

ABSTRACT

Title of dissertation: Essays on Capital Flow Management

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This dissertation investigates two questions about capital flow management: first, how to manage capital flows when there is more than one market imperfection; second, whether capital flow restrictions lead to multilateral spillover effects.

In Chapter 2, I study the first question in a small open-economy DSGE model with two frictions: downward nominal wage rigidity and a price-dependent borrowing constraint. Wage rigidity introduces an aggregate demand externality under fixed exchange rates and the borrowing constraint introduces a pecuniary externality. I provide an analytical characterization of optimal capital flow management measures and show how they mitigate the externalities. Specifically, I find that the optimal policy in this economy is to restrict capital inflows when the risk of financial crisis is high or when wage is increasing, and to restrict capital outflows when unemployment is high and the risk of financial crisis is low. Using quantitative methods and standard calibration, I show that the optimal state-contingent capital inflow tax and even a non-state-contingent flat tax can significantly reduce unemployment and prevent financial crises, hence ultimately improving welfare. These results are

of particular relevance for members of a currency union or emerging economies with an exchange rate peg.

I consider the second question in Chapter 3. In a simple model of capital flows and controls, I show that inflow restrictions distort international capital flows to other countries and that, in turn, such capital flow deflection may lead to a policy response. I then test the theory using data on inflow restrictions and gross capital inflows for a large sample of developing countries between 1995 and 2009. My estimation yields strong evidence that capital controls deflect capital flows to other countries with similar risk levels. Notwithstanding these strong cross-border spillover effects, I do not find evidence of a policy response.

ESSAYS ON CAPITAL FLOW MANAGEMENT

by

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Dedication

In memory of my grandpa, Zhu Yajia.

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List of Abbreviations

AR(1)	Autogressive Model of Order 1
AMECO	Annual Macro-Economic Database
AREAER	Annual Report on Exchange Arrangements and Exchange Restrictions
BMP	Balance of Payments Manual
DPI	Database of Political Institutions
DSGE	Dynamic Stochastic General Equilibrium
FDI	Foreign Direct Investment
FE	Fixed Effects
FRED	Federal Reserve Economic Data
FTA	Free Trade Agreements
GATT	General Agreement on Trade and Tariffs
GDP	Gross Domestic Product
IFS	International Financial Statistics
IMF	International Monetary Fund
IV	Instrumental Variable
NIIP	Net International Investment Position
PRS	Political Risk Service
ROG	Rest of the Group
SOE	Small Open Economy
WEO	World Economic Outlook
WTO	World Trade Organization
VIX	Chicago Board Options Exchange Market Volatility Index

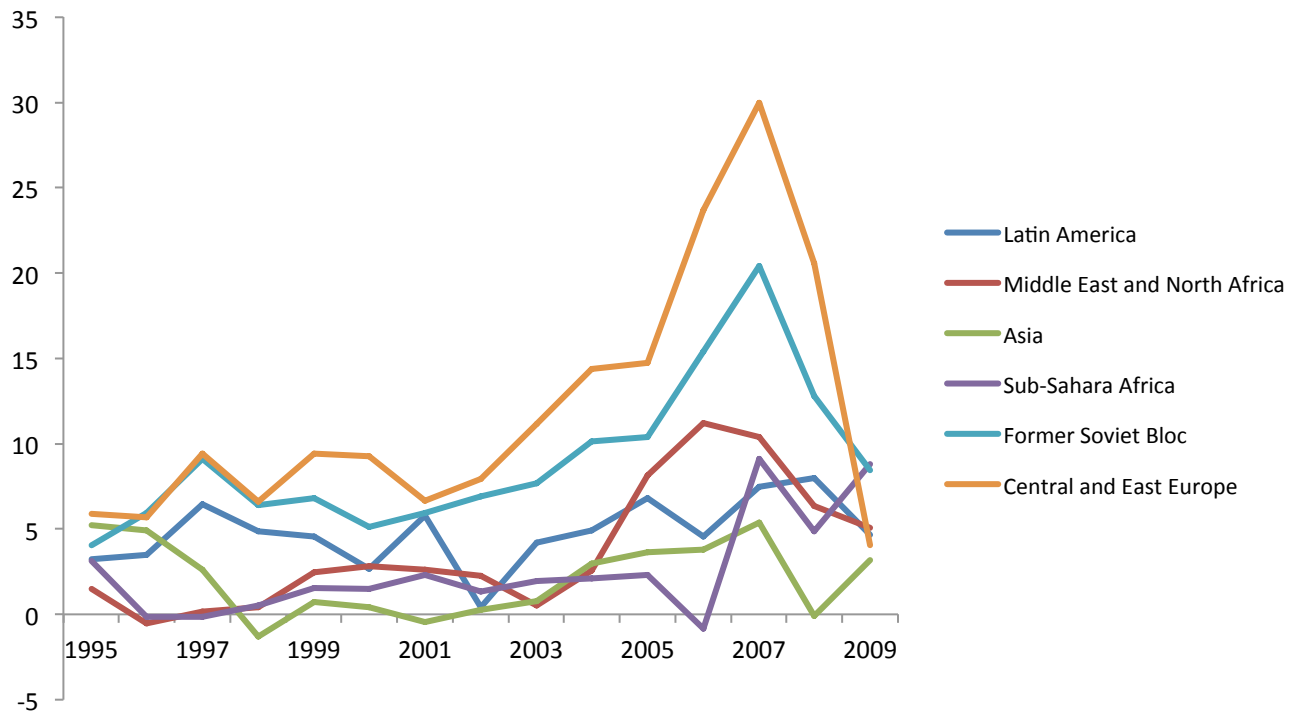
Chapter 1: Introduction

Over the last two decades, cross-border capital flows have experienced an extraordinary increase in both volume and volatility (see Figure 1.1). Although large capital inflows are good news for the countries that are in need of investment, they carry significant economic and financial risks. On the one hand, large capital inflows could accelerate the formation of asset bubbles and exacerbate economic overheating. On the other hand, capital inflows could suddenly stop or even reverse when international investors decide to look elsewhere, which could lead to severe financial crises, known as episodes of *sudden stops*. For instance, some economists argue that the large capital inflows during the 2003-2007 pre-crisis period was a major contributory factor to the subsequent crisis in the euro area (see e.g. Lane, 2013).

As a result, capital flow management (also known as *capital controls*), once seen as the enemy of free trade and open market, is now becoming increasingly popular among policy makers. For example, Brazil introduced a tax on foreign capital inflows (IOF tax) in 2009, and it made active adjustments to the policy throughout the financial crisis (see Table 1.1).¹ The International Monetary Fund (IMF) has also recently endorsed capital flow management as a part of the toolkit

¹The IOF tax was created to replace the CPMF tax, abolished in 2008.

Figure 1.1: Annual Gross Inflows (% GDP) by Region



for safeguarding macroeconomic and financial stability (IMF, 2012). This change in perspective among policy makers is not only a response to the reality of the increasingly volatile capital flows across the world, but it is also a reflection of recent advances in academic research.

As Jeanne (2012) points out, the theoretical literature had little to say about capital flow management until recently. Much of the previous research had focused on establishing the empirical connection between capital account liberalization and economic performance.² Though the empirical findings were mixed, most were in favor of capital account liberalization (see e.g. Kose et al., 2009, for a survey on

²See e.g. Edwards (2001), Eichengreen (2001), Prasad et al. (2003), and Bekaert et al. (2005).

Table 1.1: Brazil Capital Controls: IOF Tax Since 2009

Date	Capital Controls
19-Oct-09	2% IOF entry tax on portfolio inflows (equities & fixed income)
4-Oct-10	4% IOF entry tax on fixed income inflows
18-Oct-10	6% IOF entry tax on fixed income inflows
29-Mar-11	6% IOF entry tax on foreign loans with maturity below 1 year
6-Apr-11	6% IOF entry tax on foreign loans with maturity below 2 years
29-Feb-12	6% IOF entry tax on foreign loans with maturity below 3 years
9-Mar-12	6% IOF entry tax on foreign loans with maturity below 5 years
14-Jun-12	Tax on foreign loans with maturity above 2 years drops to 0%.
05-Jun-13	Tax on foreign loans with maturity above 1 year drops to 0%.
05-Jun-14	Tax on foreign loans with maturity above 180 days drops to 0%.

Source: Financial Times, Haver

the vast literature).³ However, more recently, a growing welfare-based analysis has provided policy makers the theoretical justification for employing capital flow management. Specifically, Korinek (2010) shows that capital flow management could improve welfare when financial market is imperfect; Schmitt-Groé and Uribe (2013a) show that capital flow management could reduce unemployment when real wage is downwardly rigid; Farhi and Werning (2013b) show that capital flow management is effective at addressing risk-premium shocks.⁴

This dissertation builds on these recent development in the theoretical literature on capital flow management. It aims to answer the following two questions:

first, how to conduct capital flow management when there is more than one mar-

³Many argued against capital account liberalization: see e.g. Rodrik, 1998; Bhagwati, 1998; Stiglitz, 2000.

⁴Costinot et al. (2014) provide another justification for large economies to employ capital flow management. They show that large economies could benefit by manipulating inter-temporal terms of trade with capital flow management.

ket imperfection; second, whether capital flow management leads to multilateral spillover effects.

The first question is *normative* in nature and it is studied using a welfare-based analysis in Chapter 2. Specifically, I solve for optimal capital flow management in an environment with imperfections in both financial and labor markets—households face borrowing constraint and wage is downwardly rigid. In this analytical framework, capital flows carry both financial and macroeconomic risks. On the one hand, large capital inflows lead to rapid build-up of debt, increasing the risks of financial crisis and painful deleveraging in the future. On the other hand, large capital inflows are used to finance consumption boom that leads to an unsustainably rise in real wage, increasing the risk of high levels of unemployment in the future. Both of which resemble the recent experiences of the periphery countries in the euro area during the Eurozone crisis.

Moreover, in this model environment, there is a trade-off between macroeconomic stability and financial stability when employing capital controls in some states of nature. For instance, consider a country with high levels of unemployment and debt. A prudential inflow restriction could bring down the debt level and hence improve financial stability. However, the same inflow restriction would increase the cost of borrowing for domestic households and firms. Then aggregate demand would decrease and unemployment rate would rise. Therefore, the optimal capital control must strike a balance between safeguarding financial stability and managing aggregate demand. I show that the optimal policy in this environment is to restrict capital inflows when financial stability risk is high or when economy is overheating,

and to restrict capital outflows (or encourage capital inflows) when unemployment rate is high and when financial risk is low.

The second question is *positive* in nature and it is examined empirically using panel analysis in Chapter 3. Specifically, I first identify two potential multilateral spillover effects of capital flow management in a simple model: inflow restrictions introduced in one country would deflect capital flows to the other countries (*capital flow deflection*), and the higher inflows from the deflection would induce the recipient countries to respond by increasing their inflow restrictions (*policy response*).

Then I test these two spillover effects using a dataset consisting of 78 countries over the period of 1995-2009. I find strong empirical evidence for the capital flow deflection among countries with similar risk levels, but no evidence for any policy response. The finding implies that, when Brazil introduced IOF tax in 2009, capital is only deflected to those countries with similar risk levels as Brazil, in particular those with similar risk levels. I would like to interpret the lack of evidence for policy response as a failure to find the evidence rather than the evidence of no policy response. In Brazil's example, at least two of the countries with similar risk levels as Brazil raised their capital controls in response to the IOF tax.⁵ In 2010, Peru increased the fee on non-resident purchase of central bank paper to 400 basis points (from 10 basis points), while Thailand imposed a 15 percent withholding tax on non-residents' interest earnings and capital gains on state bonds. Therefore, more research needs to be done on this topic.

⁵See Table 3.1 for lists of countries with similar risk levels.

Chapter 2: Employment and Financial Stability:

Dual Goals of Capital Flow Management

2.1 Introduction

The literature on optimal capital flow management can be divided into two streams: one focuses on reducing financial stability risks (see e.g. Korinek 2010); the other focuses on macroeconomic stabilization (see e.g. Farhi and Werning, 2013a and Schmitt-Grohé and Uribe, 2013a).

This chapter brings together the two streams of research by studying how capital flow management can address both macroeconomic and financial stability risks. It is important to consider both risks simultaneously since there is a trade-off between macroeconomic and financial stability. A restriction on capital inflows that aims to reduce financial stability risk, for instance, could decrease aggregate demand and eventually worsen unemployment. Moreover, it is relevant to study capital flow management with dual objectives since some countries, such as the euro area

⁰This chapter is adapted from my job market paper under the same title. I would also like to thank Anton Korinek, Cristina Arellano, Sebnem Kalemli-Ozcan, Felipe Saffie, Luminita Stevens, and seminar participants at the University of Maryland, Miami University, Miami University, the PBC School of Finance, Tsinghua University, the Central University of Finance and Economics, and Peking University HSBC Business School for their valuable comments and discussions. The views expressed here are those of the author and all errors are the sole responsibility of the author.

member states, do not have an independent monetary policy for macroeconomic stabilization.

To offer normative guidance for designing capital flow management with dual objectives, I study a small open economy model with a price-dependent borrowing constraint and a downwardly-rigid wage. On one hand, the borrowing constraint binds when borrowing capacity falls relative to the level of debt. Once the constraint binds, capital inflows would stop, resulting in financial crises. Since borrowing capacity is determined endogenously, financial crises are endogenous in the model. On the other hand, the downward wage rigidity restricts wage from falling during economic downturns, causing unemployment to rise. Since wage is determined endogenously, unemployment is also endogenous in the model.

A laissez-faire economy suffers from an aggregate demand externality as in Schmitt-Grohé and Uribe (2013a) and Farhi and Werning (2012, 2013b). The aggregate demand externality arises because private agents fail to internalize the impact of their individual consumption choices on the labor market. More specifically, they increase consumption excessively during booms, raising nominal wage and the risk of future unemployment. On the contrary, agents reduce consumption excessively during busts, driving down labor demand and causing unemployment to rise immediately. Therefore the laissez-faire economy has a high unemployment rate as a result of the aggregate demand externality.

A laissez-faire economy also suffers from a pecuniary externality as in Korinek (2010). The pecuniary externality arises because private agents fail to internalize the positive impact of their wealth on asset price. More specifically, they carry too

much debt into a financial crisis. Had they borrowed less during tranquil times, the asset price would have been higher during the financial crisis, and the financial crisis would be less severe. Therefore the laissez-faire economy suffers from frequent severe financial crises as a result of the pecuniary externality.

I provide an analytical solution for optimal capital flow management in this environment by solving a constrained social planner's problem. The planner faces the same set of constraints as private agents, but he is able to internalize the impacts of individual actions on asset price and the labor market. I provide an explicit formula for the optimal capital inflow tax (or subsidy) that decentralizes the constrained planner's allocations. Moreover, I show that the optimal tax can be broken down into three components: one corrects the aggregate demand externality; the other corrects the pecuniary externality; the third accounts for the interaction of the two externalities. The first term is counter-cyclical: it is a prudential tax when the economy has full employment and it is a stimulative subsidy when the economy has unemployment. The sum of the second and the third terms is a prudential tax when the probability of a binding borrowing constraint in next period is positive.

Using a novel graphical framework, I illustrate the impacts of a prudential capital inflow tax on unemployment and financial stability in a laissez-faire economy. The inflow tax decreases aggregate demand and lowers debt by increasing the cost of borrowing. A lower level of debt reduces the probability of a financial crisis in next period. If the initial laissez-faire economy suffers from unemployment, then the lower aggregate demand increases unemployment. Therefore, there is a trade-off between employment and financial stability: the inflow tax improves financial stability at

the cost of higher unemployment. Thus, a prudential inflow tax is optimal if the welfare gain of better financial stability outweighs the cost of higher unemployment. Otherwise, a stimulative inflow subsidy is optimal. However, if the initial laissez-faire economy has full employment, then the lower aggregate demand lowers wage level, reducing future unemployment. Therefore, inflow tax is optimal since it improves both financial stability and future employment.

Using quantitative analysis, I show that optimal capital flow management is able to reduce both unemployment and financial stability risk significantly compared to the laissez-faire economy. I calibrate the model to the Spanish economy and show that optimal capital inflow tax lowers average unemployment rate by 2%, reduces the frequency of severe financial crisis by 6%, and improves permanent consumption by 1% compared to levels in the laissez-faire economy. Moreover, I find that simple tax rules also lead to significant improvements in the laissez-faire economy. For example, a rule that imposes a 4% inflow tax when unemployment rate is below 2% and no tax when unemployment is above 2% improves permanent consumption by more than 0.5%.

This chapter builds on a large literature on pecuniary externalities (see e.g. Korinek, 2010; Bianchi and Mendoza, 2010; Jeanne and Korinek, 2010; Bianchi, 2011; Korinek, 2011a,b; Jeanne and Korinek, 2013; Davila, 2014). These papers examine the inefficiencies that arise from a price-dependent borrowing constraint and derive the optimal policies that could mitigate the externality. My paper contributes to this literature by combining it with an aggregate demand externality and examining the optimal capital policy that corrects both externalities. In addition,

my paper also adds to both literatures by providing a novel graphical framework for conducting comparative statics.

In particular, the downward nominal wage rigidity in my paper builds on the work of Schmitt-Grohé and Uribe (2011, 2012, 2013a,b). These authors investigate the inefficiencies that arise from the wage rigidity and the optimal policies that can be used to mitigate these inefficiencies.¹ However, their analysis of optimal inflow tax is numerical in nature. In this chapter, I provide an analytical characterization of the inefficiency and an explicit solution for the optimal inflow tax. These analytical results contribute to a better understanding of the ways in which optimal policy depends on the structural parameters of the economy as well as generating additional insights into the nature of the aggregate demand externality.

This chapter also contributes to a growing literature that studies the models with both nominal and financial frictions by providing the first numerical solution for the laissez-faire equilibrium in a DSGE framework with both nominal and financial frictions. The numerical solution is difficult because of non-linearities in the value function, the large number of state variables, and inequality constraints. For example, Farhi and Werning (2012, 2013b) and Davis and Presno (2014) study models with financial and nominal frictions, but these models do not account for uncertainty. Woodford (2012) studies optimal monetary policy in a reduced-form model with both financial and nominal frictions. Ottonello (2014) studies exchange rate policy during financial crises using a model that is similar to the one in this

¹In an earlier version, Schmitt-Grohé and Uribe (2013a) include an extension that features a price-dependent borrowing constraint in addition to the downward wage rigidity and provide numerical solutions.

chapter, but he does not solve for the laissez-faire equilibrium.

The rest of the chapter proceeds as follows: in Section 2, I set up the model and define the laissez-faire equilibrium. In Section 3, I solve a constrained social planner's problem, characterize the externalities associated with the frictions, and derive a formula for the optimal capital inflow tax. Section 4 presents a graphical framework for comparative statics. In Section 5, I conduct a quantitative analysis and present numerical results. Section 6 concludes.

2.2 Model

Consider a DSGE model of a small open economy with a tradable good and a non-tradable good. The economy consists of two types agents: a unit mass of identical households and a unit mass of identical non-tradable goods producers. There are two sources of exogenous shocks: a stochastic country-specific interest rate r and a stochastic tradable endowment y_T .

2.2.1 Household

A representative household has lifetime welfare function

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t). \quad (2.1)$$

where \mathbb{E}_0 is the expectation function at $t = 0$. The period utility function follows the CRRA form with the inter-temporal elasticity of substitution of $\frac{1}{\sigma}$:

$$u(c_t) = \frac{c_t^{1-\sigma} - 1}{1-\sigma}, \quad \sigma > 0.$$

The aggregate consumption c_t is an Armington-type CES aggregator with the elasticity of substitution of ξ between tradable consumption c_t^T and non-tradable consumption c_t^N

$$c_t = \left[a(c_t^T)^{1-\frac{1}{\xi}} + (1-a)(c_t^N)^{1-\frac{1}{\xi}} \right]^{\frac{\xi}{\xi-1}}, \quad \xi < 1, a \in (0, 1). \quad (2.2)$$

I assume the intra-temporal elasticity of substitution is greater than the inter-temporal elasticity of substitution

$$\frac{1}{\sigma} < \xi, \quad (2.3)$$

so that the marginal utility of c_t^T , denoted as $u_T(t)$, is decreasing in c_t^N .

In each period, the representative household is endowed with y_t^T units of tradable goods and one unit of labor. Let tradable goods be the numeraire. The household sells labor at real wage w_t in the labor market and takes labor demand h_t as given. The household also receives dividend π_t from non-tradable producers. In international financial market, the household has access to a one-period non-state-contingent bond denominated in tradable goods with country-specific real interest

rate r_t . Therefore the household's period budget constraint is

$$c_t^T + p_t^N c_t^N + d_{t-1} = y_t^T + w_t h_t + \pi_t + \frac{d_t}{(1+r_t)}, \quad (2.4)$$

where d_t is real outstanding debt due in period $t + 1$, p_t^N is the relative price of non-tradable goods in units of tradable goods, which is also real exchange rate.

The household is subject to a borrowing constraint imposed by international lenders that outstanding debt can not exceed a fraction κ of household income:²

$$d_t \leq \kappa(y_t^T + w_t h_t + \pi_t) \quad (2.5)$$

The borrowing constraint (2.5) is not formally derived as a feature of an optimal credit contract; it is an ad-hoc financial constraint that has become standard in the literature of the financial crisis of small open economies (see e.g. Mendoza, 2002; Korinek, 2010). Mendoza (2002) provides two rationales for the ad-hoc borrowing constraint. First, it could result from an optimal credit contract under traditional financial-market frictions such as monitoring costs or bankruptcy risks. The intuition is that the borrowing constraint could be thought of as a mechanism to manage default risk by limiting the ability of borrowers to acquire debt based on their income. In fact, in the calibration exercise of Section 2.5, borrowers' realized

²I have also solved the model using an alternative borrowing constraint:

$$\frac{d_t}{1+r_t} \leq \kappa(y_t^T + w_t h_t + \pi_t)$$

Most results continue to hold except that the laissez-faire equilibrium allocations are independent of state variable r_t when the borrowing constraint binds. Then higher interest rate does not lead to more deleveraging or lower consumption during crisis.

incomes are always high enough to repay their debts in full thanks to the borrowing constraint.

The second rationale behind the borrowing constraint is that it is consistent with standard lending criteria widely used in mortgage and consumer loans. For instance, the Federal Housing Administration of the United States imposes a debt-to-income ratio of 31% on mortgage payment.³ In particular, the total mortgage payment (principal and interest, escrow deposits for taxes, hazard insurance, mortgage insurance premium, homeowners' dues, etc.) cannot exceed 31% of the gross monthly income. Therefore, despite the lack of micro-foundation, the borrowing constraint (2.5) has become standard in the literature to capture financial-market frictions.

The household's problem is to choose stochastic process $\{c_t^T, c_t^N, d_t\}_{t=0}^\infty$ to maximize expected lifetime welfare (2.1) subject to the budget constraint (2.4) and the borrowing constraint (2.5) while taking $\{p_t^N, y_t^T, w_t, h_t, \pi_t, r_t\}_{t=0}^\infty$ and the initial outstanding debt d_0 as given.

The household's optimality conditions are

$$p_t^N = \frac{1-a}{a} \left(\frac{c_t^T}{c_t^N} \right)^{\frac{1}{\xi}} \quad (2.6)$$

$$u_T(t) = (1 + r_t)\beta\mathbb{E}_t u_T(t+1) + (1 + r_t)\lambda_t^{CC} \quad (2.7)$$

where λ_t^{CC} is the multiplier on the borrowing constraint (2.5).

Equation (2.6) defines the real exchange rate as a function of tradable and

³See http://www.fha.com/fha_requirements_debt.

non-tradable consumption. (2.7) is the household's Euler equation. It sets the household's marginal utility of an additional unit of tradable consumption to its marginal cost. The cost of higher tradable consumption includes both lower a reduction in future consumption and a deterioration of today's borrowing constraint as more debt is necessary to finance the higher tradable consumption today.

2.2.2 Non-tradable Goods Producer

I assume there is a unit mass of identical firms that produces non-tradable goods using labor as the only input. The firms are price-takers in both input and output markets. Therefore, a representative firm's problem is to choose h_t in each period to maximize profit, given by

$$\pi_t = \max_{h_t} p_t^N f(h_t) - w_t h_t$$

where $f(h_t)$ is the Cobb-Douglas production function with the factor of labor equals to α :

$$f(h_t) = h_t^\alpha.$$

The firm's optimal labor demand decision sets the marginal cost of labor equal to the marginal revenue of labor:

$$w_t = \alpha p_t^N h_t^{\alpha-1} \tag{2.8}$$

2.2.3 Wage Rigidity

I assume wage is rigid. Specifically, I follow Schmitt-Grohé and Uribe (2013a) by imposing a downwardly rigid constraint on nominal wages

$$W_t \geq \gamma W_{t-1}$$

so that nominal wage W_t can never fall below a fraction γ of previous period's nominal level W_{t-1} . I also assume the economy to have fixed exchange rate, then nominal rigidity becomes real rigidity:

$$w_t \geq \gamma w_{t-1} \tag{2.9}$$

Henceforth, I refer to (2.9) as the wage rigidity constraint and γw_{t-1} as the wage floor.

In the labor market, labor demand must not exceed labor supply

$$h_t \leq 1 \tag{2.10}$$

Last, complementary slackness condition must be satisfied

$$(1 - h_t)(w_t - \gamma w_{t-1}) = 0 \tag{2.11}$$

Equation (2.11) guarantees at least one of inequalities (2.9) and (2.10) must hold

at equality.⁴ So when the wage rigidity constraint is slack, the economy has full employment.

2.2.4 Market Clearing

Finally the non-tradable goods market must clear:

$$c_t^N = f(h_t) \tag{2.12}$$

2.2.5 Laissez-faire Equilibrium

Definition 1 (Definition of Laissez-faire Equilibrium) *Given stochastic shocks $\{y_t^T, r_t\}_{t=0}^\infty$ and initial outstanding debt d_{-1} , the laissez-faire equilibrium consists of stochastic process $\{c_t^T, c_t^N, h_t, p_t^N, w_t, d_t, \lambda_t^{CC}\}_{t=0}^\infty$ that satisfy (2.6) -(2.16):*

$$d_t = (1 + r_t) (c_t^T + d_{t-1} - y_t^T) \tag{2.13}$$

$$\lambda_t^{CC} \geq 0 \tag{2.14}$$

$$d_t \leq \kappa(y_t^T + p_t^N y_t^N) \tag{2.15}$$

$$\lambda_t^{CC} [\kappa(y_t^T + p_t^N y_t^N) - d_t] = 0 \tag{2.16}$$

To simplify notation, I drop time subscripts in the rest of the chapter. I

denote the variables of the subsequent period with superscript ', the variables of

⁴It also guarantees the uniqueness of the equilibrium. Consider when (2.11) is not imposed as an equilibrium condition, then there can be an infinite number of equilibria when full employment wage (the wage that clears the labor market at full employment) is larger than the wage floor: every wage equal or larger than the full employment wage is an equilibrium.

the previous period with subscript -1 , and variables associated with tradable goods and non-tradable goods with subscripts T and N respectively.

2.2.6 Unemployment and Aggregate Demand

Proposition 1 (Tradable Consumption and Unemployment) *The economy has full employment if and only if $c_T \geq \hat{c}_T$, where*

$$\hat{c}_T = \left(\frac{a}{1-a} \frac{1}{\alpha} \gamma w_{-1} \right)^\xi. \quad (2.17)$$

If c_T is below \hat{c}_T , then unemployment increases in w_{-1} and decreases in c_T .

Proof First prove that if $c_T \geq \hat{c}_T$ then $h = 1$ by contradiction.

Suppose $h < 1$ when $c_T \geq \hat{c}_T$. Then $w = \gamma w_{-1}$. Substitute (2.6) and (2.12) into (2.8):

$$w = \alpha \frac{1-a}{a} (c_T)^{1/\xi} (h)^{\alpha - \alpha/\xi - 1} \quad (2.18)$$

Substitute $c_T \geq \hat{c}_T$, $h < 1$, and (2.17) into (2.18) gives $w > \gamma w_{-1}$. which contradicts with $w = \gamma w_{-1}$. Therefore $h = 1$ when $c_T \geq \hat{c}_T$.

Next prove that if $h = 1$ then $c_T \geq \hat{c}_T$. If $h = 1$ then $w > \gamma w_{-1}$. Substitute $h = 1$ and $w > \gamma w_{-1}$ into (2.18) then

$$\alpha \frac{1-a}{a} (c_t^T)^{1/\xi} \geq \gamma w_{t-1}.$$

Rearranging terms gives $c_T \geq \hat{c}_T$. Therefore, $h = 1$ if and only if $c_T \geq \hat{c}_T$.

Given what I have shown above, if $c_T < \widehat{c}_T$, then $h < 1$. When $h < 1$, $w = \gamma w_{-1}$. Then (2.18) becomes

$$h = \left[\alpha \left(\frac{1-a}{a} \right) \left(\frac{1}{\gamma w_{-1}} \right) \right]^{\frac{\xi}{\xi - \alpha \xi + \alpha}} (c_T)^{\frac{1}{\xi - \alpha \xi + \alpha}} \quad (2.19)$$

So $\frac{dh}{dc_T} > 0$ and $\frac{dh}{dw_{-1}} < 0$ when $c_T < \widehat{c}_T$. ■

Proposition 1 shows that equilibrium unemployment is determined by previous period's real wage and contemporaneous aggregate tradable consumption. Higher w_{-1} pushes up real wage floor and increases the cost of labor. Producers respond to higher cost by decreasing employment. c_T should be interpreted as the aggregate demand for tradable goods. Lower aggregate demand for tradable goods must lead to lower aggregate demand for the non-tradable goods at initial p_N . Then p_N must fall to clear the incipient excess supply of non-tradable goods. Meanwhile, firms would respond to the lower price by reducing production, and hence unemployment increases. Intuitively, the economy suffers from unemployment when the aggregate demand is insufficient (less than \widehat{c}_T), and lower the aggregate demand, the worse the unemployment is.

