Prudential Policy For Peggers

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Abstract

This paper shows that in a small open economy with downward nominal wage rigidity pegging the nominal exchange rate creates a pecuniary externality. The externality causes unemployment, overborrowing, and depressed consumption. Ramsey optimal capital control policy is characterized and shown to be prudential. For it taxes capital inflows in good times and subsidizes external borrowing in bad times. Under plausible calibrations, this type of macro prudential policy is shown to lower the average unemployment rate by 10 percentage points, to reduce average external debt by 10 to 50 percent, and to increase welfare by over 9 percent of consumption per period.

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1 Introduction

Fixed-exchange rate arrangements are often part of broader economic reform programs that include liberalization of international capital flows. For small emerging economies, such a policy combination has been a mixed blessing. A case in point is the European currency union, which imposes capital account liberalization as a prerequisite for admission. Figure 1 displays the average current-account-to-GDP ratio, an index of nominal hourly wages in Euros, and the rate of unemployment for a group of peripheral European countries that are either on or pegging to the Euro over the period 2000 to 2011. In the early 2000s, these peripheral members of the eurozone enjoyed large capital inflows, which through their expansionary effect on domestic absorption, led to sizable appreciations in hourly wages. With the onset of the global recession in 2008, however, capital inflows dried up and aggregate

Figure 1: Boom-Bust Cycle in Peripheral Europe: 2000-2011
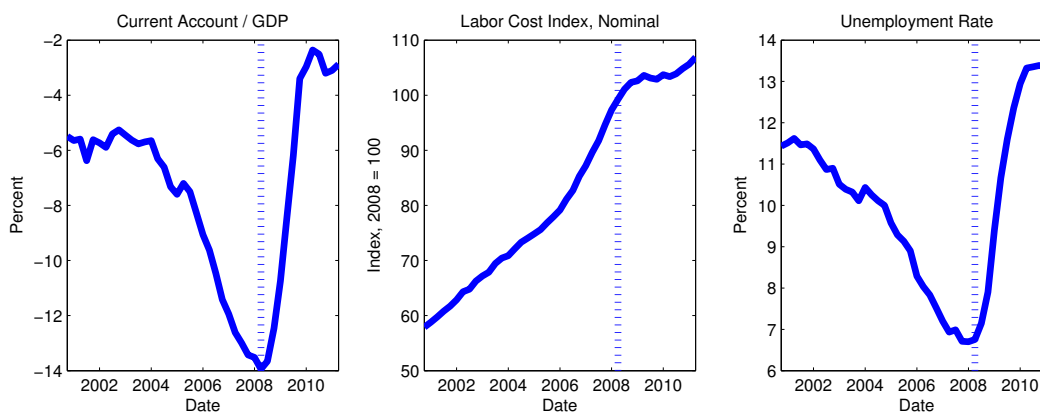
Data Source: Eurostat. Data represents arithmetic mean of Bulgaria, Cyprus, Estonia, Greece, Lithuania, Latvia, Portugal, Spain, Slovenia, and Slovakia.

demand collapsed. At the same time nominal wages remained at the level they had achieved at the peak of the boom. The combination of depressed levels of aggregate demand and high nominal wages was associated with a massive increase in involuntary unemployment. In turn, local monetary authorities were unable to reduce real wages via a devaluation because of their commitment to the currency union.

This narrative evokes several interrelated questions. One is what is the connection between capital mobility and the economic performance of fixed exchange rate regimes. Another is whether emerging-country peggers might be better off imposing capital controls. And, if so, whether optimal capital controls are prudential in nature. The goal of this paper is to address these questions in the context of a dynamic, stochastic, optimizing model of an

emerging economy. The central counterfactual situation considered in our analysis, i.e., the imposition of capital controls, serves as a way to highlight the costs imposed by the current institutional arrangement in the European Union that insists on free capital mobility. The main point that emerges from our analysis is that the combination of free capital mobility and currency pegs is highly deleterious for peripheral members of the union.

Our theoretical laboratory is the Schmitt-Grohé and Uribe (2011a) model of an open economy with tradable and nontradable goods, downward nominal wage rigidity and a fixed exchange rate. The model economy is driven by exogenous and stochastic disturbances to the endowment of tradable goods and to the country interest rate. We show that in the context of this model, the combination of downward nominal wage rigidity, a fixed exchange rate, and free capital mobility creates a negative pecuniary externality. The nature of the externality identified in the present paper is as follows. Expansions in aggregate demand drive up wages, putting the economy in a vulnerable situation. For in the contractionary phase of the cycle, downward nominal wage rigidity and a fixed exchange rate prevent real wages from falling to the level consistent with full employment. Agents understand this mechanism, but are too small to internalize the fact that their individual expenditure decisions collectively cause inefficiently large increases in wages during expansions, which exacerbate unemployment during contractions.

The existence of the pecuniary externality creates a rationale for government intervention. We focus on capital controls as a second-best instrument. In particular, we assume that the government levies a proportional tax (subsidy) on net external debt holdings. The tax is equivalent to an interest rate markup on net foreign liabilities. We then characterize analytically and numerically optimal capital control policy under commitment. We show that the Ramsey-optimal tax on external debt is positive on average and highly procyclical. Thus, the optimal capital control policy is prudential in nature, as it restricts capital inflows in good times and subsidizes external borrowing in bad times.

In our model, a benevolent government has an incentive to levy taxes on external debt during expansions as a way to limit nominal wage growth. Moderating wage growth during booms helps ameliorate the unemployment problem caused by downward wage rigidity during contractions. In turn, capital controls affect wage growth through their effect on the aggregate absorption of tradable goods. In our small open economy, consumption of tradables acts as a shifter of the demand for nontradables. As a result, the government can indirectly affect employment in the nontraded sector by manipulating the intertemporal price of tradables (the interest rate) via capital controls. Thus, the government in a fixed-exchange-rate economy determines the optimal capital control policy as the solution to a trade off between intertemporal distortions (caused the capital controls themselves) and

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static distortions (caused by downward real wage rigidity).

Importantly, the optimal capital control policy implied by our model does not belong to the class of beggar-thy-neighbor policies. For it does not seek to increase foreign demand for domestic goods during crises. On the contrary, the optimal capital control policy in our model is one in which during crises the government subsidizes domestic absorption of tradable goods, thereby discouraging exports. The reason why the government has incentives to stimulate imports during downturns is that greater domestic absorption of tradables increases demand for nontradables, thereby reducing unemployment in the nontraded sector.

Versions of the model calibrated to Argentina, Greece, and Spain show that the optimal capital control policy achieves significant reductions in unemployment (about 10 percentage points) and that the welfare gains from macro prudential policy are large, amounting to over 9 percent of consumption per period.

Further, we find that free capital mobility induces peggers to overborrow. Specifically, for our baseline calibration, the average external debt-to-output ratio in the economy with free capital mobility is more than twice as large as the one induced under optimal capital controls.

Capital controls are not the only instruments through which the policymaker can address the inefficiencies arising from the combination of a currency peg and downward nominal wage rigidity. Elsewhere, we have shown that the first-best allocation can be achieved by means of optimal labor or consumption subsidies (Schmitt-Grohé and Uribe, 2011a, 2012b). A natural question is then why bother characterizing optimal capital controls, if, after all, they achieve only a second-best allocation. The reason is that policymakers may find that capital controls is the only instrument that they can implement in practice. The use of labor subsidies to achieve the first best may be difficult from a political point of view. In Schmitt-Grohé and Uribe (2011a, 2012b) we show that the labor subsidy scheme that implements the first best inherits the stochastic properties of the underlying shocks, which in emerging countries like those in the periphery of Europe, are highly volatile. Thus the optimal labor subsidy scheme would require large variations in wage subsidies at a quarterly frequency. This may be highly problematic in light of the fact that the institutional arrangements (especially the legislative process) that govern the determination of income taxes is highly inertial, making large swings in labor subsidies on a quarter-to-quarter basis unrealistic. By contrast, capital controls can be politically portrayed as taxes on foreign speculators. As a result the executive branch of the government typically is given much more leeway to set capital-inflow taxes at business-cycle frequency.

In the case of Europe, all three policy options for addressing the inefficiencies brought about by downward nominal wage rigidity, namely devaluation, labor/production subsidies,

and capital controls, are limited by existing supranational arrangements. If peripheral Europe is to achieve stability central aspects of these arrangements are likely to change. It is therefore of interest to fully characterize the business-cycle implications of each of these three policy alternatives. The contribution of the current paper is to investigate the potential benefits of moving away from free capital mobility toward a policy of optimally designed capital controls.

