Capital Controls and Monetary Policy Autonomy in a Small Open Economy*

Scott Davis†
Federal Reserve Bank of Dallas

Ignacio Presno‡
Universidad de Montevideo

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Abstract

This paper examines the link between capital controls and monetary policy autonomy in a country with a floating exchange rate. Large swings in net capital flows into emerging markets can potentially lead to excessive volatility in asset prices and credit supply. In order to lessen the impact of capital flows on financial instability, a central bank with a floating currency may find it optimal to use the domestic interest rate to "manage" the capital account. In an open-economy DSGE framework, we consider how capital account restrictions might affect the behavior of optimal monetary policy in a small open economy subject to large exogenous shocks to net capital flows. Capital controls, both temporary episodic "gates" and "walls" that simply shut down all channels for international borrowing and lending lead to improved monetary policy autonomy. Empirical results confirm that even for a country with a floating currency, the imposition of capital account restrictions leads to a significant improvement in measured monetary policy autonomy.

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†Federal Reserve Bank of Dallas, 2200 N. Pearl Street, Dallas, TX 75201, USA Email: scott.davis@dal.frb.org

‡Universidad de Montevideo, Dept. of Economics, Prudencio de Pena 2544, Montevideo, CP: 11600, Uruguay Email: jipresno@um.edu.uy
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1 Introduction

Repeated cycles of capital flows into and out of emerging markets are a fixture of the financially integrated global economy. Surges in capital inflows have led to talk of "currency wars" and the danger of overheating in many emerging markets. Likewise, a sudden reversal of capital flows has been blamed for the recent financial and macroeconomic instability in many emerging markets.

Rey (2015) and Forbes and Warnock (2012) show that capital flows into and out of emerging markets are largely driven by global factors. They both show that a measure of global risk is one of the main determinants of international capital flows. Reinhart and Reinhart (2009) argue that surges in capital inflows into emerging markets are associated with a higher likelihood of banking, inflation, and currency crises, and contribute to economic and financial instability. Kaminsky, Reinhart, and Végh (2005) show that capital inflows are a primary reason for the procyclicality of fiscal and monetary policy observed in many emerging markets. Rey (2015) argues that since these foreign capital flows can lead to asset price bubbles, excess credit creation, and financial instability, capital controls or some tool of active capital account management is necessary in many countries. She argues that this cycle of capital inflows and outflows means that the classic "trilemma" of international finance is actually more of a "dilemma", and that "independent monetary policies are possible if and only if the capital account is managed." Obstfeld (2015) acknowledges that under certain conditions, a central bank with a floating exchange rate has complete monetary autonomy, but he discusses how financial globalization affects the trade-offs faced by monetary policy makers.

In this paper, we address this issue. Do exogenous cycles of capital inflows and outflows into many small open economies mean that the trilemma is actually a dilemma? Various frictions lead to welfare reducing distortions, and a policy maker sets policy in order to minimize those distortions. If there are multiple distortions then the policy maker is faced with a trade-off. How are these trade-offs in a small open economy affected by exogenous
shocks to capital inflows and outflows, and how will this affect optimal monetary policy? How will capital account restrictions affect the trade-offs that the policy maker faces?

The classic trilemma has been a feature of the international macroeconomics literature since Mundell (1963). The trilemma states that a country cannot simultaneously maintain a fixed exchange rate, an open capital account, and monetary policy autonomy. Given that a shift in net capital flows could lead to exchange rate appreciation or depreciation, a country with fixed nominal exchange rate and an open capital account is forced to use the domestic interest rate to "manage" the capital account, either by raising the interest rate to attract capital flows and prevent depreciation or lowering the interest rate to discourage capital flows and prevent appreciation.

In technical terms, the fact that the combination of a fixed exchange rate and an open capital account lead to the loss of monetary policy autonomy is purely mechanical. When a central bank maintains a fixed exchange rate, the central bank’s monetary policy rule, either a Taylor-type feedback rule or the solution to a maximization problem, is replaced with a rule stating that the nominal exchange rate is held constant. So in a mechanical sense when a country has a floating exchange rate they are freed of this constraint on the nominal exchange rate, and this constraint can be replaced by a monetary policy rule that is focused on domestic concerns. As long as policy avoids an indeterminate solution, a central bank with a floating exchange rate can do whatever it wants with its interest rate.

But beyond this purely mechanical explanation, this paper shows that a central bank with a floating exchange rate may still find it optimal to use its interest rate instrument to "manage" the capital account. When borrowers are subject to collateral constraints, exogenous capital inflows and outflows can lead to financial instability. When the amount that individuals can borrow depends on the value of existing collateral at the current market price. A surge in capital inflows following a foreign shock can push up asset prices and loosen the collateral constraint in the small open economy, leading to excess credit creation and a boom-bust cycle in the provision of credit. In this case, the central bank of the small
open economy may find it optimal to cut the interest rate in order to deter capital inflows, even though the foreign shock is leading to an increase in inflation and the output gap. The distortion created by the collateral constraint leads the central bank to use the interest rate to manage the capital account. This is not because the central bank is subject to a constraint like maintaining a constant nominal exchange rate, but rather this outcome is the solution to a central bank optimization problem where the central bank sets policy in order to minimize losses due to price and credit frictions.

Given this finding, we then show how the use of capital controls can free the interest rate from this need to ”manage” the capital account. Similar to how the use of capital controls allow greater monetary policy autonomy in a country with a fixed exchange rate, we show how the use of capital controls allow greater monetary policy autonomy in a country with a floating exchange rate. In the spirit of Klein (2012), these capital controls could take one of two forms. They could either be ”gates”, that is temporary episodic capital controls which are treated as a policy instrument and vary over the cycle, or ”walls”, a simple closing of the capital account.¹

A number of recent papers have addressed the issue of how capital controls can be used to minimize the effects of distortions arising from financial frictions. Korinek (2010), Jeanne and Korinek (2010), Bianchi and Mendoza (2013), Bianchi (2011), Benigno, Chen, Otrok, Re-

¹This paper will address in a theoretical framework how the use of capital controls might affect monetary policy autonomy in a country with a floating exchange rate. The potential effectiveness of these capital controls is a separate, empirical, question. Klein (2012) argues that temporary episodic capital controls have little effect on many macroeconomic variables. Cordero and Montecino (2010) argue that capital controls can be a useful tool of monetary policy and can help countries keep inflation under control and also maintain a stable and competitive real exchange rate. Ostry, Ghosh, Chamon, and Qureshi (2012) show that while capital controls tend to be of limited use in controlling the aggregate volume of capital flows, inflow controls can be a useful instrument of policy to reduce the financial stability risks associated with surges in capital inflows. Forbes, Fratzscher, and Straub (2015) show that capital controls can significantly reduce some measures of financial fragility. Mitchener and Wandschneider (2015) show that in the 1930's, the use of capital controls did enable countries to control gold outflows.

Baba and Kokenyne (2011) and Magud, Reinhart, and Rogoff (2011) both find that while in practice capital controls do little to affect the volume of capital flows or other key macroeconomic variables, they do tend to ”provide room” for monetary policy and tend to make monetary policy more independent in many emerging markets. Fréndez, Rebbucci, and Uribe (2013) discuss how theory suggests that policy makers should use capital controls countercyclically as a tool of macroprudential policy, but empirically they find that capital controls tend to be acyclical.
bucci, and Young (2013), Korinek (2013), and Brunnermeier and Sannikov (2015) all discuss how the fact that collateral constraints depend on asset prices, which are subject to fluctuations from capital inflows, leads to over-borrowing and financial instability. Specifically the over-borrowing is caused by a pecuniary externality, where agents don’t internalize the effect that their collective actions are having on asset prices, and thus collateral constraints. They discuss how counter-cyclical taxes on capital inflows and other macroprudential measures can be used to offset this externality and reduce financial vulnerabilities. In a different framework, Heathcote and Perri (2016) discuss how capital controls can be welfare enhancing if they correct the distortions created by incomplete financial markets and limited risk sharing. Engel (2015) surveys the recent literature on capital controls and macroprudential policy in a world of volatile international capital flows and discusses how capital controls can be used as a macroprudential regulation to correct for certain financial distortions.

However, while the aforementioned papers consider the effect of distortions arising from financial frictions (or in the case of Heathcote and Perri, incomplete markets), the models are real and do not have a role for conventional monetary policy. Schmitt-Grohe and Uribe (2012b), Schmitt-Grohe and Uribe (2012a) and Farhi and Werning (2012) show how counter-cyclical capital controls policy can play a role in macroeconomic stabilization in a small open economy with a fixed exchange rate, but in these models, conventional monetary policy is dedicated to maintaining a fixed exchange rate. This paper will instead consider the case where monetary policy can be set freely, but the central bank is faced with two distortions, those arising from price frictions and those arising from credit frictions.