\widehat{c}_T is the full-employment-threshold of aggregate tradable consumption. When aggregate tradable consumption is above the threshold, the economy has full employment. Then higher demand would not reduce unemployment. Instead, it leads to higher real wage, which increases future unemployment.

There is a trade-off between financial stability and employment in the model. On the one hand, lower debt reduces the probability of a binding borrowing con-

straint in next period, decreasing financial stability risk. On the other hand, lower debt implies lower contemporaneous aggregate consumption, increasing unemployment when the aggregate demand is insufficient. Households do not internalize their individual actions on aggregate variables, therefore the trade-off between financial stability and employment might be inefficient in the laissez-faire equilibrium, providing a rationale for capital flow management that takes both objectives into account.

2.3 Optimal Capital Flow Management

2.3.1 Constrained Planner's Problem

A constrained planner directly sets allocations c_T, h , and d , but it is subject to the same set of constraints private agents face. Moreover, the planner is subject to the laws of supply and demand in goods and labor markets, so it must take the market determination of real exchange rate and real wage as given. The planner differs from private agents in its ability to internalize the impacts of allocations on price and wage levels. More specifically, the constrained planner's problem can be expressed in following recursive form:

$$V^{CP}(w_{-1}, d_{-1}, y_T, r) = \max_{c_T, h, d} u(c_T, f(h)) + \beta \mathbb{E} V^{CP}(w(c_T, h), d, y'_T, r') \quad (2.20)$$

subject to

$$h \leq 1 \quad (2.21)$$

$$y_T + \frac{d}{1+r} - c_T - d_{-1} = 0, \quad (2.22)$$

$$d \leq \kappa [y_T + p_N(c_T, h) f(h)], \quad (2.23)$$

$$w(c_T, h) \geq \gamma w_{-1}, \quad (2.24)$$

$$[w(c_T, h) - \gamma w_{-1}] (1 - h) = 0, \quad (2.25)$$

where

$$p_N(c_T, h) = \frac{1-a}{a} \left(\frac{c_T}{f(h)} \right)^{1/\xi}, \quad (2.26)$$

and

$$w(c_T, h) = \alpha \frac{1-a}{a} (c_T)^{1/\xi} h^{\alpha - \alpha/\xi - 1}. \quad (2.27)$$

The planner takes resource constraints (2.21) and (2.22), borrowing constraint (2.23), wage rigidity constraint (2.24), complementary slackness condition (2.25), real exchange rate function (2.26) and real wage function (2.27) as given. Since the wage rigidity depends on the previous period's wage, therefore w_{-1} is a state variable in the planner's problem.

Definition 2 (Constrained-Optimal Allocations) *Constrained-optimal allocations consist of allocation rules $\{c_T^{CP}(w_{-1}, d_{-1}, y_T, r), c_N^{CP}(w_{-1}, d_{-1}, y_T, r), d^{CP}(w_{-1}, d_{-1}, y_T, r)\}$ that solve the recursive optimization problem of a constrained planner.*

Henceforth, I use superscript *LF* and *CP* to denote laissez-faire equilibrium allocations and constrained-optimal allocations respectively.

2.3.2 Aggregate Demand and Pecuniary Externalities

Following the literature (see e.g. Bianchi, 2011), I call an equilibrium *constrained-inefficient* if it deviates from the constrained-optimal allocations. Below, I first focus

on the constrained-inefficiency of laissez-faire economy associated with wage rigidity by letting borrowing constraints be slack:

Proposition 2 (Aggregate Demand Externality) *When borrowing constraints are slack, the laissez-faire equilibrium c_T^{LF} and d^{LF} are lower than the constrained-optimal levels if $\Phi_T^{CP} > \beta(1+r)\mathbb{E}\Phi_T^{CP'}$, and higher if $\Phi_T^{CP} < \beta(1+r)\mathbb{E}\Phi_T^{CP'}$, where*

$$\Phi_T = \begin{cases} u_N f'(h) \frac{dh}{dc_T} > 0 & \text{when } c_T < \hat{c}_T \\ -\beta \mathbb{E} \lambda'_w \gamma \frac{dw}{dc_T} \leq 0 & \text{when } c_T \geq \hat{c}_T. \end{cases}$$

Proof When borrowing constraints are slack, the constrained planner's Euler equation can be expressed as

$$u_T + \Phi_T = \beta(1+r)\mathbb{E}(u'_T + \Phi'_T).$$

See Appendix A.1 for detailed derivation. Then

$$u_T^{CP} \leq \beta(1+r)\mathbb{E}u_T^{CP'} \quad \text{if } \Phi_T^{CP} \geq \beta(1+r)\mathbb{E}\Phi_T^{CP'}.$$

On the other hand, the households in the laissez-faire economy set

$$u_T^{LF} = \beta(1+r)\mathbb{E}u_T^{LF'}. \quad (2.28)$$

Therefore when $\Phi_T^{CP} > \beta(1+r)\mathbb{E}\Phi_T^{CP'}$, the constrained-optimal consumption must be higher than the laissez-faire equilibrium levels, and hence debt is also higher.

And the opposite is true when $\Phi_T^{CP} < \beta(1+r)\mathbb{E}\Phi_T^{CP'}$. ■

When borrowing constraints are slack, the planner’s marginal benefits of tradable consumption includes the direct increase in utility u_T and the indirect change in utility Φ_T . This indirect term, not considered by private agents, captures how an increase in c_T affects labor market.

It follows from Proposition 1 that c_T affects both contemporaneous and future labor markets. When c_T is insufficient, an additional unit of c_T increases employment by $\frac{dh}{dc_T}$, so non-tradable consumption increases by $f'(h)\frac{dh}{dc_T}$ and welfare increases by $u_N f'(h)\frac{dh}{dc_T}$. When c_T is sufficiently high, an additional unit of c_T increases real wage by $\frac{dw}{dc_T}$ and tightens next period’s wage rigidity by $\gamma\frac{dw}{dc_T}$, which has a shadow value of λ'_w , and therefore welfare decreases by $\beta\mathbb{E}\lambda'_w\gamma\frac{dw}{dc_T}$.

The intuition behind Proposition 2 is that the constrained planner would allocate more tradable consumption (compared to the private agents in laissez-faire economy) to the period when it can improve unemployment the most. Therefore, private agents under-consume and under-borrow relative to the constrained planner when higher c_T could improve unemployment more than higher c'_T , otherwise they over-consume and over-borrow.

The aggregate demand externality arises because private agents fail to internalize the impacts of aggregate tradable consumption on present and future labor markets, which is the nature of aggregate demand externality.⁵

⁵The literature has focused on the inter-temporal channel. For example, Schmitt-Grohé and Uribe (2013a) explain the nature of the externality associated with the wage rigidity as “the excessive expansion of private absorption in response to favorable shocks, causing inefficiently large increases in real wages”. The authors describe the inefficiency in the laissez-faire economy as

The size of aggregate demand externality Φ_T is decreasing in ξ and increasing in γ . To see this relation, I rewrite Φ_T as

$$\Phi_T = \begin{cases} u_N \frac{f(h)}{c_T} \frac{1}{\xi(1/\alpha-1)+1} & \text{when } c_T < \hat{c}_T \\ -\beta\gamma \frac{\alpha}{\xi} \frac{1-a}{a} \left[\frac{c_T}{f(h)} \right]^{\frac{1}{\xi}-1} h^{-1} \mathbb{E}\lambda'_w & \text{when } c_T \geq \hat{c}_T. \end{cases} \quad (2.29)$$

$u_N \frac{f(h)}{c_T}$ is decreasing in $f(h)$. So the higher the unemployment, the higher is the marginal benefit of higher c_T from improving unemployment. And by equation (2.19), unemployment is increasing in γ . Therefore, when aggregate tradable consumption is insufficient, Φ_T is positive and it is increasing in γ . When the aggregate tradable consumption is sufficient, $\Phi_T < 0$ and it is decreasing in γ . So the *size* of aggregate demand externality term Φ_T is always increasing in γ .

Next, I let wage rigidity constraints be slack and focus on the inefficiency associated with the financial friction only. Since following results are standard in the literature (see e.g. Korinek, 2010, and Bianchi, 2012), I keep discussion brief.

When present borrowing constraint binds, the laissez-faire equilibrium allocations are generally identical to the constrained-optimal levels.⁶ So the planner would go through the same deleveraging process as private households do. The “over-borrowing”. However, there could be excessive decline of private absorption (in response to adverse shocks) as well, causing inefficiently large increases in unemployment. In other words, there could be either “under-borrowing” or “over-borrowing” in the laissez-faire equilibrium compared to the constrained-optimal allocations due to the wage rigidity.

⁶ c_T, h , and d are determined by the same set of equations: (2.21)-(2.27) with (2.23) at equality. The household is also subject to the constraint on Euler equation

$$u_T \geq \beta(1+r)\mathbb{E}u_T^{CP'},$$

while the planner is not. However, the planner almost always chooses the allocations that satisfy the household’s Euler equation constraint unless debt deflation process is extremely severe, in which case it would increase leverage instead of deleveraging.

result holds even when the wage rigidity constraints bind. One could rationalize this result by observing that government policies are usually ineffective in stopping sudden stops.⁷ For the rest of the discussion in this subsection, I assume present borrowing constraint to be slack.

When there is a positive probability of a binding borrowing constraint in next period, the laissez-faire tradable consumption and debt levels are higher compared to the constrained-optimal levels. Inefficiency arises because private agents fail to internalize the benefit of higher future tradable consumption from relaxing future borrowing constraint. Higher tradable consumption relaxes borrowing constraint by boosting real household income. Let $\Psi(c_T, h) = \kappa [p_N(c_T, h)f(h) + y_T]$, and Ψ_T denotes the first derivatives of Ψ with respect to c_T . Then $\lambda_{CC}\Psi_T$ measures the marginal benefit of tradable consumption from relaxing the borrowing constraint.

borrowing constraint also depends on the level of employment. Denote Ψ_h as the first derivative of Ψ with respect to h . Then $\Psi_h < 0$ since $\xi < 1$. The model in Ottonello (2014) has a “unemployment-credit access trade-off” because $\Psi_h < 0$. However, this trade-off is absent in my model. In my model, Ψ_h is only a partial equilibrium effect, and it is dominated by a general equilibrium effect of opposite direction. More specifically, c_T must fall in order for unemployment to rise (see Proposition 1), so the general equilibrium effect of an extra unit of unemployment on the borrowing capacity is $\lambda_{CC}[-\Psi_h - \Psi_T \frac{dc_T}{dh}]$, which is less than or equal to

⁷Governments still try to stop or alleviate these deleveraging process despite they usually do not work. For example, the “fragile five” introduced various measures, including raising interest rates and capital controls, when international investors took capital out with the expectation of higher U.S. interest rates due to the Fed’s tapering of Q.E.

0.⁸ While in Ottonello's model, $\frac{dc_T}{dh} = 0$, therefore the impact of unemployment on borrowing constraint is $-\lambda_{CC}\Psi_h > 0$. The reason is that aggregate demand externality is absent from Ottonello (2014) since he assume flexible exchange rates which undo the nominal friction.

Finally, I consider the case that both constraints bind:

Proposition 3 (Dual Externalities) *When both constraints bind, laissez-faire equilibrium allocations c_T^{LF} and d^{LF} are lower than the constrained-optimal levels if*

$$\Phi_T - \beta(1+r)\mathbb{E}\Phi'_T > \beta(1+r)\mathbb{E}\left[\lambda'_{CC}\left(\Psi'_T + \Psi'_h\frac{dh'}{dc'_T}\right)\right], \quad (2.30)$$

and higher otherwise. (2.30) is evaluated at the constrained planner's allocations.

Proof When $\lambda_{CC} = 0$ and $\mathbb{E}\lambda'_{CC} > 0$, the constrained planner's Euler equation becomes

$$u_T + \Phi_T = \beta(1+r)\mathbb{E}\left[u'_T + \Phi'_T + \lambda'_{CC}\left(\Psi'_T + \Psi'_h\frac{dh'}{dc'_T}\right)\right]. \quad (2.31)$$

When (2.30) holds,

$$u_T^{CP} < \beta(1+r)\mathbb{E}u_T^{CP'}.$$

Compare (2.31) to the private agent's Euler equation (2.28), the constrained-optimal level of c_T must be higher than the laissez-faire level, so debt level must also be higher. When unemployment is positive, higher c_T also implies higher h . The opposite is true when the inequality of (2.30) holds in opposite direction. ■

⁸ $-\Psi_h - \Psi_T\frac{dc_T}{dh} = -\kappa\frac{1-a}{a}\left[\frac{c_T}{f(h)}\right]^{1/\xi}\frac{f'(h)}{\alpha} = -\frac{\kappa p_N f(h)}{h} < 0$.

Proposition 3 encapsulates the optimal trade-off between macroeconomic and financial stability. If the marginal welfare gains of better employment (by increasing c_T) outweighs the marginal welfare loss of higher financial stability risk (from the higher debt to finance c_T), then planner would increase consumption and borrow more relative to the laissez-faire economy. Otherwise the planner decreases consumption and borrow less.

The left hand side of equation (2.30) measures the marginal effect of c_T on welfare through its impact on unemployment. It could be either positive or negative: it is positive when present unemployment is more severe than expected future unemployment, and it is negative when expected future unemployment is more severe. When the marginal welfare effect is positive, there is a trade-off between macroeconomic and financial stability: higher c_T improves labor market but increases financial stability risk. When the marginal welfare effect is negative, there is no trade-off between macroeconomic and financial stability: higher c_T deteriorates both unemployment and financial stability.

The right hand side of equation (2.30) is the marginal welfare loss of c_T from deteriorating financial stability, and it consists of two terms since lower c'_T affects the borrowing capacity function $\Psi(c'_T, h')$ through both input arguments. The first term Ψ'_T is positive since higher c'_T bids up asset price. The second term $\Psi'_h \frac{dh'}{dc'_T}$ is negative when $c'_T < \widehat{c}'_T$, since lower c'_T lowers h' , which improves asset price. The

sum of the two terms can be written as

$$\Psi_T + \Psi_h \frac{dh}{dc_T} = \begin{cases} \frac{\kappa}{\xi} \frac{1-a}{a} \left[\frac{c_T}{f(h)} \right]^{\frac{1}{\xi}-1} & \text{when } c_T < \widehat{c}_T \\ \kappa \frac{1-a}{a} \left[\frac{c_T}{f(h)} \right]^{\frac{1}{\xi}-1} \left[\frac{1}{\alpha+\xi(1-\alpha)} \right] & \text{when } c_T \geq \widehat{c}_T. \end{cases} \quad (2.32)$$

Therefore, the pecuniary externality term $\mathbb{E} \left[\lambda'_{CC} \left(\Psi'_T + \Psi'_h \frac{dh'}{dc'_T} \right) \right] \geq 0$, and lower debt always leads to an improvement in financial stability. It is clear from the expressions in (2.32) that the pecuniary externality term is increasing in κ and decreasing in ξ .

2.3.3 Optimal Capital Inflow Tax

A capital inflow tax could be used to correct the constrained-inefficiencies by implementing the constrained optimal allocations in the laissez-faire economy. Letting τ be a tax charged on debt, then the Euler equation in a regulated decentralized equilibrium is:

$$u_T = (1+r)(1+\tau)\beta \mathbb{E}_t u'_T + (1+r)(1+\tau)\lambda^{CC}.$$

Proposition 4 (Optimal Capital Inflow Tax) *The constrained-optimal allocations can be implemented in the decentralized economy by imposing tax τ (subsidy if $\tau < 0$) on debt and rebating tax revenue back to households as lump sum transfer :*

$$\tau = \frac{\beta(1+r)\mathbb{E} \left[\Phi_T^{CP'} + \lambda_{CC}^{CP'} \Psi_T^{CP'} + \lambda_{CC}^{CP'} \Psi_h^{CP'} \frac{dh^{CP'}}{dc_T^{CP'}} \right] - \Phi_T^{CP}}{\beta(1+r)\mathbb{E} u_T^{CP'}}, \quad (2.33)$$

where (2.33) is evaluated at the constrained-optimal allocations.

Proof See Appendix A.2. ■

When present borrowing constraint is slack, the optimal capital inflow tax is non-zero and it corrects the constrained-inefficiencies in the laissez-faire equilibrium. When present borrowing constraint binds, the optimal capital inflow tax is zero as the constrained-optimal allocations are identical to the laissez-faire equilibrium.

τ can be broken down into three terms: τ^{AD} corrects for the aggregate demand externality; τ^{FS} corrects for the pecuniary externality; $\tau^{AD,FS}$ corrects for the interaction between the two externalities.

$$\tau^{AD} = \frac{\beta(1+r)\mathbb{E}\Phi_T^{CP'} - \Phi_T^{CP}}{\beta(1+r)\mathbb{E}u_T^{CP'}},$$

$$\tau^{FS} = \frac{\mathbb{E}[\lambda_{CC}^{CP'}\Psi_T^{CP'}]}{\mathbb{E}u_T^{CP'}},$$

$$\tau^{AD,FS} = \frac{\mathbb{E}\left[\lambda_{CC}^{CP'}\Psi_h^{CP'}\frac{dh^{CP'}}{dc_T^{CP'}}\right]}{\mathbb{E}u_T^{CP'}}.$$

If wage rigidity is the only source of friction in the model (e.g. Schmitt-Grohé and Uribe, 2013a), then the optimal capital inflow tax simplifies to τ^{AD} . If the price-dependent borrowing constraint is the only source of friction in the model (e.g. Korinek, 2010), then the optimal capital inflow tax simplifies to τ^{FS} .

τ^{AD} is counter-cyclical: it is negative when present unemployment is high and positive when the economy has full employment. In other words, it is a stimulative subsidy (to encourage capital inflows) during economic downturns, and it is a

prudential tax (to restrict capital inflows) during booms.

Since the size of Φ_T is increasing in γ and decreasing in ξ , a higher γ or a lower ξ implies a more volatile τ^{AD} . Intuitively, a higher γ and a lower ξ increase the marginal effect of tradable consumption on both employment and wage. Therefore, they require a larger prudential tax during booms and a larger stimulative subsidy during recessions to correct the aggregate demand externality.

τ^{FS} is prudential and it is acyclical. τ^{FS} is positive when the probability of a binding borrowing constraint in next period is positive, otherwise it is zero. The borrowing constraint in the next period is more likely to bind when debt level is higher. Therefore, τ^{FS} is a prudential policy to restrict capital inflows when debt is high. Moreover, since debt could increase during both booms and recessions, τ^{FS} is acyclical.⁹

The interaction term $\tau^{AD,FS}$ partially offsets the prudential tax τ^{FS} . A binding borrowing constraint usually leads to unemployment, so $\tau^{AD,FS} < 0$ when $\tau^{FS} > 0$. Then the sum $\tau^{FS} + \tau^{FS,AD} < \tau^{FS}$. By equation (2.32), $\tau^{FS} + \tau^{FS,AD} \geq 0$, and $\tau^{FS} + \tau^{FS,AD}$ is increasing in κ and decreasing in ξ . Intuitively, higher κ and lower ξ increases the marginal effect of tradable consumption on the borrowing capacity. Therefore, they require a larger prudential tax for correcting the pecuniary externality when debt level is high.

⁹ τ^{FS} could in fact be pro-cyclical. The borrowing constraint is more likely to bind when the economy is hit by an adverse shock in next period. Given the persistence of shocks, the risk of a future binding borrowing constraint is higher when the economy is hit by an adverse shock in the present period compared to a favorable shock (assuming they lead to the same debt level). Therefore, τ^{FS} is higher when the economy is hit by an adverse shock.

Finally, when there is a trade-off between macroeconomic and financial stability, the optimal policy is a prudential tax on inflows when financial stability is the dominant concern, and it is a stimulative subsidy on inflows (or a tax on outflow) when macroeconomic stability is the dominant concern.

2.4 Graphical Analysis

In this section, I first provide a graphical framework of the theoretical model. Then I use it to analyze the impacts of an inflow tax in a laissez-faire economy.

2.4.1 Graphical Framework: EE , WR and CC Curves

The graphical framework focuses on the decentralized partial equilibrium in a given period. A partial equilibrium consists of two endogenous variables h and c_t for given exogenous variables $\{d_{-1}, w_{-1}, \tau, r, y_T, c'_T, h'\}$. An equilibrium pair (h^*, c_T^*) is determined by the intersections of three curves, which are described below.

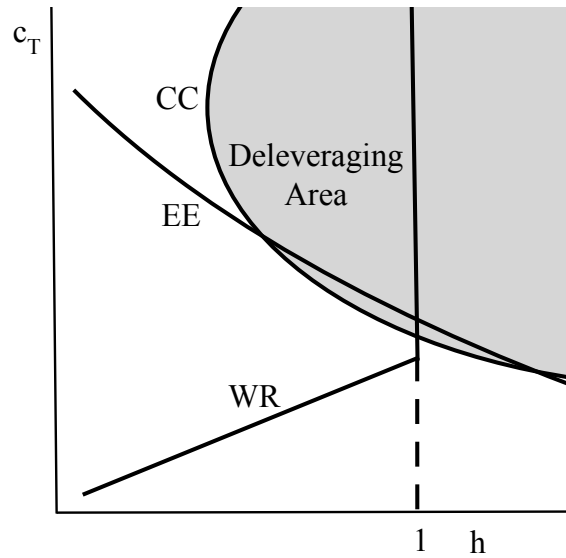
The first curve captures the inter-temporal optimality at equilibrium. Since it is derived from the Euler equation, I denote it as EE and define it below.

Definition 3 (EE Curve) *Given $\{r, \tau, c'_T, h'\}$, EE is the collection of all the positive employment-consumption bundles (h, c_T) that satisfy:*

$$(c_T)^{-1/\xi} [c(c_T, h^\alpha)]^{-\sigma+1/\xi} = \beta(1+r)(1+\tau)\mathbb{E} (c'_T)^{-1/\xi} [c(c'_T, f(h'))]^{-\sigma+1/\xi}. \quad (2.34)$$

It is clear from equation (2.34) that EE is downward-sloping as in Figure 2.1 for given $\{r, \tau, c'_T, h'\}$ under the assumption of equation 2.3. When the borrowing constraint is slack, equilibrium (h^*, c_T^*) lies on EE . When the borrowing constraint is binding, equilibrium (h^*, c_T^*) lies below EE . Therefore equilibrium (h^*, c_T^*) never lies above EE curve.

Figure 2.1: Graphical Framework: EE, WR and CC Curves



Note: EE is defined in Definition 3. WR is defined in Definition 4. CC is defined in Definition 5.

EE shifts toward the origin when r or τ increases, or when c'_T or h' decreases. Intuitively, households would like to consume more tomorrow and less today when domestic real interest rate is higher. And effective domestic gross real interest rate faced by the households is $(1+r)(1+\tau)$. Therefore today's aggregate demand goes down when r or τ increases, and lower aggregate demand is represented by an inward shift of EE .

The second curve captures the nominal friction in the model and it is derived from the wage rigidity constraint. So I denote the curve as WR and it is defined below:

Definition 4 (WR Curve) *Given w_{-1} , WR is the set of all the positive employment-consumption bundles (h, c_T) that satisfy*

$$h = \begin{cases} \left[\alpha \left(\frac{1-a}{a} \right) \left(\frac{1}{\gamma w_{-1}} \right) \right]^{\frac{\xi}{\xi - \alpha \xi + \alpha}} c_T^{\frac{1}{\xi - \alpha \xi + \alpha}} & \text{when } c_T \leq \hat{c}_T \\ 1 & \text{when } c_T \geq \hat{c}_T. \end{cases} \quad (2.35)$$

WR consists of two segments: an upward sloping segment when $c_T < \hat{c}_T$ and a vertical segment when $c_T \geq \hat{c}_T$. The wage rigidity constraint binds and there is involuntary unemployment on the upward sloping segment, while the wage rigidity constraint is slack and economy is in full employment on the vertical segment. See the Proof of Proposition 1 for a detailed derivation of equation (2.35).

The kink point $(\hat{c}_T, 1)$ and the upward sloping segment of WR would shift down if w_{-1} decreases. Intuitively, a lower γw_{-1} relaxes the downward wage rigidity, hence it should be easier for economy to reach full employment. That is, the minimum tradable consumption required to reach full employment must be lower. Thus, the kink point and the upward-sloping segment of WR are also lower.

The third curve in the graphical framework captures the financial friction. Since it is derived from the borrowing constraint, so I denote it as CC . It is defined below:

Definition 5 (CC Curve) Given $\{r, y_T, d_{-1}\}$, CC is the set of all the positive employment-consumption bundles (h, c_T) that satisfy

$$(1+r)(c_T - y_T + d_{-1}) = \kappa \left[y_T + \frac{1-a}{a} c_T^{1/\xi} (h^\alpha)^{1-1/\xi} \right]. \quad (2.36)$$

CC slices the (h, c_T) space into two regions. The borrowing constraint is not satisfied at allocations in the shaded area to the right of CC . In the shaded area, real household income is too low to secure the level of debt needed to finance consumption, so the household must deleverage.¹⁰ Henceforth I refer to the shaded area as the *deleveraging area*. The borrowing constraint is satisfied at equality on CC where real household income is just high enough to secure the debt $(1+r)(c_T - y_T + d_{-1})$. The borrowing constraint is slack to the left of CC where real household income is more than enough to secure the debt. Equation (2.36) is derived by substituting equations (2.6) and (2.13) into borrowing constraint (2.15) at equality.

CC is U -shaped with the opening facing to the right as illustrated in Figure 2.1. Denote the inflection point $(h^{inflect}, c_T^{inflect})$, they are given by

$$h^{inflect} = \left[\frac{\kappa(1-a)}{a\xi(1+r)} \right]^{\frac{\xi}{\alpha(1-\xi)}} (c_T^{inflect})^{\frac{1}{\alpha}},$$

and

$$c_T^{inflect} = \frac{(1+r)(y_T - d_{-1}) + \kappa y_T}{(1-\xi)(1+r)}.$$

¹⁰The statement depends on the assumption that $\xi < 1$. If $\xi > 1$, then the deleveraging area is the area to the left of CC .

The debt deflationary process is extremely severe on the upward sloping segment of CC since one unit reduction in c_T decreases borrowing capacity by more than it decreases debt.

Following the literature (see e.g. Korinek and Mendoza, 2014), I focus on the equilibrium space below $c_T^{inflect}$ by assuming moderate values for κ and ξ . As a result, the planner would not intervene during financial crisis and choose to go through the same deleveraging process as the households.

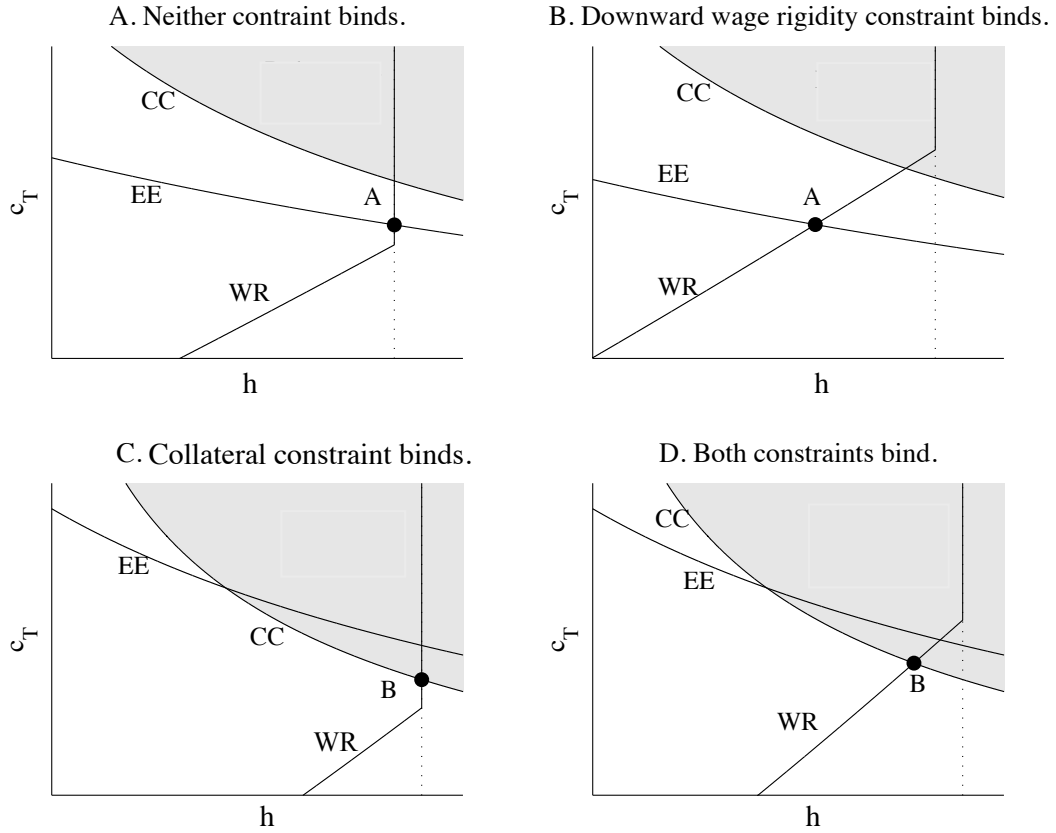
CC shifts toward the origin when d_{-1} or r increases, or when y_T decreases. Intuitively, the borrowing constraint must be binding at more sets of (h, c_T) when initial level of outstanding debt or real interest rate increases, or when real income that can be used to secure debt decreases. So the deleveraging area must expand and it follows that CC must shift toward the origin.

