

**FINDING STABILITY IN A TIME OF CRISIS: LESSONS
OF EAST ASIA FOR EASTERN EUROPE**

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HKIMR Working Paper No.05/2014

March 2014



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Finding Stability in a Time of Crisis: Lessons of East Asia for Eastern Europe

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Abstract

This paper examines the options of small open economies in Eastern Europe pegged to the Euro, in a time of crisis. Specifically, should Bosnia and Herzegovina, Bulgaria, Latvia and Lithuania move to full Euro area accession, as Estonia, Slovakia, and Slovenia have done, or follow the examples of Poland, the Czech Republic, and Hungary and opt out of the Euro area?

This paper argues that going forward to full monetary union offers benefits over a pure fixed exchange-rate regime. Specifically, the experience of Hong Kong at the time of the Asian crisis in the late 1990's, illustrates the benefits of a credible currency link during a time of crisis.

JEL Classification: E52, E62, F41

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McNelis' research for this project began as a visiting scholar at the Hong Kong Institute for Monetary Research in December 2012. Further research was supported by the Department of Economic Research of the Bank of Portugal in 2013.

The views expressed in this paper are those of the author, and do not necessarily reflect those of the Hong Kong Institute for Monetary Research, its Council of Advisers, or the Board of Directors.

1. Introduction

In the course of the Euro Area crisis since 2007, a number of Euro area countries (Cyprus, Ireland, Greece, Italy, Portugal and Spain) have experienced sharp reversals in capital inflows. The reversal of capital flows seen in Europe was part of a broader global development, since a number of non-Euro Area and non-European countries also experienced capital flow reversals in previous decades.

Sharp reversals in capital flows are not new phenomena. Since the 1980's many countries have experienced sudden stops. Famous episodes are the ERM crisis of 1992/1993 in Europe, Mexico in 1994 (the Tequila crisis), Hong Kong, Indonesia, Malaysia, South Korea, Thailand, during the Asian crisis of the late 1990's (the Asian Flu) and Russia and a number of other countries in 1998 (the "Russian crisis").

The recent crisis in the Euro area, of course, puts the question of full monetary union in center stage for Bosnia and Herzegovina, Bulgaria, Latvia and Lithuania, now pegged to the Euro. While Estonia, Slovakia, and Slovenia have become full members of the Euro area, a number of other countries, such as Poland, the Czech Republic, and Hungary, have not moved forward to Euro area accession by fixing their exchange rates to the Euro.

Clearly, it is in times of crisis that choices about membership in a monetary union are most critical. After all, in normal times, exchange-rate regime choice, while interesting, is not a front and center policy issue. The question facing the four countries pegged to the Euro is simple: should they go forward, follow the lead to Estonia, Slovakia and Slovenia, or take their cues from Poland, the Czech Republic and Hungary?

Like the members of the Euro area, these countries are vulnerable to sudden stops, when collateral constraints become binding in the wake of adverse shocks, or simply due to contagion effects from nearby countries, even when public debt is trivial (as the experience of Hong Kong shows). This paper argues that it is precisely in these times of adversity that it makes sense to be in a monetary union. For these transition economies of Eastern Europe, the monetary union is the Euro area.

The experience of Hong Kong during the Asian crisis of the late 1990's offers important lessons for this issue. Hong Kong has maintained a currency board with the United States dollar since 1984. To be sure, Hong Kong has neither a de jure or de facto monetary union with the United States, since only its monetary base is backed by US dollar reserves. However, much more than the other East Asian currencies, the Hong Kong currency has had a strong and credible link with the U.S. dollar. With large abundant reserve holdings of U.S. dollars, the monetary authority of Hong Kong at the time of the crisis was able to provide to banks and financial markets special funding, much as the Federal Reserve board provided special funding to financial institutions at the time of the crisis in 2008. This experience provides important lessons for countries in Easter Europe in the process of linking to the Euro.

Specifically, the Hong Kong Monetary Authority, authorized in 1998 what has been called an “audacious move”, the purchase of US\$15 billion in stocks amidst the market panic. The measure restored calm, and effectively defended the Hong Kong fixed exchange rate parity against the US dollar. The move was initially criticized as a very unorthodox form of monetary policy but later praised by Alan Greenspan, no less, as a “savvy move” with “exquisite timing”.¹

The distinguishing feature of the Euro area case is the fact that sudden stops occurred in a set of countries which are part of a monetary union. In this situation, a common central bank conducts a single monetary policy aimed at ensuring broadly similar monetary conditions across participating countries. Under this regime, net private capital outflows are partially offset by the actions of the central bank. This paper explores in greater detail the implications of such a facility for a country experiencing a sudden stop, comparing the adjustment with a country with a fixed exchange rate.