In a DSGE model with both price and credit frictions, we calculate the monetary policy in the small open economy that would minimize these distortions following an exogenous shock to the world interest rate under different levels of capital account openness, one where the capital account is open, one where it is closed, and one where capital controls themselves are

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2In addition, some recent papers, like Costinot, Lorenzoni, and Werning (2011) and de Paoli and Lipinska (2013), Heathcote and Perri (2016), and Farhi and Werning (2014) discuss the optimal use of capital controls for terms-of-trade manipulation as a way to improve welfare in the open economy, but we abstract from that here.
a separate instrument of monetary policy. Through impulse responses and the calculation of the responsiveness of the domestic interest rate to changes in the foreign interest rate we show how the use of capital controls significantly affects the degree of monetary policy autonomy and allows the central bank to use its monetary policy instrument for domestic stabilization. Throughout this analysis we will also examine the impact of capital controls in a country with a fixed exchange rate. This is simply to show the parallels between the use of capital controls in a country with a fixed exchange rate (the classic trilemma) and the use of capital controls in a country with a floating exchange rate where monetary policy is determined optimally. However, this paper makes no contribution to the study of capital controls and monetary policy autonomy in a country with a fixed exchange rate, this paper’s contribution is to show how capital controls affect monetary policy autonomy in a country with a floating exchange rate.

The finding that capital account restrictions can lead to an improvement in monetary policy autonomy in a small open economy even when monetary policy is chosen optimally can be tested empirically. In regressions similar to those in Shambaugh (2004), Obstfeld, Shambaugh, and Taylor (2005), and Klein and Shambaugh (2015), we show that imposing capital account restrictions leads to a significant improvement in monetary policy autonomy. This empirical finding is true not only for countries with a pegged currency where this gain in autonomy is mechanical but for countries with a floating currency as well. Furthermore, the gains in monetary policy autonomy from the imposition of capital controls in the data are nearly identical to the gains when measured through simulations of our model.

This paper will proceed as follows. The theoretical model used to derive these optimal policy results is described in section 2. The calibration of the model is discussed in section 3 and the results from are presented in section 4. Here we will examine impulse responses in the home country to a sharp drop in capital inflows from the rest of the world. Using simulated data from the model, we will then calculate the responsiveness of a country’s policy interest rate to that in the rest of the world. Empirical results are presented in section 5.
Finally section 6 concludes.

2 The model

In this infinite-horizon model there are two countries, home and foreign. As in the open-macro framework of Obstfeld and Rogoff (1995), the home country is size $n$ and the foreign country is size $1 - n$. As $n \to 0$, the model becomes one with a small open economy and the rest of the world. Foreign variables are denoted with an asterisk (*) while home variables are not. In the following description of the model, equations pertaining the foreign economy are omitted for brevity.

Each country is populated by a representative household, a representative entrepreneur, a final good firm and a continuum of intermediate good firms. Households supply labor to domestic firms, consume, and lend to entrepreneurs through one-period non-contingent bonds.

Entrepreneurs borrow from households to finance capital accumulation, and they rent out this capital to firms in the intermediate good sector. However, a financial friction limits their ability to raise funds from households. Entrepreneurs are subject to a collateral constraint and cannot borrow more than a given fraction of the market value of their current capital stock, similar to Liu, Wang, and Zha (2013). This credit constraint can be seen as emerging endogenously due to limited enforcement: if entrepreneurs renege on their debt contracts, the creditors can seize their assets and recover only part of the liquidation value of the physical capital.

Intermediate firms hire labor and rent capital in perfectly competitive markets and produce differentiated intermediate goods. These firms are engaged in monopolistic competition and set prices according to a Calvo (1983) style price setting framework. Domestic and foreign intermediate goods are combined to produce a final good that is used for consumption and investment.
Monetary policy is set as the solution to a Ramsey problem to minimize the distortions created by price and credit frictions in the model. The conventional monetary policy instrument in this cash-less economy is the risk-free nominal rate of interest. The central bank in the small open economy can also implement capital flow management measures (capital controls). Here we assume a few specifications. In one scenario, the central bank simply shuts down all international borrowing and lending. In another the central bank can impose temporary, episodic taxes or subsidies on capital inflows and outflows in order to deter or encourage capital flows, and thus capital controls are a separate instrument of the central bank.

In this section we will present the model and the key equilibrium conditions; the full set of first-order conditions and market-clearing conditions is available in the appendix.

2.1 Households

Households supply labor to the intermediate good sector, and (in equilibrium) lend to domestic entrepreneurs. They consume from their labor income, interest on savings and profits from domestic firms. Households are risk-averse and derive utility from consumption and disutility from labor effort.

The representative household in the home economy chooses consumption, $C_t$, labor effort, $H_t$, and home and foreign bond holdings, $B_{t+1}$ and $B_{t+1}'$ respectively, to maximize expected lifetime utility given by:

$$E_0 \sum_{t=0}^{\infty} \beta^t A_t \ln (C_t) - \psi H_t^{1+\frac{1}{\sigma_H}}$$

with $\beta \in (0, 1)$, $\psi > 0$, and the Frisch elasticity of labor $\sigma_H > 0$.

The cumulative discount factor of home country household at time $t$ is given by $\beta^t A_t$, where $A_t = A_{t-1} e^{\lambda_t}$, and $\lambda_t$ is an intertemporal preference shock, which follows an AR(1)
process:
\[
\lambda_{t+1} = (1 - \rho) \lambda + \rho \lambda \lambda_t + \varepsilon_t^\lambda
\]

with \(|\rho| < 1\), and where the innovation \(\varepsilon_t^\lambda\) has mean zero. Also, we assume that \(\lambda > 0\) to ensure that in the steady state households are relatively more impatient and hence are net savers while entrepreneurs are net borrowers.

The households’ budget constraint expressed in local currency is given by:

\[
P_t C_t + B_{t+1} + S_t B_t^f = W_t H_t + \Xi_t + (1 + i_t) B_t + (1 - \tau_t) (1 + \tau_t S_t) S_t B_t^f + T_t
\]

where \(P_t\) is the price of the final consumption good, \(W_t\) is the nominal wage rate, \(S_t\) is the nominal exchange rate expressed in units of the home currency per units of the foreign currency, \(\Xi_t\) is profit from domestic firms in the intermediate good sector, and \(T_t\) are lump-sum transfers from the government.\(^3\)

The gross returns from foreign bond holdings are taxed at a rate \(\tau_t = \tau_t + \tau S_t B_t^f\). This tax has two components to reflect the two types of capital controls we consider in this model, gates and walls. In the capital control gates scenario, the tax rate \(\tau_t\) is treated as a separate policy instrument by the central bank, as in Farhi and Werning (2012). In the version of the model with capital control gates it has a steady-state value of zero but the central bank can adjust it to any positive or negative number to encourage or discourage capital outflows. In the versions of the model without capital control gates it is simply set to zero.

In the capital control walls scenario, the constant \(\tau \to \infty\), this makes foreign borrowing prohibitively expensive, and as in the limiting case in Heathcote and Perri (2016), all international borrowing and lending shuts down (financial autarky). When we are not considering the effect of capital control walls, \(\tau\) is a small positive number. This small positive tax simply ensures the stationarity of the linear approximation of the model, as in Schmitt-Grohe and

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\(^3\)Throughout the paper, bond holdings denoted with a superscript \(f\) are denominated in the foreign country currency while bond holdings written without it are denominated in the home country currency.
The analogous budget constraint for the foreign household expressed in foreign currency is:

\[ P_t^* C_t^* + B_{t+1}^* + \frac{B_{t+1}^*}{S_t} = W_t^* H_t^* + \Xi_t^* + (1 + i_{t-1}^*) B_t^{f*} + (1 - \hat{\tau}_t^*) (1 + i_{t-1}) \frac{B_t^*}{S_t} \]

where \( \hat{\tau}_t^* = \tau_t^* + \bar{\tau} \frac{B_t^*}{S_t} \). Just as before, this tax has two components that reflect the two scenarios we consider when considering capital controls. In the gates scenario, \( \tau_t^* \) is a separate policy variable set by the home country central bank and is the tax on foreign household’s holdings of home currency denominated bonds (a tax on capital inflows). In the walls scenario, the constant \( \bar{\tau} \to \infty \), imposing international financial autarky.

The total proceeds from the capital control taxes \( \hat{\tau}_t \) and \( \hat{\tau}_t^* \) are redistributed to the domestic households in a lump-sum fashion via \( T_t \):

\[ T_t = \hat{\tau}_t (1 + i_{t-1}) S_t B_t^f + \hat{\tau}_t^* (1 + i_{t-1}) \frac{B_t^*}{S_t} \]

The first order condition of the household’s problem with respect to domestic bond holdings yields the familiar Fisher equation that links the nominal interest rate, \( i_t \), to the real interest rate, \( r_t \), and the expected inflation rate, \( E_t (\pi_{t+1}) \), where \( 1 + \pi_t = \frac{P_t}{P_{t-1}} \):

\[ i_t \approx r_t + E_t (\pi_{t+1}) \]

The real interest rate satisfies households’ Euler condition:

\[ 1 + r_t = \frac{\Lambda_t}{\beta E_t (e^{\lambda_{t+1} + \Lambda_{t+1}})} \]

where \( \Lambda_t \) is the equilibrium marginal utility of household consumption.