2.4.2 Determination of the Partial Equilibrium

The partial equilibrium is determined jointly by three curves. The intersection of EE and WR is an equilibrium point if it lies outside the deleveraging area. Otherwise, the intersection of WR and CC that lies below EE is the equilibrium point of the model. See Appendix A.3 for the proof of the existence and the uniqueness of the partial equilibrium.

Figure 2.2 shows four cases of equilibrium that differ by the set of constraints that bind. In panels A and B, the equilibrium is determined by the intersection of EE and WR , point A , since it lies outside the deleveraging area. The borrowing

Figure 2.2: Four Cases of Equilibrium



Note: The deleveraging area is indicated by the shaded area. Equilibrium is at point A in panels A and B. And equilibrium is at point B in panels C and D.

constraint is slack at the equilibrium in both panels. The downward wage rigidity is slack in Panel A since the equilibrium point lies on the full employment segment of WR , and the wage rigidity constraint binds in panel B, since point A lies on the involuntary segment of WR .

In panels C and D, point A is inside the deleveraging area. Therefore, the equilibrium is determined by the intersection of CC and WR that lies below EE , point B , and the borrowing constraint binds at the equilibrium in both panels. The wage rigidity constraint is slack in Panel C since point B lies on the full employment

segment of WR , and the wage rigidity constraint binds in Panel D since its point B is on the involuntary unemployment segment of WR .

2.4.3 Impacts of Capital Inflow Tax in a Laissez-faire Economy

Below I consider the introduction of an inflow tax in a laissez-faire economy and evaluate its static impact in the present period and the dynamic effect in subsequent period using the graphical framework laid out in the previous subsection.

Within-period Impacts of Capital Inflow Tax

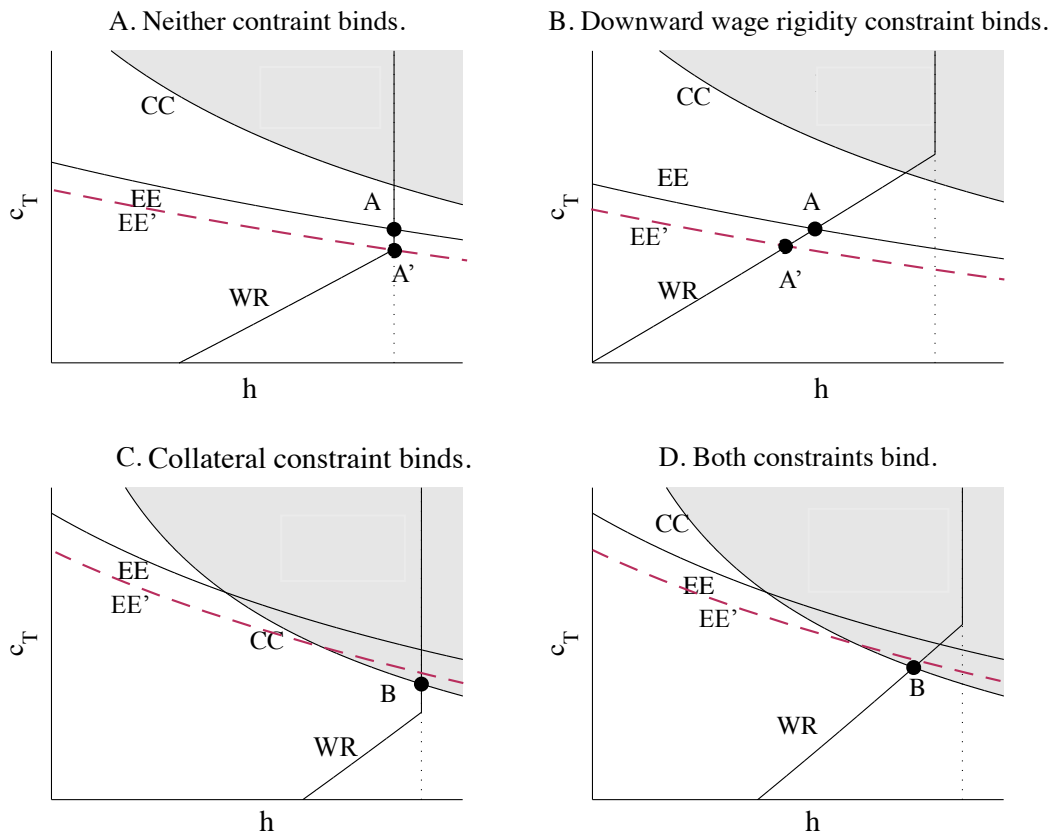
Figure 2.3 plots the impact of the introduction of a positive τ in laissez-faire economies. As in Figure 2.2, there are four cases of laissez-faire economies depending on the binding constraints. Let the solid lines represent curves in the laissez-faire economy.

A small inflow tax shifts EE out to EE' . When the borrowing constraint binds at the laissez-faire equilibrium (see panels C and D), a small outward shift of EE has no real impact. When the borrowing constraint is slack at the laissez-faire equilibrium (see panels A and B), the equilibrium moves from point A to A' . Therefore the inflow tax reduces c_T and hence d . And when the wage rigidity constraint binds (panel B), the inflow tax also reduces h . w decreases in panel A but not in panel B.¹¹

If a large inflow tax is introduced, then a slack wage rigidity constraint could

¹¹The inflow tax also has general equilibrium effect: a lower debt implies a higher c'_T , which partially offsets some of the inward shift in EE .

Figure 2.3: Impacts of A Small Capital Inflow Tax in Laissez-faire Economy



Note: The deleveraging area is indicated by shaded area. The solid lines represent a laissez-faire economy. The dash lines represent the impacts of the inflow tax. The superscript ' indicates the new equilibrium points under the inflow tax.

become binding, causing unemployment. Consider the full employment laissez-faire economies in panels A and C: a large inflow tax would cause a large downward shift in CC , moving decentralized economies from panel A to B, and from panel C to D.

To conclude, a small inflow tax decreases tradable consumption and debt levels when the borrowing constraint is slack at the laissez-faire equilibrium, it also decreases wage if the wage rigidity constraint is also slack at the laissez-faire equilibrium, and it increases unemployment when the wage rigidity binds at the laissez-faire

equilibrium. A large inflow tax tightens the wage rigidity constraint, and decreases tradable consumption, debt, real wage, and employment.

The inflow tax in the present period could have dynamic effects in next period through lower debt level and lower real wage, which I discuss below separately.

Impacts of Lower Initial Debt

Figure 2.4 shows the impact of a small decrease in d_{-1} in decentralized economies. Lower d_{-1} shifts CC outward to CC' . If the borrowing constraint is slack at initial equilibrium (panels A and B), there is no real impact. If the borrowing constraint binds at initial equilibrium (panels C and D), c_T increases since constrained households could borrow more. When the wage constraint also binds (panel D), h also increases because of the aggregate demand externality.¹²

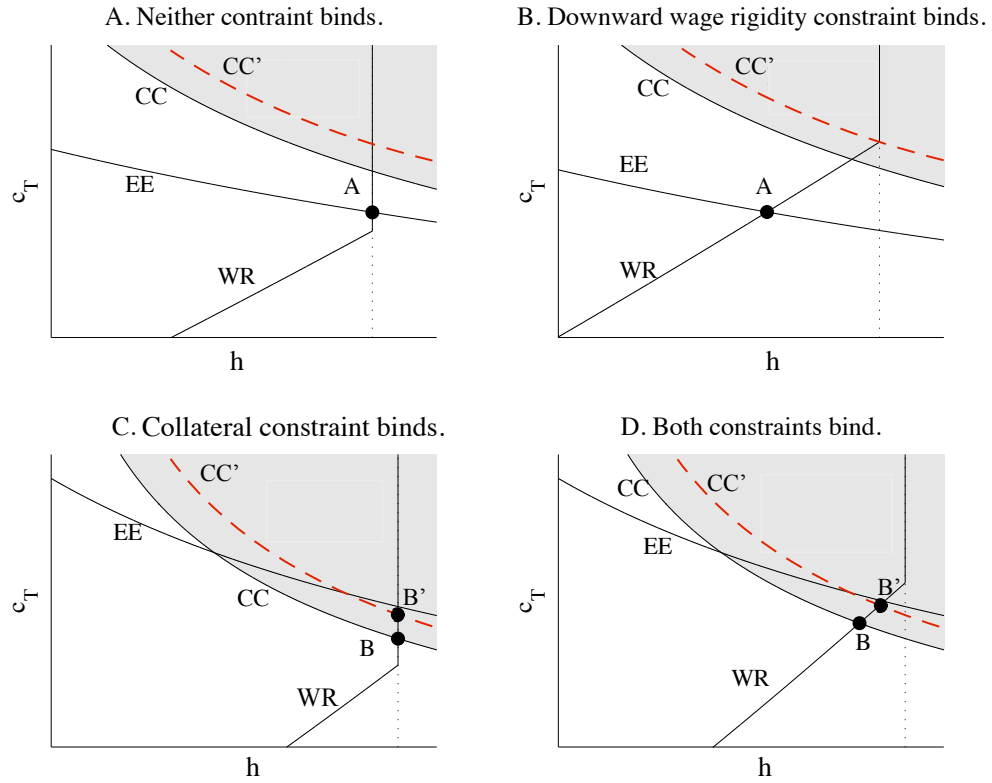
If the decrease in d_{-1} is large, then a binding borrowing constraint could become slack. Consider financially constrained economies in panels C and D, a large outward shift of CC move the economies from panel C to A, and from D to B, and the economy avoids financial crisis.

Impacts of Lower Initial Real Wage

Figure 2.5 shows the impact of a small decrease in w_{-1} in laissez-faire economies. Lower w_{-1} shifts WR down to WR' . If the economy has full employment at initial equilibrium panels A and C), there is no real impact. If the economy has unemploy-

¹²The smaller d_{-1} also have general equilibrium effect: c'_T should increase. Therefore EE shifts outward, leading to higher c_T in panel A and B, and higher h in panel B.

Figure 2.4: Comparative Statics: $d_{-1} \downarrow$



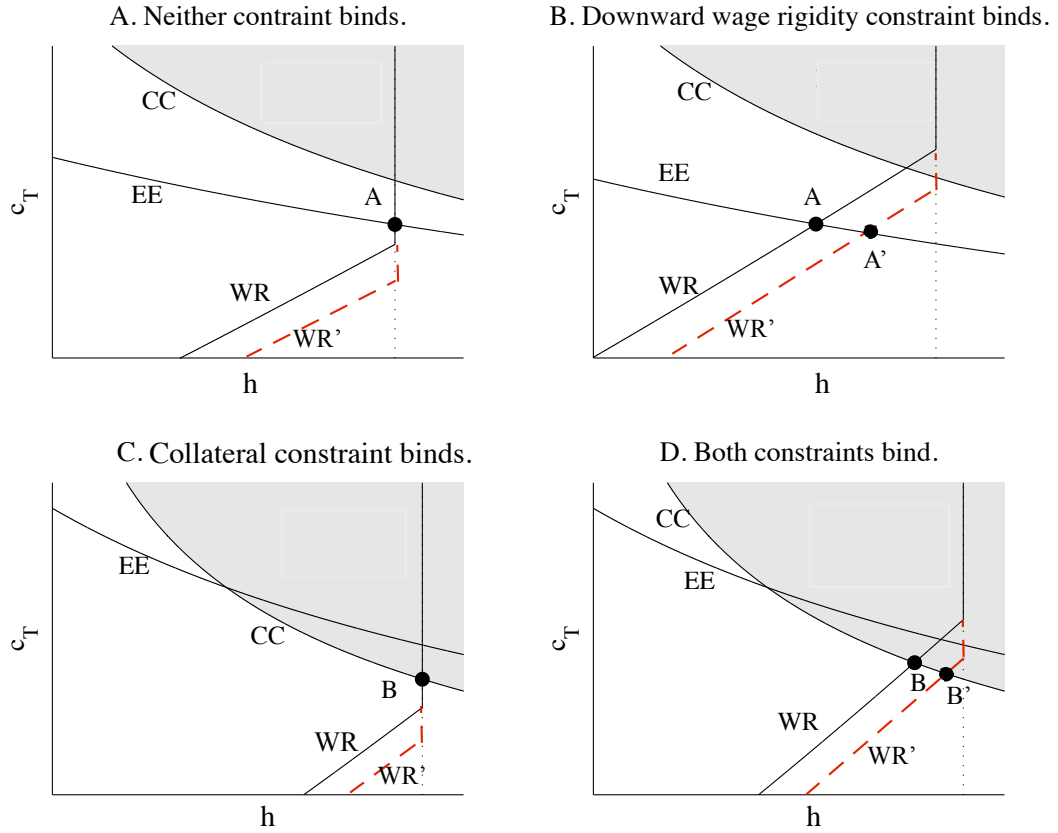
Note: The deleveraging area is indicated by the shaded area. The solid lines represent the initial economy. The dash lines represent the impacts of the lower d_{-1} . The superscript ' indicates the new equilibrium points.

ment at initial equilibrium (panels B and D), h increases and c_T decreases.¹³

If the decrease in w_{-1} is large, then a binding wage rigidity constraint could become slack. Consider economies with unemployment in panels B and D, a large downward shift of WR move the economies from panel B to A, and from D to C, where the economies would be in full employment at the new equilibrium.

¹³The lower w_{-1} also have general equilibrium effect in panel B: lower d increases c'_T , which shifts EE out, offsetting some of the decrease in c_T and increasing h by even more.

Figure 2.5: Comparative Statics: $w_{-1} \downarrow$



Note: The deleveraging area is indicated by the shaded area. The solid lines represent initial economy. The dash lines represent the impacts of the lower w_{-1} . The superscript ' indicates the new equilibrium points.

Dynamic Impacts of Capital Inflow Tax in a Laissez-faire Economy

Table 2.1 summarizes the impacts of the introduction of a small inflow tax on employment and borrowing constraint in the laissez-faire economies for different combinations of binding constraints. Table 2.1 omits the case of a binding borrowing constraint in the present period because a small inflow tax has no real impact in the laissez-faire economy.

The first row of Table 2.1 shows that an inflow tax improves either future

Table 2.1: Impacts of a (Small) Capital Inflow Tax on Employment and the borrowing constraint

		Next Period			
		CC' slack, WR' slack.	CC' slack, WR' binds.	CC' binds, WR' slack.	CC' binds, WR' binds.
Present Period	CC slack, WR slack.	No Impact.	$h' \uparrow$.	CC' relaxes.	CC' relaxes, $h' \uparrow$.
	CC slack, WR binds.	$h \downarrow$.	$h \downarrow$, $h' \uparrow$.	$h \downarrow$, CC' relaxes.	$h \downarrow$, CC' relaxes, $h' \uparrow$.

Note: WR denotes the wage rigidity constraint. CC denotes the borrowing constraint. h denotes employment. The superscript ' denotes the variables in next period. \uparrow denotes an increase in employment and \downarrow denotes a decrease in employment.

unemployment or financial stability or both in the laissez-faire economy when both constraints are slack in the present period and one of the constraint binds in the subsequent period. The second row of Table 2.1 shows the benefits of an inflow tax on future employment and financial stability persists, but at a cost of higher current unemployment. Therefore, an inflow tax is desirable when present unemployment is low. Since an inflow subsidy has the opposite effect as an inflow tax, an inflow subsidy is desirable when present unemployment is high.

2.5 Quantitative Analysis

This section solves the model presented in Section 2 numerically and quantifies the welfare improvements of capital flow management.

2.5.1 Parameter Calibration

I calibrate the model at annual frequency using Spain’s data from 1980-2013. Table 2.2 shows the benchmark calibration. The sample period starts in 1980 because of the data availability.¹⁴ More specifically, β and κ are calibrated so that net international investment position (NIIP) to GDP ratio and the frequency of sudden stops in simulated laissez-faire economy match with those moments from the Spanish data. Since the NIIP data are only available from 1992, I construct the NIIP from 1980-1991 using net flow data. The sample average NIIP-GDP ratio of Spain is -28%.¹⁵ Since NIIP equals to debt level in the model, the time discount factor β is calibrated to 0.92 so that the long-term average debt-GDP ratio in the simulated laissez-faire economy is 28%.¹⁶

Following Forbes and Warnock (2012), I define sudden stops as episodes with gross inflows exceeding one standard deviation, where gross inflows are the sum of net portfolio investment liabilities, other liabilities, and net foreign direct investment.¹⁷ The frequency of sudden stops is 6% during the sample period in Spain,

¹⁴See Table D.1 for data source.

¹⁵To focus on private liability, I exclude official loans from NIIP by deducting (net) “Other Investment, Liabilities, General Government (Excludes Exceptional Financing)”. The exclusion of official loans lowers NIIP significantly. The NIIP reported in IFS is -98.2% of GDP in 2013. After I exclude official loans, the number becomes -72% of GDP. See Figure D.1 in the appendix for a comparison of the reconstructed NIIP and reported NIIP. In reality, a large proportion of the increase in foreign liabilities during the financial crisis was in the form of official loans to the government. See Figure D.2 in the appendix for a comparison of household’s debt and public debt levels.

¹⁶Prior to 1998, the exchange rate regime of Spain could be not characterized as a fixed exchange rate during the entire sample period as the currency depreciated against Deutsch Mark numerous times (see Bacchetta 1997). Fortunately, the long-term average debt-GDP ratio in the simulated laissez-faire economy with the benchmark calibration when the wage rigidity is dropped (equivalent to having an optimal flexible exchange rate) is also about 28%.

¹⁷Since Forbes and Warnock (2012) use quarterly data, they use the two standard deviation cut-off line. In contrast, I use annual data, so I lower the cutoff line to one standard deviation like

Table 2.2: Baseline Parameter Calibration

Parameter	Value	Description
β	0.92	Discount factor
ξ	0.83	Intra-temporal Elasticity of substitution
κ	0.32	Share of income that is used to secure debt
γ	0.96	Degree of downward wage rigidity
σ	2	Inverse of inter-temporal elasticity of consumption
α	0.75	Labor share in the non-tradable goods sector
a	0.31	Share of tradable

Note: Parameters are calibrated to Spain's data at annual frequency.

which is similar to the average level found in a panel study by Eichengreen et al. (2006).¹⁸ κ is calibrated to 0.32 so the frequency of sudden stops is also 6% in the simulated laissez-faire economy.

ξ and γ are calibrated to the values found in empirical literature. Empirical literature finds ξ to be between 0.40 and 0.83.¹⁹ Since a lower ξ implies a more severe debt-deflationary process, I set ξ at the upper bound 0.83 as a conservative estimate of debt deflationary process. Schmitt-Grohé and Uribe (2013a) find γ to be between 0.99 and 1.02 using quarterly data from Argentina and Europe. I use the lower bound 0.99 as a conservative estimate of the wage rigidity. Since my model has annual frequency, then γ is set to 0.96.

The rest of parameter calibration are all standard in the small open economy in Eichengreen et al. (2006).

¹⁸I find two episodes of sudden stops in the Spanish data: one during the Mexico Peso crisis of 1994 (also known as the Tequila crisis) and the other during the height of the Euro crisis of 2010. Using a panel dataset of 24 emerging economies spanning from 1980-2003, Eichengreen et al. (2006) find the average frequency of sudden stops to be 5.5%.

¹⁹See Mendoza (2006), Martin Gonzalez-Rozada and Andres Neumeyer (2003) and Alan Stockman and Linda Tesar (1995)

DSGE literature: the inter-temporal elasticity of substitution is set to be 0.5 with $\sigma = 2$; the share of labor input α is 0.75; and a is set at 0.31 so the share of tradable consumption is about one third of aggregate consumption.

The model has two sources of exogenous shocks: a tradable endowment y_t^T and a country-specific interest rate r_t . I assume that shocks (y_t^T, r_t) follow a bivariate AR(1) process. Estimating the AR(1) process using Spain's annual data from 1980-2013, I find the coefficients to be:

$$\begin{bmatrix} \ln y_t^T \\ \ln \frac{1+r_t}{1+r} \end{bmatrix} = \begin{bmatrix} 0.66 & -0.22 \\ -0.03 & 0.90 \end{bmatrix} \begin{bmatrix} \ln y_{t-1}^T \\ \ln \frac{1+r_{t-1}}{1+r} \end{bmatrix} + u_t \quad (2.37)$$

where $r = 0.048$, and u_t is a random variable vector of 2 by 1 with normal distribution $N(\emptyset, \Sigma_u)$,

$$\Sigma_u = \begin{bmatrix} 0.000855 & -0.000007 \\ -0.000007 & 0.000132 \end{bmatrix}. \quad (2.38)$$

The unconditional standard deviations of $\ln(y_t^T)$ and r_t are 4.93 percent and 3.05 percent respectively.²⁰

I approximate the bivariate AR(1) process using a discrete method. I first generate the AR(1) process for 50 million consecutive periods using my estimated coefficients. Then I discretize the (continuous) realized shocks space with three grid points for y^T and three grid points for r .²¹ Last, I compute the transition

²⁰The tradable GDP is computed as the sum of the value added in the tradable sectors. The definition tradable sector is standard. The tradable sector includes: industry excluding building and construction and agriculture, forestry and fishery. The real interest rate time series is computed as the difference between annualized interest rate on the 10 government bond and the inflation rate computed from the euro area's GDP deflator.

²¹In each dimension, one grid point is at the unconditional mean, a second point is 1.5 un-

probabilities of going from one state (one combination of grid points) to the other. I find the discretized (Markov) shock process closely resemble the bivariate AR(1) process.²²

The dynamic stochastic model must be solved using a global method because of the non-linearities in decision rules and value functions caused by the inequality constraints—the borrowing constraint and the wage rigidity constraint. The constrained-optimal allocations are solved using value function iteration while the laissez-faire allocations are solved using policy function iteration. The value function and the policy functions are defined over a discrete state-space of four state variables (w_{-1}, d_{-1}, y_T, r) . Appendix B provides a detailed description of solution methods.²³

Means and Standard Deviations

To see the dynamic impacts of optimal capital flow management, I simulate both a laissez-faire economy and the economy with optimal capital flow management for 1000,000 periods. The laissez-faire economy is simulated using the laissez-faire

conditional standard deviation above the mean, and a third point is 1.5 unconditional standard deviation below the mean. There should be 9 states because there are 3 grid points in each dimension. However, some state is almost never realized. Therefore, I reduce the 9 states to 7 states by eliminating the states with the stationary probability smaller than 1%. The states that are dropped are not the "Black Swan" events that would have catastrophic or extraordinary impacts once realized. They are the pairs of a favorable y_T (or r) shock combined with an adverse r (or y_T) shock. *Neither* the most adverse shocks or the most favorable shocks is dropped.

²²I also approximate the bivariate AR(1) process using Tauchen's method (86) and it produces similar results.

²³The lower and upper bounds of w_{-1} and d_{-1} are set so all the simulated w and d are well above the lower bounds and well below the upper bounds. I use 600 grid points for state variable d_{-1} , 60 grid points for state variable w_{-1} , and 7 grid points for the shock process (y_T, r) . More grid points are allocated to d_{-1} than w_{-1} because the non-linearity in value functions and the policy functions are found to be more severe in d_{-1} .

decision rules solved in Appendix B.2. The economy with optimal capital flow management is simulated using the decision rules solved from the constrained planner's problem (see Appendix B.1). Table 2.3 reports the simulated means and standard deviations of some key economic variables.

Table 2.3: Means and Standard Deviations

	Laissez-faire	Optimal τ
Aggregate Consumption	0.98 (0.04)	0.99 (0.02)
Unemployment Rate (%)	1.96 (4.62)	0.07 (0.64)
Tradable Consumption	0.96 (0.07)	0.96 (0.05)
Real Wage	1.62 (0.11)	1.60 (0.10)
Current Account	0.00 (0.05)	0.00 (0.02)
Trade Balance	0.04 (0.05)	0.04 (0.03)
Outstanding Debt	0.93 (0.05)	0.81 (0.04)
GDP	3.12 (0.22)	3.13 (0.17)
Real Exchange Rate	2.15 (0.15)	2.13 (0.13)
Capital Inflow Tax (%)	0.00 (0.00)	3.63 (2.98)

Note: Standard deviations are reported in the parenthesis. Optimal τ refers to the economy with optimal capital flow management. Means and standard deviations are computed using the simulated data.

Table 2.3 shows that optimal capital flow management significantly reduces average unemployment rate, increases average aggregate consumption, and decreases the volatilities in both unemployment rate and aggregate consumption. Average unemployment rate is almost 2 percentage points lower under optimal capital flow management τ compared to the level in the laissez-faire economy, and average aggregate consumption is 1% higher. The lower average unemployment rate implies higher average non-tradable consumption, which contributes to the higher aggregate

consumption under the optimal τ .

Table 2.3 also shows that optimal capital flow management stabilizes capital flows. The volatility of current account under optimal τ is less than half the level in laissez-faire economy. The lower volatility in current account is consistent with the lower volatilities in trade balance and debt. These results are in stark contrast to the ones found by Schmitt-Grohé and Uribe (2013a). They find optimal capital flow management to induce higher volatilities in capital flows, tradable balance, and debt compared to the laissez-faire economy. My results differ from theirs because of the additional financial friction—the borrowing constraint. Without borrowing constraint, the planner would encourage a large capital inflow to increase aggregate consumption and reduce unemployment during economic downturns. However, when households are subject to a borrowing constraint, a large inflow increases the probability of a binding borrowing constraint in next period and increases financial stability risk. In other words, the existence of financial stability risk restrains the planner’s use of current account to boost aggregate demand and reduce unemployment.

The average optimal capital flow management is an inflow tax of 3.63%, which lowers average debt level by 3% of GDP. However, τ is not always positive. In particular, τ is negative—a stimulative inflow subsidy or outflow tax—when unemployment rate is high. The stimulative inflow subsidy or outflow tax in the simulation has an average rate of 1.76%, and it happens 12% of the time.²⁴

²⁴When the borrowing constraint binds, τ is zero.

2.5.2 Correlations with GDP

Table 2.4 reports the simulated correlations between GDP and key economic variables along with the observed correlations from the Spanish data. Spain can be characterized as a laissez-faire economy. The simulated correlations of laissez-faire model are similar to the observed counterparts in the Spanish data. Therefore, the model accounts for the observed business cycle moments in Spain reasonably well.

Table 2.4: Correlation with GDP

	Model Laissez-faire	Model Optimal τ	Data Spain
Aggregate Consumption	0.86	0.97	0.92
Unemployment Rate	-0.60	-0.21	-0.83
Trade Balance-GDP	-0.72	-0.34	-0.77
Current Account-GDP	-0.51	0.22	-0.78

Note: Correlations are computed from the simulated data and from the observed Spanish data respectively.

Table 2.4 reveals that the laissez-faire economy suffers from pro-cyclical unemployment and pro-cyclical capital flows. Optimal capital flow management reduces these pro-cyclicalities by leaning against wind. The negative correlations between unemployment and GDP and between current account (as a percent of GDP) and GDP imply that unemployment rate rises and capital inflows drops during economic downturns, both of which amplify boom and bust cycle's fluctuations. Under optimal τ , unemployment becomes less pro-cyclical and it falls by a lesser degree during economic downturns, and capital inflows become counter-cyclical—inflows increase

during economic downturns, both of which help to smooth out boom and bust cycles. These changes are all due to the counter-cyclical nature of optimal capital flow management τ increases when GDP increases, and it decreases when r increases. The correlation between τ and r is -0.8 (not reported in Table 2.4).

