domestic consumption of the imported goods, that is,

$$y^F_t=c^F_t+i^F_t+\frac{\varphi^F}{2}y^F_t\left[\frac{\pi^F_t}{\pi^F}-1\right]^2. \tag{A.13}$$

The balance of payments vis-à-vis the rest of the world defines the trade balance as a function of net foreign assets

$$R^*_t(b^*_t+b^{g*}_t)-(b^*_{t+1}+b^{g*}_{t+1})=c^{H*}_t-p^F_t y^F_t. \tag{A.14}$$

Finally, the national income identity that reflects investment adjustment costs built in capital accumulation condition (25) would read,

$$y_t=p^H_t y^H_t-p^F_t y^F_t. \tag{A.15}$$

A.6 Definition of competitive equilibrium

A competitive equilibrium is defined by sequences of prices $\left\{p_t^H, p_t^F, p_t^I, \pi_t, w_t, q_t, s_t, R_{kt+1}, R_{t+1}, R_{t+1}^*\right\}_{t=0}^{\infty}$, government policies $\{r_{nt}, rr_t, M_{0t}, T_t\}_{t=0}^{\infty}$, allocations $\left\{c_t^H, c_t^F, c_t, h_t, m_t, b_{t+1}, b_{t+1}^*, \varphi_t, l_t, n_t, \kappa_t, \nu_t^l, \nu_t^*, \nu_t, i_t, i_t^H, i_t^F, k_{t+1}, y_t^H, y_t^F, y_t, u_t, rmc_t, c_t^{H*}, D_t^H, \Pi_t, \delta_t\right\}_{t=0}^{\infty}$, initial conditions, $b_0, b_0^*, k_0, m_-, n_0$ and exogenous processes $\left\{A_t, g_t^H, \psi_t, r_{nt}^*, y_t^*\right\}_{t=0}^{\infty}$ such that;

i) Given exogenous processes, initial conditions, government policy, and prices; the allocations solve the utility maximization problem of households (5)-(6), the net worth maximization problem of bankers (15)-(16), and the profit maximization problems of capital producers (24), final goods producers (A.8), and intermediate goods producers (A.9)-(A.10) and (28)-(29).

ii) Home and foreign goods, physical capital, investment, security claims, domestic deposits, money, and labor markets clear. The balance of payments and GDP identities (A.14) and (A.15) hold.