\(^4\) In many contexts it is customary to call this small tax \( \bar{\tau} \) an adjustment cost, as in De Paoli and Lipinska (2013). Heathcote and Perri (2016) treat this \( \bar{\tau} \) as a policy variable. Here we do not and keep the instrument \( \tau_t \) as the policy variable, \( \bar{\tau} \) is simply used to differentiate between versions of the model, either \( \bar{\tau} \) is a small positive number in the versions of the model with international bond trade or \( \bar{\tau} \to \infty \) in the version of the model with international financial autarky.
Household first-order conditions for home and foreign currency bond holdings give rise to the uncovered interest parity conditions:

\[
\frac{S_t}{S_{t+1}} = \frac{(1 + i_t^*) (1 - \tilde{\tau}_{t+1})}{1 + i_t (1 - \tilde{\tau}_{t+1}^*)}
\]

The first condition comes from the home country households’ first order condition with respect to holdings \(B_{t+1}^h\) of home currency denominated bonds and holdings \(B_{t+1}^f\) of foreign denominated bonds. The second comes from the foreign country households’ first order condition with respect to their holdings \(B_{t+1}^{f*}\) of foreign country currency denominated bonds and holdings \(B_{t+1}^{*h}\) of home country currency denominated bonds. The equilibrium conditions in the model ensure that the two tax rates \(\tau_t\) and \(\tau_t^*\) are closely linked (\(\tau_t \approx -\tau_t^*\)), so in the model with capital control gates, the central bank has one additional instrument.

The real exchange rate in the home economy is \(Q_t = S_t \frac{P_t}{P_t^*}\). An increase of \(Q_t\) implies a real depreciation of the home country.

### 2.2 Entrepreneurs

In each country there is a representative entrepreneur. Entrepreneurs supply labor to domestic firms. In addition, they own capital and rent this capital to firms. They finance this stock of capital partially with their own equity and partially by borrowing in their local currency.

The representative entrepreneur in the home country chooses their consumption, \(C_t^e\), labor effort, \(H_t^e\), investment, \(I_t\), capital stock, \(K_{t+1}\), and domestic currency bond holdings, \(b_{t+1}\), to maximize expected lifetime utility given by:

\[
E_0 \sum_{t=0}^{\infty} \beta^t \left[ \ln (C_t^e) - \psi \left( H_t^e \right)^{1+\frac{1}{\sigma_u}} \right]
\] (2)
subject to his budget constraint:

\[ P_t C_t^e + P_t I_t + b_{t+1} = W_t H_t^e + R_t K_t + (1 + \delta_t) b_t \]

\( K_t \) is his stock of home country capital, \( R_t \) is the rental rate on capital in the home country, and \( b_t \) is his asset position on one-period bonds denominated in local currency.\(^5\)

Capital accumulation is subject to a constant depreciation rate \( \delta \) and investment adjustment costs captured by the function \( F (I_t, I_{t-1}) \). The stock of capital evolves according to the following capital accumulation equation:

\[ K_{t+1} = (1 - \delta) K_t + F (I_t, I_{t-1}) I_t \]

where we assume that \( F (I_t, I_{t-1}) = 1 - \frac{\kappa}{2} \left( \frac{I_t}{I_{t-1}} - 1 \right)^2 \), with \( \kappa > 0 \), as in Christiano, Eichenbaum, and Evans (2005). A similar law of motion applies to the capital stock in the foreign county, \( K_t^* \).

A direct implication of this investment adjustment cost is that there is not a one-to-one transformation from consumption/investment goods and existing capital. This ensures that the current price of existing capital relative to the price of the consumption/investment good is a function of past, present and future investment decisions and the investment adjustment friction parameter, \( \kappa \). In a competitive market where existing capital can be traded among

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\(^5\) Bonds issued in the home currency can be held by three agents: home country households, home country entrepreneurs, and foreign households. The market clearing condition for the market for these bonds is:

\[ n B_t + n b_t + (1 - n) B_t^f = 0. \]

The analogous market clearing condition for bonds denominated in the foreign currency is:

\[ (1 - n) B_t^* + (1 - n) b_t^* + n B_t^f = 0. \]

The restriction that home entrepreneurs cannot hold foreign currency denominated bonds in the model is not accidental. Since all assets on an entrepreneurs balance sheet are denominated in the home currency, this restriction prevents exchange rate fluctuations from having a distortionary balance-sheet effects on entrepreneurs, as in Cespedes, Chang, and Velasco (2004). This would give the central bank even more incentive to sacrifice monetary independence in favor of capital flows and exchange rate stability. Allowing entrepreneurs to borrow in the foreign currency would only strengthen the results of this paper.
entrepreneurs, the equilibrium relative price of existing capital, $P_t^K$, is given by:

$$ 1 = \left(1 - \kappa \left(\frac{I_t}{I_{t-1}} - 1\right) \right) P_t^K + \kappa E_t \left(\frac{I_{t+1}}{I_t} - 1\right) \left(\frac{I_{t+1}}{I_t}\right)^2 \frac{E_t \left[P_{t+1}^K\right]}{1 + \iota_t} \tag{3} $$

As in Liu, Wang, and Zha (2013), due to limited enforcement considerations, entrepreneurs face a collateral constraint, through which they cannot borrow more than a fraction $\theta$ of the expected market value of their capital stock next period:

$$ -b_{t+1} \leq \theta E_t \left[P_{t+1}^K\right] K_{t+1} \tag{4} $$

In equilibrium this credit friction would typically limit the entrepreneur’s ability to raise funds and hence would be affecting his investment, consumption and labor decisions.

2.3 Firms

2.3.1 Final Goods Producers

In each county, a final goods sector produces output in a perfectly competitive market. Each of the final good firms combines domestic and foreign intermediate goods in a CES Armington aggregator:

$$ y_t = \left( (\omega)^\frac{1}{\rho} \left[ y_{t}^d \right]^{\frac{\rho-1}{\rho}} + (\omega^f)^\frac{1}{\rho} \left[ y_{t}^m \right]^{\frac{\rho-1}{\rho}} \right)^{\frac{\rho}{\rho-1}} \tag{5} $$

where the parameter $\rho$ is the Armington elasticity between the composites $y_{t}^d$ and $y_{t}^m$, and $\omega$ is the Armington weight of the former reflecting the degree of home bias in the local production. The composites $y_{t}^d$ and $y_{t}^m$ result from combining a continuum of domestic and foreign differentiated intermediate goods, respectively, through a Dixit-Stiglitz aggregator:

$$ y_{t}^d = \left( \int_0^{\iota} y_{t}^d (i) \frac{\sigma-1}{\sigma} \text{d}i \right)^{\frac{\sigma}{\sigma-1}} \quad y_{t}^m = \left( \int_{\iota}^1 y_{t}^m (i) \frac{\sigma-1}{\sigma} \text{d}i \right)^{\frac{\sigma}{\sigma-1}} $$
where $\sigma > 1$ is the elasticity of substitution across varieties within the same country.

Final output is used in the home country for consumption of households and entrepreneurs and investment,

$$y_t = C_t + C_t^e + I_t$$

From the aggregator function in (5), and its foreign counterpart (not listed), the demand for the output from domestic differentiated input $i \in [0 \ n]$ in both the home and foreign markets is given by:

$$y^d_t(i) = \eta \omega \left( \frac{P_t(i)}{P^d_t} \right)^{-\sigma} \left( \frac{P^d_t}{P_t} \right)^{-\rho} y_t$$

$$y^{m*}_t(i) = \eta^* \omega^* \left( \frac{S_t P_t(i)}{P^{m*}_t} \right)^{-\sigma} \left( \frac{P^{m*}_t}{P^*_t} \right)^{-\rho} y^*_t$$

with $\eta \equiv (n)^{\frac{1}{\sigma} - 1}$, $\eta^* \equiv (1 - n)^{\frac{1}{\sigma} - 1}$, and where $P_t(i)$ is the price set by local firm $i \in [0 \ n]$. The Law of One Price holds for each variety $i$, so if the variety has a price $P_t(i)$ in the home market, then its price in the foreign market is $S_t P_t(i)$. The price indices $P^d_t$ and $P^{m*}_t$ pertain the price levels of the composites of domestic and foreign intermediate goods, while $P_t$ is the general price level in the home economy, all expressed in terms of local currency units.

In equilibrium, these various price indices are given by:

$$P^d_t = \left( \frac{1}{n} \int_0^n (P_t(i))^{1-\sigma} \, di \right)^{\frac{1}{1-\sigma}}$$

$$P^{m*}_t = \left( \frac{1}{1-n} \int_1^n \frac{P^*_t(i)}{S_t} \right)^{1-\sigma} \left( \frac{P^*_t}{P^*_t} \right)^{\frac{1}{1-\sigma}}$$

$$P_t = \left[ \omega \left( n \right)^{\frac{1}{1-\rho}} (P^d_t)^{1-\rho} + \omega^f \left( 1 - n \right)^{\frac{1}{1-\rho}} (P^{m*}_t)^{1-\rho} \right]^{\frac{1}{1-\rho}}$$
2.3.2 Intermediate Goods Producers

In the intermediate good sector, varieties \( i \in [0, n] \) are produced in the home country and traded both in the home and foreign markets in quantities \( y^d_t(i) \) and \( y^{m*}_t(i) \), respectively. Similarly, the foreign economy supplies varieties \( i \in [n, 1] \). Intermediate good producer \( i \) in the home economy operates a production function:

\[
y^d_t(i) + y^{m*}_t(i) = h_t(i)^{1-\alpha} k_t(i)^{\alpha} - \phi
\]  

(7)

where the parameter \( \alpha \in (0, 1) \) is capital’s share of income, common across all varieties, \( h_t(i) \) and \( k_t(i) \) are the labor and capital employed by the intermediate good firm in period \( t \), and \( \phi > 0 \) is a fixed cost of production.