Clearly, what has happened in Spain, Ireland, Greece, Portugal can happen to Eastern European countries. This paper argues that the funding of a monetary union provides an additional effective cushion in times of adversity. This cushion of the additional reserve funding to member countries in a monetary union functions much like the cushion the Hong Kong Monetary Authority was able to provide markets at the time of the Asian crisis.

This paper does not go into the details of the history or mechanics of Eastern European countries or the Hong Kong monetary system. Rather we start from a relatively simple model of a small open economy subject to sudden stops, and examine adjustment with and without the benefits of a monetary union, when recurring adverse negative shocks make collateral constraints binding, setting off further debt-deflation dynamics. We then simulate the Hong Kong experience, basically that of contagion effects, leading to a collapse of the share market index. We show with the same model how the reserve funding was able to cushion the effects of the adverse contagion effect.

The Hong Kong adjustment, while harsh, to be sure, did not come as a result of high public indebtedness or the need for large scale banking-sector intervention, as in the stressed European countries. But the experience of Hong Kong should serve as an even more significant lesson. Adverse shocks can and do come, even if the fundamental of public sector finances are sound.

This paper makes use of the small open economy model of Mendoza (2010). With the model, we can generate “sudden stop events”, generated by normal business cycle shocks (to total factor productivity (TFP) and world interest rates) rather than by assumed exogenous contagion effects. However, with the same model, we are able compare adjustment of a Hong Kong style contagion effect, with and without the benefits of emergency financing.

The model is based on rigorous microfoundations, and avoids a number of ad-hoc elements which

¹ See the Bloomberg web page, <http://www.bloomberg.com/apps/news?pid=newsarchive&sid=aTDcelSOTQU4&refer=home>.

have been used in alternative frameworks.

Third, the model incorporates important linkages between asset prices, specifically Tobin's q , collateral values and borrowing constraints which have played an important role in the recent crisis.

While taking the Mendoza model as the starting point, we make several modifications. We allow for downward nominal wage rigidity since this potentially has important implications for macroeconomic adjustment under fixed exchange rate regimes (Schmitt-Grohe and Uribe (2011)). Second, and more to the point, this paper embeds a central bank funding facility characterizing a monetary union. We switch this feature on and off to explore its effect on macroeconomic adjustment to sudden stops, in the case of binding collateral constraints.

The literature generally follows the Calvo definition in which sudden stops are defined as *“large and unexpected falls in capital inflows that have costly consequences in terms of disruptions in economic activity”* (Calvo et al. (2004b) p.14).

The macroeconomic response of the affected Euro Area economies to the sudden stop events is similar, in some ways, to previous experience elsewhere. This can be seen in Figure 1. In this figure, we follow Mendoza (2010), by looking at the “average” dynamics of key variables before and after the event for a span of five years². The year in which the sudden stop starts is denoted $t = 0$, with the level of each variable (except for capital flows and net export ratios) for the preceding year ($t = -1$.) being normalized to unity. The figure shows the average dynamics for all sudden stop episodes found in the data as well as for the Tequila, Asian and Euro Area crises.

Figure 1 shows that the most severe drops took place in Asia. In terms of GDP, consumption and investment, the collapse in the Euro zone was not as severe as the Asian crises. The patterns are similar and the earlier crises in Asia represented signs of things to come elsewhere in the world.

Figure 2 pictures the adjustment of key variables in Hong Kong before and after the Asian financial crisis of 1997. Unfortunately, balance of payments are not available for the period leading up to the crisis in Hong Kong. This figure shows the severe drop in GDP growth at the time of the crisis, by more than 10 percent, along with the drop in export growth, and government spending. This figure also shows the sharp increase in the domestic interest rate relative to the international LIBOR rate, to which the Hong Kong dollar remained pegged. The figure also shows the onset of a period of deflation at the time of the crisis which lasted for almost a decade.