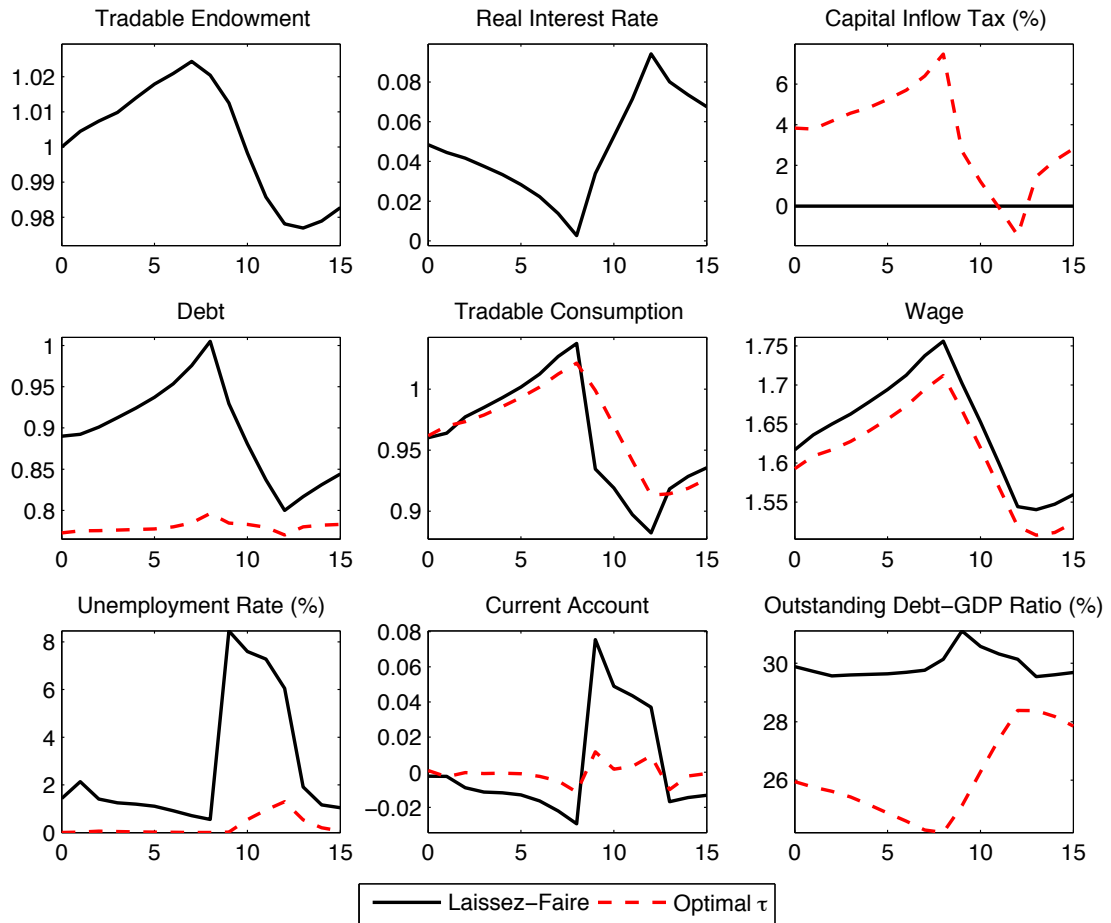
2.5.3 Boom and Bust Cycle

To see how counter-cyclical capital controls stabilize economy over time, Figure 2.6 plots some key economic variables through a typical boom and bust cycle in the model simulation. The variables plotted are computed by taking the average over all the boom and bust cycles that satisfy the following criteria: both shocks are at their mean values in period 0; r is 1.5 standard deviations below its mean in period 8 and 1.5 standard deviations above its mean in period 12; y_T is equal to or above its mean in period 8 and equal to or below its mean in period 12. This definition of a boom and bust cycle aims to capture a long period of cheap credit followed by a sudden rise in the cost of borrowing.

Figure 2.6 shows that the cheap credits during boom leads to capital inflows and a rapid build-up of debt in the laissez-faire economy. The capital inflows finance an expansion of tradable consumption, which pushes up real wage during a boom.²⁵ Once the cost of borrowing increases, capital inflows come to a sudden stop. Households are forced to go through a deleveraging process by cutting back consumption. The contraction in aggregate demand increases unemployment rate

²⁵Despite of the rising wage, unemployment rate is positive during boom. This is because the graphs are plotted from the averages of 4000 unique boom and bust cycles. As long as one of the 4000 boom and bust cycles has a boom period with a binding wage rigidity constraint, the average unemployment would be positive despite the wage rigidity constraint being slack on average.

Figure 2.6: Boom and Bust Cycle



Note: The variables in the figure are computed by taking the average over all the boom and bust cycles that satisfy the following criteria: both shocks are at their mean values in period 0; r is 1.5 standard deviations below its mean in period 8 and 1.5 standard deviations above its mean in period 12; y_T is equal to or above its mean in period 8 and equal to or below its mean in period 12.

because wage could not fall fast enough. Moreover, the high real wage set during boom causes the unemployment rate to rise even further.

Under optimal capital flow management, capital inflows are restricted during booms, so the level of debt does not increase. Tradable consumption still expands but by less compared to the laissez-faire economy. As a result, the rise in real wage is more moderate. When the cost of borrowing increases, the optimal policy leans

against wind—a stimulative inflow subsidy is introduced to encourage inflows. Unlike the laissez-faire case, the economy with optimal capital flow management does not experience a sudden stop in capital inflows because debt is kept relatively low. As a result, the contraction in consumption is smaller, alleviating unemployment

Figure 2.6 also illustrates the trade-off between macroeconomic and financial stability. During bust, despite unemployment rate is positive, the planner stops employing stimulative policy once outstanding debt is above 28% of GDP, and imposes a prudential tax instead. If the planner had continued with stimulative policy, unemployment rate would have been even lower, but debt would have risen to a risky level. So the planner switched from a stimulative policy to a prudential one when financial stability concern dominates unemployment concern.

2.5.4 Frequency and Severity of Sudden Stops

Table 2.5 reports the frequency and severity of sudden stops in the model simulations. I consider sudden stops because they are the episodes of severe financial crises. Following the standard definition in literature (see e.g. Bianchi, 2012), a sudden stop episode is defined as one with a binding borrowing constraint and a current account reversal that is greater than one standard deviation.

Sudden stops are rare events: they happen 6% of the time in the laissez-faire economy, and they almost never happen under optimal capital flow management. Once a sudden stop happens, the cost of welfare is equally high in both laissez-faire economy and under optimal capital flow management: aggregate consumption drops

Table 2.5: First Moments During Sudden Stops

	Laissez-faire	Optimal τ
Sudden Stops Frequency (%)	5.96	0.07
Aggregate Consumption	0.86	0.87
Unemployment Rate (%)	15.15	13.09
Current Account	0.11	0.09
Trade Balance	0.14	0.13

Note: The moments are computed using the simulated data.

by 12%, and unemployment rates increase by 13%. Therefore, most of the welfare gains from better financial stability under capital flow management comes from the lower frequency of severe financial crises such as sudden stops.

2.5.5 Unemployment and Binding Borrowing Constraint

Table 2.6 reports the simulated joint probability distributions of unemployment and the risk of a binding borrowing constraint in the next period. I define a period to have the risk of a binding borrowing constraint if borrowing constraint binds when the economy is hit by the worst possible shock in next period. So the first cell 24.3% means that the laissez-faire economy spends 24.3% of the time in the states with some unemployment in current period and a positive probability of binding borrowing constraint in next period. Then one can compute the frequency of unemployment by summing up the numbers in the first row, and compute the frequency of having financial stability risk by summing up the numbers in the first column.

Table 2.6: Joint Probability Distribution

Laissez-faire		
	$E\lambda_{CC}^{LF'} > 0$	$E\lambda_{CC}^{LF'} = 0$
Unemployment	24.3%	7.0%
Full Employment	60.7%	8.0%
Optimal τ		
	$E\lambda_{CC}^{CSP'} > 0$	$E\lambda_{CC}^{CSP'} = 0$
Unemployment	2.4%	0.2%
Full Employment	5.9%	91.5%

Note: Conditional probabilities computed using the simulated data are reported in this table. A period is defined to have risk of a binding borrowing constraint if the borrowing constraint binds when the economy is hit by the worst possible shock in subsequent period, that is $E\lambda'_{CC} > 0$.

Table 2.6 shows that optimal capital flow management significantly reduces the frequency of unemployment and the frequency of having a positive probability of binding borrowing constraint in next period. The frequency of unemployment decreases from 31% in the laissez-faire economy to only 3% under the optimal capital flow management. In addition, the frequency of having a positive probability of binding borrowing constraint decreases from 85% to only 8%. Moreover, the laissez-faire economy spends only 8% of time in the best states of nature—with full employment and no financial stability risk – and the frequency increases to 91.5% under the optimal capital flow management.

Table 2.6 also shows that the trade-off between macroeconomic and financial stability is relevant in the model. The laissez-faire economy spends a quarter of the time in the states with both financial stability risk and unemployment. In these

states, an inflow tax reduces financial stability risk at the cost of higher unemployment.

2.5.6 Decomposition of Optimal Tax

Table 2.7 shows the decomposition of the optimal tax. The means (the first row in the table) reveal that τ is mostly determined by τ^{AD} . The reason is that τ^{FS} and $\tau^{AD,FS}$ are zero most of the time. τ^{FS} is nonzero only when the probability of a binding borrowing constraint is positive ($E\lambda_{CC}^{CP'} > 0$), which happens about 6.5% of the time. τ^{FS} is nonzero only when the probability of a binding borrowing constraint together with unemployment is positive ($E\lambda_{CC}^{CP'} \mathbb{1}_{h' < \bar{h}} > 0$), which happens 5.3% of the time.

Table 2.7: Optimal Tax and its Components (%)

	τ	τ^{AD}	τ^{FS}	$\tau^{AD,FS}$
Mean	3.6	3.1	0.7	-0.2
Min	-12.9	-45.8	0.0	-22.2
Max	3.6	9.8	68.8	0.0
Conditional Mean	1.7	-6.3	11.8	-3.8

Note: The moments are computed using the simulated data. The row reports conditional means when $\tau^{AD,FS} < 0$. See Appendix B.3 for detail on how to compute these numbers.

However, during 5.3% of the time when $\tau^{AD,FS}$ is different from zero, $\tau^{AD,FS}$ is twice as large as τ in magnitude, and they have the opposite signs. The last row reports the conditional means when $\tau^{AD,FS} \neq 0$. The conditional means reveal that the economy is suffering from both insufficient aggregate demand (as indicated by the large and negative τ^{AD}) and severe financial risk (as indicated by the large and

positive τ^{FS}) when $\tau^{AD,FS} \neq 0$. Overall, the optimal tax is still positive because the financial risk concern dominates aggregate demand concern.

The interaction component, $\tau^{AD,FS}$, is negative because less deleveraging is required when there is unemployment in the period of financial crisis. When there is no unemployment in the period of financial crisis, the real exchange rate depreciation and hence the debt-deflation process is caused by the decline of c'_T only. When there is unemployment in the period of financial crisis, the real exchange rate still depreciates because of the decline of c'_T , but the real depreciation and hence the debt-deflation process is alleviated thanks to the decline of c'_N . So there is less need to limit the decline of c'_T by reducing debt level with inflow tax. Therefore, the optimal tax is smaller when the unemployment is larger in the period of financial crisis, and hence $\tau^{AD,FS}$ is negative.

2.5.7 Welfare Analysis of Capital Flow Management

Optimal capital flow management requires frequent policy adjustments to shocks. However, frequent policy changes are unrealistic given political constraints (see Eichengreen and Rose, 2014). Therefore, I consider two simple capital control rules. The first (simple rule A) is a flat inflow tax of 4%. The second (simple rule B) is contingent on unemployment rate: a 4% inflow tax if unemployment rate is below 2%; and no tax otherwise. The 4% inflow tax rate is the average tax rate imposed under optimal capital flow management when $\tau > 0$. The flat tax could be rationalized as a prudential tax aimed to improve financial stability. Simple rule B

differs from A by taking employment into account.

To quantify the welfare gains of capital flow management, I follow DSGE literature by computing the percentage increases in permanent consumption when capital controls are introduced in the laissez-faire economy. Permanent consumption is defined below as a function of the state variables:

$$C_{Perm}^i(d_{-1}, w_{-1}, y_T, r) = [(1 - \beta)(1 - \sigma)V^i(d_{-1}, w_{-1}, y_T, r) + 1]^{\frac{1}{1-\sigma}}$$

where i denotes regime type, which can be laissez-faire (LF), optimal capital flow management, simple rule A, or simple rule B. $V^i(d_{-1}, w_{-1}, y_T, r)$ is the value function of representative household under regime i . Thus, the percentage increases in permanent consumption when the capital control τ_i introduced in the laissez-faire economy is

$$\Delta C_{Perm}^{\tau_i}(d_{-1}, w_{-1}, y_T, r) = \frac{C_{Perm}^{\tau_i}(d_{-1}, w_{-1}, y_T, r)}{C_{Perm}^{LF}(d_{-1}, w_{-1}, y_T, r)} - 1. \quad (2.39)$$

Capital flow management leads to significant welfare improvement. Table 2.8 reports the minimum, maximum, and weighted averages of permanent consumption increase at the non-zero-measure states of laissez-faire economy's ergodic distribution for different capital control rules. The weighted average is computed by weighing permanent consumption increase by the ergodic density of each state. The optimal (state-contingent) capital controls increase permanent consumption by close to 1% on average. The simple rules are also effective, increasing permanent consumption by 0.5% on average.

Table 2.8: Welfare Gains of Capital Flow Management

	Optimal τ	Simple Rule A	Simple Rule B
Weighted Average	0.91	0.43	0.53
Minimum	0.66	-0.43	0.13
Maximum	1.31	0.73	0.77

Note: All numbers are in percentage of permanent consumption increase and they are computed from the simulated data. Welfare improvements are computed using equation (2.39).

Table 2.8 also shows the importance of taking both macroeconomic and financial stability into account. Simple rule B outperforms simple rule A. Moreover, simple rule A decreases permanent consumption in the worst scenario—the minimum welfare gain is negative. The reason is that simple rule A only takes financial stability into account: prudential inflow tax increases unemployment during economic crises, and the loss of higher unemployment exceeds the gains of lower financial stability risk, so welfare is lower compared to the level in the laissez-faire economy. On the contrary, simple rule B always increases welfare because it takes both macroeconomic and financial stability into account.

2.5.8 Sensitivity Analysis

This subsection investigates how sensitive the numerical results presented in this section are to alternative parameter calibration. In particular, I focus on three key parameters that affect aggregate demand externality and pecuniary external-

ity: γ , κ , and ξ . The size of aggregate demand externality is increasing in γ and decreasing in ξ , and the pecuniary externality is increasing in κ and decreasing in ξ . Though κ increases the size of pecuniary externality when borrowing constraint binds, it also makes the borrowing constraint less likely to bind. Therefore, the overall effect of κ on welfare could be ambiguous.

Recall the baseline model is calibrated to the empirical lower bound of γ and the empirical upper bound of ξ , so I consider a higher γ of 0.98 and a lower ξ of 0.70 as alternative calibration. In addition, I consider a higher κ of 0.34 so all three parameter changes would increase the size of externalities. To isolate the impact of each parameter, I change one parameter at a time and keep the rest unchanged.

Table 3.7 presents the numerical results of alternative parameter calibration. The average welfare improvement of optimal capital flow management becomes higher under each alternative calibration compared to the baseline results, all because of larger externalities as predicted. More specifically, higher γ and lower ξ increase aggregate demand externality, as evident in the higher and more volatile unemployment rate in the laissez-faire economy compared to the baseline results. In addition, higher κ and lower ξ increase the pecuniary externality, so consumption contraction and unemployment rise in the laissez-faire economy during sudden stops are 1% higher than those in the baseline results.

Moreover, Table 3.7 shows that average optimal capital inflow tax is higher and it requires larger adjustments to shocks (higher volatility) when γ is higher and when ξ is lower.

Table 2.9: Numerical Results: Alternative Parameter Calibration

	$\gamma = 0.98$		$\kappa = 0.34$		$\xi = 0.70$	
	Laissez-Faire	Optimal τ	Laissez-Faire	Optimal τ	Laissez-Faire	Optimal τ
Means and Standard Deviations						
Unemployment Rate (%)	3.24 (5.39)	0.13 (0.91)	2.01 (4.81)	0.07 (0.66)	2.30 (4.91)	0.08 (0.70)
Aggregate Consumption	0.97 (0.05)	0.99 (0.02)	0.98 (0.05)	0.99 (0.02)	0.97 (0.05)	0.99 (0.02)
Outstanding Debt	0.93 (0.05)	0.73 (0.09)	0.98 (0.05)	0.86 (0.04)	0.92 (0.05)	0.78 (0.05)
Current Account	0.00 (0.04)	0.00 (0.03)	0.00 (0.05)	0.00 (0.02)	0.00 (0.04)	0.00 (0.03)
Capital Inflow Tax (%)		3.69 (3.24)		3.62 (3.02)		3.65 (3.10)
Sudden Stops						
Sudden Stop Frequency	5.6%	0.1%	5.3%	0.1%	5.1%	0.1%
Avg. Aggregate Consumption	0.85	0.86	0.85	0.85	0.85	0.86
Avg. Unemployment Rate (%)	17.77	13.91	16.09	14.71	16.68	13.87
Avg. Current Account	0.11	0.10	0.12	0.11	0.11	0.10
Avg. Trade Balance	0.14	0.14	0.15	0.15	0.14	0.14
Welfare Improvement						
Weighted Average		1.29%		0.95%		1.03%
Minimum		0.85%		0.68%		0.73%
Maximum		2.22%		1.37%		1.52%

Note: Standard deviations are reported in the parenthesis. Welfare improvements are in percentage of permanent consumption increase, and defined in (2.39).

2.6 Conclusion

This chapter conducts a normative analysis of optimal capital flow management in a small open economy with both financial and nominal frictions. The laissez-faire economy suffers from frequent financial crises and high unemployment because of the aggregate demand and pecuniary externalities. I show that the size of the aggregate demand externality is increasing in the wage rigidity parameter (γ), and decreasing in the intra-temporal elasticity of substitution between tradable and non-tradable goods (ξ). In addition, I show that the pecuniary externality is increasing in the share of income that can be used to secure debt (κ), and decreasing in the intra-temporal elasticity of substitution between tradable and non-tradable goods (ξ).

I provide an explicit solution to optimal capital flow management problem in the form of a tax on international capital inflows. I show that the optimal policy can be broken down into three components: one corrects the aggregate demand externality, the second corrects the pecuniary externality, and the third accounts for the interaction of both externalities. The first component is counter-cyclical: it is a prudential tax (to restrict capital inflows) when the economy has full employment; it is a stimulative subsidy (or tax on outflows to restrict capital outflows) when the economy has unemployment. The second and third components combined represent a prudential tax when the probability of a binding borrowing constraint is positive.

By calibrating the model to the Spanish economy, I show that capital flow management could lead to significant welfare improvements in the laissez-faire economy

by reducing both the frequency of financial crises as well as the level and the volatility of unemployment rate. In addition, I show that simple inflow tax rules that take into account both financial and macroeconomic stability could lead to significant welfare improvements in the laissez-faire economy.

Although this chapter focuses on optimal capital flow management, its results have implications that are applicable to the design of other financial regulations, for example capital requirements for banks and loan-to-value ratio or debt-income ratio on household mortgages. The bulk of the current discussion on financial regulations has focused on their roles in reducing financial stability risk (prudential role). However, financial regulations could lead to unintended macroeconomic instability if they only focus on financial stability. I argue that countries could use independent and effective monetary policies to correct for these unintended macroeconomic consequences. However, if the countries do not have independent monetary policies at their disposal (e.g. the euro area member states) or if they are in a liquidity trap, then regulators must take into account the impact of financial regulations on macroeconomics stability when making policies. Therefore, the analyses on the optimal capital flow management with dual objectives presented in this chapter could be relevant and useful for designing other types of financial regulations.

Chapter 3: Capital Flow Deflection: Multilateral Effects of Capital Flow Management

3.1 Introduction

What type of multilateral institutions do countries need to govern international capital flows? As the size and volatility of capital flows, namely to developing countries, have largely increased in recent years (see Figure 1.1), this question has raised the interest of both academic economists and policymakers. The ensuing debate has led the IMF to review its position on the liberalization and management of capital flows and to provide a set of recommendations to help countries deal with these flows. Part of this new institutional view is the emphasis on the need for international agreements to coordinate or set the appropriate standards for policy intervention. However, as recognized by the IMF, “much further work remains to be done to improve policy coordination in the financial sector” (IMF, 2012, page 28).

⁰This chapter is adapted from the paper titled “Capital Flow Deflection” that I co-authored with Paolo E. Giordani (LUISS “Guido Carli” University), Michele Ruta (the World Bank), and Hans Weisfeld (the IMF). We would like to thank Tam Bayoumi, Chad Bown, Arnaud Costinot, Martin Kaufman, Lance Kent, Anton Korinek, David Romer, Kamal Saggi, Sarah Sanya, Robert Staiger and seminar participants at the University of Maryland, the University of Groningen, George Mason University, Vanderbilt University, Stanford University, and the International Monetary Fund for helpful comments and suggestions. The views expressed in this chapter are those of the authors and do not necessarily reflect those of the IMF or the World Bank.

The trade policy literature can be useful to macroeconomists interested in international policy coordination. From a methodological point of view, this literature has shown that multilateral institutions are effective when they provide a framework to address relevant cross-border spillovers related to countries' unilateral policies. In particular, Bagwell and Staiger (1999 and 2002) have shown that the World Trade Organization (WTO) and its predecessor, the General Agreement on Trade and Tariffs (GATT), have effectively improved international trade cooperation because they allow countries to neutralize a relevant trade policy externality, the (intra-temporal) terms-of-trade effect. Similarly, *understanding what are the relevant spillovers associated with the use of capital flow management is an essential building block to improving multilateral cooperation in the financial sector.*

This chapter reviews the coordination problem among countries that have at their disposal capital controls as the instrument to manage capital inflows.¹ In the spirit of the trade policy literature, I present a simple framework to identify a cross-border spillover associated with capital controls and then empirically test the relevance of this effect. The key insight is that, just like import tariffs can deflect exports to other markets and may induce a policy response by affected countries (Bown and Crowley, 2006 and 2007), capital inflow restrictions induce *capital flow deflection* and lead to policy response by affected countries.²

¹Capital controls encompass a variety of measures, such as taxes, quantitative restrictions and regulations, that affect cross-border financial activities by discriminating on the basis of residency (IMF, 2013).

²The term “trade deflection” was introduced in Bown and Crowley (2006) to indicate a situation where an increase in a trade barrier in one market determines a change in destination in exports. This is different from the concept of “trade diversion” (Viner, 1950), where the reduction of a tariff granted to a trading partner increases imports from the latter and reduces imports from other (potentially more efficient) exporters. An example of trade deflection discussed in Bown and

Figure 3.1 provides preliminary motivating evidence for the chapter. It shows the high correlation between the gross capital inflows (as a share of GDP) to South Africa and the inflow restrictions imposed by Brazil in a period where capital inflow restrictions in South Africa were essentially stable. Two recent event studies focusing on Brazil (Forbes et al. 2012; and Lambert et al. 2011) provide further motivating evidence. In particular, Forbes et al. (2012) find that more stringent capital inflow restrictions set by Brazil between 2006 and 2011, such as the introduction of a 2 percent tax on portfolio equity and debt inflows in 2009, have led investors to increase the share of their portfolios allocated to other countries, including Indonesia, Korea, Peru and Thailand. And interestingly, all these countries have imposed measures designed to limit capital inflows in 2010-11.³

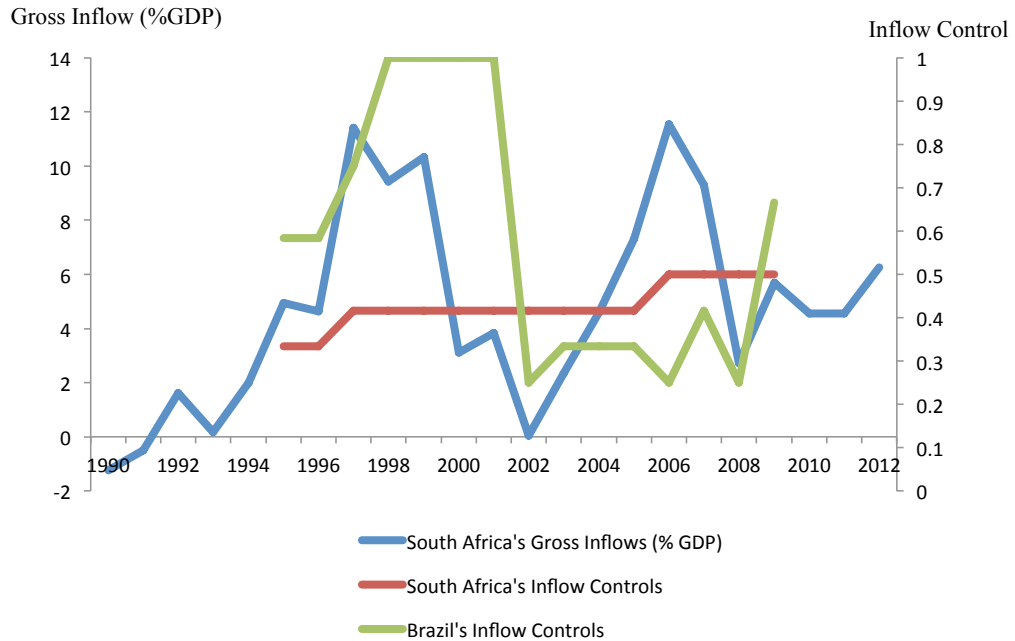
To examine the problem of policy coordination among recipient countries and to guide the empirical analysis, I build a parsimonious model based on work by Korinek (2013). In this setting, governments have two main reasons for influencing capital flows. A first rationale comes from the desire to manipulate the intertemporal terms-of-trade in their favor as discussed in Costinot et al. (2014). A large country setting capital controls takes into account that its policy choice affects the world interest rate and finds it unilaterally efficient to exploit this market power.

The second motive for capital controls is to manipulate the domestic interest rate

Crowley (2007) is the steel safeguard, a set of tariffs and quotas, imposed by the US on Chinese exports in 2002. Shortly afterwards, the EU reacted with similar measures, claiming that the change in US policy had deflected Chinese steel exports to its market.

³In 2010, Peru increased the fee on non-resident purchase of central bank paper to 400 basis points (from 10 basis points), while Thailand imposed a 15 percent withholding tax on non-residents' interest earnings and capital gains on state bonds. In 2011, Indonesia introduced a limit on short-term foreign borrowing by banks to 30 percent of capital and Korea restored a 14 percent withholding tax on interest income on non-resident purchases of treasury bonds (IMF, 2013).

Figure 3.1: Brazil's Controls and South Africa's Flows



Note: The left vertical axis provides the scale for gross inflows as share of GDP. The right vertical axis provides the scale for inflow restrictions as measured by Schindler (2009).

to address domestic distortions, such as financial fragility.⁴ I refer to the latter as the *prudential* motive (as it is often called in the literature), while the first is the *terms-of-trade* motive. Note that this model is simple and does not account for the aggregate demand externality introduced in the last chapter because the goal of the model is to illustrate the potential spillover effects, which the current set-up suffices.

In this context, I formally investigate the causes and consequences of capital flow deflection. Inflow restrictions imposed by a large country, or a sufficiently large set of small countries, lower world interest rate, as they subtract demand for

⁴In the words of Keynes (1943), “the whole management of the domestic economy depends upon being free to have the appropriate rate of interest without reference to the rates prevailing elsewhere in the world. Capital control is a corollary to this.”

capital from the world market. This change in the world interest rate leads to higher borrowing by recipient countries that have not altered their capital controls. The cross-border policy spillover effect among borrowers is what I refer to as capital flow deflection. It is insightful to look at this effect of capital controls from the perspective of foreign investors. For them all borrowing countries are identical (by assumption), except for capital controls. As international investors perceive a lower return of exporting capital to countries that tightened capital controls, they reallocate their capital to the other borrowers. This insight plays an important role in my empirical strategy.

Capital flow deflection, in turn, induces a policy response by borrowers. Importantly, while the spillover effect is independent of the underlying rationale for capital controls, this is not the case for the policy response. Specifically, capital flow deflection has an ambiguous impact on the terms-of-trade motive for capital controls. Intuitively, the incentive to manipulate the international interest rate with capital controls depends on the elasticity of global savings faced by the country. On the other hand, the prudential motive for capital controls is strengthened by capital flow deflection. The higher inflows exacerbate domestic distortions and increase the incentive to manipulate the domestic interest rate with capital controls to offset them. This result has an interesting corollary. If the primary motive for capital controls is to manipulate the domestic interest rate, as for prudential controls, then uncoordinated inflow restrictions can magnify exogenous shocks, such as a sudden increase in global liquidity. Intuitively, with capital flow deflection, inflow restrictions are complementary policies, so that a shock initiates a chain reaction and leads

to a multiplier effect.⁵

In my empirical investigation, I use a dynamic panel model to estimate the impact of capital controls on inflows to other countries and on the policy response. To my knowledge, this is the work first that investigates these issues in a cross-sectional study. There is a well known literature on the push and pull factors that determine capital flows (e.g. Forbes and Warnock, 2012; Ghosh et al. 2013), but these studies generally abstract from the role of capital controls by third countries. Two exceptions, as discussed above, are the event study approach by Forbes et al. (2012) and Lambert et al. (2011) that find evidence of capital flow deflection spurring from the policies implemented in Brazil between 2006 and 2011. Finally, a small recent literature examines the factors that cause policymakers to change capital controls (Fratzcher, 2012; Fernandez et al. 2013). These studies, however, disregard the policy response to the capital controls imposed by other borrowers.

I use data on gross capital inflows for a large sample of developing countries between 1995 and 2009 and use the so called Schindler index (Schindler, 2009) which allows us to identify the capital controls aiming at restricting inflows. To test the model, I divide countries into groups of likely substitutes based on common characteristics, such as geographic location, export specialization, return and risk. This is an important step, as the model features symmetric countries and, therefore, abstracts from the multiple features of cross-country heterogeneity that may influence investors' decisions in practice. In the first set of regressions, I introduce a variable

⁵Similar arguments have been informally made by others. In particular, Ostry et al. (2012) and Korinek (2013) talk of the possibility of a “capital control arms race” .

capturing the level of capital controls in the rest of group in an otherwise standard push-pull analysis. In the second set of regressions, I use a probit model to estimate the probability that capital controls by some countries may trigger a reaction in a country of the same group.