From its cost minimization problem, the demand from intermediate good firm \( i \) for labor and capital are given by:

\[
h_t(i) = (1 - \alpha) \frac{MC_t}{W_t} (y^d_t(i) + y^{m*}_t(i) + \phi)
\]

(8)

\[
k_t(i) = \alpha \frac{MC_t}{R_t} (y^d_t(i) + y^{m*}_t(i) + \phi)
\]

where \( MC_t = \left( \frac{W_t}{1-\alpha} \right)^{1-\alpha} \left( \frac{R_t}{\alpha} \right)^{\alpha} \) denotes the marginal cost of production. Due to sticky output prices, the firm may earn a non-zero profit in some periods. Profits, given by \( \Xi_t(i) = P^*_t(i) (y^d_t(i) + y^{m*}_t(i)) - W_t h_t(i) - R_t k_t(i) \) are returned lump-sum to the households.

Market clearing in the labor and capital markets requires that the total demand for labor by firms is equal to the supply of labor from households and entrepreneurs:

\[
\int_0^n h_t(i) \, di = H_t + H^e_t
\]

and the quantity of physical capital employed by firms in period \( t \) is equal to the economy’s
stock of physical capital at the beginning of the period:

\[ \int_0^n k_t(i) \, di = K_t \]

**Price setting.** Firms in the intermediate good sector set prices according to a Calvo style price setting framework. In period \( t \), each firm will be able to change its price in the domestic market with probability \( 1 - \xi_p \).

Thus if allowed to change their price in period \( t \), the firm will set a price to maximize:

\[
\max E_t \sum_{\tau=0}^{\infty} \beta^\tau (\xi_p)^\tau \Lambda_{t+\tau} \left\{ P_t(i) \left( y^d_t(i) + y^m_t(i) \right) - MC_{t+\tau} \left( y^d_t(i) + y^m_t(i) \right) \right\}
\]

where \( \Lambda_t \) is the marginal utility of household consumption in period \( t \). The firm that is able to change its price in period \( t \) will set its price to:

\[
P_t(i) = \frac{\sigma}{\sigma - 1} \frac{E_t \sum_{\tau=0}^{\infty} \beta^\tau (\xi_p)^\tau \Lambda_{t+\tau} \left( \omega \left( \frac{1}{P_{t+\tau}} \right)^{-\sigma} \left( \frac{P^{m*}_{t+\tau}}{P_t} \right)^{-\rho} y_{t+\tau} + \omega f_s \left( \frac{S_{t+\tau}}{P^{m*}_{t+\tau}} \right)^{-\sigma} \left( \frac{P^{m*}_{t+\tau}}{P_t} \right)^{-\rho} y^s_{t+\tau} \right)}{E_t \sum_{\tau=0}^{\infty} \beta^\tau (\xi_p)^\tau \Lambda_{t+\tau} \left( \omega \left( \frac{1}{P_{t+\tau}} \right)^{-\sigma} \left( \frac{P^{d*}_{t+\tau}}{P_t} \right)^{-\rho} y_{t+\tau} + \omega f_s \left( \frac{S_{t+\tau}}{P^{m*}_{t+\tau}} \right)^{-\sigma} \left( \frac{P^{m*}_{t+\tau}}{P_t} \right)^{-\rho} y^s_{t+\tau} \right)}
\]

If prices are flexible, i.e. \( \xi_p = 0 \), then this expression collapses to:

\[
P_t(i) = \frac{\sigma}{\sigma - 1} MC_t
\]

which implies that the firm will change a constant mark-up over its marginal cost.

Write the price set by the firm that can reset prices in period \( t \) as \( \tilde{P}_t(i) \) to denote that it is an optimal price. Firms that can reset prices in period \( t \) will all reset to the same level, so \( \tilde{P}_t(i) = \tilde{P}_t \). Substitute this optimal price into the price index \( P^d_t = \left( \frac{1}{n} \int_0^n (P_t(i))^{1-\sigma} \, di \right)^{\frac{1}{1-\sigma}} \). Since a firm has a probability of \( 1 - \xi_p \) of being able to change their price, then by the law of large numbers in any period \( 1 - \xi_p \) percent of firms will reoptimize prices, and the prices of \( \xi_p \) percent of firms will be automatically reset using the previous period's inflation rate.
Thus the price index for domestic traded goods, $P^d_t$, can be written as:

$$P^d_t = \left( \xi_p \left( \pi_{t-1} P^d_{t-1} \right)^{1-\sigma} + (1 - \xi_p) \left( \bar{P}_t \right)^{1-\sigma} \right)^{\frac{1}{1-\sigma}}$$

### 2.4 Monetary and Capital Policy

Price frictions and credit frictions lead to distortions between the decentralized market allocation and the efficient allocation under no frictions. Monetary policy and (potentially) capital controls policy can be used to minimize the effect of these distortions. In terms of conventional monetary policy, here we consider two specifications. In the first we assume that the central bank sets monetary policy in order to maintain a fixed nominal exchange rate. In this case the monetary policy rule is simply a rule specifying that the nominal exchange rate is held constant. In the second specification, monetary policy is chosen as the solution to a Ramsey problem to minimize the effect of the distortions caused by price and credit frictions.\(^6\)

Recall that the tax on the gross proceeds from domestic households holding foreign currency denominated bonds is $\hat{\tau}_t = \tau_t + \bar{\tau} S_t B_t^f$, and the tax on the gross proceeds from foreign households holding domestic currency denominated bonds is $\hat{\tau}_t^* = \tau_t^* + \bar{\tau} \frac{B_t}{S_t}$.

We consider three scenarios relating to capital account openness. In the first scenario we assume an open capital account, and thus $\tau$ and $\tau^f$ are set equal to zero, and the constant $\bar{\tau}$ is simply a small positive number calibrated to match the volatility of net exports in the data.

In the second scenario, as in Farhi and Werning (2012), the tax rates, $\tau_t$ and $\tau_t^*$, can be used as an instrument by the policy maker. They have a steady state value of zero and function as temporary episodic capital controls. These temporary, episodic, capital controls

---

\(^6\)A strand of the capital controls literature also studies the case where a country can impose capital controls to manipulate relative prices in a way that is beneficial to it but detrimental to its trading partners. We abstract from that, in this model, the objective of monetary policy is to minimize the effect of the distortions caused by price and credit frictions.
are chosen by the policy maker to minimize the effect of distortions caused by price and credit frictions, thus in the case where the policy maker sets capital controls and has a floating currency, the policy maker sets policy using two instruments (the capital tax variable $\tau_t$ and the conventional monetary policy instrument, the nominal risk-free rate). These type of capital controls would be referred to as "gates" in Klein (2012) and represent the theoretically optimal role for capital controls.

In the third scenario, we assume a closed capital account. As in the limiting case of Heathcote and Perri (2016), the second component of the tax on foreign bond holdings, $\bar{\tau} \to \infty$. This makes international borrowing and lending prohibitively expensive and in equilibrium, $B^f_t \approx 0$ and $B^h_t \approx 0$. These type of capital controls would be referred to as "walls" in Klein (2012).

For simplicity, we assume that the foreign central bank simply follows a policy of price stability.

3 Calibration and Solution

The model’s parameters and their values are reported in table 1. The first seven parameters in the table, the discount factor, capital’s share of value added, the capital depreciation rate, the investment adjustment cost parameter, the probability that a firm cannot change prices in a given period, and the elasticities of substitution between goods from different firms, and between home and foreign traded goods, are all set to values commonly used in the literature. The tax rate $\bar{\tau}$ affects the volatility of net exports. In the versions of the model without capital control walls, it is set such that in the benchmark version of the model, the ratio of net exports to GDP is about two-thirds as volatile as GDP, as reported in Engel and Wang (2011). In the version of the model with capital control walls, $\bar{\tau} \to \infty$, imposing financial autarky. The relative country size parameter, $n$, is set very small to ensure that the home economy is a small open economy and does not have a significant effect on events
in the rest of the world. The weights on domestic and foreign goods in the traded goods aggregator function, $\omega$ and $\omega^f$, are set such that the steady state import share of the home country is equal to 50%.$^7$ Since the home country is a small open economy, the equivalent parameters for the rest of the world are $\omega^* \approx 1$ and $\omega^{f*} \approx 0$.

The steady state value of the discount factor shock, $\bar{\lambda}$, implies that the first-order excess return is about 3.6% per year.$^8$

The parameter $\theta$ measures the entrepreneur’s steady state loan to value ratio. We use a value of 0.75, which is the value used by Liu, Wang, and Zha (2013). In a model with collateral constraints for multiple types of agents, Iacoviello (2005) estimates this parameter and shows that it lies between 0.55 (for households) and 0.89 (for firms).