While adjustment in Hong Kong was indeed harsh, as it is now for Greece, Ireland, Italy, Portugal, and Spain, it could have been worse, much worse, without the financing through dollar reserves. We

² With the exception of capital flow and net export ratios, all variables in the Figure are computed using deviations from a Hodrick-Prescott filter.

argue that the same is true for member countries of the Euro area. The message of this paper to Bosnia and Herzegovina, Bulgaria, Latvia and Lithuania is that bad things can happen, in the form of sudden stops, whether generated by adverse business cycle triggering collateral constraints, or by contagion effects (being in the wrong region of the world at the wrong time). Given that bad things can and do happen, it is much better to be in a credible monetary union than not.

This paper proposes that the European crises reflect the debt/deflation mechanism coming from binding collateral constraints, while the Hong Kong crisis a decade earlier represents more clearly a contagion effect, more specifically, a case of the “holy trinity” of financial contagion, in that it was fast and furious, came as a surprise, and involved leveraged international creditors operating within a broader region [see Kaminsky et al. (2003)]. From the perspective of Bosnia and Herzegovina, Bulgaria, Latvia and Lithuania, does it really matter how the bad news comes? The issue is how they can best adjust to the bad news.

Calvo and Mendoza (2000) rationalize a sudden stop in countries with sound fundamentals, due to the fixed costs of gathering and processing country-specific information within a region where other crises are taking place. The shows how the presence of these costs lead to herding behavior by rational investors. Billio et al. (2005) find empirical evidence for such a contagion effect in Hong Kong during the 1997 financial crisis.

In the next section we lay out the structure of the model, and show how it can be used to simulate endogenous sudden stops coming from binding collateral constraints as well as exogenous stops due to contagion effects. We then discuss the calibration and simulation method. Following this, we examine the behavior of the model with collateral constraints, in which question of monetary union comes to center stage. We then discuss the behavior of the model with contagion effects, for given stochastic shocks to productivity and world interest rates, where there is little or no public debt. We show that the availability of reserve financing in a time of crisis, makes a significance difference.

2. Model

On the theoretical front, during the past decade, sudden stop phenomena have been the subject of different general equilibrium frameworks. Models differ depending in a number of respects such as: single country versus two country, the type of sectoral breakdown (single good versus traded/non-traded split), the type of frictions included (e.g. sticky versus flexible prices and capital adjustment costs), and the type of shocks considered.

Calvo et al. (2004a,c) drew attention to sudden stops arising as a consequence of uncertainty about fiscal or real exchange-rate sustainability. This approach was soon challenged by Chari et al. (2005), who argued that sudden stops were simply a consequence of expected negative shocks to real output.

This controversy is mirrored in the theoretical literature. One set of models treats sudden stops as exogenous determined events. Another set of models treats sudden stops as endogenously generated events, or recurring set of events, with the productivity, terms of trade or foreign interest rates as the forcing variables driving the economy.

Braggion et al. (2009) model the sudden stop as an exogenous permanent regime switch from one steady state to another. In the initial state, there is no borrowing constraint on the economy. The sudden stop is then modeled as a shift towards a permanently binding borrowing constraint. Curdia (2008) use the framework of Bernanke et al. (1996) in which the economy faces an external finance premium. The sudden stop takes the form of an exogenous shock to an external financing premium. Unlike Braggion et al. (2009), this shock is not permanent.

Devereux et al. (2006) also examine the role of the external financing premium in the spirit of Bernanke et al. (1996). Unlike Curdia (2008), the premium is endogenously determined by the stochastic shocks driving the model (terms of trade and world interest rate shocks). They also embed nominal frictions in terms of sticky prices and imperfect exchange-rate pass through.

In contrast with the above approaches, Mendoza and Arellano (2003); Mendoza (2010) use a small-open economy real business cycle framework with financial frictions in the form of collateral constraints on international borrowing, following the specification of Kiyotaki and Moore (1997a). In this framework, shocks take the usual form of recurring productivity, foreign interest rate, and external price changes. Sudden stop phenomena emerge as endogenously recurring, albeit infrequent, events, arising when collateral constraints become binding. When the borrowing constraint hits, consumption and investment fall. At the same time, the working capital channel induces firms to reduce inputs, leading to a fall in output. This mechanism is exacerbated by a “debt deflation mechanism” with falls in the q-ratio leading to a further tightening of the borrowing constraint.

2.1 Benchmark Model

Following Mendoza (2010) the small open economy contains a representative firm-household model which produces a single good using three factors of production: labor L_t , capital k_t and imported intermediate goods v_t . In addition to the usual intertemporal budget constraint, agents are subject to a working capital requirement on labor and intermediate inputs, quadratic adjustment costs for capital accumulation and the usual intertemporal borrowing constraint. In addition agents are subject to occasionally binding external borrowing constraints.