We view our work as most closely related to the Mundellian literature on the trilemma of international finance, according to which a country cannot have at the same time a fixed exchange rate, free capital mobility, and an independent interest rate policy. (For a recent treatment, see Obstfeld et al., 2010.) We present an explicit articulation of this view in the context of a dynamic, optimizing model of a small open economy with downward nominal wage rigidity. We take a fixed exchange rate regime as a given, because we wish to understand the policy options available to the peripherical members of the eurozone short of breaking away from the common currency arrangement. In our model economy, the benevolent government has an incentive to vary the effective interest rate (through capital controls) as a way to insulate the nontraded sector from external shocks. The existing theoretical literature on optimal capital controls based on the trilemma of international finance is quite informal and reduced form. By contrast, the building blocks of our theoretical framework are welfare maximizing households, profit maximizing firms, and a benevolent government operating in a dynamic and uncertain environment. Consequently, our model, once calibrated to capture key elements of actual emerging economies, allows us to derive sharp predictions about the welfare-maximizing capital control process and its associated real allocation.

A second strand of the related literature stresses financial distortions, such as collateral constraints on external borrowing as a rationale for capital controls (Auernheimer and García-Saltos, 2000; Uribe, 2006, 2007; Lorenzoni, 2008; Korinek, 2010; Benigno et al., 2011; and Bianchi, 2011). A third line of work is based on the classical trade theoretic argument that large countries can affect the interest rate, or the intertemporal price of consumption (e.g., Obstfeld and Rogoff, 1996 section 1.4, Schmitt-Grohé and Uribe, 2012a section 4.4, and Costinot et al., 2011). As a result, governments of large countries have incentives to apply capital controls as a means to induce households to internalize the country's market power in financial markets. Our theory of capital controls is distinct from the above two in that it does not assume the existence of collateral constraints or market power in financial markets.

The remainder of the paper is organized in eight sections. Section 2 embeds capital controls into a small open economy model with downward nominal wage rigidity and a

fixed-exchange rate. Section 3 characterizes optimal capital control policy under commitment. It shows analytically that the optimal capital-control policy is prudential. Section 4 calibrates the model to the Argentine economy. It analyzes quantitatively the behavior of the economy with and without capital controls undergoing a boom-bust cycle. Section 5 presents the effects of optimal capital controls on first and second unconditional moments of key macroeconomic aggregates. Section 6 identifies and quantifies overborrowing induced by the combination of a currency peg and downward nominal wage rigidity. Section 7 investigates the welfare losses due to free capital mobility in fixed exchange rate economies. Section 8 shows that our main results are robust to using data from Greece and Spain in the econometric estimation of the exogenous driving forces. Section **??** concludes.

2　An Open Economy With Downward Wage Rigidity

We embed capital controls into the small open economy model with downward nominal wage rigidity developed in Schmitt-Grohé and Uribe (2011a). We assume that the nominal wage rate, denoted W_t, must satisfy the following restriction

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

where γ is a nonnegative parameter governing the degree of downward nominal wage rigidity. The larger is γ, the more stringent is the downward rigidity in nominal wages. In Schmitt-Grohé and Uribe (2011a), we present empirical evidence suggesting that γ is close to unity.

Throughout the present analysis, we assume that the central bank pegs the nominal exchange rate. Specifically, letting E_t denote the domestic-currency price of one unit of foreign currency, we impose

$$E_t = \bar{E} \tag{2}$$

for all t, where $\bar{E}$ is a positive constant. The combination of a fixed-exchange-rate regime and downward nominal wage rigidity introduces a real rigidity. Specifically, the wage rate in terms of foreign currency, denoted $w_t \equiv W_t/E_t$ is downwardly rigid. This rigidity makes the economy vulnerable to any shock that requires a fall in real wages. The inability of the real wage to fall will in general cause unemployment and therefore a loss of welfare.

The inefficiency introduced by the combination of downward nominal wage rigidity and a fixed exchange rate, opens the door to welfare-improving fiscal policy. In the present investigation, we study the extent to which capital controls can help ameliorate this inefficiency. We model capital controls as a proportional tax on gross capital inflows.

The model features two types of good, tradables and nontradables. Tradable output is

exogenous and stochastic, while nontraded output is produced with labor services. The economy is driven by two exogenous shocks. One is the endowment of tradables just described. The second shock emerges from the assumption that the interest rate charged to the small open economy in international financial markets is exogenous and stochastic.

2.1 Households

The economy is populated by a large number of identical households with preferences described by the utility function

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U(c_t), \tag{3}$$

where c_t denotes consumption. The period utility function U is assumed to be strictly increasing and strictly concave and the parameter β, denoting the subjective discount factor resides in the interval $(0,1)$. The symbol $\mathbb{E}_t$ denotes the mathematical expectations operator conditional upon information available in period t. The consumption good is a composite of tradable consumption, c_t^T, and nontradable consumption, c_t^N. The aggregation technology is of the form

$$c_t = A(c_t^T, c_t^N), \tag{4}$$

where A is an increasing, concave, and linearly homogeneous function.

We assume full liability dollarization. Specifically, households have access to a one-period, internationally traded, state non-contingent bond denominated in tradables. We let d_t denote the level of debt assumed in period $t-1$ and due in period t and r_t the interest rate on debt held between periods t and $t+1$. The sequential budget constraint of the household is given by

$$c_t^T + p_t c_t^N + d_t = (1 + \tau_t^y)[y_t^T + w_t h_t + \phi_t] + \frac{d_{t+1}(1 - \tau_t^d)}{1 + r_t}, \tag{5}$$

where $p_t \equiv P_t^N / P_t^T$ denotes the relative price of nontradables in terms of tradables, with P_t^N and P_t^T, denoting, respectively, the nominal prices of nontradables and tradables. We assume that the law of one price holds for tradables. Specifically, we let P_t^{T*} denote the foreign currency price of tradables and E_t the nominal exchange rate, defined as the domestic-currency price of one unit of foreign currency. Then, the law of one price implies that

$$P_t^T = P_t^{T*} E_t.$$

We assume that the foreign-currency price of tradables is constant and normalized to unity, $P_t^{T*} = 1$.

The variable τ_t^d denotes the tax rate on debt acquired in period t. For each unit of tradable good that the household promises to pay in period $t+1$, it receives $(1-\tau_t^d)/(1+r_t)$ units in period t. The government intervention in the international financial market alters the effective gross interest rate paid by the household from $1+r_t$ to $(1+r_t)/(1-\tau_t^d)$. The rate τ_t^d can take positive or negative values. When it is positive, the government discourages borrowing by raising the effective interest rate. In this case, we say that the government imposes capital controls. On the other hand, when τ_t^d is negative, the government subsidizes international borrowing by lowering the effective interest rate. As we will see shortly, a benevolent government will make heavy use of cyclical adjustments in capital controls to stabilize consumption and employment.

The variable τ_t^y denotes a proportional income subsidy rate (tax rate if negative) determined by the government. It serves as a channel for the government to rebate the fiscal revenues created by the imposition of capital controls. Because all of the components of nonfinancial individual income are taken as exogenous by the household, the income tax τ_t^y is nondistorting. Specifically, nonfinancial household income is given by $y_t^T + w_t h_t + \phi_t$, where h_t denotes hours worked and ϕ_t denotes profits from the ownership of firms. Households supply inelastically $\bar{h}$ hours to the labor market each period. However, because of the presence of downward nominal wage rigidity, they may not be able to sell all of the hours supplied. As a result, households take employment, $h_t \leq \bar{h}$, as exogenously given.