### 3.1 Shock process and solution procedure

The model is solved with a first-order approximation around the steady state where the collateral constraint (4) is binding, as in Iacoviello (2005), Jermann and Quadrini (2012), and Liu, Wang, and Zha (2013).

We will just consider the effect of shocks originating in the rest of the world on the small open home economy. We will consider the optimal policy response to a foreign shock that would lead to a surge in capital flows into or out of the small open economy: a shock to the foreign real interest rate.

This shock to the foreign real interest rate is simply engineered by a stochastic shock to the foreign household’s discount factor, $\beta e^{\lambda_{t+1}}$. A negative shock to $\lambda_{t+1}$ would make

$^7$From the demand functions for domestic and imported traded goods in (6), the steady state import share is: $m = \frac{\int_0^1 P_m(i)y_m^m(i) di}{\int_0^n P^r(i)y_r^r(i) + \int_0^1 P_m(i)y_m^m(i) di} = \frac{\omega^f(1-n)^{1-\beta}/\beta + \omega^f(1-n)^{1-\beta}}{\omega^f(1-\beta) + \omega^f(1-n)^{1-\beta}}$

$^8$The steady state risk-free interest rate, $r_t = \frac{1}{\beta(1+\bar{\lambda})} - 1$, which reflects the household’s discount rate, $\beta (1+\bar{\lambda})$. The steady state return on investment, $R_t - \delta = \frac{1}{\beta} - 1$, reflects the entrepreneur’s discount rate $\beta$. The per annum steady state first-order excess return is then given by $(1 + R_t - \delta - r_t)^4 - 1 \approx 4\beta\bar{\lambda}$

$^9$This discount rate shock has been featured in Eggertsson and Woodford (2003) and Christiano, Eichenbaum, and Rebelo (2011) among others.
foreign household’s less patient, they would save less, and the foreign real interest rate would increase. Of course, the foreign real interest rate is exogenous from the perspective of the small open economy, so for the first shock driving the model, assume that the foreign real interest rate increases by 1% and that this shock has a half-life of one quarter.

\[ r_t^s = 0.5r_{t-1}^s + \varepsilon_t^s \]

and \( \varepsilon_1^s = 1 \) and \( \varepsilon_t^s = 0 \) for \( t > 1 \).

Since the model is solved with a first-order approximation, for the most part the variance of the shocks are immaterial for both simulations and the calculation of optimal policy. The one caveat is that this model is solved with a first-order approximation in the neighborhood of the steady state where the collateral constraint is binding. If a shock that loosens this constraint is "too big" it could result in an equilibrium where the constraint does not bind, and thus our approximation around the binding constraint is inaccurate. The need for the collateral constraint to always bind provides an upper bound on the size of the shocks. In the impulse response diagrams in the next section we will plot the response of the multiplier on the collateral constraint and show that it remains positive under every shock.

4 Optimal Monetary and Capital Policy

In discussing optimal capital controls policy, we will present the results in two steps. First, we will consider optimal capital controls policy in a model with flexible prices. We then consider capital controls policy in a sticky price model, and thus in a model where there is already a role for conventional monetary policy. With that we can examine how the use of capital controls affects the conduct of conventional monetary policy.
4.1 Flexible Prices

The responses of home domestic demand, investment, credit constraints (measured by the multiplier on the borrowing constraint), nominal interest rate, real exchange rate, current account, and asset prices following a shock to the foreign real interest rate are presented in figure 1. The figure presents the responses from the frictionless model (turquoise), the model with credit frictions and an open capital account (blue), the model with credit frictions and a closed capital account (green), and the model with credit frictions and optimally chosen capital controls (red).

The positive shock to the foreign real interest rate acts like a negative shock to net capital inflows into the small open economy, and the figure shows that in the frictionless, efficient equilibrium, there is an increase in the current account in the small open economy. This leads to a slight decrease in asset prices, investment, and domestic demand, and a depreciation in the real exchange rate in the efficient equilibrium. But when credit frictions are included in the model, these same responses are amplified. This fall in the price of capital following the decrease in net capital inflows leads to a tightening of the borrowing constraint. These credit frictions lead to a further decline in investment and domestic demand, which leads to an even further fall in capital inflows and further fall in asset prices.

Thus when the capital account is open, this feedback loop caused by falling asset prices and a tightening credit constraint amplify domestic responses to the shock to net capital inflows. If instead the capital account is closed, this feedback loop never gets started in the first place. There is a slight fall in domestic demand and investment through normal trade channels, but with a closed capital account, this increase in the foreign real interest rate is not a negative shock to net capital inflows. This arrests the destabilizing fall in asset prices and credit tightening.

As the impulse responses show, under a closed capital account, there is almost no response of home variables to the foreign interest rate shock. However, as is shown in the blue line representing the frictionless equilibrium, some decrease in net capital inflows and some fall in
domestic demand and investment in the small open economy is the efficient response to this foreign real shock. As shown in the red impulse response, when capital controls are chosen optimally, there is some increase in the home current account, although much less than in the model with credit frictions and an open capital account. Thus there is some decrease in asset prices and credit tightening and fall in domestic demand, but much less than under the open capital account. In addition, by allowing some decrease in net capital inflows into the home country, the model with optimal capital controls delivers responses that are much closer to the efficient equilibrium than simply closing the capital account.

### 4.2 Sticky Prices

In the version of the model with sticky prices, there is role for conventional monetary policy. We will first consider the specification where conventional monetary policy is dedicated to maintaining a constant nominal exchange rate. We will then consider the version of the model where instead the nominal exchange rate is allowed to float and conventional monetary policy is chosen optimally.

#### 4.2.1 Fixed Exchange Rate

The responses of these same variables to the same positive shock to the foreign real interest rate in the version of the model with sticky prices and conventional monetary policy dedicated to nominal exchange rate stability are presented in figures 2 and 3. Here again the blue line represents an open capital account, the green line represents a closed capital account, the red line represents optimally chosen capital controls. Figure 2 presents the results from the model without credit frictions (and thus the only source of distortion arises from sticky prices) and figure 3 presents the results from the version of the model with credit frictions (and thus both sticky prices and credit frictions are a source of distortions).

As can be seen in the UIP condition, in order to maintain a constant nominal exchange rate, the central bank in the small open economy with an open capital account is forced to
match all changes in the foreign nominal interest rate. So in response to the increase in the foreign interest rate, the central bank of the small open economy is forced to tighten monetary policy and cause an increase in the domestic nominal interest rate. The small open economy was already facing a fall in domestic demand and investment as a result of the negative shock to net capital inflows, and the domestic monetary tightening simply adds to this decline. A comparison of the impulse responses in figure 2 with those from the frictionless model in figure 1 shows that this monetary tightening leads to a fall in investment that is about twice the size it would have been in the frictionless equilibrium. Imposing capital controls, either gates or walls, allows the central bank to keep the currency stable without the need to match the increase in the foreign nominal interest rate one-for-one and thus there is not the same degree of monetary tightening.

Figure 3 presents the same impulse responses to the same shock, but in the model with credit frictions. It shows that the combination of a perfectly open capital account, monetary policy dedicated to exchange rate stability, and credit frictions in the form of borrowing constraints leads to a vicious spiral of capital outflows and tightening borrowing constraints that results in an extreme outcome. In this case the combination of the negative shock to capital inflows and the domestic monetary tightening leads to a sharp fall in asset prices and thus a sharp tightening of credit conditions, resulting in an extreme fall in both investment and domestic demand.

When the capital account is either completely closed or simply restricted in some way, the central bank is no longer forced through the trilemma to match the increases in the foreign interest rate. Figure 3 shows that in the model with credit frictions, the central bank raises the tax on capital outflows $\tau_t$ in response to the increase in the foreign interest rate in order to keep the nominal exchange rate stable without the need to raise the domestic interest rate. Since the small open economy is that is hit by a negative shock to capital flows is not forced to tighten monetary conditions, there is not the same vicious spiral of capital outflows and tightening borrowing constraints that led to the extreme outcome in the model.
with the perfectly open capital account.

4.2.2 Floating Exchange Rate

The responses of these same variables to the same positive shock to the foreign real interest rate in the version of the model with sticky prices and conventional monetary policy that is chosen optimally are presented in figures 4 and 5. Here again the blue line represents an open capital account, the green line represents a closed capital account, the red line represents optimally chosen capital controls. Figure 4 presents the results from the model without credit frictions and figure 5 presents the results from the model with credit frictions.

Freed from the requirement to maintain a stable nominal exchange rate, monetary policy is chosen optimally. In terms of the trilemma, allowing the exchange rate to float has restored monetary policy autonomy in the small open economy. In the version of the model without credit frictions, the central bank raises the nominal interest rate following the foreign shock. In this model without credit frictions there are not large real distortions caused by a binding borrowing constraint and the central bank’s optimal policy is inflation stabilization. Giving the central bank the option to set episodic capital controls barely affects their optimal policy and while capital taxes are an available instrument, they are barely used since monetary policy can nearly achieve the efficient allocation alone. This of course arises from the ”divine coincidence” result in the New Keynesian model where price frictions are the only source of distortion (Blanchard and Galí 2007).