The representative household optimizes an intertemporal welfare function V_t positively related to consumption c_t and negatively related to labor L_t .

In order to ensure stationarity of net foreign assets the welfare function embodies an endogenous discount factor D_t

$$V_t = U[c_t - N(L_t)] + D_t V_{t+1} \quad (1)$$

$$U(\cdot) = \frac{1}{1 - \sigma_c} [c_t - N(L_t)]^{1 - \sigma_c} \quad (2)$$

$$N(L_t) = \frac{1}{\omega} L_t^\omega \quad (3)$$

The parameters σ_c and ω represent the relative risk version coefficient and the Frisch elasticity of labor supply in the labor component of the utility function, $N(L_t)$. This specification of the utility function, which follows Greenwood et al. (1988), implies that there are no wealth effects on labor supply. This has important implications for the ability of the model to match the response of the economy to sudden stop episodes. As noted by Chari et al. (2005) standard preferences would imply an increase in labor supply (and thus output) following the imposition of a borrowing constraint on an economy. Suppressing the wealth effect on labor supply as done here eliminates this counterfactual feature.

The discount factor D_t has the following functional form:³

$$D_t = \rho(c_t - N(L_t)) \quad (4)$$

$$\rho(c_t - N(L_t)) = \exp\{-\gamma \ln[1 + c_t - N(L_t)]\}$$

The budget constraint for the household is given by the following relation:

$$c_t + i_t + g_t = y_t - p_t v_t - \phi(R_t - 1)(w_t L_t + p_t v_t) - q_t^b b_{t+1} + b_t \quad (5)$$

where y_t represents total domestic output at time t , c_t consumption, i_t investment, g_t government spending, b_t one-period international bonds. The price index p_t is the cost of the intermediate goods for the firm, w_t the real wage rate, and q_t^b the price of international bonds.

The working capital requirement for the representative firm is given by the parameter ϕ while $(R_t - 1)$ represents the net nominal world interest rate. The price of international bonds is exogenous, with $q_t^b = 1/R_t$.

In addition to the economy-wide budget resource constraint, the following collateral constraint applies to international borrowing b_{t+1} :

³ Schmitt-Grohe and Uribe (2003) closing note that endogenous discounting is only one way for closing open-economy models. Other ways include a risk premium on foreign debt, an adjustment cost on foreign debt accumulation, and the assumption of complete markets.

$$q_t^b b_{t+1} - \phi R_t (w_t L_t + p_t v_t) + \kappa q_t k_t \geq 0 \quad (6)$$

where q_t is the price of capital, and ϕ is the working-capital coefficient, giving the percent of the wage and intermediate-goods bill which must be financed. As Mendoza (2010) notes, “the collateral constraint implies that total debt, including both debt in one-period bonds and working capital loans for labor and intermediate goods, cannot exceed a fraction κ of the 'marked-to-market' value of capital” [Mendoza (2010): p.1947]. As Mendoza also pointed out, this is the standard, widely-used form of imposing collateral constraints, due to Kiyotaki and Moore (1997b).

Capital accumulation is equal to investment, net of depreciation and adjustment costs:

$$i_t = \delta k_t + (k_{t+1} - k_t) \left[1 + \Psi \left(\frac{k_{t+1} - k_t}{k_t} \right) \right] \quad (7)$$

The parameter δ is the rate of depreciation and Ψ is the adjustment cost function. The adjustment cost function in turn is quadratic:

$$\Psi \left(\frac{z_t}{k_t} \right) = \frac{a}{2} \left(\frac{z_t}{k_t} \right)^2 \quad (8)$$

$$a > 0$$

$$z_t = (k_{t+1} - k_t)$$

where the variable z_t denotes capital accumulation ($k_{t+1} - k_t$), at time t , and a is the adjustment-cost parameter.

For simplicity, net capital accumulation z_t may be expressed in the following way:

$$z_t = i_t - \delta k_t - \Psi \left(\frac{z_t}{k_t} \right) z_t \quad (9)$$

Government spending g_t is assumed to be unproductive and funded by a time-invariant *ad-valorem* consumption tax, tc . As noted by Mendoza, this tax does not distort the consumption-leisure decision [Mendoza (2010), p.1952].