Households are assumed to be subject to the following debt limit, which prevents them from engaging in Ponzi schemes.

$$d_{t+1} \leq \bar{d}, \tag{6}$$

where $\bar{d}$ denotes the natural debt limit. Households choose contingent plans $\{c_t, c_t^T, c_t^N, d_{t+1}\}$ to maximize (3) subject to (4)-(6) taking as given w_t, h_t, ϕ_t, y_t^T, r_t, τ_t^d, τ_t^y, and p_t. The optimality conditions associated with this problem are (4)-(6) and

$$\frac{A_2(c_t^T, c_t^N)}{A_1(c_t^T, c_t^N)} = p_t, \tag{7}$$

$$\lambda_t = U'(c_t) A_1(c_t^T, c_t^N),$$
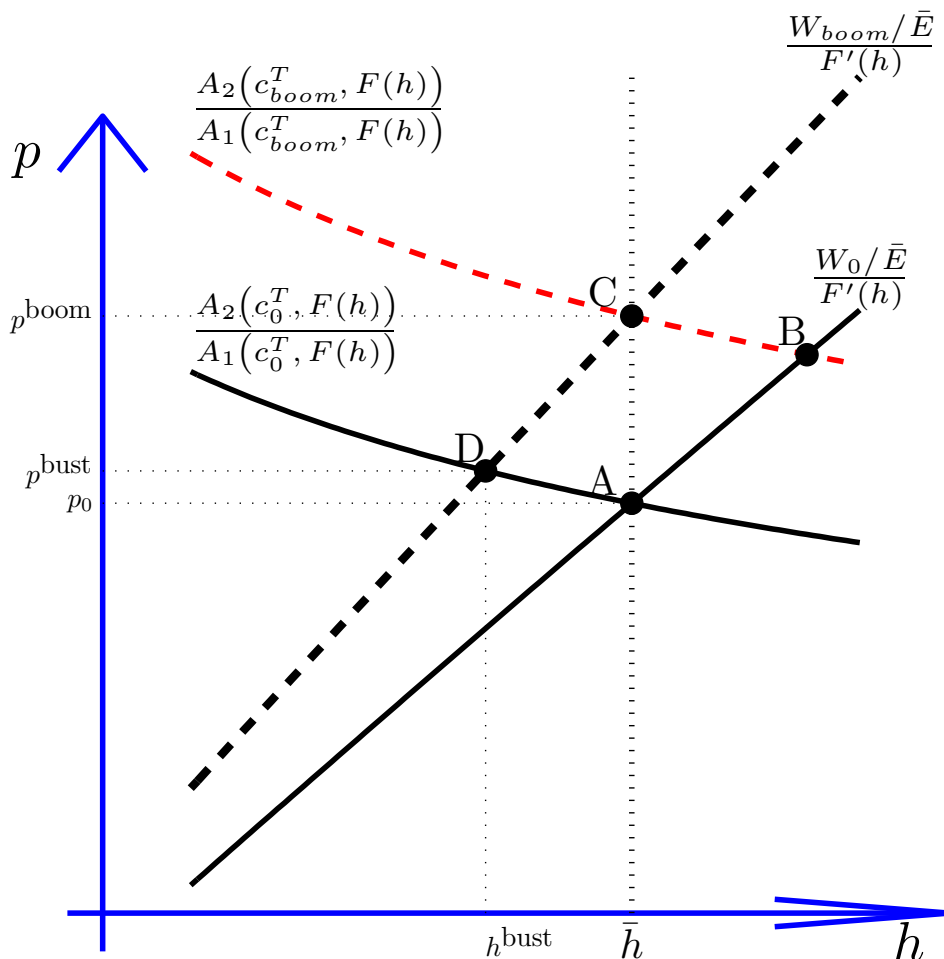
$$\frac{\lambda_t(1-\tau_t^d)}{1+r_t} = \beta \mathbb{E}_t \lambda_{t+1} + \mu_t,$$

$$\mu_t \geq 0,$$

$$\mu_t(d_{t+1} - \bar{d}) = 0,$$

where λ_t and μ_t denote the Lagrange multipliers associated with (5) and (6), respectively.

Figure 2: Pecuniary Externality

Equation (7) describes the demand for nontradables as a function of the relative price of nontradables, p_t, and the level of tradable absorption, c_t^T. Given c_t^T, the demand for nontradables is strictly decreasing in p_t. This is a consequence of the assumptions made about the aggregator function A. It reflects the fact that as the relative price of nontradables increases, households tend to consume relatively less nontradables. The demand function for nontradables is depicted in figure 2 as a downward sloping solid line. (Notice that in the figure, the demand function is plotted in the space (h_t, p_t), rather than in the space (c_t^N, p_t). As will become clear shortly, we are jumping ahead and using the fact that under market clearing in the nontraded sector, $c_t^N = F(h_t)$ at all times. We refer to the depicted locus as the demand function for nontradables, even though strictly speaking it is not.) An increase in the absorption of tradables shifts the demand schedule up and to the right, reflecting normality. This shift is shown with a dashed downward sloping line in figure 2, for an increase in traded consumption from c_0^T to c_{boom}^T. It follows that absorption of tradables can be viewed as a

shifter of the derived demand for labor. Of course, c_t^T is itself an endogenous variable, which is determined simultaneously with all other endogenous variables of the model.

2.2 Firms

Nontraded output is produced by perfectly competitive firms. Each firm operates a production technology given by $F(h_t)$, which uses labor services as the sole input. The function F is assumed to be strictly increasing and strictly concave. Firms choose the amount of labor input to maximize profits, given by

$$\phi_t \equiv p_t F(h_t) - w_t h_t.$$

The optimality condition associated with this problem is

$$p_t F'(h_t) = w_t.$$

This condition represents the supply of nontradable goods. It is depicted with a solid upward sloping line in the space (h, p) in figure 2. Ceteris paribus, the higher is the relative price of the nontraded good, the higher is the demand for labor and therefore the larger the supply of nontradable goods. Also, all other things equal, the higher is the labor cost w_t, the smaller are the demand for labor and the supply of nontradables at each level of the relative price p_t. Figure 2 displays with a broken upward sloping line the shift in the supply schedule that results from an increase in the nominal wage rate from W_0 to $W_{boom} > W_0$, holding the nominal exchange rate constant at $\bar{E}$.

2.3 Closure of the Labor Market

The following three conditions must hold at all times:

$$w_t \geq \gamma w_{t-1},$$

$$h_t \leq \bar{h},$$

and

$$(h_t - \bar{h})(w_t - \gamma w_{t-1}) = 0.$$

The first two constraints were already introduced. The third is a slackness condition stating that whenever there is underemployment the lower bound on wages must bind, and that whenever this lower bound is not binding, the labor market must operate at full employment.

2.4 The Government

The government imposes a proportional tax (subsidy) on debt, τ_t^d, and a proportional subsidy (tax) on income, τ_t^y. Given τ_t^d, whose determination we will discuss shortly, the government sets income subsidies to balance the budget period by period. Specifically, τ_t^y satisfies

$$\tau_t^y(y_t^T + w_t h_t + \phi_t) = \tau_t^d \frac{d_{t+1}}{1 + r_t}$$

2.5 Competitive Disequilibrium Dynamics

Because product prices are assumed to be fully flexible, the market for nontraded goods must clear at all times. That is, the condition

$$c_t^N = F(h_t)$$

holds for all t. Combining this condition, the household's budget constraint, the government's budget constraint, and the definition of firms' profits, we obtain the following market-clearing condition for traded goods:

$$c_t^T + d_t = y_t^T + \frac{d_{t+1}}{1 + r_t}. \tag{8}$$

The complete set of conditions describing the competitive disequilibrium dynamics is then given by (8) and

$$P(c_t^T, h_t)F'(h_t) = w_t, \tag{9}$$

$$h_t \leq \bar{h}, \tag{10}$$

$$w_t \geq \gamma w_{t-1}, \tag{11}$$

$$d_{t+1} \leq \bar{d}, \tag{12}$$

$$\lambda_t = U'(A(c_t^T, F(h_t)))A_1(c_t^T, F(h_t)), \tag{13}$$

$$\frac{\lambda_t(1 - \tau_t^d)}{1 + r_t} = \beta \mathbb{E}_t \lambda_{t+1} + \mu_t, \tag{14}$$

$$\mu_t \geq 0, \tag{15}$$

$$\mu_t(d_{t+1} - \bar{d}) = 0, \tag{16}$$

$$(h_t - \bar{h})(w_t - \gamma w_{t-1}) = 0, \tag{17}$$

$$\tau_t^y = \tau_t^d \frac{d_{t+1}/(1 + r_t)}{y_t^T + P(c_t^T, h_t)F(h_t)}, \tag{18}$$

where

$$P(c_t^T, h_t) \equiv \frac{A_2(c_t^T, F(h_t))}{A_1(c_t^T, F(h_t))}$$

denotes the relative price of nontradables in terms of tradables expressed as a function of consumption of tradables and employment.

3   Optimal Capital Controls

The combination of downward nominal wage rigidity and a currency peg creates a negative pecuniary externality. The nature of this externality is that in periods of economic expansion, elevated demand for nontradables drives real wages up placing the economy in a vulnerable situation. For in the contractionary phase of the cycle, downward nominal wage rigidity and the currency peg hinder the downward adjustment of real wages, causing unemployment. Individual agents understand this mechanism, but are too small to internalize the fact that their own expenditure choices collectively exacerbate disruptions in the labor market.