When there are credit frictions in the model, this now gives rise to an additional source of distortion and thus the central bank with the open capital account is faced with a trade-

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10The ”divine coincidence” result does not hold perfectly because these sticky prices actually give rise to two sources of distortion. The main distortion is of course the usual price distortion in production and depends on the inflation rate of domestically produced goods. The second, and much smaller source of distortion is the fact that bond contracts are nominal, so unexpected inflation leads to a reallocation due to the Fisher effect, and this small distortion depends on the CPI inflation rate. By stabilizing the prices of home produced goods the central bank can eliminate the first distortion, but exchange rate fluctuations will still lead to a change in the CPI, and thus the Fisher distortion is still present. Giving the central bank two instruments will lead to a small improvement over the case where they just have one instrument, but since the size of the distortion due to the nominal bond contracts is small, the effect is quantitatively insignificant.
The fall in net capital inflows tightens the borrowing constraint. The central bank is divided between raising interest rates to stabilize capital flows, and lowering interest rates to spur real activity and loosen the borrowing constraint. Figure 5 shows that the central bank with an open capital account will raise the nominal interest rate, although not to the same extent that they did when there were no credit frictions in the model. Even though the central bank is free to pursue any monetary policy they choose, the central bank in the small open economy will still raise interest rates, although not to the same extent that they did in order to maintain a fixed exchange rate, in order to prevent capital outflows, attract capital inflows, and prevent a further fall in asset prices and a further tightening of credit conditions.

Giving the central bank a second instrument allows it to stabilize capital flows with an increase in the tax on capital outflows and at the same time cut its interest rate in order to loosen the borrowing constraint. When the capital account is restricted, the central bank is no longer driven to raise the domestic interest rate in order to prevent a sudden decline in net capital inflows, and the result is that there is much less of a fall in real activity and asset prices, and there is much less tightening of the borrowing constraint.

4.2.3 Trilemma regressions from simulations of the model

As shown in Shambaugh (2004), Obstfeld, Shambaugh, and Taylor (2005), and Klein and Shambaugh (2015), a way to measure monetary policy autonomy in the data is to regress the interest rate in one country on a base country interest rate. These papers find that the coefficient in this regression is much higher in countries with a pegged currency than in those with a floating currency, and the coefficient is higher for a country with an open capital account than in a country with a closed capital account.

Here we can replicate these trilemma regressions using data generated from simulations of the model under the various specifications relating to the stance of monetary policy (fixed exchange rate or optimal floating rate) and capital account openness. We simply regress
year-over-year changes in the home nominal interest rate on year-over-year changes in the foreign nominal interest rate. This coefficient from each of the various monetary and capital account policy specifications in the model is presented in table 2.

In the model with a fixed exchange rate and an open capital account the coefficient is 1, exactly as would be expected from the UIP condition. The first column of the table also shows that when capital controls are introduced, either outright closing of the capital account or optimal, episodic capital controls, the coefficient is close to zero. This is an obvious implication of the trilemma; by using capital controls the central bank with a fixed exchange rate regains complete monetary autonomy.

What is interesting is the behavior of this coefficient under a floating exchange rate, and thus optimal monetary policy. Freed from the constraint of maintaining a fixed nominal exchange rate, the coefficient is of course less under the floating exchange rate, but when the capital account is open, it is still positive. Thus when the capital account is open, given the potential for destabilizing shifts in capital flows, the central bank will still find it optimal to track the foreign real interest rate, to a limited extent. As we saw in the previous set of impulse response diagrams, the increase in the foreign interest rate leads to a shift in capital flows away from the home economy, and this leads to falling asset prices, credit contraction, and a fall in investment and domestic demand. To curtail, or at least mitigate, this destabilizing shift in capital flows, the central bank in a country with an open capital account will find it optimal to raise the interest rate. The second column of the table shows that capital account restrictions reduce this need to use the interest rate to manage this shift in capital flows. When the capital account is closed, this coefficient falls to close to 0. When capital controls are episodic and chosen optimally, this coefficient falls to $-0.21$, implying that the central bank will now find it optimal to sharply cut the domestic real interest rate following the shock to the foreign rate.
5 Empirical evidence of capital controls and monetary policy autonomy

As discussed earlier Shambaugh (2004), Obstfeld, Shambaugh, and Taylor (2005), and Klein and Shambaugh (2015), show that a way to measure monetary policy autonomy in the data is to regress the interest rate in one country on a base country interest rate. These papers run the following regressions:

\[ \Delta R_{it} = \alpha + \beta \Delta R_{bit} + \varepsilon_{it} \]

where \( \Delta R_{it} \) is the change in the nominal policy rate in country \( i \) from year \( t - 1 \) to year \( t \) and \( \Delta R_{bit} \) is the change in the nominal policy rate in the base country. In this regression \( \beta \) represents the responsiveness of country \( i \)'s policy rate to a change in the base country policy rate. If \( \beta = 1 \) the country has no monetary policy autonomy and must simply match the changes in the base country interest rate, if \( \beta = 0 \) the country has full monetary policy autonomy and can act independently of the base country. The base country will vary across \( i \). For most countries, the base country currency is the U.S. dollar, for some it may the the euro, the yen, or the pound.

Klein and Shambaugh consider an unbalanced panel of 134 countries and 39 years, 1973-2011. There are a total of 3126 observations in the unbalanced panel. These 3126 observations can be divided into 3 subgroups, based on whether the country-year observation has a floating currency, a soft peg, or an exchange rate peg. A pegged exchange rate is one where over the course of the year, the exchange rate never varies out of a band ±2% with the reference currency. A soft peg is one where it does vary outside of the ±2% band but stays within a ±5% band, and a float is everything else.

Klein and Shambaugh estimate this equation separately for each subgroup, for brevity we will instead estimate the following:
\[
\Delta R_{it} = \alpha + \beta_{\text{peg}} I_{it}^{\text{peg}} \Delta R_{bit} + \beta_{\text{soft}} I_{it}^{\text{soft}} \Delta R_{bit} + \beta_{\text{fl}} I_{it}^{\text{fl}} \Delta R_{bit} + \varepsilon_{it}
\]

where \( I_{it}^{\text{peg}} \), \( I_{it}^{\text{soft}} \), and \( I_{it}^{\text{fl}} \) are indicator variables that take a value of 1 if the country-year observation falls into the pegged, soft peg, or floating category, and 0 else. The results from this estimation are presented in the first column of table 3.

The results in the first column of table 3 confirm the findings in Klein and Shambaugh and the earlier results in our theoretical model. The estimated coefficient, whether in this empirical regression or using simulated data from the theoretical model, is always higher for a country with a pegged currency than for a country with a floating currency. A country with a pegged currency has less monetary policy autonomy than a country with a floating currency.

But to this regression we then go one step further and consider how this regression is affected by the openness of the capital account. Klein and Shambaugh also do this and split the sample into 3 more subgroups based on the value of the Chinn and Ito (2008) capital account openness index. They then estimate the \( \beta \) coefficient in each of the 9 subgroups (3 for currency flexibility and 3 for capital account openness) and conclude that the estimated \( \beta \) coefficient is higher in countries with a more open capital account. For brevity we won’t repeat that here and instead will estimate the following:

\[
\Delta R_{it} = \alpha + \beta_{\text{peg}} I_{it}^{\text{peg}} \Delta R_{bit} + \beta_{\text{soft}} I_{it}^{\text{soft}} \Delta R_{bit} + \beta_{\text{fl}} I_{it}^{\text{fl}} \Delta R_{bit} + \\
\gamma_{\text{peg}} K_{it} I_{it}^{\text{peg}} \Delta R_{bit} + \gamma_{\text{soft}} K_{it} I_{it}^{\text{soft}} \Delta R_{bit} + \gamma_{\text{fl}} K_{it} I_{it}^{\text{fl}} \Delta R_{bit} + \varepsilon_{it}
\]

where \( K_{it} \) is the value of the Chinn-Ito capital account openness index in country \( i \) in year \( t \) (normalized on a 0-1 scale, where 0 represents a completely closed capital account and 1 represents a completely open capital account). For a country with a closed capital account, the coefficients describing monetary policy autonomy are given by \( \beta_{\text{peg}}, \beta_{\text{soft}}, \) and \( \beta_{\text{fl}} \). For a
country with an open capital account they are given by $\beta_{\text{peg}} + \gamma_{\text{peg}}, \beta_{\text{soft}} + \gamma_{\text{soft}}$, and $\beta_{\text{fl}} + \gamma_{\text{fl}}$. Thus if $\gamma_{\text{peg}}, \gamma_{\text{soft}}$, or $\gamma_{\text{fl}}$ were significantly different from zero then one would conclude that capital controls have an effect on monetary policy autonomy for a country with a peg, soft peg, or floating exchange rate.