Production is based on a constant-returns-to-scale Cobb-Douglas function, multiplied by a total factor productivity shock, given by the exponent of ε_t^A :

$$y_t = \exp(\varepsilon_t^A) A k_t^\beta L_t^\alpha v_t^\eta \quad (10)$$

$$0 < \alpha, \beta, \eta < 1$$

$$\alpha + \beta + \eta = 1$$

$$A > 0$$

2.2 First Order Conditions

The first order conditions for the representative household/firm are obtained by maximizing function V_t subject to the intertemporal resource constraint, given by equation 5, the law of motion of capital, in equation 7, and the borrowing constraint, in equation 6, with respect to c_t, L_t, k_{t+1}, v_t and b_{t+1} .

For first order conditions for consumption and labor (assuming flexible wages), given by c_t and L_t , we have the following expressions:

$$\lambda_t = u_c(c_t - N(L_t)) + \rho_c(c_t - N(L_t))\mathbf{E}_t[V_{t+1}] \quad (11)$$

$$-\lambda_t w_t = -u_c(c_t - N(L_t))N_L(L_t) - \rho_c(c_t - N(L_t))N_L(L_t)\mathbf{E}_t[V_{t+1}] \quad (12)$$

where λ_t is the Lagrangian for the resource constraint and \mathbf{E}_t is the expectations operator. The partial derivative of the discount factor with respect to consumption, $\rho_c(c_t - N(L_t))$, has the following form:

$$\rho_c(c_t - N(L_t)) = \left(\frac{-\gamma}{1 + c_t - \frac{L_t^\omega}{\omega}} \right) \exp \left[-\gamma \ln \left(1 + c_t - \frac{L_t^\omega}{\omega} \right) \right] \quad (13)$$

Dividing the labor and consumption Euler equations, we obtain the following familiar labor supply/real wage relation:

$$N_L(L_t) = w_t \quad (14)$$

The real wage w_t obeys the following first order condition:

$$\lambda_t (\exp(\varepsilon_t^A) F_L(k_t, L_t, v_t) - w_t(1 + \phi(R - 1))) - \mu_t \phi R_t w_t = 0 \quad (15)$$

Similarly, for intermediate goods, v_t , the following first order condition applies:

$$\lambda_t (\exp(\varepsilon_t^A) F_V(k_t, L_t, v_t) - p_t(1 + \phi(R - 1))) - \mu_t \phi R_t p_t = 0 \quad (16)$$

In both of these equations, the variable μ_t , as mentioned above, represents the Kuhn-Tucker multiplier applied to the borrowing constraint.

When the borrowing constraint does not bind, with $\mu_t = 0$, the above first order condition simply states that the marginal productivity of intermediate goods, multiplied by the marginal utility of income, should be equal to the marginal cost, including working capital costs. The same is true for the marginal product of labor with respect to the real wage w_t including working-capital costs. When the borrowing constraint binds ($\mu_t > 0$), the multiplier acts like a tax on the use of intermediate inputs and labor, inducing firms to use less of them.

The first-order condition for the international bond b_{t+1} implies the following asset-pricing relation between the price of bonds and the marginal utility of income:

$$\lambda_t q_t^b = \mu_t q_t^b + D_t \lambda_{t+1} \quad (17)$$

The condition implies the following law of motion for the marginal utility of income, λ_t :

$$\lambda_t = \mu_t + D_t R_t \lambda_{t+1} \quad (18)$$

The gross real interest rate on one-period domestic bonds (R_t^h) satisfies the usual condition which links it to the stochastic discount factor:

$$\frac{1}{R_t^h} = \frac{\mathbf{E}_t[D_t \lambda_{t+1}]}{\lambda_t}$$

When the collateral constraint is not binding ($\mu_t = 0$) the domestic and foreign rates are identical. However, when the collateral constraint binds (with $\mu_t > 0$), a spread between the two rates emerges. This spread is the difference between the effective real interest rate, given by R_t^h and the international interest rate, R_t :

$$R_t^h - R_t = \frac{\mu_t}{\mathbf{E}_t \lambda_{t+1}} \quad (19)$$

Optimizing with respect to investment k_{t+1} leads to the following expression:

$$\begin{aligned} & D_t \lambda_t \exp(\varepsilon_{t+1}^A) F_k(k_{t+1}, L_{t+1}, v_{t+1}) + q_t \left\{ - \left[1 + \Psi \left(\frac{z_t}{k_t} \right) \right] - z_t \Psi_z \left(\frac{z_t}{k_t} \right) \frac{1}{k_t} \right\} + \\ & q_{t+1} \left\{ -\delta + \left[1 - \Psi \left(\frac{z_{t+1}}{k_t + 1} \right) \right] + z_{t+1} \Psi_z \left(\frac{z_{t+1}}{k_t + 1} \right) \left(1 + \frac{z_{t+1}}{k_t + 1} \right) \frac{1}{k_{t+1}} \right\} \\ & + \mu_{t+1} \kappa q_{t+1} = 0 \end{aligned} \quad (20)$$

The symbol D_t is the discount factor, equal to $\rho(c_t - N(L_t))$.

To simplify the first-order condition for the capital stock, we first define expected dividends, d_{t+1} as the expected marginal productivity of capital less depreciation plus the gains in the form of reduced adjustment costs by the higher stock of capital:

$$d_{t+1} = \exp(\varepsilon_{t+1}^A) F_1(k_{t+1}, L_{t+1}, v_{t+1}) - \delta + \left(\frac{z_{t+1}}{k_{t+1}}\right)^2 \Psi_z\left(\frac{z_{t+1}}{k_{t+1}}\right) \quad (21)$$

Tobin's q in this model is derived from the familiar asset-pricing formula:

$$q_t = \mathbf{E}_t \left[\sum_{j=0}^{\infty} \left(\prod_{i=0}^j \left(\frac{1}{\bar{R}_{t+i+1}^{t+1}} \right) \right) d_{t+1+j} \right] \quad (22)$$

with the discount factor \bar{R}_{t+i+1}^{t+1} defined in the following way:

$$\bar{R}_{t+i+1}^{t+1} = \frac{\lambda_{t+i} - \mu_{t+i}K}{\lambda_{t+i+1}} \quad (23)$$

As equations (24) and (25) make clear, if the borrowing constraint binds (or is expected to bind in the future), the rate at which dividends are discounted will rise. This leads to a decline in the q -ratio. Since the borrowing constraint itself depends on q , the fall in q will in turn lead to a tightening of the borrowing constraint, leading to further falls in q . This debt-deflation mechanism is a key feature of the model and plays an important role in driving the macroeconomic response to sudden stops. Furthermore, the debt deflation mechanism increases the financing cost of working capital, depressing investment, employment and output even more.

2.3 Contagion Effect Model

In the contagion effect, the level of public debt is thus irrelevant. Foreign investors impose a risk premium or wedge between the domestic and foreign interest rate. In this version of the Mendoza model, the Lagrange multiplier, providing a wedge between the domestic and foreign interest rate, μ , is determined by an exogenous stochastic process, and is not affected by the level of international borrowing.

Lim and McNelis (2012) estimated a Bayesian model for Hong Kong, including a stochastic process for the interest-rate differential between the Hong Kong dollar and the international US dollar interest rate. We will use the parameters from this estimated process to assess the effects of an exogenous risk premium process, independent of the fundamentals of the economy.

2.4 Downward Nominal Wage Rigidity

Schmitt-Grohe and Uribe (2011) have drawn attention to downward nominal wage rigidity (DNWR) as the key source of nominal frictions in the economy which weakens the ability of the economy to adjust under fixed exchange rate. In their setup, nominal wages can not adjust (sufficiently) downwards in response to adverse shocks. This implies that exchange rate pegs will lead to higher levels of unemployment on average than a flexible exchange rate regime with an optimal monetary policy. The implied costs are large. On average, the unemployment rate is more than 10 percentage points higher and the welfare cost of a currency peg under this form of rigidity amounts to 4 to 10% of consumption. In a complimentary paper, Schmitt-Grohe and Uribe (2013) inflation, for this reason, advocate a Euro Area wide annual inflation rates of 4.3% in order to restore full employment to the Euro zone countries over a period of five years. This is more than twice the annual inflation target rate of 2%.

Given the importance of DNWR in recent policy discussion of the Euro Area, we embed this feature into our model. We do this by means of an asymmetric Calvo wage setting scheme. We base our modeling of DNWR on the results of Fagan (2013) who analyzed micro data on wage changes for four countries (the US, Germany, Belgium and Portugal). He found that an asymmetric Calvo scheme best matches the cross sectional distribution of wage changes. He also shows that the case of a strictly binding constraint on wage cuts, as in Schmitt-Grohe and Uribe (2011), is a special case of this more general model.