The pecuniary externality can be visualized in figure 2. The initial position of the economy is at point A, where the labor market is operating at full employment, $h_t = \bar{h}$. In response to a positive external shock, traded absorption increases from c_0^T to c_{boom}^T causing the demand function to shift up and to the right. If nominal wages stayed unchanged, the new intersection of the demand and supply schedules would occur at point B. However, at that point, employment would exceed the available supply of labor $\bar{h}$. The excess demand for labor drives up the nominal wage from W_0 to W_{boom} causing the supply of nontradables to shift up and to the left. The new intersection of the demand and supply schedules occurs at point C, where full employment is restored and the excess demand for labor has disappeared.

Suppose now that the external shock fades away, and that, therefore, absorption of tradables goes back to its original level c_0^T. The decline in c_t^T shifts the demand schedule back to its original position. However, the economy does not immediately return to point A, because, due to downward nominal wage rigidity, the nominal wage stays at W_{boom} and, as a result, the supply schedule does not move. The new intersection is at point D. There, the economy suffers involuntary unemployment equal to $\bar{h} - h_{bust}$. Over time, the economy will return to point A. However, the convergence is inefficient because it features unemployment throughout. Consequently, the government has an incentive to prudentially regulate capital flows to curb the initial expansion in tradable consumption in response to positive external shocks. Such policy would dampen the initial increase in nominal wages and in that way mitigate the subsequent unemployment problem as the economy returns to its initial state.

In the present study, we focus on a second-best type of government intervention that

takes the form of capital controls. Specifically, we assume that the instruments available to the government are the tax rate on debt τ_t^d and the income subsidy τ_t^y. The latter tax is merely used as a vehicle to rebate in a nondistorting fashion the revenues generated by capital controls. The government is assumed to be benevolent and to be endowed with full commitment. We therefore refer to the fiscal authority as the Ramsey planner. It is worth noting that the battery of fiscal instruments available to our Ramsey planner is limited to capital controls, and, in particular, does not include wage-subsidy schemes in labor markets afflicted by downward wage rigidity. Elsewhere (Schmitt-Grohé and Uribe, 2011a) we show that appropriately designed wage subsidies can fully eliminate the distortions arising from the combination of downward wage rigidity and a currency peg.

The Ramsey planner's optimization problem consists in choosing a tax scheme $\{\tau_t^d, \tau_t^y\}$ to maximize the household's lifetime utility function (3) subject to the complete set of conditions describing the competitive dynamics, equations (8)-(18). The strategy we follow to characterize the Ramsey allocation is to drop conditions (13)-(18) from the set of constraints of the Ramsey planner's problem and then to show that the solution to this less constrained problem satisfies the omitted constraints.

Accordingly, the Lagrangian of the less constrained Ramsey problem is given by

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\begin{aligned}
\mathcal{L} = \ & \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left\{ U(A(c_t^T, F(h_t))) \right. \\
& + \lambda_t^c \left[y_t^T + \frac{d_{t+1}}{1+r_t} - c_t^T - d_t \right] \\
& + \lambda_t^p \left[P(c_t^T, h_t) F'(h_t) - w_t \right] \\
& + \lambda_t^h \left[\bar{h} - h_t \right] \\
& + \lambda_t^w \left[w_t - \gamma w_{t-1} \right] \\
& \left. + \lambda_t^d \left[\bar{d} - d_{t+1} \right] \right\},
\end{aligned}
$$

where $\lambda_t^c > 0$, $\lambda_t^h \geq 0$, $\lambda_t^w \geq 0$, $\lambda_t^d \geq 0$, and λ_t^p are Lagrange multipliers.

The first-order optimality conditions with respect to λ_t^c, λ_t^p, λ_t^h, λ_t^w, λ_t^d, c_t^T, h_t, d_{t+1}, w_t, and associated slackness conditions are, respectively, (8)-(12) and

$$U'(A(c_t^T, F(h_t)))A_1(c_t^T, F(h_t)) = \lambda_t^c - \lambda_t^p P_1(c_t^T, h_t) F'(h_t) \tag{19}$$

$$U'(A(c_t^T, F(h_t)))A_2(c_t^T, F(h_t))F'(h_t) = \lambda_t^h - \lambda_t^p [P_2(c_t^T, h_t) F'(h_t) + P(c_t^T, h_t) F''(h_t)] \tag{20}$$

$$\frac{\lambda_t^c}{(1+r_t)} = \beta \mathbb{E}_t \lambda_{t+1}^c + \lambda_t^d \tag{21}$$

$$\lambda_t^w = \beta\gamma\mathbb{E}_t\lambda_{t+1}^w + \lambda_t^p \tag{22}$$

$$(h_t - \bar{h})\lambda_t^h = 0 \tag{23}$$

$$\lambda_t^w(w_t - \gamma w_{t-1}) = 0 \tag{24}$$

$$(d_{t+1} - \bar{d})\lambda_t^d = 0 \tag{25}$$

We now show that allocations $\{c_t^T, h_t, w_t\}$ that satisfy the optimality conditions of the less constrained Ramsey problem, that is, conditions (8)-(12) and (19)-(25), also satisfy the constraints that were omitted from the Ramsey problem, namely, conditions (13)-(18). To see this, first pick λ_t to satisfy (13). Next, set $\mu_t = 0$ for all t.[1] It follows that (15) and (16) are satisfied. Pick τ_t^d to satisfy (14). To ensure that the Ramsey policy is revenue neutral, pick τ_t^y to satisfy (18). It remains to be shown that (17) is also implied by the set of Ramsey optimality conditions. To see that this is the case, consider the following proof by contradiction. Suppose, contrary to what we wish to show, that in the Ramsey allocation $h_t < \bar{h}$ and $w_t > \gamma w_{t-1}$ at some date and state. Then, by (23) and (24), it must be the case that $\lambda_t^h = \lambda_t^w = 0$. But then, by (20) and by the facts that $P_2(c_t^T, h_t) < 0$ and $F''(h_t) < 0$, we have that $\lambda_t^p > 0$. This implication contradicts condition (22), which indicates that $\lambda_t^p = -\beta\gamma E_t\lambda_{t+1}^w \leq 0$ (recall that $\lambda_t^w \geq 0$).

From the arguments presented above, we have that the optimal capital control policy must deliver tax rates on debt satisfying

$$\tau_t^d = 1 - \beta(1 + r_t)\frac{E_t U'(c_{t+1})A_1(c_{t+1}^T, c_{t+1}^N)}{U'(c_t)A_1(c_t^T, c_t^N)}, \tag{26}$$

where c_t, c_t^T, and c_t^N denote the Ramsey-optimal processes of consumption, consumption of tradables, and consumption of nontradables, respectively.[2] It follows from the above expression that, all other things equal, capital controls are positive when the marginal utility of tradables is expected to fall. That is, capital controls are more likely to be put into place

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[1]Note that in states in which the Ramsey allocation calls for setting $d_{t+1} < \bar{d}$, μ_t must be chosen to be zero. However, in states in which the Ramsey allocation yields $d_{t+1} = \bar{d}$, μ_t need not be chosen to be zero. In these states, any positive value of μ_t could be supported in the decentralization of the Ramsey equilibrium. Of course, in this case, τ_t^d will depend on the chosen value of μ_t. In particular, τ_t^d will be strictly decreasing in the arbitrarily chosen value of μ_t and will be smaller than the one given in equation (26).

[2]The Ramsey allocation can also be supported through consumption taxes. Specifically, assume that instead of taxing external debt, the government taxes total consumption expenditures, $c_t^T + p_t c_t^N$ at the rate τ_{t-1}^c, so that the after-tax cost of consumption in period t is $(c_t^T + p_t c_t^N)(1 + \tau_{t-1}^c)$. The consumption tax rate is determined one period in advance. That is, in period t the government announces the tax rate on consumption expenditures in period $t + 1$. One can show that the Ramsey allocation can be supported by a consumption-tax-rate process of the form $1 + \tau_t^c = (1 - \tau_t^d)(1 + \tau_{t-1}^c)$, for any initial condition $\tau_{-1}^c > -1$, where τ_t^d represents the Ramsey optimal tax rate on external debt given in equation (26).

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when either total consumption or consumption of tradables or both are expected to grow.[3] Conversely, all other things equal, the Ramsey fiscal authority loosens capital restrictions when aggregate consumption or consumption of tradables or both are expected to decline. It follows that the optimal capital control policy is essentially prudential, in the sense that restrictions to capital inflows are imposed during the expansionary phase of the cycle and loosened during the contractionary phase.