I find strong evidence of a capital flow deflection. The spillover effect of inflow restrictions is estimated to be strong and significant among countries that have similar risk level. Perhaps surprisingly, I find no significant spillover effects on countries in the same region. This finding is consistent with the view that investors are guided by the common economic characteristics of countries, rather than their geographic location—a result that confirms in a cross-section the evidence of existing event studies. Capital flow deflection is also found to be economically relevant. While somehow an extreme case, we estimate that gross inflows to South Africa as a share of GDP would have been between 0.5 and 1.0 percent lower if Brazil had not imposed higher inflow restrictions in 2009. Finally, these results are robust to a number of tests. In particular, spillovers to countries with similar risk levels continue to be significant when I use different measures of capital controls or risk, when I focus on episodes of capital flow surges and when I use an instrumental variable (IV) approach to address endogeneity problems.

Notwithstanding the strength of capital flow deflection, I find no evidence of a policy response. This result is independent of how I group countries and persists even if I focus on small economies, which have no terms-of-trade motives to set capital controls. I see two possible explanations for this somewhat puzzling result. The first has to do with the nature of the data on capital controls. The Schindler

index, as the other available measures of capital controls, do not record a change in intensity of a measure (say, an increase in the tax on capital inflows from 2% to 4%), but only whether the measure is in place or not. To the extent that countries react to capital flow deflection by toughening existing policies rather than creating new ones, the empirical findings would be biased against a policy response.

The second reason has to do with the model I use to guide empirical analysis. As discussed in a large literature following the seminal work of Bartolini and Drazen (1997), capital controls can work as a signal to markets in presence of uncertainty over the government type. If policymakers anticipate this, they may be more reluctant to use capital controls in short run in fear that investors will interpret them as a change in the course of future policies.⁶ In this case, a policy response can be muted even in presence of capital flow deflection.

Finally, a third explanation is that prudential controls are less relevant in practice than theory seems to suggest. This may be either because governments resort to instruments other than inflow restrictions to deal with capital flow deflection or because there are situations where this deflection can have a positive impact, such as when countries have difficulties accessing international financial markets.

The rest of the chapter is organized as follows: Section 2 presents a simple general equilibrium model of capital flows and establishes the two main results on capital flow deflection. Section 3 brings these two predictions to data. I first provide

⁶Some may see this argument as contradicting the notion that capital controls can be a legitimate (even if second-best) instrument to address a domestic distortion. This idea, however, has only recently become widely accepted (for instance, the institutional view of the IMF on capital flow management was published in 2012), while my dataset covers the period of 1995-2009. An interesting question is, therefore, whether in the future a policy response to capital flow deflection will become a more permanent feature of the international financial system.

evidence of the cross-border spillover effect of capital controls and then I focus on the policy reaction to inflow restrictions. Concluding remarks and policy implications are in Section 4.

3.2 A Two-Period Model of Capital Controls

In this section I introduce the simplest model of international capital flows. I assume a multi-country world lasting two periods ($t = 1, 2$) where economic agents face a standard inter-temporal consumption decision problem. There is a single homogeneous good that is tradable across borders. Consumers could shift consumption across two periods using an intentional bond that is denominated in tradable goods. Each country can introduce capital controls to affect consumers' decisions.

The model is a further simplified version of the framework presented in Korinek (2013). Even this, admittedly highly stylized, theoretical framework is sufficient to identify the two effects that I am interested in, and that are investigated empirically in Section 3: (i) the *capital flow deflection*, whereby a country raising its capital controls leads to higher capital inflows to other countries; (ii) the *policy response*, whereby a country alters its capital controls in response to a change in controls by other borrowers. I start by introducing the characteristics of a generic country i .

3.2.1 Economic Structure of Country i

Country i is populated by a unit mass of identical consumers who earn y_t^i at time t and value consumption c_t^i according to the following utility function:

$$U^i(c_1^i, c_2^i) = u(c_1^i) + \beta^i u(c_2^i) + e(C_1^i - Y_1^i), \quad (3.1)$$

with $u' > 0$, $u'' < 0$ and $\beta^i < 1$. C_1^i and Y_1^i denote, respectively, *aggregate* consumption and income in country i in the first period, both of which are taken as given by individual agents. Therefore, $C_1^i - Y_1^i$ measures the current account deficit of country i in the first period, which also equals to the country's capital inflows (outflows) if $C_1^i - Y_1^i$ is positive (negative). Function $e(\cdot)$ captures the fact that capital inflows may be associated with negative external effects, such as the risk that results from domestic households ignoring the consequences of their foreign borrowing decisions on the country's financial stability (financial fragility). Specifically, this externality is defined as

$$e(C_1^i - Y_1^i) \equiv \begin{cases} -x(C_1^i - Y_1^i) & \text{when } C_1^i - Y_1^i > 0 \\ 0 & \text{when } C_1^i - Y_1^i \leq 0, \end{cases}$$

where $x(\cdot)$ is a positive twice continuously differentiable function with $x'(\cdot), x''(\cdot) > 0$.⁷ If a country is a lender ($C_1^i - Y_1^i \leq 0$), the externality is null. If instead a country is a borrower ($C_1^i - Y_1^i > 0$), the externality associated with capital inflows enters

⁷The convexity of the externality function is a common assumption in the literature. In the context of financial fragility, convexity is justified by the fact that the risk to a country's financial stability is likely to increase at a faster rate as foreign debt rises.

individual welfare function.

Consumers must satisfy the following inter-temporal budget constraint:

$$(c_1^i - y_1^i)(1 + \tau^i)R = y_2^i - c_2^i + T^i, \quad (3.2)$$

where $R \equiv 1 + r$ is the world gross real interest rate, and τ^i is a tax/subsidy on individual borrowing at time 1. In the context of a representative agent economy, τ^i can also be interpreted as the capital control policy at time 1. A positive τ^i denotes a capital inflow tax (outflow subsidy) and a negative τ^i denotes a capital inflow subsidy (outflow tax) if the country is a borrower (lender). For the rest of the chapter, I simply refer to τ^i as capital controls. Tax revenue (or the cost of subsidy) is assumed to be rebated to (or financed from) consumers in lump-sum, so that

$$T^i = (c_1^i - y_1^i)\tau^i R. \quad (3.3)$$

In each country i , the representative consumer maximizes her objective function (3.1) while satisfying the budget constraint (3.2), and taking the world interest rate R , the policy τ^i as well as aggregate variables as given. Maximization gives rise to the usual Euler Equation:

$$u'(c_1^i) = \beta^i R u'(c_2^i)(1 + \tau^i), \quad (3.4)$$

implying consumption demands $c_1^i(\bar{R}, \bar{\tau}^i)$ and $c_2^i(\bar{R}, \bar{\tau}^i)$. Assuming substitution effect dominates income effect, a higher interest rate implies higher savings ($c_1^i \downarrow, c_2^i \uparrow$),

and hence a fall in the demand of capital in borrowing countries and a surge in the supply of capital from lending countries. On the other hand, a country i that raises its capital controls ($\tau^i \uparrow$) creates a wedge between world interest rate and domestic interest rate ($R^i = R(1 + \tau^i)$), thus stimulating domestic savings ($c_1^i \downarrow, c_2^i \uparrow$) and, hence, reducing its demand of capital.

Substitute (3.3) into (3.2) yields the resource constraint of country i :

$$c_1^i - y_1^i = \frac{(y_2^i - c_2^i)}{R}. \quad (3.5)$$

3.2.2 Competitive World Market Equilibrium

Assume a world economy made up of n countries, I now characterize the world market equilibrium. The mass of country i is denoted by m^i , with $m^i \geq 0$ and $\sum_{i=1}^n m^i = 1$. Hence, $m^i = 0$ implies that country i is small with respect to the world economy. The world supply of capital must equal to the world demand in period one:

$$\sum_{i=1}^n m^i [y_1^i - c_1^i(R, \tau^i)] = 0. \quad (3.6)$$

The competitive world market equilibrium is a configuration in which agents maximize their utility and international capital market clears. Specifically,

Definition 6 (Competitive World Market Equilibrium) *Given $\{y_1^i, y_2^i, \beta^i, m^i, \tau^i\}_{i=1}^n$, a world competitive market equilibrium consists of gross real world interest rate R^* and each country's consumption plan $\{c_1^{i*}, c_2^{i*}\}_{i=1}^n$ that satisfy (3.4), (3.5), and (3.6).*

3.2.3 Capital Flow Deflection

In this subsection, we analyze the cross-border spillovers associated with capital controls. In particular, I carry out a comparative statics exercise to analyze the effects of a change in capital controls in a set of countries on world interest rate, as well as its impact on capital flows to the rest of the world.

Lemma 1 *A rise in capital controls in a non-negligible set of countries S ($\sum_{i \in S} m^i > 0$) lowers the equilibrium world interest rate.*

Proof Apply the implicit function theorem to the world market clearing condition (3.6) yields:

$$\sum_{i \in S} m^i \frac{\partial c_1^{i*}}{\partial \tau^i} d\tau^i + \sum_{i \in \Omega} m^i \frac{\partial c_1^{i*}}{\partial \tau^i} dR^* = 0$$

then

$$dR^* = - \frac{\sum_{i \in S} m^i \frac{\partial c_1^{i*}}{\partial \tau^i} d\tau^i}{\sum_{i \in \Omega} m^i \frac{\partial c_1^{i*}}{\partial \tau^i}},$$

which is negative because $\frac{\partial c_1^{i*}}{\partial \tau^i} < 0$ and $\frac{\partial c_1^{i*}}{\partial \tau^i} < 0$. ■

Lemma 1 is instrumental to prove the propositions on the multilateral effects of capital controls. The first of these effects is *capital flow deflection*, which is the spillover effect of more stringent controls in one (or more) countries on the amount of capital inflows accruing to other countries. This effect is studied below

Proposition 5 (Capital Flow Deflection) *A rise in capital controls in a non-negligible set of countries S causes an increase in capital inflows to the other countries.*

Proof By Lemma 1 the equilibrium R increases. Then the equilibrium c_1^i must increase because $\frac{\partial c_1^i}{\partial R} < 0$. Therefore, the net capital inflows $c_1^i - y_1^i$ must also increase for all $i \notin S$. ■

Proposition 5 should come at no surprise as it simply states that, when a country raises its barriers to capital inflows, it deflects part of these flows to other countries. The existence of this cross-country spillover effect of capital controls will be verified empirically in the second part of this chapter.

3.2.4 Optimal Capital Controls

So far, I have taken capital controls as given. Now let's consider what happens when capital controls become endogenous. Country i 's national planner maximizes the following social welfare function:

$$W^i(c_1^i, c_2^i) = u(c_1^i) + \beta^i u(c_2^i) + e(c_1^i - y_1^i), \quad (3.7)$$

subject to the budget constraint (3.5).

The crucial difference between the individual's and the social planner's optimization problem is that the latter *internalizes* the aggregate impact of individual consumption plans on capital inflows to country i . The socially optimal consumption plans for country i are implicitly determined by the following Euler equation:

$$u'(c_1^i) - \beta^i R u'(c_2^i) - x'(c_1^i - y_1^i) - \beta^i u'(c_2^i)(c_1^i - y_1^i) \frac{dR}{d[m^i(c_1^i - y_1^i)]} = 0. \quad (3.8)$$

A comparison of the two Euler equations (3.4) and (3.8) shows that there are two reasons for policy intervention in this economy. A first reason results from the presence of a domestic externality. The government may restrict capital inflows as a means to manipulate the domestic interest rate ($R^i = R(1 + \tau^i)$), thus affecting agents' saving patterns and offsetting this distortion. I follow the literature on financial fragility and refer to this rationale as the *prudential* motive for capital controls. While not explicitly modeled here, other non-prudential motives commonly discussed in the literature (e.g. targeting the real exchange rate or dealing with the “trilemma”) can also fit into this category. As prudential controls, they aim at correcting the domestic interest rate rather than manipulating the international one.

While the first motive of capital control improves domestic inefficiency by correcting pecuniary externality, the second motive leads to global inefficiency by exploiting a country's market power. The second motive of capital control arises whenever country i is large enough to affect the world interest rate ($m^i > 0$). It is well known in the literature that large countries attempt to exploit their market power by taking advantage of the effect that their policy has on world interest rate (*inter-temporal terms-of-trade* effect). For instance, a country exploits its monopolistic power in capital market by taxing capital inflows so as to limit domestic demand and thus keep a “low” cost of capital. In solving the optimization problem defined above, the national planner of country i knows that R depends on its own domestic capital demand $m^i(c_1^i - y_1^i)$ through the market-clearing condition for the world economy (3.6). In the rest of the chapter, I refer to this second rationale for

imposing capital controls as the *terms-of-trade* motive.⁸

I am now ready to characterize the optimal capital control for country i .

Lemma 2 (Unilaterally Optimal Capital Controls) *The unilateral optimal policy (τ^{i*}) can be decomposed into a prudential motive ($\widehat{\tau}^i$) and a terms-of-trade motive ($\widetilde{\tau}^i$), such that*

$$1 + \tau^{i*} = (1 + \widehat{\tau}^i)(1 + \widetilde{\tau}^i), \quad (3.9)$$

with

$$\widehat{\tau}^i = \begin{cases} \frac{x'(c_1^i - y_1^i)}{u'(c_1^i) - x'(c_1^i - y_1^i)} & \text{when } c_1^i - y_1^i > 0 \\ 0 & \text{when } c_1^i - y_1^i \leq 0 \end{cases}. \quad (3.10)$$

and

$$\widetilde{\tau}^i = m^i \cdot \varepsilon^{-i}, \quad (3.11)$$

where ε^{-i} is the inverse elasticity of global savings faced by country i , and it is given by $\varepsilon^{-i} = [dR/d(Y_1^{-i} - C_1^{-i})] \cdot (Y_1^{-i} - C_1^{-i})/R$ with $Y_1^{-i} \equiv \sum_{j \neq i} m^j Y_1^j$ and $C_1^{-i} \equiv \sum_{j \neq i} m^j C_1^j$.

Proof See Appendix A.4. ■

Capital controls can be imposed for prudential or terms-of-trade reasons or both. Expression (3.10) captures country i 's optimal prudential controls. They are null whenever i is a lender. In fact, since the externality is null, the solution to the

⁸As the above discussion highlights, in this standard macro framework, we could define national welfare as $W^i(R^i, R)$; that is, directly in terms of the local and world interest rates that capital control selections imply. This general formulation is equivalent to the one used in the trade policy coordination literature (Bagwell and Staiger, 1999 and 2002), where the governments' objectives are a function of the local and world prices implied by tariff selection.

welfare maximization for a rational forward-looking national planner coincides with the utility maximization of the representative consumer, and optimal prudential policy is no-intervention: $\widehat{\tau}^i = 0$. Capital controls are instead strictly positive when country i is a borrower. In particular, the expression $x'(c_1^i - y_1^i)/[u'(c_1^i) - x'(c_1^i - y_1^i)]$ implies that the intensity of capital control should increase in the severity of externality and decrease in the level of aggregate consumption.

Expression (3.11) is the well known formula for the unilaterally optimal tax of a country that exploits its market power. A borrowing country faces a positive elasticity ($\varepsilon^{-i} > 0$), and hence taxes capital inflows ($\widetilde{\tau}^i > 0$). In particular, a more rigid supply of capital from the rest of the world (that is, a higher ε^{-i}) commands stronger controls on capital inflows (that is, a higher $\widetilde{\tau}^i$). On the other hand, a lending country faces a negative elasticity ($\varepsilon^{-i} < 0$), and hence taxes capital outflows ($\widetilde{\tau}^i < 0$). Moreover, a more rigid demand of capital from the rest of the world (that is, a lower ε^{-i}) implies stronger controls on capital outflows (that is, a lower $\widetilde{\tau}^i$).

3.2.5 Capital Controls' Response

I now introduce the policy response of countries to capital controls imposed by the others. I show that the nature of this policy response depends on the motive (prudential or terms-of-trade) for capital controls. My findings are summarized below

Proposition 6 (Policy Response) *A rise in the capital controls in the set of countries S^{-i} ($\tau^{S^{-i}} \uparrow$) causes a policy response by country i which can be decomposed*

into

$$\frac{d\tau^{i*}}{d\tau^{S-i}} = \frac{d\hat{\tau}^i}{d\tau^{S-i}}(1 + \tilde{\tau}^i) + \frac{d\tilde{\tau}^i}{d\tau^{S-i}}(1 + \hat{\tau}^i).$$

where

$$(i) \frac{d\hat{\tau}^i}{d\tau^{S-i}} = \frac{d\hat{\tau}^i}{dR} \frac{dR^*}{d\tau^{S-i}} > 0 \quad \text{and} \quad (ii) \frac{d\tilde{\tau}^i}{d\tau^{S-i}} = -\frac{m^i \frac{d\varepsilon^{-i}}{d\tau^{S-i}}}{m^i \frac{d\varepsilon^{-i}}{d\tau^i} - 1} \leq 0.$$

Proof See Appendix A.5. ■

I have isolated two and possibly opposing forces that govern the relationship of capital control policies among countries. The presence of a capital inflows' negative externality makes the policies complementary, while the exploitation of market power by large countries may or may not act in the same direction depending on the impact of capital controls on the elasticity of global savings.

This result can be rationalized as follows. A rise in capital controls in a set of countries (or just in a single large country) lowers the equilibrium interest rate (Lemma 1) and raises capital inflows to country i (Proposition 5). This exacerbates the negative domestic externality and thus leads country i to “defend itself” from an excessive capital inflow by raising its own capital controls for prudential reasons ($d\hat{\tau}^i/dR < 0$). If country i is small, its reaction to an increase of capital controls in other countries is unambiguous: it responds by raising its own barriers.

If country i is large, instead, the nature of the relationship among capital controls—namely whether capital controls are complements or substitutes - also depends on the sign of $d\tilde{\tau}^i/d\tau^{S-i}$, which in turn depends on how the (inverse of the)

elasticity of global savings faced by country i (ε^{-i}) responds to changes in the capital controls of the countries involved. In fact, in deciding its optimal policy response, a large country i takes into account, not only the effect of countries S^{-i} 's policies but also the one of its own policy on elasticity ε^{-i} . In the proof of Proposition 6, I show that both effects are ambiguous and ultimately rest on the preference fundamentals of consumers. In particular, I show that the complementarity or substitutability of the terms-of-trade driven capital controls depend on whether these controls become more or less effective in affecting world interest rate as they increase.⁹

The proposition shows how prudential controls (and, more broadly, any inflow restrictions aiming at manipulating domestic interest rate) respond to exogenous shocks. Taken together, Lemma 1 and Proposition 6 delineate a complementary relationship between world interest rate and prudential capital control policies, whereby a lower interest rate leads to more restrictions on capital inflows, and *vice versa*. Such complementarity may amplify the effects of exogenous shocks to the world economy or to any subset S of it, thus giving rise to what is usually called a *multiplier effect*. More formally, denote by $\hat{\tau}^i(R^*, \rho)$ the optimal prudential policy function for country $i \in S$, and where parameter ρ captures any feature that affects $\hat{\tau}^i$ other than changes in R^* (such as the endowments y_t^i , or the discount factor β^i).

I am now ready to formulate the following:

⁹This is not surprising: by definition, optimal terms-of-trade driven controls for country i are stronger, the greater the sensitivity of world interest rate to the supply of capital faced by country i ($dR/d(y_1^{-i} - c_1^{-i})$). As a result, if an increase in $\tau^{S^{-i}}$ implies an ever greater impact of capital inflows on the world interest rate ($d^2R/d(y_1^{-i} - c_1^{-i})^2 \cdot d(y_1^{-i} - c_1^{-i})/d\tau^{S^{-i}} > 0$), then, other things equal, country i is more likely to respond to such increase by raising its own policy, thus implying that the terms-of-trade driven capital controls are more likely to be complementary ($d\hat{\tau}^i/d\tau^{S^{-i}} > 0$).

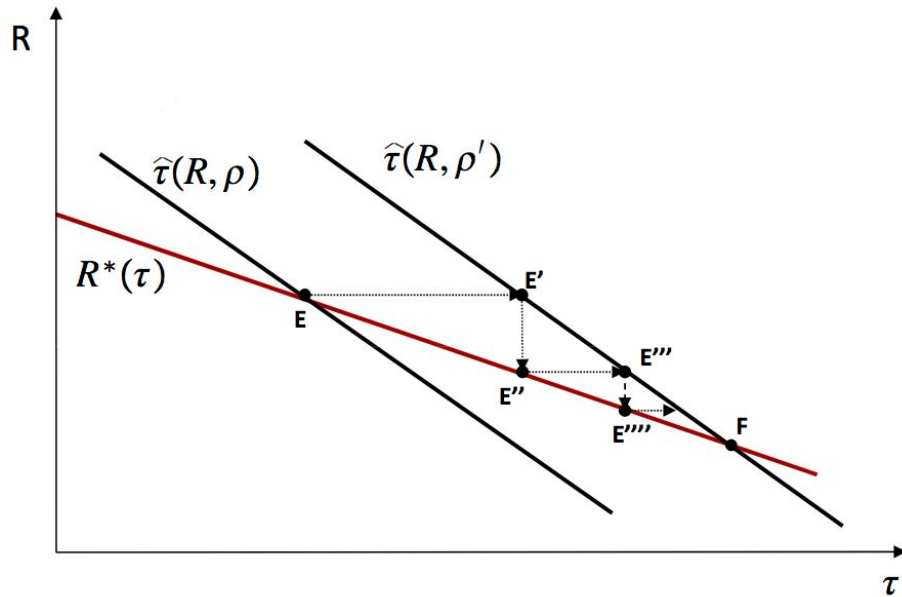
Corollary 1 (Multiplier Effect) *A shock to any subset of countries S causes a prudential policy response of each country $i \in S$ which can be decomposed into*

$$\left| \frac{d\hat{\tau}^i}{d\rho} \right| = \left| \frac{\partial \hat{\tau}^i}{\partial \rho} + \frac{d\hat{\tau}^i}{dR} \frac{dR^*}{d\tau^{S-i}} \cdot \frac{d\hat{\tau}^{S-i}}{d\rho} \right| > \left| \frac{\partial \hat{\tau}^i}{\partial \rho} \right|.$$

A multiplier effect characterizes the prudential capital control policy of each country i , as total equilibrium response is higher than partial equilibrium response because $(d\hat{\tau}^i/dR)(dR^/d\tau^{S-i}) > 0$.*

The complementary relationship between $\hat{\tau}^i$ and R^* that gives rise to the multiplier effect is illustrated graphically in Figure 3.2. To gain an intuition of this corollary, suppose a non-negligible fraction of borrowing countries are hit by an exogenous shock ($\rho \uparrow$) that induces them to raise their restrictions on capital inflows, say from point E to E' in Figure 3.2. This rise in capital controls lowers world interest rate (Lemma 1 1), which moves from E' to E'' . Each country, however, reacts to a lower R by further increasing its optimal capital controls from E'' to E''' , which in turn triggers a further decrease in world interest rate, and so on and so forth. As a result of this chain reaction, the aggregate policy response to the shock, as measured by the horizontal distance between point E and point F , exceeds the initial capital controls imposed by each individual borrowing country, as measured by the length EE' .

Figure 3.2: The Multiplier Effect in Capital Controls



3.3 Do Capital Controls Deflect Capital Flows and Lead to a Policy Response?

The previous section shows the existence of a spillover effect of capital controls on other countries and of a policy response (Propositions 5 and 6). In this section, I investigate their empirical relevance. In particular, I use a dynamic panel and push-pull factors model to study the impact of inflow controls on gross inflows to other countries and the impact of inflow controls on capital controls imposed by other countries.

The recent empirical literature on capital flows differentiates between gross and net flows (Forbes and Warnock, 2012). Gross inflows are the net of foreign purchases of domestic assets and foreign sales of domestic assets. In other words,

gross inflows measure the change in the stock of gross foreign liability before any valuation adjustment. Gross outflows measure the change in the stock of foreign assets before any valuation adjustment. Net flows are the difference between the two.

Capital controls can target either gross inflows or gross outflows. Inflow controls target gross inflows: these are restrictions imposed on foreign purchases of domestic assets and/or foreign sales of domestic assets. Inflow controls could be imposed either on the foreigner who trades the domestic assets with a domestic counterpart or on the domestic resident who trades the domestic assets with a foreign counterpart. On the other hand, outflow controls target gross outflows: these are restrictions imposed on domestic residents' purchases of foreign assets or domestic residents' sales of foreign assets. Such restrictions could be imposed either on the domestic resident who trades foreign assets with a foreign counterpart or foreigner who trades foreign assets with a domestic counterpart. Both inflow and outflow controls have in common that they discriminate on the basis of residency. In this respect, they differ from the broader set of capital flow management measures and from other (non-discriminatory) prudential measures (IMF, 2013).

In order to precisely test the theory in Section 2, I focus on a measure of inflow controls (rather than generic capital controls, which also include restrictions on capital outflows) and on gross inflows instead of net flows, because the latter include the gross outflow component. My empirical investigation has two parts. First, I examine the impact of inflow controls imposed by other countries on one's

gross inflows (capital flow deflection).¹⁰ Second, I examine the impact of inflow controls imposed by other countries on one's inflow controls (policy response).

3.3.1 Data

My sample consists of 78 less industrialized countries and emerging markets (see Table 3.1 for a complete list). I focus on developing countries as they are more likely to employ capital controls than more advanced countries which are blessed with a wider set of policy instruments to address domestic distortions.¹¹ The sample period spans 15 years from 1995-2009 and the data are in annual frequency. A country is included in my sample only if it has at least ten years of observations for all variables used in the regression models. While sample period, data frequency, and the selection of countries are all inevitably constrained by data availability, the panel covers several interesting episodes including the crises in Asia in the 1990s and in South America in the early 2000s and the first two years of the Great Recession, 2007-2009.

I use Schindler's (2009) index of capital controls, which is a *de jure* measure constructed from information contained in the Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER) provided by the IMF.¹² The

¹⁰Obviously, capital controls can have more than one spillover effect. Gross outflows are directly affected by inflow controls in recipient countries as one's outflow is another's inflow. Following the terminology in the trade literature, I can refer to this spillover effect as capital flow *depression*, which differs from the capital flow deflection analyzed here.

¹¹There are 443 instances of changes in inflow controls from 1995-2009 among developing countries, while the number is 69 among more advanced economies during the same period. The average inflow restriction index for the period is 0.5 among developing countries, while it is only 0.2 among more advanced countries.

¹²Schindler's (2009) dataset consists of 56 developing countries from 1995-2005. I use a dataset consisting of 124 developing countries from 1995-2009 built using Schindler's method (see Appendix

Table 3.1: Country List by Risk

High Risk	High-Moderate Risk	Low-Moderate Risk	Low Risk
Angola	Albania	Argentina	Bahamas, The
Burkina Faso	Algeria	Azerbaijan	Bahrain
Republic of Congo	Armenia	Bolivia	Botswana
Cote d'Ivoire	Bangladesh	Brazil	Chile
Dem. Rep. of the Congo	Belarus	Bulgaria	China
Ethiopia	Cameroon	Dominican Republic	Costa Rica
Guinea	Colombia	Egypt	Croatia
Guinea-Bissau	Ecuador	El Salvador	Hungary
Haiti	Ghana	Gabon	Jordan
Iraq	Guyana	Guatemala	Kuwait
Lebanon	Honduras	India	Latvia
Liberia	Indonesia	Iran	Libya
Malawi	Kenya	Jamaica	Lithuania
Mozambique	Madagascar	Kazakhstan	Malaysia
Myanmar	Mali	Papua New Guinea	Mexico
Nicaragua	Moldova	Paraguay	Morocco
Niger	Mongolia	Peru	Namibia
Nigeria	Romania	Philippines	Oman
Pakistan	Senegal	Russia	Panama
Sierra Leone	Sri Lanka	South Africa	Poland
Sudan	Suriname	Syria	Qatar
Togo	Tanzania	Thailand	Saudi Arabia
Turkey	Uganda	Ukraine	Trinidad and Tobago
Zambia	Venezuela	Uruguay	Tunisia
Zimbabwe	Yemen	Vietnam	United Arab Emirates

Note: Time-invariant groups by composite risk. The countries in bold are used in the regression analysis. All the countries listed are used in computing τ^{S-i} .

main advantage of this index relative to others commonly used in the literature such as Chinn and Ito (2006) is that the Schindler index distinguishes between controls on capital inflows and outflows. In particular, Schindler's index calculates inflow controls as the average of the restriction dummies on the following series of international transactions: purchase of financial assets locally by nonresidents, sale or issue of financial assets abroad by residents, collective investment by nonresidents to residents, financial credits by nonresidents to residents, inward direct investment, and

C). I would like to thank colleagues at the IMF for sharing the expanded dataset.

liquidation of direct investment.¹³ The index varies between 0 (i.e. no restriction) and 1 (i.e. restrictions on all international transactions).