These results are presented in the second column of table 3. The table shows that the estimated $\gamma$ coefficients are significant for each of the 3 currency subgroups. The estimated $\gamma$ coefficient is highest for a country with a pegged currency, implying that the gains to monetary policy autonomy from capital account restrictions are highest for countries with a pegged exchange rate, but $\gamma_{\text{fl}}$ is significant and positive as well, implying that there are gains from monetary policy autonomy even in countries with a floating exchange rate. Furthermore, the bottom section of table 3 calculates the estimated autonomy parameter for a country with an open capital account (so $\beta + \gamma$) and it is significantly different from zero in all three currency subgroups. It is of course highest for countries with a pegged exchange rate, but it is significantly positive even for countries with a floating exchange rate, implying that these countries do not enjoy complete monetary autonomy.

Furthermore, it is interesting to compare the estimated monetary policy autonomy parameters in 3 with those calculated from simulations of the theoretical model in 2. In the data, the estimated coefficient for a country with a pegged exchange rate and an open capital account is 0.77 and for a country with a closed capital account it is 0.24. In the model these coefficients are 1 for a country with a perfectly open capital account and close to 0 for a country with a perfectly closed capital account. The estimated coefficient for a country with a floating currency and an open capital account is 0.16 in the data and 0.25 in simulations of the model. For a country with a floating currency and a closed capital account these coefficients are -0.11 in the data and 0.02 in the model. Both the model and the data, the estimated reduction in this parameter (and thus improvement in central bank autonomy) from closing the capital account is about 0.25 in a country with a floating currency.
6 Conclusion

Traditionally, capital controls have been thought of as one leg of the Mundell-Fleming "trilemma of international finance". Capital controls were necessary for macroeconomic stabilization since they provided a degree of monetary independence for a country with a fixed exchange rate, but if the exchange rate was allowed to float, capital controls were unnecessary because monetary policy could be chosen optimally. However, dramatic shifts in capital flows into and out of many emerging market economies over the past few years have led to an interesting dilemma for many emerging market policy makers. A sharp decline in capital outflows will lead to falling asset prices and tightening credit conditions. The central bank could loosen policy in response to this decline in domestic economic conditions, but this loosening of policy would drive further net capital outflows. Alternatively the central bank could tighten policy in order to arrest the decline in net capital flows, but this would exacerbate the fall in domestic economic conditions.

We began this paper by citing the statement by Rey (2015) that "independent monetary policies are possible if and only if the capital account is managed." Obstfeld (2015) address this same issue and acknowledges that under certain conditions, a central bank with a floating exchange rate has complete monetary autonomy, but he discusses how financial globalization affects the trade-offs faced by monetary policy makers.

Various frictions lead to welfare reducing distortions, and a policy maker sets policy in order to minimize the effect of those distortions. In this paper there were two frictions, sticky prices and borrowing constraints. This led to multiple distortions then the policy maker was faced with a trade-off. This paper shows that for a small open economy faced with exogenous shocks to capital inflows and outflows, as monetary policy faces a trade-off between these two sources of distortions, monetary policy in the small open economy will end up at least partially trying to minimize the credit distortion by using the interest rate to manage the capital account. In practice, this will look like the central bank in the small open economy is tying their interest rate to that in the rest of the world, and thus sacrificing some monetary
policy autonomy in order to minimize credit distortions. Capital account restrictions change
the trade-off and thus free the central bank from the need to use the interest rate to manage
the capital account.
A Technical Appendix - Not for Publication

A.1 Equilibrium conditions of the model

In the model there are two countries, home and foreign. The home country is size $n$ and the foreign country is size $1 - n$. As $n \to 0$, the model becomes one with a small open economy and the rest of the world. Other than country size, the two countries are identical. Foreign country variables are written with an asterisk (*). For brevity only the equations for the home country will be listed here.

Each country is populated by representative households, entrepreneurs, and firms. Households supply labor to domestic firms and consume. They are net savers. Entrepreneurs borrow from domestic households to finance a capital stock, and they rent this capital to firms. Due to limited enforcement, entrepreneurs are subject to a collateral constraint and cannot borrow more than a given fraction of the value of their capital stock. Firms hire labor, rent capital, and produce an output. The output from domestic firms is combined with the output from foreign firms to produce a final good that is used for consumption and investment. Firms are engaged in monopolistic competition and set prices according to a Calvo (1983) style price setting framework. Monetary policy is set as the solution to a Ramsey problem to minimize the distortions created by price and credit frictions in the model. The conventional monetary policy instrument in this cash-less economy is the risk-free nominal rate of interest. The central bank in the small open economy also has the potential to impose temporary, episodic taxes or subsidies on capital inflows and outflows in order to deter or encourage capital flows.

A.1.1 Households

Households choose the combination of $C_t$, $H_t$, $B_{t+1}$, and $B_{t+1}^f \forall t$ to maximize:

$$
\max E_0 \sum_{t=0}^{\infty} \beta^t A_t \left[ \ln (C_t) - \psi (H_t)^{1+\sigma_H / \sigma_H} \right]
$$
subject to their budget constraint:

\[ P_tC_t + B_{t+1} + S_t B_t^f = W_tH_t + \Xi_t + T_t + (1 + i_t) B_t + (1 - \hat{\tau}_t) (1 + i_t^*) S_t B_t^f \]  

The multiplier on the budget constraint is \( \Lambda_t \) (the marginal utility of income). The household takes \( A_t, P_t, S_t, W_t, \Xi_t, T_t, i_t, \tau_t, \) and \( i_t^* \) as given.

The first order conditions of the household’s problem are given by:

\[ \frac{1}{C_t} = P_t \Lambda_t \]  
\[ \frac{1}{\sigma_H^{1/\psi}} \psi (H_t) \frac{1}{\sigma_H} = W_t \Lambda_t \]

\[ \Lambda_t A_t = \beta \Lambda_{t+1} A_{t+1} (1 + i_t) \]  
\[ \Lambda_t A_t S_t = \beta \Lambda_{t+1} A_{t+1} (1 - \hat{\tau}_{t+1}) (1 + i^*_{t+1}) S_{t+1} \]

### A.1.2 Entrepreneurs

Entrepreneurs choose the combination of \( C^e_t, H^e_t, b_{t+1}, I_t, K_{t+1} \) \( \forall t \) to maximize:

\[
\max E_0 \sum_{t=0}^{\infty} \beta^t \left[ \ln \left( C^e_t \right) - \psi \left( H^e_t \right)^{\frac{1+\sigma_H}{\sigma_H}} \right]
\]

subject to their budget constraint, the capital accumulation equation, and a borrowing constraint.
\[ P_tC_t^e + P_lI_t + b_{t+1} = W_tH_t^e + R_tK_t + (1 + i_t)b_t \]  

\[ K_{t+1} = (1 - \delta)K_t + F(I_t, I_{t-1})I_t \]  

\[-(1 + i_t)b_{t+1} \leq \theta_tE_tKP_{t+1}K_{t+1} \]

where \( F(I_t, I_{t-1}) = 1 - \frac{2}{2} \left( \frac{\mu}{\mu_{t-1}} - 1 \right)^2 \). The multipliers for the budget constraint, the capital accumulation equation, and the borrowing constraint are given by \( \Lambda_t^e, \upsilon_t, \) and \( \mu_t \), respectively.

The first order conditions of the entrepreneur’s problem are given by:

\[ \frac{1}{C_t^e} = P_t\Lambda_t^e \]  

\[ \frac{1 + \sigma_H}{\sigma_H} = W_t\Lambda_t^e \]

\[ \Lambda_t^e - (1 + i_t)\mu_t = \beta (1 + i_t)E_t[\Lambda_{t+1}^e] \]

\[ P_t\Lambda_t^e = F(I_t, I_{t-1})v_t + F_1(I_t, I_{t-1})I_tv_t + \beta E_t[F_2(I_{t+1}, I_t)I_{t+1}v_{t+1}] \]

\[ v_t - \theta_tE_tKP_{t+1}^K\mu_t = \beta E_t[R_{t+1}\Lambda_{t+1}^e + (1 - \delta)v_{t+1}] \]

To obtain equation (3), substitute \( P_t^K \) for \( \frac{w}{F_t\Lambda_t^e} \) in the FOC with respect to investment.

A.1.3 Firms

Firms set prices according to a Calvo style price setting framework. In period \( t \), the firm will be able to change its price in the domestic market with probability \( 1 - \xi_p \).