An implication of the previous analysis is that one can characterize the Ramsey allocation as the solution to the following Bellman equation problem:

$$v(y_t^T, r_t, d_t, w_{t-1}) = \max \left[U(A(c_t^T, F(h_t))) + \beta \mathbb{E}_t v(y_{t+1}^T, r_{t+1}, d_{t+1}, w_t) \right] \tag{27}$$

subject to (8)-(12), where $v(y_t^T, r_t, d_t, w_{t-1})$ denotes the value function of the representative household. We exploit this formulation of the Ramsey problem in our numerical analysis.

We close this section by pointing out that the model with Ramsey optimal capital controls is equivalent to one in which a benevolent government chooses the level of external debt and households cannot participate in financial markets but are hand-to-mouth agents. In this formulation, households receive a transfer from the government each period and their choice is limited to the allocation of expenditure between tradable and nontradable goods. The government then chooses the aggregate level of external debt taking into account the pecuniary externality created by the combination of downward nominal wage rigidity and a currency peg.

4   Dynamics Under Optimal Capital Controls

We wish to characterize aggregate dynamics under optimal capital controls. Of particular interest is to compare the model's predictions with and without capital controls. Given the complexity of the model, this question must be addressed using numerical methods. Specifically, using a calibrated version of the model, we compare aggregate dynamics and welfare associated with free capital mobility and with the optimal capital control policy.

We assume a CRRA form for the period utility function, a CES form for the aggregator function, and an isoelastic form for the production function of nontradables:

$$U(c) = \frac{c^{1-\sigma} - 1}{1 - \sigma},$$

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[3]Strictly speaking, the marginal utility of consumption of tradables is decreasing in total consumption only if the intertemporal elasticity of substitution is smaller than the intratemporal elasticity of substitution.

Table 1: Calibration

Parameter	Value	Description
γ	0.99	Degree of downward nominal wage rigidity (Schmitt-Grohé and Uribe, 2011a)
σ	5	Inverse of intertemporal elasticity of consumption (Ostry and Reinhart, 1992)
y^T	1	Steady-state tradable output
$\bar{h}$	1	Labor endowment
a	0.26	Share of tradables (Schmitt-Grohé and Uribe, 2011a)
ξ	0.44	Intratemporal Elasticity of Substitution (González Rozada et al., 2004)
α	0.75	Labor share in nontraded sector (Uribe, 1997)
β	0.9375	Quarterly subjective discount factor (Schmitt-Grohé and Uribe, 2011a)

Note. See Schmitt-Grohé and Uribe (2011a) for details.

$$A(c^T, c^N) = \left[a(c^T)^{1-\frac{1}{\xi}} + (1-a)(c^N)^{1-\frac{1}{\xi}} \right]^{\frac{\xi}{\xi-1}},$$

and

$$F(h) = h^\alpha.$$

We calibrate the model at a quarterly frequency. All parameter values are taken from Schmitt-Grohé and Uribe (2011a) and are shown in table 1. The single most relevant parameter in our model is γ, governing the degree of downward nominal wage rigidity. In Schmitt-Grohé and Uribe (2011a), we present empirical evidence suggesting that nominal wages are downwardly rigid, and that our calibration of 0.99 for γ is conservative, in the sense that the empirical evidence points to values of γ greater than 0.99.

We also borrow from earlier work (Schmitt-Grohé and Uribe, 2011a) the stochastic process driving aggregate fluctuations in our economy. Specifically, we assume that tradable output and the country interest rate, denoted r_t, follow a bivariate, first-order, autoregressive process of the form

$$\begin{bmatrix} \ln y_t^T \\ \ln \frac{1+r_t}{1+r} \end{bmatrix} = A \begin{bmatrix} \ln y_{t-1}^T \\ \ln \frac{1+r_{t-1}}{1+r} \end{bmatrix} + \nu_t, \tag{28}$$

where ν_t is a white noise of order 2 by 1 distributed $N(\emptyset, \Sigma_\nu)$. The parameter r denotes the deterministic steady-state value of r_t. The country interest rate r_t represents the rate at which the country can borrow in international markets. In Schmitt-Grohé and Uribe (2011a), we estimate the system (28) using Argentine data over the period 1983:Q1 to 2001:Q4. Our OLS estimates of the matrices A and Σ_ν and of the scalar r are

$$A = \begin{bmatrix} 0.79 & -1.36 \\ -0.01 & 0.86 \end{bmatrix}; \qquad \Sigma_\nu = \begin{bmatrix} 0.00123 & -0.00008 \\ -0.00008 & 0.00004 \end{bmatrix}; \qquad r = 0.0316.$$

We discretize the AR(1) process given in equation (28) using 21 equally spaced points for $\ln y_t^T$ and 11 equally spaced points for $\ln(1+r_t)/(1+r)$. For details, see Schmitt-Grohé and Uribe (2011a).

We numerically approximate the equilibrium dynamics under the optimal capital control policy by applying the method of value function iteration over a discretized state space. The state of the economy in period $t \geq 0$ consists of the exogenous variables y_t^T and r_t, the endogenous state d_t, and the endogenous predetermined variable w_{t-1}. The welfare of the representative household under the optimal capital control policy can be approximated by solving the functional equation (27) subject to (8)-(12).

Approximating the dynamics of the model economy under free capital mobility is computationally more demanding than doing so under optimal capital control policy. The reason is that, because of the distortions introduced by the combination of downward nominal wage rigidity and a currency peg, aggregate dynamics can no longer be cast in terms of a Bellman equation without introducing additional state variables. We therefore approximate the solution by policy function iteration over a discretized version of the state space $(y_t^T, r_t, d_t, w_{t-1})$. For details see Schmitt-Grohé and Uribe (2011a).

In approximating the aggregate dynamics of the economies with and without capital controls, we discretize the endogenous dimensions of the state space using 501 equally spaced points for the level of d_t and 500 equally spaced points for the logarithm of w_{t-1}.

4.1   Capital Controls During a Boom-Bust Episode

To illustrate the prudential nature of optimal capital controls in an economy undergoing a currency peg, we simulate a boom-bust episode. We define a boom-bust episode as a situation in which tradable output, y_t^T, is at or below trend in period 0, at least one standard deviation above trend in period 10, and at least one standard deviation below trend in period 20. To this end, we simulate the model economy for 20 million periods and select all subperiods that satisfy our definition of a boom-bust episode. We then average across these episodes.

Figure 3 depicts the model's predictions during a boom-bust cycle. Solid lines correspond to the economy with free capital mobility and broken lines to the economy with optimal capital controls. The two top panels of the figure display the dynamics of the two exogenous driving forces, tradable output and the country interest rate. By construction, y_t^T and r_t are unaffected by capital controls. The middle left panel of the figure shows that capital controls increase significantly during the expansionary phase of the cycle, from about 2 percent at the beginning of the episode to almost 7 percent at the peak of the cycle. During the contractionary phase of the cycle, capital controls are drastically relaxed. Indeed at the