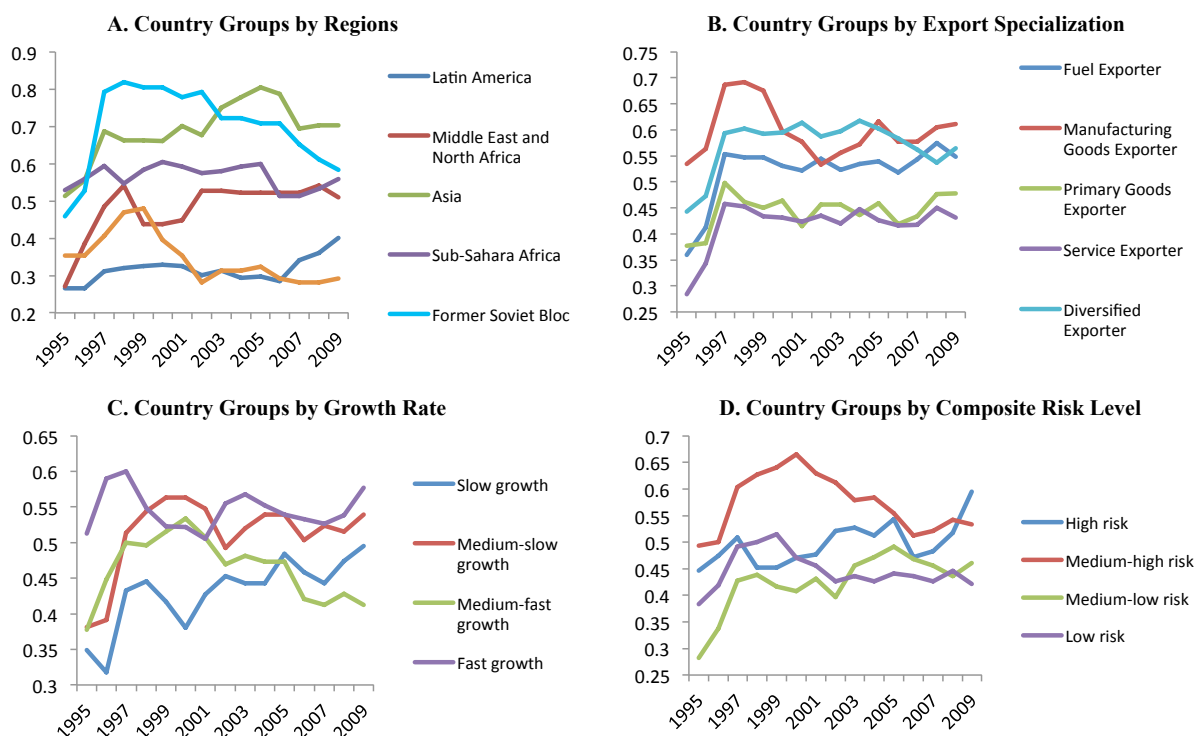
The data on capital controls are depicted in Figure 3.3. Panel A plots the inflow controls by regions, with higher numbers indicating more stringent restrictions.¹⁴ There are noticeable differences as well as some common trends across regions. Asian and former Soviet bloc countries are more likely to have higher inflow restrictions than Latin American and central and east European countries. Countries across all regions tightened inflow controls during the Asian financial crisis, and the high level persisted in most regions except for central and east European countries that were going through capital account liberalizations in preparation for EU membership. During the 2007 financial crisis, most regions tightened inflow controls except for countries of the former Soviet bloc whose restrictions were nevertheless very stringent compared to other regions except for Asia.

Figure 3.3 also depicts inflow restrictions when I group countries by economic characteristics rather than geographic location. Specifically, we focus on export specialization (Panel B), growth rate (Panel C) and composite risk (Panel D). By dividing countries into groups, I aim at capturing characteristics that render them close substitutes from the perspective of international investors. In this regard, the natural way to group countries together is based on the similarity of risk and return, as they are the two main determinants of investment decisions. Forbes et

¹³Financial assets are shares or other securities of a participating nature, bonds or other debt securities, other market instruments. A more detailed description of the index and its methodology are available in Appendix C.

¹⁴I follow the IMF World Economic Outlook (WEO) and divide countries into six regional groups: Latin America, Middle East and North Africa, Sub-Saharan Africa, Former Soviet Bloc, and Central and East Europe.

Figure 3.3: Schindler's Inflow Control Index by Groups



Note: Schindler's index of inflow controls is on the vertical axis. 1 indicates full restriction, 0 indicates no restriction. Year is on the horizontal axis. Group averages are used to plot the graphs in each panel.

al. (2012) find that countries exporting to China are affected by Brazil's capital inflow restrictions. Since these countries are mostly commodity exporters, I also consider export specialization as a relevant country grouping.¹⁵ Just like geographic location, groups by economic characteristics also display some interesting common patterns. In particular, countries with lower composite risk tend to display more stable and lower capital controls relative to riskier countries. Primary goods and

¹⁵For export specialization I continue to follow the WEO classification and divide countries into five groups: fuel exporters, primary goods exporters, manufacturing exporters, service exporters, and diversified exporters.

service exporters tend to have lower inflow restrictions than fuel, manufacturing and diversified exporters. Finally, no clear pattern emerges when I group countries by growth rate.

Following Forbes and Warnock (2012) I compute gross capital inflows as the sum of net portfolio investment liabilities, other liabilities, and net foreign direct investment. All components of gross capital inflows are available from the IMF's International Financial Statistics (IFS) database as reported in BPM5 format.¹⁶ Table 3.2 shows summary statistics of inflow controls, gross inflows, and other variables used in the regression analysis. Table D.1 reports the data sources. Note that I have two measures that capture the risk of investing in a country: composite risk and law and order. Higher values indicate lower risk. The composite risk index is a measure of a country's combined economic, financial, institutional, and political risks, while law and order index captures mainly the institutional risk of a country. For this reason, I focus on the composite risk index as the proxy for country risk in my main regressions. The other measures of country risk are used in the robustness analysis. The other variables in the spillover analysis are standard taken from the push-pull factor literature. I use real US interest rate as a proxy for world real interest. This is computed from annualized US three month treasury rate adjusted by US inflation. The VIX index is used as a proxy for global volatility. Inflation and other country specific variables come from the WEO, while I use Ilzetki et al. (2010) for exchange rate regime classifications.

¹⁶Some components of gross inflows have value 0 in some countries, but our data source does not specify whether these are really zero or missing information. In the regression analysis, I try both interpretations and they lead to the same findings. Below, I report the results where gross capital flows are computed by treating a 0 observation as no capital inflows.

Table 3.2: Summary Statistics

Variable	Obs	Mean	S.D.	Min	Max
Schindler index (inflows restrictions)	1170	0.49	0.34	0.00	1.00
Gross inflows (% GDP)	1108	4.84	8.08	-38.99	63.85
VIX	1170	21.54	6.45	12.58	34.04
Real US interest rate	1170	0.94	1.63	-2.36	3.18
Inflation	1135	15.01	54.01	-9.86	1061.21
Real GDP growth rate	1169	4.12	4.72	-24.79	62.19
Nominal GDP per capita in USD (logged)	1159	7.42	1.17	4.38	10.66
Nominal GDP in USD (logged)	1170	10.10	1.70	6.47	15.42
Real effective exchange rate	1170	106.78	33.93	56.09	597.37
Composite risk	1138	66.24	8.72	28.00	86.70
Law and order	1138	3.38	1.14	1.00	6.00
de facto exchange rate regime	1134	2.17	1.15	1.00	6.00

Table 3.3: Data Sources

Data	Source
Capital flows	International Financial Statistics (IFS)
Capital controls	Schindler (2009)
VIX	Yahoo Finance
US three month treasury rate	Federal Reserve Economic Data (FRED)
Inflation rate	World Economic Outlook (WEO)
Real GDP growth rate	WEO
Nominal GDP per capita in US\$	WEO
Nominal GDP in US\$	WEO
Real Effective Exchange Rate	Information Notice System (INS)
Composite risk index	Political Risk Service (PRS)
Law and Order	PRS
de facto Exchange rate regime classification	Reinhart et al. (2008)
Election Year	Database of Political Institutions (DPI)
Political Orientation of the Ruling Party	DPI

3.3.2 Evidence of Capital Flow Deflection

In this subsection, I present evidence that capital controls deflect capital flows to other countries. I first present the empirical strategy, which extends the standard push-pull factor model to account for spillover effects. Then I present the regression results for the entire sample of developing economies and for groups of countries that are likely substitutes from the perspective of international investors. Finally, we undertake a series of robustness tests.

Empirical Strategy

I follow closely the empirical literature on the determinants of capital flows (e.g. Ghosh et al. 2012, Forbes and Warnock, 2012) and use a standard pull-push model with an additional variable that captures the spillover effect of inflow restrictions.¹⁷ Specifically, the regression equation is

$$\omega_t^i = \beta_0 + \beta_1 R_t + \beta_2 \tau_{t-1}^i + \beta_3 \tau_t^{S^{-i}} + \beta_4 x_t^i + u_t^i, \quad (3.12)$$

where ω_t^i denotes country i 's gross capital inflow as a percentage of GDP at time t (henceforth, subscript t denotes time and i denotes country i.d.), R_t is real world interest rate, τ_{t-1}^i denotes country i 's capital inflow controls (lagged once), $\tau_t^{S^{-i}}$ denotes the (weighted average of the) inflow restrictions of all countries in the set

¹⁷See Magud et al. (2012) for a survey of the literature.

S^{-i} (where, recall, $S^{-i} = \{S/i\}$ and $i \in S$), which is computed from

$$\tau_t^{S^{-i}} = \frac{\sum_{j \in S^{-i}} \bar{y}_j \tau_t^j}{\sum_{j \in S^{-i}} \bar{y}_j}, \quad (3.13)$$

\bar{y}_j being the sample-period-average of country j 's real GDP, x_t^i is a vector of the rest of pull-push factors that determine ω_t^i commonly used in the literature, and u_t^i is the error term.

The model in Section 2 predicts that β_1 and β_2 are negative as households reduce current consumption by borrowing less when world real interest rate goes up or when inflow restrictions tighten, so that the domestic interest rate increases vis-a-vis the world interest rate. Differently from previous studies, I also include $\tau_t^{S^{-i}}$ as an explanatory variable since capital controls in the set of countries S^{-i} can deflect capital flows to country i . β_3 captures this spillover effect, and the model predicts it to be positive. The rest of the standard pull-push factors include global volatility, real GDP growth rate, real GDP growth rate shock, real GDP per capita, and country risk.¹⁸ I lag all the domestic pull factors as well as domestic inflow controls to reduce endogeneity problems. Global push factors and the rest of the world's capital inflow controls are contemporaneous as they are less likely to suffer from endogeneity with the dependent variable. The expected signs of explanatory variables are reported in the last column of the regression tables for convenience.

¹⁸The real GDP growth rate shock is the log difference between real GDP growth rate and its H-P filtered trend. The country risk is included because Alfaro et al. (2008) show that institutional quality plays an important role in determining capital flows. In the regressions, I also introduce additional controls used in the literature of push and pull factors. They include: domestic inflation, real effective exchange rate overvaluation, de facto exchange rate regime. The findings discussed below are robust to the inclusion of these additional variables. However, I do not include them in the baseline regressions because their coefficients are never significant.

Benchmark Regression

Table 3.4 shows the OLS estimation results of equation (3.12) for the entire sample (i.e. when $S = \Omega$). For expositional clarity, variables are divided into three blocks: global push variables that only vary across time and are invariant across countries; domestic pull factors that vary across both time and countries; and the spillover variable—the rest of world’s capital inflow control—which also varies both across time and countries. Column (1) reports the OLS coefficients for equation (3.12). To reduce possible omitted variable bias, column (2) reports the OLS coefficients when year fixed effects are included. Since global push factors only vary over time but do not vary across countries, they drop out in the specification with year fixed effects.

Both specifications are able to explain more than 10% of the variation in gross capital inflows. Most variables are significant determinants of gross capital inflows and their coefficients have the expected signs.¹⁹ Country’s own capital control is insignificant once country fixed effects are introduced, but it is significant with expected sign when country fixed effects are not included (not reported). The reason is that many countries do not change capital controls frequently.²⁰ The key variable

¹⁹A priori, it is not obvious what sign the coefficient on real GDP per capita should have. On the one hand, higher real GDP per capita is associated with higher level of financial development, which should lead to more inflows. On the other hand, lower real GDP per capita is also associated with weak economic infrastructure and financial capacity, which implies more need for foreign investment and capital inflows. Previous studies find mixed results. Ghosh et al. (2012) find real GDP per capita to reduce the probability of experiencing a net flow surge, while Forbes and Warnock (2012) find no evidence that real GDP per capita is associated with gross inflow surge.

²⁰When I rerun the regressions using different measure of capital controls, I find own control to be significant with the expected sign in most cases (see Table 3.7). The difference is the other measures capture more than just restrictions on capital inflows, and hence have more time-variation.

Table 3.4: Capital Flow Deflection (Entire Sample)

	(1)	(2)	Expected Signs
Global Push Factors			
Real US interest rate	-0.122 (0.142)		-
VIX	-0.166*** (0.0516)		-
Domestic Pull Factors (all lagged)			
Real GDP growth rate	0.425* (0.219)	0.396* (0.218)	+
Real GDP growth rate shock	-0.369 (0.231)	-0.364 (0.230)	-
Real GDP per capita (logged)	4.912*** (1.219)	3.793* (1.935)	+
De jure Capital inflow control	1.169 (1.256)	1.263 (1.303)	-
Composite risk index	0.107 (0.0720)	0.0982 (0.0729)	+
Spillovers			
ROG's inflow control	12.80** (5.046)	-6.113 (32.55)	+
Year FE	No	Yes	
Country FE	Yes	Yes	
Number of Countries	87	87	
Sample Period	1,007	1,007	
R-squared	0.137	0.165	

Note: Robust standard errors clustered at country level in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

of interest, the rest of group's capital inflow controls ($\tau_t^{S^{-i}}$), is significant in the standard push-pull factor model. But the variable becomes insignificant once I control for the year fixed effects, implying that the spillover effect found in column (1) is likely to be due to omitted variable bias. In particular, global push factors other than the ones included in regression (3.12) may cause gross capital inflows in a developing country and capital controls in the rest of the world to move in the same direction. The lesson from Table 3.4 is, therefore, that the pull-push model (3.12) explains gross capital inflows to developing countries reasonably well, but the

evidence of spillover effects from the rest of the world is not robust.

The lack of evidence of capital flow deflection for the entire sample is hardly surprising and is in line with other studies (Forbes et al., 2012). In particular, note that this exercise is not a good test of the model in Section 2. An underlying assumption of the model is that countries are identical, if not for the capital controls they implement. In other words, there is a single perfectly integrated world capital market, where all these countries are perfect substitutes from the perspective of investors. This assumption clearly does not hold when I consider the entire sample, where countries are highly heterogeneous, but it could be more reasonable when I look at a smaller group of countries with similar characteristics. Specifically, capital flow deflection may be significant within well defined groups of developing economies, while still be on average irrelevant for the broad (and highly heterogeneous) sample. This is precisely what I investigate next.

Capital Flow Deflection within Country Groups

In this subsection, I divide countries into groups of likely substitutes based on some common characteristics and investigate the existence of capital flow deflection within these groups. In particular, I group countries based on geographic location, export specialization, return, and risk. In other words, I consider the subset of countries S to which country i belongs either as a geographic region (say, Latin America or Sub-Saharan Africa) or as a group defined by certain economic characteristics (say, fuel exporters, fast growing economies, or high risk countries).

As discussed above, I use composite risk index as a proxy for country specific risk and real GDP growth rate as a proxy for country specific return. I divide countries into four groups based on their average real GDP growth rates and average composite risk across the sample period. For example, *low return group* consists of countries whose sample average growth rates are in the bottom 25 percentile. I call these groups as *time-invariant* groups since the composition of groups remains constant over time. To allow the composition of groups to change over time, I also consider *time-variant* groups. For example, a country i belongs to the low return group at time t if it is in the bottom 25 percentile among all countries at t . So a country could move from *low return group* to *medium-low return group* as it grows faster over time. Export specialization and geographic regions follow the definitions used in the IMF’s WEO. As mentioned earlier, there are six geographic regions and five export specializations. Table 3.1 shows the time-invariant groups based on risk.²¹

Table 3.5 reports the coefficients for τ_t^{S-i} , which is the main variable of interest.

The coefficients for the other variables are almost identical to the ones in Table 4.²²

²¹There are 124 countries in the list, 78 of which are in bold. All the countries listed have both GDP and capital inflow restriction data available throughout the sample period, which allows us to compute the rest of the group’s capital inflow restrictions. The countries in bold are the ones with at least ten years of observations for the rest of the explanatory variables, and hence are used for regressions.

²²The only major difference is the coefficient for a country’s own capital controls, which is positive but insignificant in the specification with country fixed effects. This finding is consistent with the empirical literature (see Magud et al., 2011) and results from the well-known endogeneity problem between a country’s own capital controls and inflows (i.e. higher flows induce a country to adjust prudential restrictions). Given the persistence of capital controls, it is not surprising that simply lagging inflow restrictions does not entirely solve this problem. Forbes et al. (2013) use a propensity score matching method to deal with this econometric challenge. They find that, while broad measures of inflow controls may not be systematically effective, specific measures (e.g. those targeting equity or bond flows) and “major” policy changes lead to a significant reduction in capital inflows.

Each coefficient reported in Table 3.5 is estimated using a different specification of (3.12). There are 36 specifications in total. These specifications differ by country-groups (which gives the six rows in the table) and by the set of controls (which gives the six columns in the table). Specifically, in columns (1)-(3) and (4)-(6) I control for a different combination of group contagion variable and country fixed effects, with the number of controls increasing as the column number ascends. Country fixed effects are introduced to reduce omitted variable bias. The group contagion variable is computed as the GDP weighted fraction of countries in S^{-i} that experience gross inflow surge and is included to control for the common shocks to the group.²³ Finally, I lag the rest of the group's inflow controls by one period in (4)-(6) to alleviate possible endogeneity problems between ω_t^i and $\tau_t^{S^{-i}}$.²⁴

I find strong evidence of within-group capital flow deflection when countries are grouped based on risk as all coefficients have the correct sign and are highly significant. Not surprisingly, grouping countries by time-variant risk groups gives more robust results relative to the time-invariant risk groups (significance is at the 1% level), as foreign investors are likely to be sensitive to changes over time to the riskiness of a country. I find no within-group spillover effect when counties are grouped by geographic location, or returns. The results are robust when I deduct FDIs from the definition of gross inflows, which suggests that short-term (portfolio and other investment) flows are the main drivers of the spillover effect.²⁵ Though

²³The group contagion variable is computed as $\frac{\sum_{j \in S^{-i}} \bar{y}^j Surge_t^j}{\sum_{j \in S^{-i}} \bar{y}^j}$ where $Surge_t^j$ is defined in 3.2.4.

²⁴In subsection 3.2.5, I use an IV approach to further address endogeneity concerns.

²⁵The coefficients for the spillover variable are very similar to the ones shown in Table 3.4 and, hence, are not reported in this chapter.

Table 3.5: Within-Group Capital Flow Deflection

Group by geographic location	2.079 (3.654)	2.735 (3.758)	1.467 (4.283)	2.045 (4.307)
Group by export specialization	8.470** (4.185)	7.145 (4.315)	9.418** (3.845)	8.363** (4.016)
Groups by returns				
Time-invariant groups by growth rate	5.713 (6.440)	4.611 (5.666)	3.622 (4.100)	2.212 (3.553)
Time-variant groups by growth rate	0.0706 (1.708)	-0.908 (1.636)	-2.731* (1.452)	-2.798** (1.404)
Groups by risks				
Time-invariant groups by composite risk	10.52* (5.324)	10.57* (5.322)	5.215 (5.168)	7.901 (5.563)
Time-variant groups by composite risk	4.451** (1.961)	2.776 (1.831)	7.314*** (2.636)	6.350** (2.426)
Year FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Group Contagion Variable	No	Yes	Yes	Yes
Lagged ROG's inflow control	No	No	Yes	Yes

Note: This table reports the spillover coefficient β_3 in regression equation (3.12) for 24 different specifications. Robust standard errors clustered at country level in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 3.5 provides some evidence of capital deflection when countries are grouped by export specialization, the finding is not robust to additional exercises in the robustness check below (see e.g. Table 3.6).

To interpret the coefficients and therefore to understand the magnitude of capital flow deflection, I compute the range of spillover effects for the increase in capital inflow restrictions in Brazil in 2009 on the gross inflows of capital to South Africa. Both countries belong to the same time-variant and time-invariant risk group. In 2009, Brazil increased its capital inflow restriction by 0.42, and in the same year South Africa's gross capital inflows were 5.69% of its GDP. The coefficient estimates of β_3 when countries are grouped by (time-variant) risk ranges between 4.45 (without lagging τ_t^{S-i}). Using the estimated value, my calculation shows that

South Africa's gross capital inflows would have been 5.13% of its GDP if Brazil had not increased its inflow restrictions in 2009. In other words we find that Brazil's introduction of inflow controls in 2009 increased gross inflows to South Africa by 0.56% of its GDP.

My findings indicate that capital flow deflection affects countries with similar risk levels, more than neighbors. The lack of evidence of spillover effects at the regional level, however, has more than one explanation. One possibility is that investors, on average, do not see countries in the same region as sufficiently similar to justify reallocation of investment within the group when one country increases capital controls. However, a second explanation is that the capital deflection model presented in the previous section is not the only mechanism at work. For instance, investors may take an increase in inflow restrictions in one country as a signal that others will introduce similar measures and, therefore, reduce rather than increase investment to the latter. If this "policy emulation" or "contagion" effect is perceived to be stronger among neighboring countries (perhaps because the electorate is more likely to be informed on, and politicians to be influenced by, policy developments in a nearby country), then it is possible that the capital flow deflection is offset by a separate spillover effect in the opposite direction in regional groupings. In this case, the average effect is imprecisely captured in regression analysis and results in an insignificant coefficient.

Robustness Tests

This subsection looks at several robustness tests of the result on capital flow deflection. Specifically, I look at surges in capital inflows (rather than at the level of gross inflows); I use measures of inflow restrictions other than the Schindler index; I consider different ways to weigh the rest of group's capital controls. I finally perform a number of additional robustness tests.

First, I focus on surges in capital inflows. Recent studies such as Ghosh et al. (2012) and Forbes et al. (2012) focus on episodes of extreme capital inflow that they refer as surges. Instead of studying the spillover effects on the magnitude of gross inflows, I investigate whether restrictions in other countries affect the probability of experiencing a surge. I use a probit model in an otherwise identical push-pull model:

$$Prob(Surge_t^i = 1) = \Phi(\beta_0 + \beta_1 R_t + \beta_2 \tau_{t-1}^i + \beta_3 \tau_t^{S^{-i}} + \beta_4 x_t^i + e_t^i), \quad (3.14)$$

where $Surge_t^i$ equals to one if country i experiences a surge at time t , and zero otherwise. Similar to Ghosh et al. (2012), I define a country to have a gross inflow surge in a year if its gross inflow to GDP is greater than 80% of its historical values across time and 80% of all countries' values in that given year.²⁶ The Probit regression results of (3.14) are reported in Table 3.6. The results are largely consistent with the findings in Table 3.5.

²⁶Ghosh et al. (2012) use the threshold of 70% and look at net flows.

Table 3.6: Within-Group Capital Flow Deflection: Surges

	(1)	(2)	(3)	(4)	(5)	(6)
Group by geographic location	-0.129 (0.645)	0.0642 (0.607)	-0.0564 (0.216)	0.117 (0.635)	0.306 (0.578)	-0.0832 (0.161)
Group by export specialization	-0.346 (0.551)	-0.445 (0.553)	0.209 (0.203)	-0.347 (0.563)	-0.443 (0.566)	0.145 (0.163)
Groups by returns						
Time-invariant groups by growth rate	0.650 (0.752)	0.692 (0.773)	0.439* (0.224)	0.578 (0.684)	0.612 (0.712)	0.396*** (0.149)
Time-variant groups by growth rate	0.152 (0.445)	0.0524 (0.464)	-0.0411 (0.0626)	-0.141 (0.537)	-0.313 (0.555)	-0.113 (0.0758)
Groups by risks						
Time-invariant groups by composite risk	-0.794 (1.358)	-0.489 (1.369)	0.178 (0.209)	-1.573 (1.252)	-1.262 (1.264)	-0.144 (0.234)
Time-variant groups by composite risk	1.686*** (0.783)	1.577* (0.825)	0.188** (0.0888)	1.992** (0.777)	1.776** (0.805)	0.220** (0.0916)
Regression	Probit	Probit	OLS	Probit	Probit	OLS
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Group Contagion	No	Yes	Yes	No	Yes	Yes
Country FE	No	No	Yes	No	No	Yes
Lagged ROG's inflow control	No	No	No	Yes	Yes	Yes

Note: This table reports the spillover coefficient β_3 in Probit model (3.14) for 24 different specifications in columns (1), (2), (4), and (5). Columns (3) and (6) report the results from the linear probability model with country fixed effects. Robust standard errors clustered at country level in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

The second robustness test relates to the measure of inflow restrictions. To see if the existence of capital flow deflection relies on the use of the Schindler index of inflow controls, I use four alternative proxies of capital controls. The first two proxies, called CAPIN and CAPITAL, come from the work of Quinn et al. (2009). CAPIN measures capital account restrictions imposed on non-residents. CAPITAL captures capital account restrictions on both residents and non-residents. The third proxy, called FINCONT2, gives financial sector specific controls and comes from the work of Ostry et al. (2012).²⁷ As both CAPITAL and FINCONT2 represent general capital controls that include restrictions on both inflows and outflows, the last proxy I consider is the updated Schindler’s index of inflow controls (Fernandez et al., 2015).²⁸

I replicate the same regressions as in Tables 3.5 with these variables. The results are reported in Table 3.7, where each row reports the coefficients for τ_t^{S-i} in equation (3.12) in the time-variant group. Due to data availability, I have a smaller sample. As for the regressions with the Schindler index, there is no spillover effect when we do not divide countries into groups. However, once I divide countries into

²⁷The data for the CAPITAL index cover restrictions imposed on capital flows by residents and by nonresidents. FINCONT2 is computed as an average of three components: (i) differential treatment of accounts held by nonresidents; (ii) limits on borrowing from abroad; and (iii) restrictions on maintenance of accounts abroad. The correlation between the various indexes is reported in the appendix. I rescale all proxies along the interval [0,1] with 0 indicating full capital account liberalization, so they are comparable to the Schindler’s index of inflow controls. The pairwise correlations of these proxies are provided in Table D.2 in the appendix.

²⁸Another commonly used proxy for capital controls comes from Chinn and Ito (2009). However this measure is less refined than the Schindler index and the other measures used here. Specifically, the Chinn-Ito index is compiled from a broader set of policies than capital controls: they include exchange rate policy, trade policy, and current account policy. As this measure is less appropriate to test the theory, I am not surprised to find no robust capital flow deflection when I proxy capital controls with the Chinn-Ito index. For more discussions on and detailed comparisons of various proxies of capital controls refer to Quinn et al. (2011).

groups based on (time-variant) risks, I find evidence of capital flow deflection in most specifications as in Table 3.5.

Third, I consider using different weights to compute the rest of the group's capital controls τ_t^{S-i} . In particular, I use gross capital inflows and exports as alternative weights to calculate τ_t^{S-i} . Then I rerun the regressions of Table 3.5 when countries are grouped based on composite risks, and the results are reported in Table 3.8. The coefficient on the spillover variable continues to be significant when using these different weights.²⁹

Finally, I also undertake a number of additional robustness tests.³⁰ First, to see if the consistent finding of spillover effects among risk groups depends on the composite risk measure, I consider other measures of country risk. In particular, I divide countries based on their index values of law and order and I still continue to find robust capital flow deflection. Second, I use other proxies for returns. Specifically, I divide countries by return on assets, return on equities, and short term treasury bond yields. The sample is smaller as coverage for these variables is more limited. In any event, I do not find evidence of capital flow deflection across groups of countries with similar returns with any of these proxies.³¹ Last, I replace the inflow controls by general capital controls, which is the average of inflow controls

²⁹The results are also robustness when I employ time-variant weights, $\tau_t^{S-1} = \frac{\sum_{j \in S-i} y_t^j \tau_t^j}{\sum_{j \in S-i} y_t^j}$.

³⁰The findings of these exercises are not reported here, but are available upon request. All the regressions in this subsection are robust when we deduct FDI from gross inflows.

³¹The full list of the different ways I grouped countries by return is: (i) Return on assets from bank-level data; (ii) Return on equity from bank-level data; (iii) Government bond yield; (iv) Stock market return. In addition, we also ran regressions dividing countries by GDP per capita (a proxy for the level of development) and GDP (a proxy for the country size). As discussed in the main text, I found no significant capital flow deflection using these variables.