Every period the firm will choose the optimal combination of \( h_t(i) \) and \( k_t(i) \) to maximize: Thus if allowed to change their price in period \( t \), the firm will set a price to maximize:

\[ \max_{P_t^H} E_t \sum_{\tau=0}^{\infty} \beta^\tau (\xi_p)^\tau \Lambda_{t+\tau} \left\{ P_t(I_t) \left( y_t^d(i) + y_t^{ms}(i) \right) - W_{t+\tau}h_{t+\tau}(i) - R_{t+\tau}k_{t+\tau}(i) \right\} \]  

(13)
subject to the demand for its output in both the domestic and foreign markets, and a production technology:

\[ \begin{align*}
    y_t^d(i) &= \omega(n) \left( \frac{P_t(i)}{P_t^d} \right)^{\frac{1}{1-\rho}} \left( \frac{P_t}{P_t^d} \right)^{-\rho} y_t, \\
    y_t^{ms}(i) &= \omega^f(n) \left( \frac{S_t P_t(i)}{P_t^{ms}} \right)^{\frac{1}{1-\rho}} \left( \frac{P_t}{P_t^{ms}} \right)^{-\rho} y_t^s, \\
    y_t^d(i) + y_t^{ms}(i) &= h_t(i)^{1-\alpha} k_t(i)^\alpha - \phi
\end{align*} \]  

The first-order conditions of the firm’s problem with respect to capital and labor inputs are given by:

\[ \begin{align*}
    h_t(i) &= (1 - \alpha) \frac{MC_t}{W_t} \left( y_t^d(i) + y_t^{ms}(i) + \phi \right) \\
    k_t(i) &= \alpha \frac{MC_t}{R_t} \left( y_t^d(i) + y_t^{ms}(i) + \phi \right)
\end{align*} \]

where \( MC_t = \left( \frac{W_t}{1-\alpha} \right)^{1-\alpha} \left( \frac{R_t}{\alpha} \right)^\alpha. \)

If they are allowed to change their price in period \( t \) then the firm will also choose the optimal \( P_t(i) \) to maximize profit:

\[ \begin{align*}
    P_t(i) &= \frac{1}{\sigma - 1} \frac{E_t \sum_{\tau=0}^{\infty} \beta^\tau \left( \xi_p \right)^{\tau} \Lambda_{t+\tau} MC_{t+\tau} \left( \omega \left( \frac{1}{P_t^{1+\tau}} \right)^{-\sigma} \left( \frac{P_{t+\tau}^d}{P_{t+\tau}^s} \right)^{-\rho} y_{t+\tau} + \omega^f \left( \frac{S_{t+\tau}}{P_{t+\tau}^{ms}} \right)^{-\sigma} \left( \frac{P_{t+\tau}^{ms}}{P_{t+\tau}^s} \right)^{-\rho} y_{t+\tau}^s \right)}{E_t \sum_{\tau=0}^{\infty} \beta^\tau \left( \xi_p \right)^{\tau} \Lambda_{t+\tau} \left( \omega \left( \frac{1}{P_t^{1+\tau}} \right)^{-\sigma} \left( \frac{P_{t+\tau}^d}{P_{t+\tau}^s} \right)^{-\rho} y_{t+\tau} + \omega^f \left( \frac{S_{t+\tau}}{P_{t+\tau}^{ms}} \right)^{-\sigma} \left( \frac{P_{t+\tau}^{ms}}{P_{t+\tau}^s} \right)^{-\rho} y_{t+\tau}^s \right)}
\end{align*} \]
A.2 Market Clearing

Goods market clearing:

\[ C_t + C_t^e + I_t = y_t = \left( \omega \right)^{\frac{1}{\sigma}} \left[ \left( \int_0^n y_t^d (i) \left( \frac{\sigma - 1}{\sigma} \right) \right)^{\frac{\sigma - 1}{\rho} + \left( \omega^f \right)^{\frac{1}{\sigma}} \left[ \left( \int_1^n y_t^m (i) \left( \frac{\sigma - 1}{\sigma} \right) \right)^{\frac{\sigma - 1}{\rho}} \right]^{\frac{\rho}{\sigma}} \right] \]

Labor market clearing:

\[ \int_0^n h_t (i) \, di = H_t + H_t^e \] (18)

Capital market clearing:

\[ \int_0^n k_t (i) \, di = K_t \] (19)

Bond market clearing:

\[ nB_t + nb_t + (1 - n) B_t^f = 0 \] (20)

\[ (1 - n) B_t^* + (1 - n) b_t^* + nB_t^f = 0 \]
References


Table 1: Parameter Values

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\beta)</td>
<td>0.98</td>
<td>discount factor</td>
</tr>
<tr>
<td>(\alpha)</td>
<td>.36</td>
<td>capital share in production of value added</td>
</tr>
<tr>
<td>(\delta)</td>
<td>0.025</td>
<td>capital depreciation rate</td>
</tr>
<tr>
<td>(\kappa)</td>
<td>2.48</td>
<td>investment adjustment cost parameter</td>
</tr>
<tr>
<td>(\xi_p)</td>
<td>0.75</td>
<td>probability that a firm cannot reset prices</td>
</tr>
<tr>
<td>(\sigma)</td>
<td>10</td>
<td>elasticity of substitution across firm varieties</td>
</tr>
<tr>
<td>(\rho)</td>
<td>3</td>
<td>Armington elasticity</td>
</tr>
<tr>
<td>(\tau)</td>
<td>0.005</td>
<td>small constant tax on foreign bond holdings</td>
</tr>
<tr>
<td>(\omega)</td>
<td>0.73</td>
<td>Armington weight on domestic goods</td>
</tr>
<tr>
<td>(\omega_f)</td>
<td>0.50</td>
<td>Armington weight on foreign goods</td>
</tr>
<tr>
<td>(\phi)</td>
<td>0.3303</td>
<td>fixed cost to ensure firms earn zero profit in steady state</td>
</tr>
<tr>
<td>(\lambda)</td>
<td>0.001</td>
<td>relative size of the home country</td>
</tr>
<tr>
<td>(\bar{\lambda})</td>
<td>0.0089</td>
<td>steady state value of discount factor shock</td>
</tr>
<tr>
<td>(\bar{\theta})</td>
<td>0.75</td>
<td>steady state value of borrowing limit</td>
</tr>
</tbody>
</table>

Table 2: Results from the regression of the home real interest rate on the foreign real interest rate in simulations of the model driven by shocks to the foreign real interest rate.

<table>
<thead>
<tr>
<th></th>
<th>Fixed</th>
<th>Floating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open Capital Account</td>
<td>1.000</td>
<td>0.254</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.034)</td>
</tr>
<tr>
<td></td>
<td>-0.039</td>
<td>0.022</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.004)</td>
</tr>
<tr>
<td>Closed Capital Account</td>
<td>0.019</td>
<td>-0.212</td>
</tr>
<tr>
<td></td>
<td>(0.015)</td>
<td>(0.076)</td>
</tr>
</tbody>
</table>

Notes: Estimates are from 100 simulations of 25 years each. Point estimate is the average estimated parameter. Standard errors in parenthesis.
Figure 1: Responses to a positive shock to the foreign real interest rate. Turquoise line is the frictionless model, blue is from the model with credit frictions and an open capital account, green is from the model with credit frictions and a closed capital account, red is from the model with credit frictions and optimally chosen capital controls.
Figure 2: Responses to a positive shock to the foreign real interest rate in the model without credit frictions. The central bank maintains a fixed nominal exchange rate. Blue line is from the model with an open capital account, green is from the model with a closed capital account, red is from the model with optimally chosen capital controls.
Figure 3: Responses to a positive shock to the foreign real interest rate in the model with credit frictions. The central bank maintains a fixed nominal exchange rate. Blue line is from the model with an open capital account, green is from the model with a closed capital account, red is from the model with optimally chosen capital controls.
Figure 4: Responses to a positive shock to the foreign real interest rate in the model without credit frictions. Conventional monetary policy is chosen optimally. Blue line is from the model with an open capital account, green is from the model with a closed capital account, red is from the model with optimally chosen capital controls.
Figure 5: Responses to a positive shock to the foreign real interest rate in the model with credit frictions. Conventional monetary policy is chosen optimally. Blue line is from the model with an open capital account, green is from the model with a closed capital account, red is from the model with optimally chosen capital controls.
Table 3: Coefficient from regression of a country’s policy rate on a base country policy rate for different subgroups depending on exchange rate flexibility and capital account openness.

<table>
<thead>
<tr>
<th>Interaction</th>
<th>$\Delta R_{it}$</th>
<th>$\Delta R_{bt}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>peg* $\Delta R_{bit}$</td>
<td>0.461*** (0.039)</td>
<td>0.235*** (0.067)</td>
</tr>
<tr>
<td>soft* $\Delta R_{bit}$</td>
<td>0.315*** (0.053)</td>
<td>0.160 (0.103)</td>
</tr>
<tr>
<td>float* $\Delta R_{bit}$</td>
<td>0.012 (0.043)</td>
<td>-0.111 (0.071)</td>
</tr>
<tr>
<td>$ka$<em>peg</em> $\Delta R_{bit}$</td>
<td>0.531*** (0.127)</td>
<td>0.272* (0.156)</td>
</tr>
<tr>
<td>$ka$<em>soft</em> $\Delta R_{bit}$</td>
<td>0.269** (0.124)</td>
<td></td>
</tr>
<tr>
<td>$ka$float* $\Delta R_{bit}$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

R2 0.052 0.058
obs 3126 3126

for $ka=1$:

<table>
<thead>
<tr>
<th>Interaction</th>
<th>$\Delta R_{it}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>peg</td>
<td>0.766*** (0.083)</td>
</tr>
<tr>
<td>soft</td>
<td>0.432*** (0.085)</td>
</tr>
<tr>
<td>float</td>
<td>0.159** (0.080)</td>
</tr>
</tbody>
</table>

notes: Standard errors are in parenthesis, the adj. R-squared from each regression is presented in brackets, and the integer in each set of results is the number of observations. ***/**/ denote significance at the 1/5/10% levels.