Figure 3: Prudential Policy For Peggers: Boom-Bust Dynamics With and Without Capital Controls
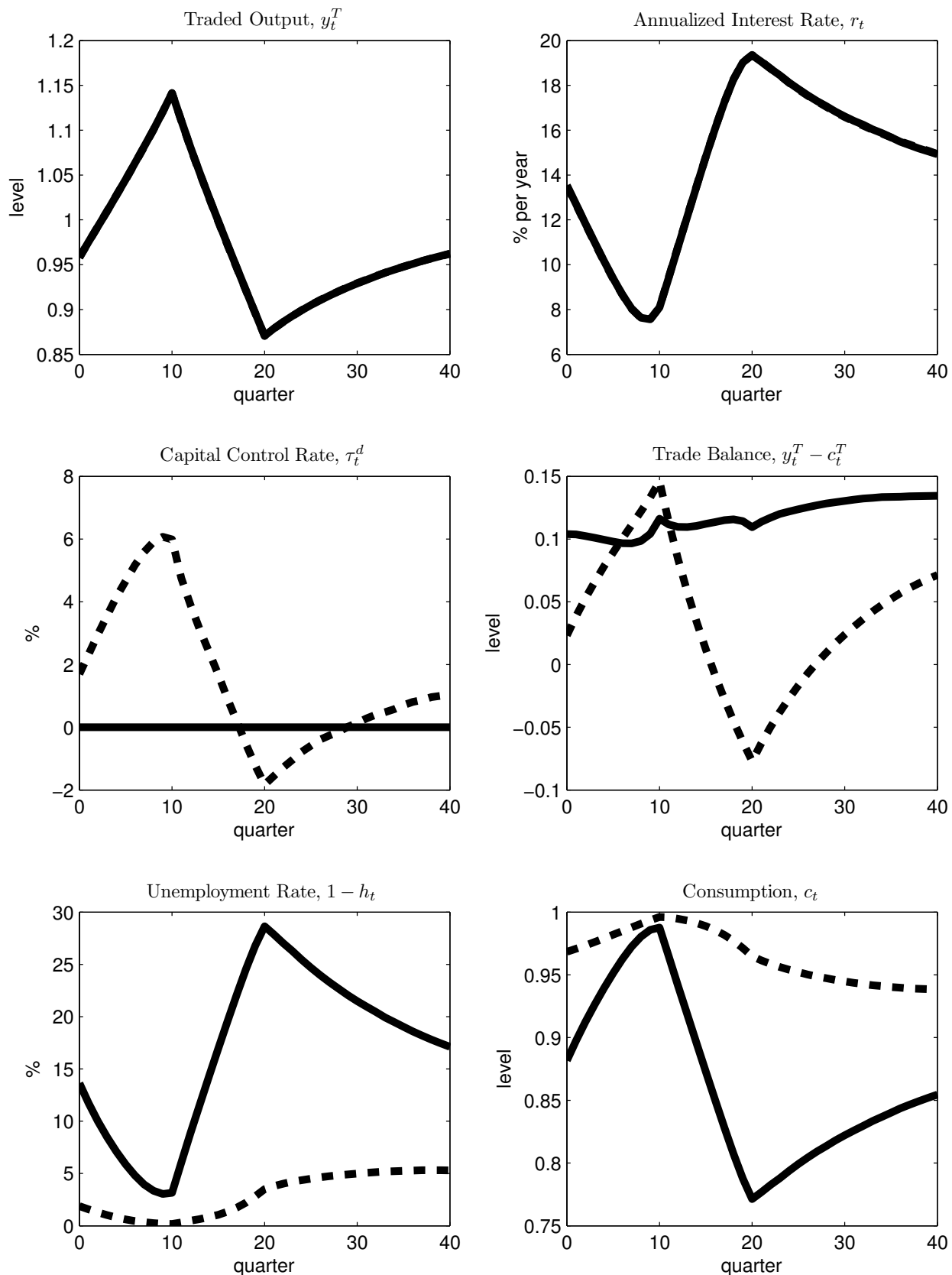
No Capital Controls   Optimal Capital Controls

bottom of the crisis, capital inflows are actually subsidized at a rate of about 2 percent.

The sharp increase in capital controls during the expansionary phase of the cycle puts sand in the wheels of capital inflows, thereby restraining the boom in consumption (see the bottom right panel of figure 3). Under free capital mobility, during the boom, consumption increases significantly more than under the optimal capital control policy. In the contractionary phase, the fiscal authority incentivates spending by subsidizing capital inflows. As a result consumption falls by much less in the regulated economy than it does in the unregulated one. During the recession, the optimal capital control policy, far from calling for austerity in the form of trade surpluses, facilitates large trade balance deficits as shown in the middle right panel of figure 3. In this way, the capital control policy is able to stabilize the absorption of tradable goods (not shown in figure 3) over the cycle. We note that the first-best policy (which, as discussed earlier, could be implemented via an optimal exchange-rate regime or with appropriate labor subsidies) calls not for running large deficits during crises, but, on the contrary, for a trade surplus (see Schmitt-Grohé and Uribe, 2011a). This difference in the behavior of the trade balance highlights the fact that the second-best allocation does not mimic the business cycle induced by the first-best allocation.

Because unemployment depends directly upon variation in the level of tradable absorption through their role as a shifter of the demand schedule for nontradables, and because optimal capital controls stabilize the absorption of tradables, unemployment is also stable over the boom-bust cycle. Specifically, as can be seen from the bottom left panel of figure 3, in the absence of capital controls, unemployment increases sharply by over 20 percentage points during the recession. By contrast, under optimal capital controls the rate of unemployment rises relatively modestly by about 3 percentage points.

Summarizing, the optimal capital control policy is prudential. It calls for restricting capital inflows during booms and encouraging them during contractions. In this way, the optimal capital control policy strengthens the role of the current account as a vehicle to stabilize domestic absorption over the business cycle. Optimal government intervention results in trade deficits during recessions and trade surpluses during booms of a much larger scale than would occur under free capital mobility.

5 Level and Volatility Effects of Optimal Capital Controls

Table 2 displays unconditional first and second moments of macroeconomic indicators of interest for the economies with optimal capital controls and free capital mobility.

Table 2: Optimal Capital Controls: Level and Volatility Effects

Variable	Symbol	Mean		Standard Deviation	
		Optimal Capital Controls	No Capital Controls	Optimal Capital Controls	No Capital Controls
Capital Control Rate	τ_t^d	2.4	0	5.2	0
Unemployment Rate	$\bar{h} - h_t$	3.1	13.5	7.6	11.7
Consumption	c_t	0.97	0.89	0.08	0.10
Trade Balance	$y_t^T - c_t^T$	0.05	0.11	0.12	0.07
Real Wage	W_t/E_t	2.1	2.3	0.6	0.7
Traded Output	y_t^T	1.0	1.0	0.1	0.1
Interest Rate	r_t	13.2	13.2	7.4	7.4
External Debt	d_t	0.9	3.4	2.3	0.7
Debt-to-Output Ratio	$d_t/4/(y^T + p_t c_t^N)$	11.2	26.0	22.1	12.6
Welfare Cost of Free Capital Mobility		9.1 percent of consumption			

Note. τ_t^d, $\bar{h} - h_t$, and $d_t/4/(y_t^T + p_t c_t^N)$ are expressed in percent, r_t is expressed in percent per year, and c_t, $y_t^T - c_t^T$, W_t/E_t, y_t^T, and d_t are expressed in levels. The welfare cost of free capital mobility is measured as the percent increase in consumption that the representative household living in the economy with free capital mobility must receive every period to be unconditionally as well off as living in the economy with optimal capital controls.

On average, the Ramsey planner imposes a positive tax on external debt of 2.4 percent. This figure implies large average levels of capital controls, for the effective interest rate faced by domestic debtors, given by $(1 + r_t)/(1 - \tau_t^d)$, increases from 13.2 percent per year under free capital mobility to 24.8 percent per year under optimal capital controls. The main reason why the Ramsey planner finds it optimal to impose capital controls on average is to lower the average level of external debt holdings. We postpone an explanation of why this is optimal until section 6.

Table 2 also shows that the tax on debt is highly volatile, with a standard deviation of 5.2 percentage points per quarter. The main payoff of imposing highly cyclical capital controls is an enormous reduction in the average rate of unemployment from 13 percent under free capital mobility to 3 percent under the optimal capital control policy. This reduction in unemployment is welfare increasing because it raises the average level of production, and hence also absorption, of nontradables, which provide utility to domestic households.

The reduction in unemployment is mediated by a significant reduction in the volatility of the growth rate of tradable absorption. The standard deviation of the growth rate of tradable consumption, c_t^T/c_{t-1}^T, not shown in the table, falls from 5.3 percent under free capital mobility to 2.9 percent under optimal capital controls. The connection between the

volatility of tradable consumption growth and unemployment follows from the fact that consumption of tradables plays the role of a shifter of the demand for nontradables. In turn, the Ramsey planner succeeds in curbing the variance of tradable expenditure growth by raising the cost of external borrowing during booms and lowering it during recessions. The correlation between traded output y_t^T and the capital control rate τ_t^d is 0.54 and the correlation between the interest rate r_t and τ_t^d is -0.58. Furthermore, the Ramsey planner engineers an effective interest rate that is positively correlated with traded output in spite of the fact that the interest rate itself is highly negatively correlated with the latter.

Table 2 shows that the first and second moments of the real (and nominal) wage rates are not significantly affected by the presence of capital controls. This prediction of the model might appear as surprising because downward wage rigidity is the sole friction in the present model, and because unemployment behaves markedly differently across capital control regimes. A reason why the unconditional moments of real wages are so similar in the two regimes is that the lower bound on wages is binding most of the time in both economies (85 percent of the time under free capital mobility and 65 percent of the time under optimal capital controls), and, when this happens, the wage rate falls at the common gross rate γ. A reason why the first and second moments of unemployment are so different across regimes in spite of the similarity in the corresponding moments of real wages is that when the wage constraint is binding the magnitude of the unemployment rate depends on the strength of the domestic absorption of tradables, which is significantly different across regimes.