Table 3.7: Within-Group Capital Flow Deflection: Other Measures of Capital Controls

	CAPIN		CAPITAL		FINCONT2		KAI (updated)	
Domestic Pull Factors (all lagged)								
Real GDP growth rate	0.739*** (0.182)	0.761*** (0.181)	0.739*** (0.187)	0.757*** (0.184)	0.633 (0.386)	0.784** (0.328)	0.592* (0.298)	0.627** (0.295)
Real GDP growth rate shock	-0.769*** (0.186)	-0.793*** (0.184)	-0.775*** (0.192)	-0.797*** (0.188)	-0.581 (0.390)	-0.724** (0.335)	-0.578* (0.319)	-0.614* (0.314)
Real GDP per capita (logged)	2.946* (1.512)	2.581* (1.499)	3.348** (1.543)	2.880* (1.514)	5.886* (3.211)	3.378 (2.568)	4.292* (2.376)	4.044* (2.289)
De jure Capital inflow control	-5.398*** (1.674)	-4.712*** (1.620)	-4.505*** (1.523)	-4.053*** (1.453)	-3.301 (2.758)	-2.700 (2.184)	0.365 (2.575)	0.425 (2.536)
Composite risk index	-0.0679 (0.0631)	-0.0437 (0.0620)	-0.0621 (0.0641)	-0.0408 (0.0631)	-0.0786 (0.134)	-0.0498 (0.126)	0.0217 (0.100)	-0.0330 (0.110)
Spillovers								
ROG's inflow control	9.323*** (3.214)		6.961* (3.659)		6.264** (2.937)		0.960 (2.895)	
ROG's inflow control (lagged)		7.062** (3.426)		6.317 (4.192)		9.360*** (3.190)		7.322** (2.905)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Group Contagion Variable	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.188	0.186	0.182	0.183	0.303	0.304	0.217	0.227
Sample Period	1990-2011	1990-2011	1990-2011	1990-2011	1995-2008	1995-2009	1995-2013	1995-2013
Number of Countries	59	59	59	59	36	36	53	53

Note: This table reports the spillover coefficient β_3 in regression equation (3.12) with *CAPIN*, *CAPITAL*, *FINCONT2*, and the updated *KAI* as proxies for capital controls. Due to the data availabilities of *CAPIN*, *CAPITAL*, and *FINCONT2*, the samples for regressions associated with these proxies are much smaller than the one for regressions with Schindler index, so I divide the countries into two groups based on composite risk for those regression analyses. The Robust standard errors clustered at country level in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 3.8: Robustness Check of Within-Group Capital Deflection: Different Weights

	(1)	(2)	(3)	(4)
Weighted by Average Gross Inflows	3.051 (1.948)	1.857 (1.958)	4.826** (2.290)	4.311* (2.204)
Weighted by Average Exports	4.407** (2.048)	2.781 (1.755)	6.130** (2.575)	5.322** (2.356)
Year FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Group Contagion	No	Yes	No	Yes
Lagged τ^{S-i}	No	No	Yes	Yes

Note: This table reports the spillover coefficient β_3 in regression equation (3.12) with three different weighting schemes and the countries are divided into time-variant groups based on risk. The Robust standard errors clustered at country level in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

and outflow controls and redo the regressions in Table 3.5. Capital flow deflection still holds. This finding is consistent with an interpretation of the signaling story in Bartolini and Drazen (1997) that international investors may interpret tighter outflow controls as a signal for future tighter inflow controls.

Cluster Analysis

So far countries are grouped based on a single characteristic: geographical locations, export specializations, real GDP growth rates, or composite risk index. As a result, countries in the same group only share one common feature. Next, I group countries using an array of country characteristics, so countries in the same group share more than one common features. In particular, I consider real GDP growth rate, real GDP, real GDP per capita, composite risk index, and general capital controls.³² I consider these variables because they capture some of the important

³²All variables are standardized so their standard deviations are 1.

aspects of a country that are relevant to international investors. I will use k-means and k-medians clustering analysis to determine country groups.

$$\underset{\mathbf{S}}{\operatorname{argmin}} \sum_{i=1}^4 \sum_{j \in S_i} \|x_j - \mu_i\|^2 \quad (3.15)$$

where $\mathbf{S} = \{S_1, S_2, S_3, S_4\}$ with $S_i \neq \emptyset \forall i$, and $\cup_i S_i = \mathcal{S}$, where \mathcal{S} is the set of all the sample countries. x_j is the vector of covariates of country j . μ_i is the sample average of x_j for $j \in S_i$ when k-means clustering is used, and μ_i is the sample median when k-medians clustering is used.³³

Groups identified using k-means clustering with absolute distance are reported in Table D.3. Notice the groups are highly unbalanced. Cluster 1 includes 29 countries, cluster 2 includes 6 countries, cluster 3 includes 5 countries, and cluster 4 includes 44 countries. However, the cluster analysis is able to group 4 members of BRICS in the same cluster together with Mexico (cluster 3). I rerun the regression specification (2) of Table 3.5 for the groups identified using cluster analysis, and results are shown in Table 3.9. There is no evidence of capital deflection among countries with similar economic characteristics. So the evidence of capital deflection is restricted to countries with similar risk levels.

Endogeneity: Instrumental Variables

To address possible endogeneity bias, I follow an instrumental variables approach to estimate specification (3.12). Omitted variables may be a concern as

³³Euclidean distance is used to measure similarity in equation (3.9), I also consider using absolute difference to measure similarity.

Table 3.9: Within-Group Capital Deflection: Cluster Analysis

	k-means		k-medians	
	Euclidean Distance	Absolute Distance	Euclidean Distance	Absolute Distance
Domestic Pull Factors (all lagged)				
Real GDP growth rate	0.317 (0.215)	0.317 (0.215)	0.325 (0.223)	0.314 (0.214)
Real GDP growth rate shock	-0.319 (0.231)	-0.325 (0.231)	-0.361 (0.237)	-0.321 (0.231)
Real GDP per capita (logged)	5.416** (2.415)	5.346** (2.408)	5.577** (2.461)	5.316** (2.437)
De jure Capital inflow control	1.720 (1.276)	1.824 (1.241)	1.732 (1.243)	1.871 (1.230)
Composite risk index	0.0610 (0.0705)	0.0504 (0.0728)	0.0519 (0.0711)	0.0514 (0.0724)
Spillovers				
ROG's inflow control	2.862 (5.466)	-2.724 (3.563)	1.083 (5.734)	-2.119 (4.322)
Year FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Observations	909	909	909	909
R-squared	0.160	0.161	0.158	0.161
Number of Countries	68	68	68	68

Note: This table reports the spillover coefficient β_3 in regression equation (3.12) when countries are divided into time-invariant groups using cluster analysis. The Robust standard errors clustered at country level in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

countries can experience a surge in inflows because of a common shock to the group. If some countries react to the surge by increasing their controls while others do not, I can find a correlation between the policy of the first and the inflow surge to the latter, but this correlation would not reflect a causal relationship. Furthermore, reverse causality may also be a concern as the rest of the group might see higher capital inflows to a member as a signal of a capital inflow surge to the entire group. If this is the case, the rest of the group may respond to inflows to country i by increasing contemporaneous capital inflow restrictions. For these reasons, I gener-

ate three instruments that are correlated with the capital controls in the rest of the groups but not with the capital inflows to country i , and use shocks to these variables to identify the effect on inflows to i .

The first instrument is based on the electoral cycle, as governments may be more willing to raise capital controls before elections in an attempt to depreciate the real exchange rate and improve competitiveness. This instrument, denoted by $elect_t^{S^{-i}}$, is the GDP weighted fraction of the countries belonging to the subset S^{-i} that have an election in the upcoming year. This variable is computed as

$$elect_t^{S^{-i}} = \frac{\sum_{j \in S^{-i}} \bar{y}^j elect_{t+1}^j}{\sum_{j \in S^{-i}} \bar{y}^j},$$

where $elect_{t+1}^j$ equals 1 if country j has an election in year $t + 1$, and 0 otherwise.

The second instrument is based on the political leaning of the ruling government, as the right-wing governments are generally found to be less likely to employ capital controls (Grilli and Milesi-Ferretti, 1997, and Ghosh et al., 2014), possibly for ideological reasons. This instrument, denoted as $right_t^{S^{-i}}$, is the GDP weighted fraction of countries with a right-wing government. The variable is computed as

$$right_t^{S^{-i}} = \frac{\sum_{j \in S^{-i}} \bar{y}^j right_t^j}{\sum_{j \in S^{-i}} \bar{y}^j},$$

where $right_t^j$ equals to 1 if country j has a right-wing government in year t , and 0 if it has a left-wing or a centrist government.³⁴

³⁴The data on election year and the government's political orientation are from World Bank's Database of Political Institutions.

The results for the IV specification when countries are grouped by (time-variant) risk are reported in Table 3.10.³⁵ As discussed above, I expect that the instruments are correlated with inflow restrictions in group S^{-i} , but that they do not directly affect the dependent variable, as there is no a priori reason why the electoral cycle, or the political color of countries in the same group as country i are directly associated with capital inflows to i . In fact, the first stage results have the expected sign and the F-statistic of the regression indicates that none of the instruments is weak. Specifically, the upcoming election instrument is positive and significant, while the right-wing government instruments is negative and significant. The second stage regression results show that the capital controls in the rest of the group still have a positive impact on capital flows to country i and the size of the coefficients is comparable to the main regressions. The instruments also pass the over-identification test (Hansen J statistic) and endogeneity test (C statistic).

Endogeneity: Propensity Score-Matching

As another effort to address the potential endogeneity problem, I use propensity score-matching to estimate the spillover effects.³⁶ In particular, the countries that experience an increase of the capital controls in the rest of the group could be different from those that do not experience an increase of capital controls in the rest of the group. One approach to correct for this selection bias is to use propensity

³⁵Due to the data restriction, I have smaller samples for IV regressions. Hence I divide countries into three groups instead. The results in Table 3.5 continue to hold when countries are divided into three groups.

³⁶I would like to thank Sebnem Kalemli-Ozcan for suggesting me to use propensity score-matching.

Table 3.10: Within-group Capital Flow Deflection: IV

Second Stage	
Rest of the Group's Inflow Control	8.791* (5.206)
First Stage	
Upcoming Election Instrument	0.154*** (0.0365)
Right-Wing Government Instrument	-0.308*** (0.0389)
IV Tests	
First Stage F statistic for the instruments	19.677
P-value of F statistic	0.000
Hansen J statistic	0.415
P-value of Hansen J statistic	0.839
GMM C statistic	1.96
P-value of GMM C statistic	0.162
Year FE	Yes
Country FE	Yes
Group Contagion Variable	Yes
Observations	448
Number of Countries	35

Note: The sample consists of 64 countries. GDP per capita and composite risk index are insignificant in all specifications and hence not reported in the table to save space. All regressions control for year fixed effects and group contagion variable. Robust standard errors clustered at country level in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

score-matching.

To use propensity score methodology, I define a “treatment” variable, $D_{i,t}$, the following way:

$$D_{i,t} = \begin{cases} 1 & \text{if } \Delta\tau_t^{S-i} > 0 \\ -(n+1)/2 & \text{if } \Delta\tau_t^{S-i} \leq 0. \end{cases} \quad (3.16)$$

So country i is “treated” if there is an increase of capital controls in the rest of

the group. The treatment variable is unusual compared to the ones in the other policy evaluation works: the “treatment” defined in (3.17) is *not* a domestic policy intervention, but (a weighted average of) policy interventions abroad.

Propensity score-matching imputes the missing potential outcome for each “subject” (country-year pair) by using an average of the outcomes of similar “subjects” that do not receive the treatment. Similarity between “subjects” is based on the estimated probabilities of receiving the treatment, known as propensity scores. I estimate the probability of a country receiving “treatment” using a logit model:

$$Prob(D_{i,t} = 1) = F(\beta x_{i,t} + e_t^i), \quad (3.17)$$

where $x_{i,t}$ include all the variables in the pull and push factor model (3.12), as well as the fraction of the rest of the group with an inflow surge, and country and time dummies. The results of the logit regression is reported in Table 3.11. The group variable, the fraction of the rest of the group with an inflow surge (the group contagion variable), is positive and significant. So the more countries of a group experience inflow surges, the more likely the rest of the group as a whole increase capital controls. However, all the domestic variables are insignificant.³⁷ An explanation is that the “treatment” is not a domestic policy intervention, but (a weighted average of) policy interventions in the rest of the group.

I am interested in the average treatment effect on the treated (ATT), which is

³⁷I rerun the logit regression with additional country characteristics in $x_{i,t}$, including those used to estimate the probit model in Table 3.13 and lagged inflows as well as lagged surge dummy $Surge_{i,t}$. The result remains the same: all the country characteristics are insignificant, and only the group variable could explain the treatment probability.

Table 3.11: Determination of Treatment: logit

Domestic Variables (lagged)	
Real GDP growth rate	0.0575 (0.0495)
Real GDP growth rate shock	-0.0540 (0.0559)
Real GDP per capita (logged)	0.187 (0.473)
De jure Capital inflow control	-0.614 (0.458)
Composite risk index	-0.0456 (0.0432)
Group Variable	
Fraction of Group with an Inflow Surge	1.244** (0.584)
Year FE	Yes
Country FE	Yes
Observations	1,007

Note: Time-variant risk groups are used for the regressions. Robust standard errors clustered at country level in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

equal to the average of the difference between the observed treated outcomes, denoted $y_{1,i,t}$, and potential untreated outcomes, denoted $y_{0,i,t}$, for the treated “subjects”:

$$ATT = E(y_{1,i,t} - y_{0,i,t} | D_{i,t} = 1). \quad (3.18)$$

If there is capital flow deflection, ATT should be positive. However, $y_{0,i,t}$ of the treated “subjects” are unobservable. Under the conditional mean independence assumption, (3.18) could be rewritten as

$$ATT = E(y_{1,i,t} | x_{i,t}, D_{i,t} = 1) - E(y_{0,i,t} | x_{i,t}, D_{i,t} = 0). \quad (3.19)$$

The advantage of (3.19) is that it could be estimated using observable data. The estimated ATT is reported in Table 3.12. The average treatment effect on the treated is positive but insignificant. So I could not find significant within-group spillover effect using propensity score-matching.

Table 3.12: Average Treatment Effect on the Treated

Coefficient	AI Robust Std. Err.	z	$P > z $	95% Conf. Interval
.0213	.532	0.04	0.968	(-1.023, 1.066)

Note: ATT is esimated using “teffects psmatch” command introduced in Stata 13. The advantage of this new command over the old one (“psmatch2”) is that it takes into the account the fact that the propensity scores are estimated, not observed (see Stata 13 User’s Guide).

There are several possible explanations of the insignificant ATT. First, the estimation of propensity score suffers from omitted variable bias. If the model suffers from selection bias that is related to country characteristics, then the treatment probability depends on unobservable variables as all the domestic variables in Table 3.11 are insignificant, and in this case it is invalid to use propensity score-matching as the conditional independence assumption would be violated (Heckman and Robb, 1985; Caliendo and Kopeinig, 2008).

Forbes et al. (2013) use propensity score-matching to study the impact of countries’ own capital controls on their macroeconomic variables, and they point out a few problems of applying propensity score-matching to panel data: “a major challenge for much of the international/macroeconomic literature is having a sufficient number of ‘similar’ observations to form a control group; this criteria is

unlikely to be met.”

3.3.3 Evidence of Policy Response

In this subsection I analyze the empirical evidence of policy responses to capital flow deflection (Proposition 6). In particular, I use a probit model to investigate whether the probability of imposing capital inflow restrictions in one country is affected by capital controls set by other countries.

There is little empirical literature on the determinants of capital controls. Fratzcher (2011) studies capital controls largely in the context of more industrialized economies.³⁸ Fernandez et al. (2013) investigate whether countries use capital controls for prudential reasons and focus only on the cyclical components of these measures. Due to the lack of established empirical literature in the field, I study the determinants of a country’s decision to change capital inflow controls using a parsimonious empirical model with the pull-push factors that are found to affect capital inflows in the previous section, complemented by additional controls suggested by the theory in Section 2 and by other studies on capital controls. The specification is:

$$Prob(Inc_t^i = 1) = \Phi(\beta_0 + \beta_1 \Delta \tau_t^{S^{-i}} + \beta_2 x_t^i + u_t^i), \quad (3.20)$$

where Inc_t^i is a dichotomous variable that equals 1 if country i raises inflow restrictions at time t and 0 otherwise.³⁹ Φ is the cumulative normal distribution function.

³⁸I tried using the specifications in Fratzcher (2011) to study capital controls in developing countries, but the model yields little explanatory power.

³⁹As countries are more likely to increase controls on destabilizing/short-term inflows such as bond inflows rather than FDIs, we run the same regressions in this subsection excluding FDI restrictions from the dependent variable, and the results are the same.

$\Delta\tau_t^{S^{-i}} = \tau_t^{S^{-i}} - \tau_{t-1}^{S^{-i}}$ is a measure of the change in inflow restrictions by countries in group S^{-i} , excluding country i . As indicated above, x_t includes the pull and push factors in the previous subsection. These factors may be important determinants of a change in capital inflow restrictions as they influence gross capital inflows, which in turn may trigger a policy response by the government. In addition x_t^i includes time fixed effects, group contagion variable, and a number of other variables (discussed below) that may be correlated with a government's decision to increase inflow restrictions.

The key variable of interest in this subsection is $\Delta\tau_t^{S^{-i}}$. Proposition 6 predicts that whether capital controls are complements or substitutes depends on the motive for which they are used. If inflow restrictions are motivated by a desire to manipulate the domestic interest rate, such as in the case of prudential capital controls, then the country will respond to an increase in inflow restrictions by other borrowers by raising its own controls. On the other hand, when the motive for capital controls is to manipulate the world interest rate, then the nature of the relationship among capital controls imposed by different countries is ambiguous. As small countries cannot influence the world interest rate, they only have domestic motives to use capital controls. I then expect the coefficient of $\Delta\tau_t^{S^{-i}}$ to be positive for small economies and ambiguous for large economies.

I also introduce in the specification a number of variables that may affect the decision of a government to increase capital controls, either to manipulate the world interest rate or to manipulate the domestic interest rate. Specifically, I control for the real GDP since the model in Section 2 predicts that larger countries are more likely

to manipulate the inter-temporal terms of trade with their capital control policies. While developing economies play a small role in international financial markets relative to advanced economies, it is still possible that certain larger countries exert at least some market power if markets are segmented, for instance because various economies are perceived to be imperfect substitutes by international investors. I also include REER (real effective exchange rate) overvaluation, domestic inflation, a flexible exchange rate regime dummy, and external debt since these variables may affect the decision to use capital controls as a means to manipulate the domestic interest rate for prudential reasons or for other non-prudential reasons.⁴⁰

Table 3.13 reports the results of the probit regression (3.20) when countries are grouped following the approach of the previous subsection. Due to data availability of inflation and de facto exchange rate regime, our sample size now reduces to 64.⁴¹ The probit model has a reasonable good fit as indicated by the Pseudo R-squares. To save space, I do not report the coefficients of the traditional pull factors that are not significant in any specification.

I find no evidence of within-group policy response as all the coefficients of $\Delta\tau_t^{S-i}$ are insignificant. This is true regardless of how I group countries: notably, this is true when I use risk-groups that display large and significant capital flow deflection. While the sample is composed of developing countries that are small relative to the size of the global financial market, one could argue that at least some of these countries are large within the groups they belong to and set capital controls

⁴⁰I also include lagged gross inflows and lagged inflow surge dummy as additional controls. Their coefficients are insignificant and the policy response coefficient remains unchanged.

⁴¹All the results from the previous subsection on spillover effect are robust to the smaller sample.

Table 3.13: Within-Group Policy Response: Probit

	(1)	(2)	(3)	(4)	(5)	(6)	Expected Sign
Domestic Variables (Lagged)							
Real GDP growth rate	-0.0486* (0.0256)	-0.0460* (0.0250)	-0.0462* (0.0251)	-0.0444* (0.0241)	-0.0459* (0.0249)	-0.0491* (0.0253)	+
Real GDP growth rate shock	0.0830** (0.0351)	0.0798** (0.0344)	0.0802** (0.0349)	0.0763** (0.0346)	0.0796** (0.0349)	0.0829** (0.0348)	-
Real GDP (logged)	0.116** (0.0470)	0.111** (0.0467)	0.114** (0.0476)	0.114** (0.0472)	0.111** (0.0483)	0.111** (0.0471)	+
REER overvaluation	-1.032* (0.570)	-0.945 (0.577)	-0.949* (0.565)	-0.938* (0.568)	-0.924* (0.556)	-0.990* (0.575)	-
Inflation	0.197** (0.0939)	0.185** (0.0918)	0.183* (0.0943)	0.180** (0.0909)	0.179* (0.0934)	0.179* (0.0926)	+
Flexible Exchange Rate	-0.0393 (0.156)	-0.0255 (0.140)	-0.0244 (0.142)	-0.0243 (0.143)	-0.0300 (0.138)	-0.0297 (0.148)	-
External Debt	-0.178 (0.129)	-0.165 (0.125)	-0.167 (0.126)	-0.160 (0.127)	-0.165 (0.123)	-0.172 (0.122)	+
Change of Weighted Inflow Controls in the ROG							
Group by geographic location	-1.383 (1.003)						+
Group by export specialization		0.293 (0.883)					+
Time-invariant group by growth			0.320 (0.965)				+
Time-variant group by growth				-0.112 (0.294)			+
Time-invariant group by risk					-1.275 (1.294)		+
Time-variant group by risk						0.0111 (0.360)	+
Observations	841	841	841	841	841	841	
Pseudo R-squared	0.151	0.151	0.150	0.150	0.150	0.150	

Note: The sample consists of 64 countries. GDP per capita and composite risk index are insignificant in all specifications and hence not reported in the table to save space. All regressions control for year fixed effects and group contagion variable. Robust standard errors clustered at country level in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

to exploit this market power. If this is the case, then the lack of evidence may be resulting from the fact that capital flow deflection is leading these countries to respond by decreasing rather than increasing their controls. However, the lack of evidence of a policy response appears to be a very resilient result. In particular, it persists also if I drop larger developing economies from the sample to remove possible terms of trade motive (no matter what definition I give to “large economy”).

I also undertake a series of robustness tests, none of which changes the finding of no policy response. First, I use a linear probability model of (3.20), where I introduce country fixed effects. The regression results are reported in Table D.4 in the appendix. Note that several of the control variables that were significant in Table 3.13 (such as the REER overvaluation) become insignificant, suggesting that unobserved country characteristics, rather than the time dimension of these variables, are correlated with the decision to increase inflow restrictions. More importantly for the analysis, the OLS regression results of the linear probability model yield the same findings as the probit model, namely the coefficient of $\Delta\tau_t^{S-i}$ continues to be statistically insignificant for all country groups.⁴²

As an alternative to the policy change variable $\Delta\tau_t^{S-i}$, I use a different definition of the main control variable and I replicate the results in Tables 3.13 and D.4. In particular, I define D_t^{S-i} which is computed as

$$D_t^{S-i} = \frac{\sum_{j \in S_i} \bar{y}^j D_t^j}{\sum_{j \in S_i} \bar{y}^j},$$

⁴²I also run instrumental variable regressions replacing $\Delta\tau_t^{S-i}$ with the sets of instruments introduced in Section 3.2.5, and these regressions yield the same results.

where D_t^j is a categorical variable that takes value 1 if country j tightens inflow control at t , -1 if j lowers inflow control, and 0 if there is no change. The results are largely the same, except that I find a policy response within export groups, but it is only significant at 10%. The coefficient of the main variable of interest for all other groupings is never significant.

Next, I conduct the same exercises focusing on a decrease (rather than an increase) in inflow controls as the dependent variable. I rerun the regressions in Tables 3.13 and D.4. Again, I do not find robust within-group policy response.

A final concern is that countries might experience a heterogeneity in externalities of capital inflows that is not captured by the model. For example, in countries facing borrowing constraints, the level of capital inflows might be sub-optimally low. In this case the capital flow deflection would correspond to a positive externality and hence it would not necessarily induce the government to increase inflow controls. To control for this, I introduce a dummy for countries that have experienced a recent default and interact this dummy with the spillover variable. I still do not find evidence of policy response for countries that have not had a recent default (i.e. for those that are less likely to face borrowing constraint).⁴³

An important question is what explains the discrepancy between the theory in Section 2 and the lack of empirical evidence of a policy response in this section. While I do not have a firm answer to this question, I have three explanations for the puzzle. A first explanation has to do with the data methodology used to compile *de jure* indices of capital controls. These measures capture the extensive margin of

⁴³The results of robustness checks are available upon request.

restrictions, but not their intensive margin. In other words, if a regulation or a tax on a certain category of financial transactions becomes more stringent, this would not necessarily be reflected in the available indices that code information in a binary form (0 for unrestricted transactions and 1 for restricted ones).⁴⁴ This methodology could bias the regression results as it reduces the variability of capital controls by construction. The second explanation has to do with the dominant view on capital controls in the historical period under analysis. Until recently, restrictions to capital flows were not considered as “legitimate” prudential policies. In this environment, governments may have been concerned that the use of capital controls could send a negative signal to international markets, as highlighted in the work of Bartolini and Drazen (1997). In this case, governments would weigh the benefit of prudential controls to offset domestic market distortions arising from excessive capital inflows with the reputation costs of introducing such measures. This may also suggest that governments might have preferred the use of policy instruments other than inflow controls when facing capital flow deflection. Again, the end result would be a muted policy response. A third explanation is that governments, or at least some governments, are in practice less likely to use prudential controls than predicted by the theory, because the problem that they face is a sub-optimally low level of capital inflows rather than excessively large and volatile flows. For these countries a sudden surge in inflows as a result of a policy change by others alleviates an existing market failure. While, as discussed above, I try to address this concern in the regression, difficulties to access international financial markets may still contribute to explain

⁴⁴See Appendix C for further details.

the low policy response to capital flow deflection that I find in the data.

3.4 Conclusion

This chapter presents a simple model of capital flow deflection, by which we mean the increase in capital inflows to third markets as a result of tightening of capital controls in some countries, and of the policy response that this cross-border spillover effect can induce in other countries. We test the implications of the model for a large sample of developing economies between 1995 and 2009 and find strong evidence of capital flow deflection, but no evidence of a policy response.

These empirical findings complement recent work on capital controls, which allows to draw some, admittedly preliminary, conclusions. First, both the event studies on Brazil (Forbes et al, 2013, and Lambert et al, 2011) and the cross-sectional approach indicate that capital controls deflect inflows to countries with similar risk levels. This spillover effect is economically relevant and, when we focus on a change in policy in Brazil, the magnitudes are comparable across studies. These findings indicate that capital controls, even when improving the management of capital flows to a country, may render more difficult the management of flows for others. As discussed in the theory section, these multilateral effects could lead to an inefficient equilibrium in realistic environments where governments have limited policy instruments and/or markets are incomplete.

Second, both the studies on the determinants of capital controls (Fratzscher, 2013 and Fernandez et al, 2013) and the results on the policy response cast doubts

on the use of capital controls for prudential reasons. However, this lack of evidence may be driven by the methodology used to collect cross-country data on inflow restrictions and/or by the specificity of the historical period under analysis, a period when capital controls were seen as stigma that governments might have been concerned with sending a negative signal to markets using capital controls. In the coming years, the changing view on the use of capital controls (IMF, 2012) may well lead governments to manage capital flows more actively to address domestic distortions. This will also increase the frequency of episodes of capital flow deflection and, possibly, of retaliatory responses as predicted by the theory. Combined with the availability of more detailed data, future empirical work may provide a different upshot.

In concluding this chapter, I would like to come back to the question we posed in the beginning. What does capital flow deflection imply for the design of the multilateral institutions needed to govern international capital flows? Ideally, multilateral rules on capital controls should aim at preserving some flexibility for efficiency enhancing capital controls, while limiting the negative consequences associated with capital flow deflection.

The regulation of safeguards in the WTO (i.e. the restriction of imports that cause injury to a country) may provide some useful lessons. Both safeguards and capital controls introduce valuable flexibility in their respective systems and both lead to deflection of trade and capital flows, respectively. But safeguards are tightly regulated in the WTO. First, they need to be temporary and respectful of the most favored nation (MFN) clause, that is safeguards cannot discriminate between

different trading partners. Second, Art. XIX of GATT and other clauses of the WTO Agreements circumscribe the situations where a safeguard can rightfully be applied. Third, the use of safeguards is subject to the WTO dispute settlement mechanism, which allows any member affected by the measure to request that a neutral panel reviews its consistency with WTO rules. Whether this regulatory framework can serve as a source of inspiration to deal with capital flow deflection is a question left for future research.