An important distinction in wage dynamics across capital control regimes that is not captured by the unconditional moments shown in table 2 is the behavior of wages during booms. During economic expansions, the Ramsey fiscal authority, through capital controls, limits the appreciation of real wages. In this way, it also reduces the need for large decreases in the real wage once the boom is over. To visualize the role of optimal capital controls in limiting wage increases during booms, figure 4 displays the cumulative probability distribution of positive wage changes under free capital mobility and under optimal capital controls. Under optimal capital controls the vast majority of wage increases are small. Specifically, 90 percent of wage increases are less than 5 percent in magnitude. By contrast, only about half of all wage increases that occur under free capital mobility are smaller than 5 percent. This difference underlines the prudential nature of optimal capital controls.

6   Peg-Induced Overborrowing

Table 2 shows that the average level of external debt in the economy with free capital mobility is more than three times higher than it is in the economy with optimal capital controls.

Figure 4: Cumulative Probability Distribution of Positive Wage Changes
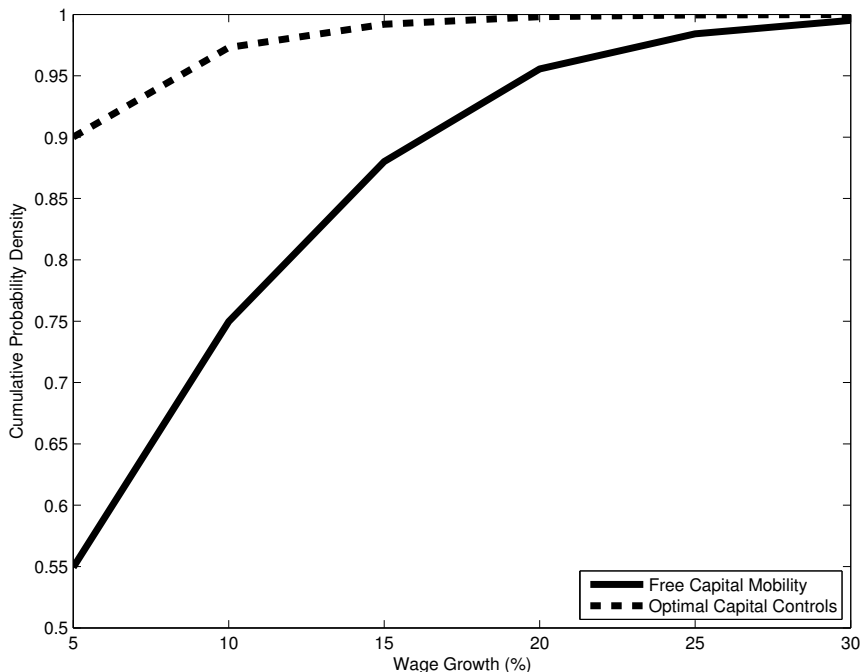
This prediction of the model is also evident from figure 5, which shows the unconditional distribution of external debt under free capital mobility (solid line) and under optimal capital controls (dashed line). The Ramsey planner induces a lower average level of external debt by taxing borrowing at a positive rate. Recall that the average tax rate on debt is 2.4 percent per quarter. It follows that pegging economies with free capital mobility accumulate inefficiently large amounts of external debt. In other words currency pegs in combination with free capital mobility lead to overborrowing.

The reason why the average level of external debt is lower under optimal capital controls than under free capital mobility is that the Ramsey planner finds it optimal to induce an external debt position that is significantly more volatile than the one associated with free capital mobility. As shown in table 2, the standard deviation of external debt is 2.3 under optimal capital controls, but only 0.7 under free capital mobility. Similarly, figure 5 shows that the distribution of external debt is significantly more dispersed under optimal capital controls than under free capital mobility. A more volatile process for external debt requires centering the debt distribution further away from the natural debt limit, for precautionary reasons. In turn, the reason why the Ramsey planner finds wide swings in the external debt position desirable is that such variations allow him to insulate the domestic absorption of tradable goods from exogenous disturbances buffeting the economy. Put differently, in the Ramsey economy, external debt plays the role of shock absorber to a much larger extent

Figure 5: The Distribution of External Debt
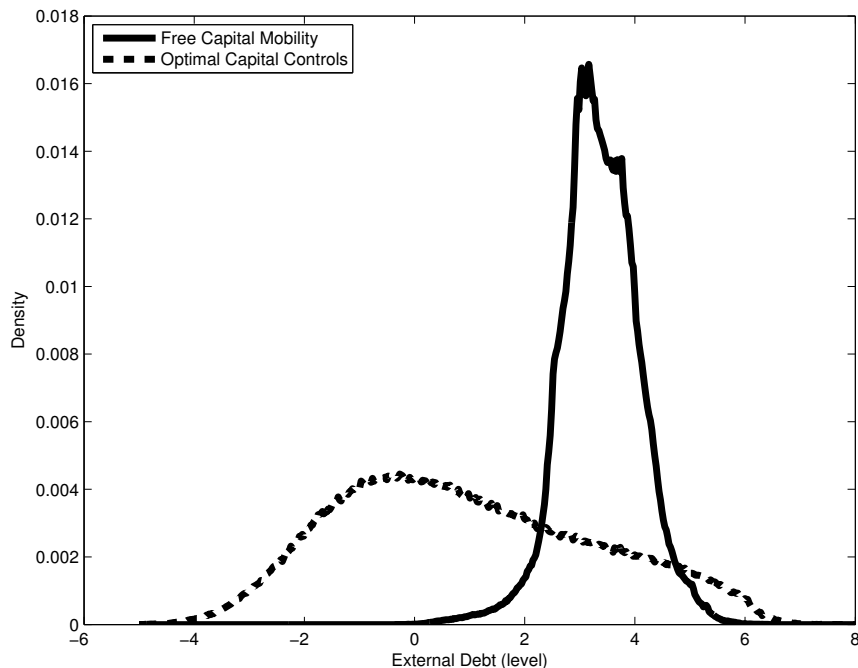
that it does in the economy with free capital mobility.

7 Welfare Costs of Free Capital Mobility for Peggers

We have established that in the present economy, free capital mobility entails excessive external debt and unemployment. Both of these factors tend to depress consumption and therefore reduce welfare. In this section, we quantify the welfare losses associated with free capital mobility in economies subject to a currency peg.

We define the welfare cost of free capital mobility, denoted λ, as the permanent percent increase in the lifetime consumption stream required by an individual living in the economy with free capital mobility to be unconditionally as well off as an individual living in the economy with optimal capital controls. Formally, λ is implicitly given by

$$\mathbb{E} \sum_{t=0}^{\infty} \beta^t U(c_t^{FCM}(1+\lambda)) = \mathbb{E} \sum_{t=0}^{\infty} \beta^t U(c_t^{OCC}),$$

where c_t^{FCM} and c_t^{OCC} denote, respectively, consumption in the economy with free capital mobility and consumption in the economy with optimal capital controls in period t.

Table 2 shows that the welfare cost of free capital mobility for a pegging economy is

enormous. The representative household living in the economy with free capital mobility requires an increase of 9.1 percent in consumption every period to be indifferent between living under free capital mobility and living under optimal capital controls. Thus, the present model speaks with a strong voice against allowing capital to flow freely across borders in economies with fixed exchange rates and downwardly rigid wages.

8 Greece and Spain

In this section we investigate the sensitivity of our main results to changes in the exogenous driving process. Specifically, we estimate the law of motion of traded output and the country interest rate using quarterly data from two peripheral European countries, Greece and Spain over the period 1980-2011. The appendix describes the data sources. The estimates of A, Σ_ν, and r defining the exogenous bivariate first-order autoregressive processes given in equation (28) are

$$A = \begin{bmatrix} 0.88 & -0.42 \\ -0.05 & 0.59 \end{bmatrix}; \quad \Sigma_\nu = \begin{bmatrix} 0.000536 & -0.000010 \\ -0.000010 & 0.000060 \end{bmatrix}; \quad r = 0.011.$$

for Greece and

$$A = \begin{bmatrix} 0.95 & 0.04 \\ 0.01 & 0.78 \end{bmatrix}; \quad \Sigma_\nu = \begin{bmatrix} 0.000134 & -0.000000 \\ -0.000000 & 0.000046 \end{bmatrix}; \quad r = 0.0123.$$

for Spain. Table 3 displays some features of the process $[y_t^T \ r_t]'$ implied by our estimates. Both Greece and Spain face lower interest rates than Argentina. The average value of r_t is about 5 percent for Greece and Spain and over 13 percent for Argentina. In addition, the two European economies face smaller external shocks. The estimated volatilities of tradable output and the interest rate in these two countries are significantly lower than their Argentine counterparts. The reduced level of external uncertainty lowers precautionary savings, and the lower average real interest rate makes external borrowing more attractive. As a result, as shown in the table, the average long-run debt-to-output ratio implied by the model is much higher under the exogenous processes estimated on Greek and Spanish data than under the one estimated on Argentine data.

Lower uncertainty and higher levels of external debt have opposite effects on the welfare costs of capital mobility for peggers. On the one hand, all other things equal, less uncertainty makes free capital mobility less costly for peggers. On the other hand, as we show elsewhere (Schmitt-Grohé and Uribe, 2011b), a higher level of external debt increases the welfare cost

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Table 3: Model Implications Using Data From Greece and Spain

Statistic	Argentina	Greece	Spain
Interest Rate (% yr.)			
Mean	13.2	4.5	5.1
Standard Deviation	7.4	5.2	4.7
Traded Output, y_t^T (% dev. from trend)			
Standard Deviation	12.3	6.5	3.6
$\mathrm{Corr}(y_t^T, r_t)$	-0.86	-0.62	0.13
Capital Control Rate, τ_t^d (% qtr.)			
Mean	2.4	3.3	3.4
$\mathrm{corr}(\tau_t^d, y_t^T)$	0.54	0.49	0.18
$\mathrm{corr}(\tau_t^d r_t)$	-0.58	-0.49	-0.56
Mean Unemployment (%)			
Free Capital Mobility	13.5	15.3	10.8
Optimal Capital Controls	3.1	3.8	2.2
Std. Dev. Consumption (%)			
Free Capital Mobility	12.5	16.1	12.1
Optimal Capital Controls	9.6	10.6	7.3
Debt-to-Output Ratio (%)			
Free Capital Mobility	26	113	162
Optimal Capital Controls	11	99	152
Welfare Cost of Free Capital Mobility			
(% of consumption)	9.2	13.4	9.2

of free capital mobility for peggers. In the case of Greece, for example, even though the level of uncertainty is lower than that of Argentina, the welfare cost of free capital mobility turns out to be higher than in Argentina. The reason is that the level of external debt induced by the exogenous driving process fit to Greek data is much higher than that induced by the process estimated with Argentine data.

The welfare cost of free capital mobility estimated for Spain is significantly smaller than that estimated for Greece even though the implied external debt level for the former is much higher. We attribute this result to the fact that the Greek interest rate is strongly countercyclical whereas the Spanish interest rate is mildly procyclical. Using the terminology coined by Kaminsky et al. (2005), when it rains in Greece it pours, whereas it does not in Spain.

9 Conclusion

The first contribution of this paper is to identify a negative pecuniary externality afflicting economies with downward nominal wage rigidity and fixed exchange rates. In this type of economic environment, private absorption expands too much in response to favorable shocks, causing inefficiently large increases in real wages. No problems are manifested in this phase of the cycle. However, as the economy returns to its trend path, wages fail to fall quickly enough because they are downwardly rigid. In addition, the central bank, having its hands tied by the commitment to a fixed exchange rate, cannot deflate the real value of wages via a devaluation. In turn, high real wages and a contracting level of aggregate absorption cause involuntary unemployment. Individual agents are conscious of this mechanism, but are too small to internalize it. The government, on the other hand, does internalize the distortion and therefore has an incentive to intervene.

The second contribution of the present study is to analyze the ability of capital controls to ameliorate the distortions introduced by the peg-induced pecuniary externality. We characterize both analytically and numerically the Ramsey optimal capital control policy. We show that, although capital controls cannot bring about the first-best allocation, they go a long way toward easing the pains of pegs. Under plausible calibrations of our model, we find that the representative household living in the economy with free capital mobility requires a 9.1 percent permanent increase in consumption to be unconditionally indifferent between continuing to live in that environment and migrating to one with optimally set capital controls.

The third contribution of the present investigation is to establish that the optimal capital control policy is prudential in nature. The benevolent government taxes capital inflows in good times and subsidizes external borrowing in bad times. As a result, the economy experiences trade surpluses during booms and deficits during recessions. The key role of capital controls is to insulate the domestic absorption of tradable goods from external shocks. In this way, the government avoids that external disturbances spill over into the nontraded sector where they would otherwise cause unemployment.

The fourth important finding of our inquiry is to establish that pegging economies are prone to overborrowing. In our calibrated model, the average debt-to-output ratio falls from 26 percent in the economy with free capital mobility to 11 percent in the economy with optimal capital controls. The regulated economy accumulates a war chest of assets (or a reduced level of debt) in order to be able to stabilize traded consumption when the economy is buffeted by negative external shocks.

In summary, the results of the present study strongly suggest that, when labor markets

suffer from downward nominal wage rigidity, fixed exchange rate arrangements should not be coupled with free capital mobility. On the contrary, in such economies, capital controls can be a highly effective instrument for macroeconomic stabilization. More importantly, the predictions of our model suggest that governments of fixed-exchange-rate economies should concentrate effort not on crisis management, but rather on crisis prevention.

Appendix: Data Description

In this appendix, we report the estimate of the exogenous driving process $[y_t^T \ r_t]'$ for the cases of Greece and Spain. We also describe how the empirical measures of y_t^T and r_t were constructed.

Greece

The estimation uses quarterly data from 1981:Q1 to 2011:Q3. Greece did not produce sectoral GDP data between 1991 and 1999. For this reason, we proxy traded output by an index of industrial production. Specifically, we use the index of total manufacturing production 2005=100 from the OECD seasonally adjusted at the source. The original series begins in 1955:Q1 and ends in 2011:Q3. We removed a cubic trend from the natural logarithm of the index over the period 1955:Q1 to 2011:Q3. We use observations of the detrended series for the period 1981:Q1 to 2011:Q3 to make the range compatible with the one corresponding to the country real interest rate.

It is also difficult to obtain a consistent measure of the Greek real interest rate over the past three decades. The reason is twofold. First, JP Morgan does not produce the EMBI index for Greece. Second, we were unable to find an interest rate for a constant maturity instrument over the whole sample. In face of these data limitations, we proceed as follows. We measure the real interest rate in terms of tradables using the formula

$$1 + r_t = (1 + i_t)\mathbb{E}_t \left[\frac{E_t P_t^{T*}}{E_{t+1} P_{t+1}^{T*}} \right],$$

where r_t denotes the real country interest rate in terms of tradables, i_t denotes the nominal interest rate in terms of national currency, E_t denotes the nominal exchnage rate defined as units of domestic currency per unit of ECU or Euro as applicable (Greece's legal tender changed to the Euro in 2001), P_t^{T*} denotes the foreign-currency price of tradables, and $\mathbb{E}_t$ denotes the expectations operator conditional on information available in period t. This formula assumes that the marginal rate of substitution is uncorrelated with the inverse of the domestic rate of inflation of tradable goods. The source for E_t is Eurostat (code `ert_h_eur_q`). We measure P_t^{T*} by the German consumer price index published by the OECD. We measure i_t as follows. For the period 1981:Q1 to 1992:Q3 it is the overnight interest rate published by the Bank of Greece. For the period 2001:Q1 to 2011:Q3 we proxy i_t by the interest rate on 10-year Greek treasury bonds published by Eurostat (code `irt_lt_mcby_q`). For the period 1992:Q4 to 2000:Q4, we measure i_t as the average of the above two interest rates. We proxy $\mathbb{E}_t \left[\frac{E_t P_t^{T*}}{E_{t+1} P_{t+1}^{T*}} \right]$ by the one-period ahead forecast of $\frac{E_t P_t^{T*}}{E_{t+1} P_{t+1}^{T*}}$

implied by an estimated AR(2) process for this variable. We discretize the driving process following the same procedure described in the body of the paper for the case of Argentina.

Spain

The estimation of the driving process uses quarterly data over the period 1980:Q3 to 2011:Q4. We proxy tradable output by the sum of sectorial GDP in agriculture, livestock breeding, forestry, fishing, and industry net of construction at constant prices of 1995. The source is INE (www.ine.es). The average share of tradables in GDP over the estimation sample is 26 percent. The logarithm of traded GDP is detrended by removing a cubic time trend. The procedure for constructing the Spanish real interest rate is similar to that emplyed for Greece, except that here we measure the nominal interest rate by the 10-year Spanish treasury bond published by Eurostat under the name EMU convergence criterion bond yields (code `irt_lt_mcby_q`).

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