Appendix A: Derivations and Proofs

A.1 Solution to the Constrained Planner's Problem

$$\begin{aligned}\mathcal{L} = & u(c_T, f(h)) + \beta \mathbb{E} V^{CP}(w(c_T, h), d, y'_T, r') + \lambda_h (1 - h) + \lambda^{CP} \left(y_T + \frac{d}{1+r} - c_T - d_{-1} \right) \\ & + \lambda_{CC}^{CP} [\Psi(c_T, h) - d] + \lambda_w [w(c_T, h) - \gamma w_{-1}]\end{aligned}$$

FOCs:

$$u_T + \beta w_T \mathbb{E} V_w^{CP'} - \lambda^{CP} + \lambda_{CC}^{CP} \Psi_T + \lambda_w w_T = 0$$

$$u_N f'(h) + \beta w_h \mathbb{E} V_w^{CP'} - \lambda_h + \lambda_{CC}^{CP} \Psi_h + \lambda_w w_h = 0$$

$$\beta \mathbb{E} V_d^{CP'} + \frac{\lambda^{CP}}{1+r} - \lambda_{CC}^{CP} = 0$$

Envelope theorem gives

$$V_w^{CP} = -\gamma \lambda_w$$

$$V_d^{CP} = -\lambda^{CP}$$

Complementary slackness requires

$$\mathbb{1}_{\lambda_h > 0} + \mathbb{1}_{\lambda_w > 0} = 1$$

Substitute the first envelope condition into the first FOC:

$$u_T - \gamma\beta w_T \mathbb{E}\lambda'_w - \lambda^{CP} + \lambda_{CC}^{CP} \Psi_T + \lambda_w w_T = 0 \quad (\text{A.1})$$

Substitute the first envelope condition into the second FOC,

$$u_N f'(h) - \gamma\beta w_h \mathbb{E}\lambda'_w - \lambda_h + \lambda_{CC}^{CP} \Psi_h + \lambda_w w_h = 0 \quad (\text{A.2})$$

When $\lambda_w > 0$, $\lambda_h = 0$, then (A.2) can be rewritten as

$$-\beta \mathbb{E}\gamma \lambda'_w w_T + \lambda_w w_T = (u_N - \lambda_{CC}^{CP} \Psi_h) \left(-\frac{w_T}{w_h} \right)$$

Substitute it into (A.1):

$$\lambda^{CP} = u_T + \lambda_{CC}^{CP} \Psi_T + (u_N - \lambda_{CC}^{CP} \Psi_h) \left(-\frac{w_T}{w_h} \right), \quad \text{when } \lambda_w > 0 \quad (\text{A.3})$$

When $\lambda_w = 0$, then (A.1) can be rewritten as

$$\lambda^{CP} = u_T - \gamma\beta w_T \mathbb{E}\lambda'_w + \lambda_{CC}^{CP} \Psi_T, \quad \text{when } \lambda_w = 0 \quad (\text{A.4})$$

Notice

$$\frac{dh}{dc_T} = \begin{cases} \frac{w_T}{w_h} & \text{when } \lambda_w > 0 \\ 0 & \text{when } \lambda_w = 0 \end{cases}$$

and

$$\Phi_T = \begin{cases} u_N f(h) \frac{w_h}{w_T} & \text{when } \lambda_w > 0 \\ -\beta\gamma w_T \mathbb{E}[\lambda'_w] & \text{when } \lambda_w = 0 \end{cases}$$

so (A.3) and (A.4) can be combined and rewritten as

$$\lambda^{CP} = u_T + \Phi_T + \lambda_{CC}^{CP} \left[\Psi_T + \Psi_h \frac{dh}{dc_T} \right] \quad (\text{A.5})$$

Substitute the second envelope condition into the third FOC,

$$\lambda^{CP} = (1+r)\beta \mathbb{E} \lambda^{CP'} + (1+r)\lambda_{CC}^{CP} \quad (\text{A.6})$$

Substituting (A.5) into (A.6) gives the constrained-optimal Euler equation:

$$u_T + \Phi_T + \lambda_{CC}^{CP} \left(\Psi_T + \Psi_h \frac{dh}{dc_T} \right) = (1+r)\beta \mathbb{E} \left[u'_T + \Phi'_T + \lambda_{CC}^{CP'} \left(\Psi'_T + \Psi'_h \frac{dh'}{dc'_T} \right) \right] + (1+r)\lambda_{CC}^{CP} \quad (\text{A.7})$$

A.2 Proof of Proposition 4

Proof Since the laissez-faire equilibrium is identical to the constrained-optimal allocations, so I just need to consider the cost when the present collateral constraint

is slack. Then household's Euler equation in the decentralized economy is

$$u_T = (1+r)(1+\tau)\beta\mathbb{E}u'_T$$

Substitute (2.33) into the household's Euler equation in the decentralized economy,

$$u_T + \Phi_T = (1+r)\beta\mathbb{E}\left[u'_T + \Phi'_T + \lambda'_{CC}\left(\Psi'_T + \Psi'_h\frac{dh'}{dc'_T}\right)\right] \quad (\text{A.8})$$

which is identical to the constrained planner's Euler equation. And since the rest of the equilibrium conditions in the decentralized economy are identical to the constrained planner's problem, then the decentralized equilibrium allocations are identical to the constrained-optimal allocations. ■

A.3 Proof of the Existence and Uniqueness of the Partial Equilibrium

Lemma 3 (Existence and Uniqueness of the Financially-Unconstrained Equilibrium)

EE and WR always have an unique intersection.

Proof Since *EE* is downward sloping, and *WR* is upward sloping or perfectly vertical. ■

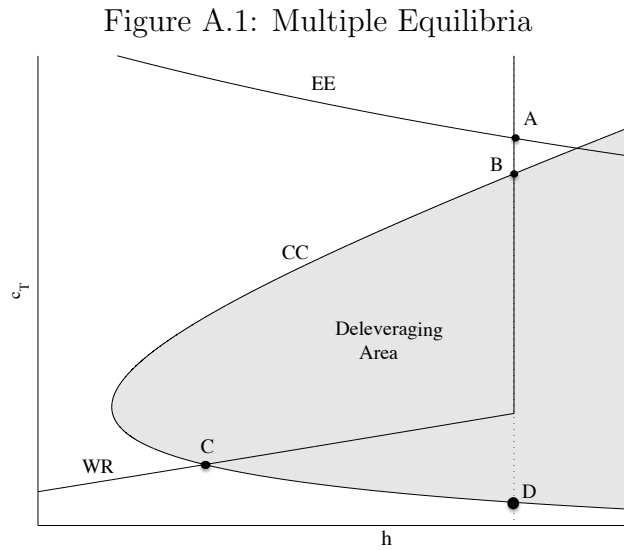
Lemma 4 (Existence and Uniqueness of the Financially-Constrained Equilibrium)

When EE and WR intersect inside the deleveraging area, WR and CC always have an unique intersection lying below EE.

Proof Straightforward by discussing all four cases. ■

Lemma 3 guarantees the uniqueness of the equilibrium when the collateral

constraint is slack, and 4 guarantees the uniqueness of the equilibrium when the financially-unconstrained equilibrium does not exist. Therefore Lemmas 3 and 4 together guarantee the existence of an equilibrium. However, the two lemmas do not guarantee the uniqueness of the equilibrium as the collateral constraint could be binding at one equilibrium while slack at the other. For example in Figure A.1, points A , B , and C all are equilibria of the model. The equilibrium is financially-unconstrained at point A , while it is financially constrained at B and D . The economy is at full employment at A and B , while there is unemployment at C .



The model features multiple equilibria because of the collateral constraint,¹ a feature of the rational expectations and the partial equilibrium. Imagine international investors could form different belief of the country's ability to borrow. At A , the international investors believe the country has ability to repay all the debt (high

¹Without the wage rigidity, the multiple equilibria are at points A , B , and D where the full employment line intersects with EE and CC .

collateral), therefore the country is financially unconstrained and the consumption and output is high, and the collateral (GDP) ends up being high which confirms the initial positive belief. At C , the international investors believe the country has trouble paying back the debt, therefore the country is borrowing constrained, which lowers both consumption and output and hence the collateral ends up being low which confirms the investor's initial negative belief.

A and B are not saddle-path stable. The reason is that the future consumption is endogenous and determined by the debt accumulated in the present period. Suppose the EE in Figure 2.1 is associated with the debt level at C . If the economy consumes at A or B , the debt goes up and future consumption goes down, therefore EE would shift down given τ . And when EE associated with the debt levels at A and B intersect with WR inside the deleverage area, A and B are not dynamically rational expectations. Therefore, I impose the following stringent selection criteria:

Definition 7 (Equilibrium Selection Criteria) *When there are multiple equilibria, let the unique equilibrium be the one associated with the lowest debt level.*

Once I imposed the selection criteria 7, I have the following definition:

Definition 8 (Determination of the Partial Equilibrium) *Given $\{r, \tau, \epsilon, d_{-1}, w_{-1}, c'_T, h'\}$, the equilibrium is determined by the lowest intersection of WR and CC that lies below EE . If such point does not exist, then the equilibrium is determined by the intersection of EE and WR .*

It then follows from Lemmas 3 and 4 that the equilibrium defined in Definition

8 exists and is unique.

A.4 Proof of Lemma 2

Maximizing (3.7) subject to (3.5), and taking both market frictions into account -domestic externality and market power-, we obtain the following Euler equation:

$$u'(c_1^i) - \beta^i R u'(c_2^i) - x'(c_1^i - y_1^i) - \beta^i u'(c_2^i)(c_1^i - y_1^i) \frac{dR}{d[m^i(c_1^i - y_1^i)]} = 0. \quad (\text{A.9})$$

Let us investigate separately the two distinct motives for policy intervention, starting with the prudential motive. If country i does not affect the world market equilibrium ($m^i = 0$), then it is $dR/d[m^i(c_1^i - y_1^i)] = 0$. Hence, for a borrowing country ($c_1^i - y_1^i > 0$), the Euler equation above simplifies to

$$u'(c_1^i) = \beta^i R u'(c_2^i) + x'(c_1^i - y_1^i). \quad (\text{A.10})$$

In order for (3.4) to be equal to (A.10), it must be

$$\frac{u'(c_1^i)}{\beta_i R (1 + \tau^i)} = \frac{u'(c_1^i) - x'(c_1^i - y_1^i)}{\beta^i R},$$

from which we obtain the formula for the optimal prudential capital controls as

$$\widehat{\tau}^i = x'(c_1^i - y_1^i) / [u'(c_1^i) - x'(c_1^i - y_1^i)].$$

For a lending country ($c_1^i - y_1^i \leq 0$) instead, it is $e(c_1^i - y_1^i) = 0$, and thus

all frictions disappear. As a result, the solution to the welfare maximization for a rational forward-looking national planner coincides with the utility maximization of the representative consumer, and the optimal prudential policy becomes $\widehat{\tau}_1^i = 0$. Hence, depending on whether country i is lender or borrower, its optimal prudential capital controls can be described by the step function defined in (3.10).

Let us now introduce the terms-of-trade motive. If country i is able to affect the world market equilibrium ($m^i > 0$), then it is $dR/d[m^i(c_1^i - y_1^i)] \neq 0$, and its unilateral optimal policy is found by equalizing Euler equation (3.8) with the one solved under the decentralized optimization problem (3.4). After a few algebraic steps, we obtain the optimal policy as

$$1 + \tau^{i*} = (1 + \widehat{\tau}^i)(1 + \widetilde{\tau}^i).$$

The expression for $\widehat{\tau}^i$ is given in (3.10), while the one for $\widetilde{\tau}^i$ is given by $\widetilde{\tau}^i = m^i \cdot \varepsilon^{-i}$, where ε^{-i} represents the inverse elasticity of global savings faced by country i , that is (and after defining $Y_1^{-i} \equiv \sum_{j \neq i} m^j y_1^j$ and $C_1^{-i} \equiv \sum_{j \neq i} m^j c_1^j$):²

$$\varepsilon^{-i} = \frac{dR}{d(Y_1^{-i} - C_1^{-i})} \frac{Y_1^{-i} - C_1^{-i}}{R}. \quad (\text{A.11})$$

²In deriving the expression for ε^{-i} , we exploit the fact that $m^i(c_1^i - y_1^i) = \sum_{j \neq i} m^j(y_1^j - c_1^j)$.

A.5 Proof of Proposition 6

Deriving expression (3.9) with respect to $\tau^{S^{-i}}$ we obtain

$$\frac{d\tau^{i*}}{d\tau^{S^{-i}}} = \frac{d\widehat{\tau}^i}{d\tau^{S^{-i}}}(1 + \widetilde{\tau}^i) + \frac{d\widetilde{\tau}^i}{d\tau^{S^{-i}}}(1 + \widehat{\tau}^i),$$

where $\widehat{\tau}^i, \widetilde{\tau}^i > 0$ for a large country.

(i) We now prove that $d\widehat{\tau}^i/d\tau^{S^{-i}}$ is always strictly positive. It is

$$\frac{d\widehat{\tau}^i}{d\tau^{S^{-i}}} = \frac{d\widehat{\tau}^i}{dR} \frac{dR^*}{d\tau^{S^{-i}}}.$$

Lemma 1 has proven that $dR^*/d\tau^{S^{-i}} < 0$. We only need to show that $d\widehat{\tau}^i/dR <$

0. Define

$$G(R, \widehat{\tau}^i) \equiv \frac{x'(c_1^i(R, \widehat{\tau}^i) - y_1^i)}{u'(c_1^i(R, \widehat{\tau}^i)) - x'(c_1^i(R, \widehat{\tau}^i) - y_1^i)} - \widehat{\tau}^i = 0$$

as the implicit function of $\widehat{\tau}^i$ w.r.t. R when country i is a borrower. By the implicit function theorem, it is

$$\frac{d\widehat{\tau}^i}{dR} = -\frac{\partial G/\partial R}{\partial G/\partial \widehat{\tau}^i}.$$

The numerator writes as

$$\frac{\partial G}{\partial R} = \frac{u'(c_1^i) \cdot x''(c_1^i - y_1^i) - u''(c_1^i) \cdot x'(c_1^i - y_1^i)}{[u'(c_1^i) - x'(c_1^i - y_1^i)]^2} \frac{\partial c_1^i}{\partial R},$$

which is strictly negative, given that $u', x', x'' > 0$, $u'' < 0$, and $\partial c_1^i/\partial R < 0$.

On the other hand, the denominator can be calculated as

$$\frac{\partial G}{\partial \widehat{\tau}^i} = \frac{u'(c_1^i) \cdot x''(c_1^i - y_1^i) - u''(c_1^i) \cdot x'(c_1^i - y_1^i)}{[u'(c_1^i) - x'(c_1^i - y_1^i)]^2} \frac{\partial c_1^i}{\partial \widehat{\tau}^i} - 1,$$

which is also strictly negative. It then follows $d\widehat{\tau}^i/dR < 0$ for all borrowing countries, which completes the proof of part (i).

(ii) We are now going to prove that $d\widetilde{\tau}^i/d\tau^{S^{-i}}$ may be positive or negative. Knowing that $\widetilde{\tau}^i = m^i \cdot \varepsilon^{-i}$, this derivative can be calculated from the implicit function defined by

$$H[\widetilde{\tau}^i, \tau^{S^{-i}}] \equiv m^i \varepsilon^{-i}(\widetilde{\tau}^i, \tau^{S^{-i}}) - \widetilde{\tau}^i = 0.$$

Applying the implicit function theorem to function H , we obtain

$$\frac{d\widetilde{\tau}^i}{d\tau^{S^{-i}}} = -\frac{\frac{dH}{d\tau^{S^{-i}}}}{\frac{dH}{d\widetilde{\tau}^i}} = -\frac{m^i \frac{d\varepsilon^{-i}}{d\tau^{S^{-i}}}}{m^i \frac{d\varepsilon^{-i}}{d\widetilde{\tau}^i} - 1}, \quad (\text{A.12})$$

which can be positive or negative. In fact, exploiting the expression for ε^{-i} given in (A.11), we find that

$$\frac{d\varepsilon^{-i}}{d\tau^{S^{-i}}} = \frac{1}{R} \left[\frac{d(Y_1^{-i} - C_1^{-i})}{d\tau^{S^{-i}} \underset{>0}{}} \left(\frac{d^2 R}{d(Y_1^{-i} - C_1^{-i})^2 \underset{\leq 0}{}} \frac{Y_1^{-i} - C_1^{-i}}{R \underset{>0}{}} + \frac{dR}{d(Y_1^{-i} - C_1^{-i}) \underset{>0}{}} \right) - \frac{dR}{d\tau^{S^{-i}} \underset{<0}{}} \varepsilon^{-i} \underset{>0}{]} \leq 0,$$

and

$$\frac{d\varepsilon^{-i}}{d\widetilde{\tau}^i} = \frac{d^2 R}{d(Y_1^{-i} - C_1^{-i}) d\widetilde{\tau}^i \underset{\leq 0}{}} - \frac{1}{R \underset{>0}{}} \varepsilon^{-i} \frac{dR}{d\widetilde{\tau}^i \underset{<0}{}} \leq 0.$$

For ease of reference, the sign of each term is reported in the expression above. The sign of expression (A.12) is then ambiguous as both the numerator and the denominator can be either positive or negative.

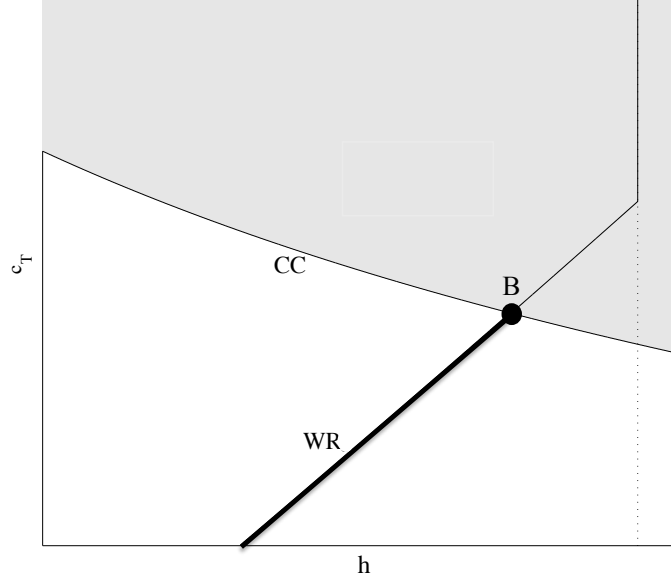
Appendix B: Numerical Solution Method

B.1 Constrained Efficient Allocations

I solve the constrained planner's problem by value function iteration. The value function is defined by (2.20). The difficult part is to find the feasible set. The feasible set is determined by the state variables (d_{-1}, w_{-1}, y_T, r) . Notice for given state variables, I can plot WR and CC as in Figure B.1. The constrained planner could choose from any point along the bolded line, which is the segment of WR that is below point B . B is the lowest intersection of CC and WR . The allocations at B are solved from (2.35) and (2.36). Therefore, the feasible allocations are determined. The rest is standard.

To summarize: for given state variables (d_{-1}, w_{-1}, y_T, r) and initial guess of value function $V^0(d_{-1}, w_{-1}, y_T, r)$, solve (2.20) by choosing allocations from the feasible set—the allocations on WR that is below B and using $V^0(d_{-1}, w_{-1}, y_T, r)$ for computing the expectation of the next period's value function. A new value function is solved this way. Repeat the process until the value function converges.

Figure B.1: WR & CC given (d_{-1}, w_{-1}, y_T, r)



Note: The feasible allocations are indicated by the bold lines.

B.2 Laissez-faire Equilibrium Allocations

The more challenging problem is to solve for the laissez-faire allocations. I will use policy function iteration with the help of the graphical framework for solving this problem.

Given initial guess of the decision rules $c_T^0(d_{-1}, w_{-1}, y_T, r)$ and $h^0(d_{-1}, w_{-1}, y_T, r)$, for any given (d_{-1}, w_{-1}, y_T, r) I redefine EE curve as

$$(c_T)^{-1/\xi} [c(c_T, h^\alpha)]^{-\sigma+1/\xi} = \beta(1+r)(1+\tau)\mathbb{E} \left[\left(c_T^{0'} \right)^{-1/\xi} \left[c(c_T^{0'}, f(h^{0'})) \right]^{-\sigma+1/\xi} \right]. \quad (\text{B.1})$$

where

$$c_T^{0'} = c_T^0((1+r)(y_T - d_{-1} - c_T), w(c_T, h), y_T', r')$$

$$h^{0'} = h^0((1+r)(y_T - d_{-1} - c_T), w(c_T, h), y_T', r')$$

Step 0 Use the policy functions of the constrained planner's problem as the initial guess of policy functions, $c_T^0(d_{-1}, w_{-1}, y_T, r)$ and $h^0(d_{-1}, w_{-1}, y_T, r)$.

Step1 Solve for the intersection of EE and WR , point A from (2.35) and (B.1), denote the solution $c_T^A(d_{-1}, w_{-1}, y_T, r)$ and $h^A(d_{-1}, w_{-1}, y_T, r)$.

Step2 If point A satisfies the collateral constraint (2.23), then it is the equilibrium and the new policy functions are

$$c_T^1(d_{-1}, w_{-1}, y_T, r) = c_T^A(d_{-1}, w_{-1}, y_T, r)$$

and

$$h^1(d_{-1}, w_{-1}, y_T, r) = h^A(d_{-1}, w_{-1}, y_T, r).$$

Step3 If point A does not satisfy the collateral constraint, solve for the intersection of WR and CC , point B from (2.35) and (2.36), denote the solution $c_T^B(d_{-1}, w_{-1}, y_T, r)$ and $h^B(d_{-1}, w_{-1}, y_T, r)$. and the new policy functions are

$$c_T^1(d_{-1}, w_{-1}, y_T, r) = c_T^B(d_{-1}, w_{-1}, y_T, r)$$

and

$$h^1(d_{-1}, w_{-1}, y_T, r) = h^B(d_{-1}, w_{-1}, y_T, r).$$

Iterate policy functions $c_T(d_{-1}, w_{-1}, y_T, r)$ and $h(d_{-1}, w_{-1}, y_T, r)$ by repeating steps 1-3 until the policy functions converge.

B.3 Optimal Tax

After solving for the constrained efficient policy functions $\{c_T^{CP}(d_{-1}, w_{-1}, y_T, r), c_N^{CP}(d_{-1}, w_{-1}, y_T, r), d^{CP}(d_{-1}, w_{-1}, y_T, r), w^{CP}(d_{-1}, w_{-1}, y_T, r)\}$, compute optimal tax using the following formula

$$\tau^*(d_{-1}, w_{-1}, y_T, r) = \frac{u_T(c_T^{CP}(d_{-1}, w_{-1}, y_T, r), c_N^{CP}(d_{-1}, w_{-1}, y_T, r))}{\beta(1+r)\mathbb{E}_{\{y'_T, r' | y_T, r\}} u_T(c_T^{CP}(d^{CP}, w^{CP}, y'_T, r'), c_N^{CP}(d^{CP}, w^{CP}, y'_T, r'))}$$

when the collateral constraint is slack at (d_{-1}, w_{-1}, y_T, r) , and $\tau^*(d_{-1}, w_{-1}, y_T, r) = 0$ otherwise.

To compute the decomposition of optimal tax, I need to approximate two shadow price functions λ_w^{CP} and λ^{CP} from the value function $V^{CP}(d_{-1}, w_{-1}, y_T, r)$ derived from the value function iteration illustrated in the last section. To approximate these two shadow price functions we need to assume the continuity of the first derivatives of the constrained planner's value function: V_d^{CP} and V_w^{CP} .

Under the continuity assumption, I can use the Newton's method to approximate V_d^{CP} and V_w^{CP} . Then

$$\lambda_w^{CP}(d_{-1}, w_{-1}, y_T, r) = -\frac{V_w^{CP}(d_{-1}, w_{-1}, y_T, r)}{\gamma}$$

and

$$\lambda^{CP}(d_{-1}, w_{-1}, y_T, r) = -V_d^{CP}(d_{-1}, w_{-1}, y_T, r).$$

Then I can find use the following equation to find λ_{CC}^{CP} :

$$\lambda_{CC}^{CP}(d_{-1}, w_{-1}, y_T, r) = \frac{\lambda^{CP}(d_{-1}, w_{-1}, y_T, r)}{1+r} + \beta \mathbb{E}_{\{y'_T, r' | y_T, r\}} V_d^{CP}(d^{CP}, w^{CP}, y'_T, r')$$

Now it remains to apply the formulas to computing the decomposition of tax.

Appendix C: Schindler's Measure of Capital Controls

Schindler (2009) compiles *de jure* indices of inflow and outflow controls using publicly available information from the IMF's Annual Report on Exchange Arrangements and Exchange Restriction (AREAER). Schindler (2009) fully exploits the IMF's post 1996 disaggregated reporting of different categories of capital transaction. The categories covered in his index are as follows:

- Restrictions on transactions in equities (eq), bonds (bo), money market instruments (mm), and collective investments (ci). Transactions are divided into four categories:
 - Purchase locally by nonresidents (plbn)
 - Sale or issue abroad by residents (siar)
 - Purchase abroad by residents (pabr)
 - Sale or issue locally by nonresidents (siln)
- Restrictions on financial credits (fc) are divided into two categories:
 - By residents to nonresidents (fco)
 - By nonresidents to residents (fci)
- Restrictions on direct investment (di) are divided into three categories:
 - Outward investment (dio)

- Inward direct investment (dii)
- Liquidation of direct investment (ldi)

The information contained in the AREAER is coded in binary form, taking a value of 0 (unrestricted) or 1 (restricted). The data can be aggregated in different ways, allowing the construction of capital control sub-indices by asset category, by residency, and by the direction of flows. Sub-indices are aggregated by taking unweighted averages of the subcategories of interest. Indices for outflow controls are constructed for each individual asset category. For example:

$$\text{inflow controls on asset category } i \text{ (} kai_i \text{)} = \frac{i_{plbn} + i_{siar}}{2}$$

where i stands for equities, money market instruments, bonds, or collective investment instruments. The aggregate inflow control (kai) is

$$kai = \frac{kai_{eq} + kai_{mm} + kai_{bo} + kai_{ci} + fci + dii}{6}.$$

Appendix D: Additional Tables and Figures

Table D.1: Data Source for Calibration

Data	Source
Capital flows	International Financial Statistics (IFS)
Net International Investment Position	IFS
GDP by Sector	Annual Macro-Economic Database (AMECO)
Interest Rate	IFS
GDP Deflator	AMECO
Current Account	IFS
Trade Balance	World Economic Outlook
Household Debt	Financial Soundness Indicators
Government Debt	World Development Indicators

Table D.2: Pairwise Correlation of Different Proxies of Capital Controls

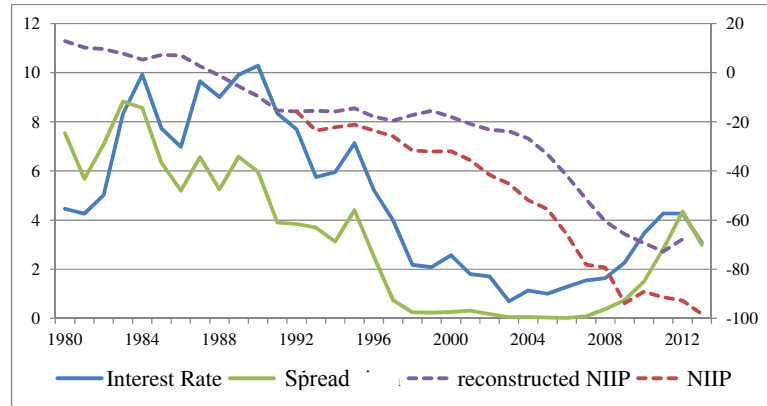
	Schindler Inflow	Schindler General	CAPITAL	CAPIN	FINCONT2
Schindler Inflow	1.000				
Schindler General	0.936	1.000			
CAPITAL	0.734	0.802	1.000		
CAPIN	0.728	0.782	0.934	1.000	
FINCONT2	0.519	0.534	0.497	0.464	1.000

Table D.4: Within-group Policy Response: Linear Probability Model

	(1)	(2)	(3)	(4)	(5)	(6)	Expected Sign
Domestic Variables (Lagged)							
Real GDP growth rate	-0.00154 (0.00803)	-0.000943 (0.00803)	-0.00175 (0.00779)	-0.00133 (0.00768)	-0.00115 (0.00773)	-0.00201 (0.00810)	+
Real GDP growth rate shock	0.0100 (0.00946)	0.00919 (0.00944)	0.00975 (0.00939)	0.00904 (0.00910)	0.00922 (0.00933)	0.0101 (0.00968)	-
REER overvaluation	-0.0386 (0.140)	-0.0256 (0.147)	-0.0263 (0.142)	-0.0289 (0.143)	-0.0360 (0.140)	-0.0372 (0.142)	-
Inflation	0.0514 (0.0401)	0.0526 (0.0394)	0.0500 (0.0415)	0.0506 (0.0405)	0.0503 (0.0418)	0.0508 (0.0414)	+
Flexible Exchange Rate	-0.252*** (0.0404)	-0.210*** (0.0340)	-0.230*** (0.0303)	-0.225*** (0.0284)	-0.214*** (0.0296)	-0.221*** (0.0357)	-
Real GDP (logged)	-0.00388 (0.366)	-0.0468 (0.365)	-0.0794 (0.377)	-0.0764 (0.369)	-0.0865 (0.370)	-0.0664 (0.369)	+
External Debt	-0.0225 (0.0361)	-0.0133 (0.0380)	-0.0167 (0.0373)	-0.0158 (0.0372)	-0.0173 (0.0369)	-0.0187 (0.0371)	+
Change of Weighted Inflow Controls in the ROG							
Group by geographic location	-0.274 (0.206)						+
Group by export specialization		0.0154 (0.147)					+
Time-invariant group by growth			0.0291 (0.198)				+
Time-variant group by growth				-0.0206 (0.0582)			+
Observations	841	841	841	841	841	841	
R-squared	0.168	0.167	0.165	0.166	0.168	0.166	

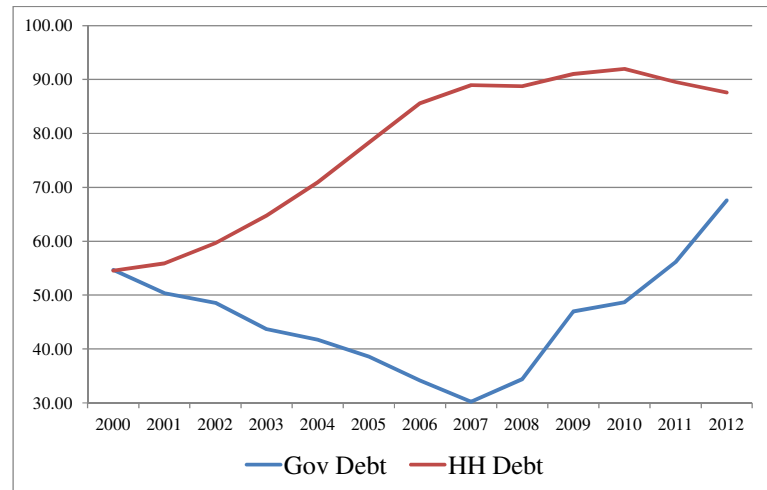
Note: The sample consists of 64 countries. GDP per capita and composite risk index are insignificant in all specifications and hence not reported in the table to save space. All regressions control for year fixed effects, group contagionvariables, and country fixed effects. Robust standard errors clustered at country level in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Figure D.1: Spain's Interest Rate and NIIP



Note: Spread is the difference between Spain's interest rate and Germany's interest rate. The left vertical axis provides scales for the real interest rate and the interest rate spread (%). The right vertical axis provides scale for the NIIPs as percentage of GDP (%).

Figure D.2: Spain's Debt by Household and Government as Percentage of GDP



Note: See Table D.1 for data source.

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