In the asymmetric Calvo mechanism, nominal wages are free to adjust upwards. However, when nominal wages are required to fall, only a fraction of wage setters are free to cut wages, with the remaining fraction leaving their nominal wage unchanged. As in the regular Calvo setup, the optimal real wage rate chosen by those agents free to cut their wages is given by w_t^{num}/w_t^{den} , where

$$w_t^{num} = (1 + tc) \lambda_t L_t w_t^{\theta_w} L_t^{\omega-1} + \psi_w \frac{D_t \lambda_{t+1}}{\lambda_t} w_{t+1}^{num} (1 + \pi)^{\theta_w} \quad (24)$$

and

$$w_t^{den} = L_t w_t^{\theta_w} \lambda_t + (1 + \pi)^{\theta_w} \psi_w \frac{D_t \lambda_{t+1}}{\lambda_t} w_{t+1}^{den} \quad (25)$$

In contrast to Schmitt-Grohe and Uribe (2011), who assume that “world” inflation is zero, we assume an inflation rate of 2%, in line with the ECB target for the Euro Area as a whole. This implies that DNWR will be less binding in our case. Our assumption on world inflation allows us to express the Calvo first order conditions in terms of real wages as in (27) and (28)⁴.

⁴ Specifically, we assume that the world price level evolves deterministically, increasing at a rate of 2% per annum. The Calvo expressions for wages is normally in terms on nominal wages. However, dividing the first order conditions for the

For the economy-wide real wage, we have the following expression:

$$w_t = \left(\psi_w(s) \left(\frac{w_{t-1}}{1+\pi} \right)^{1-\theta_w} + (1 - \psi_w(s)) \left(\frac{\theta_w}{\theta_w - 1} \frac{w_t^{num}}{w_t^{den}} \right)^{1-\theta_w} \right)^{\frac{1}{1-\theta_w}} \quad (26)$$

This expression replaces the households first order condition for labor given by (5). The parameter $\psi_w(s)$ captures the state-contingent degree of DNWR in the economy at time t . It is zero if nominal wages are rising, so that nominal wages are flexible in this case. Where nominal wages are falling, DNWR kicks in and $0 < \psi_w(s) \leq 1$.

Since we are solving our model using a global solution method, the introduction of this highly nonlinear form of wage setting poses no additional problems apart from adding an additional state variable (the previous period's wage).

2.5 Funding Facility in a Monetary Union

To capture the differences between a monetary union and a pure fixed exchange-rate regime, we note that net foreign assets may be decomposed as the sum of two components: private net foreign assets (b_t^{PR}) and central bank balances (b_t^{CB}), with borrowing via the financing facility, which is recorded as a negative value for b_t^{CB} :

$$b_t = b_t^{PR} + b_t^{CB} \quad (27)$$

The borrowing constraint applies now to private net foreign assets:

$$q_t^b b_{t+1}^{PR} - \phi R_t (w_t L_t + p_t v_t) \geq -\kappa q_t k_t$$

To complete the model, we need to specify how the special funding facilities are determined. We assume that these balances follow a linear function of the spread between the domestic and world interest rate:

$$-b_t^{CB} = \Phi(R_t^D - R_t)$$

As noted earlier, the difference the interest rate spread comes into play when the collateral constraint becomes binding. In this case, the emergence of a spread will trigger the special facility inflows. Otherwise, when the collateral constraint is not binding, these balances will be zero. The parameter Φ reflects the elasticity of central liquidity supply to the country in the monetary union. When it is zero, there is effectively no system in place, and the country operates as if it were in a fixed exchange-rate

Calvo wage-setting by the deterministic price level allows us to express the Calvo conditions in real terms as in (27) and (28).

system. As Φ tends to infinity, liquidity supply becomes infinitely elastic. In this extreme case, private capital outflows in a sudden stop are completely offset by these inflows; so that the external borrowing constraint falls away.

2.6 Stochastic Shock Specification

Both total factor productivity and the gross interest rate R_t follow exogenous stochastic processes. The total factor productivity shock, given by ε_t^A , has the following specification, with autoregressive coefficient ρ_A and innovation term η_t^A , normally distributed with mean zero and variance σ_A^2 :

$$\begin{aligned}\varepsilon_t^A &= \rho_A \varepsilon_{t-1}^A + \eta_t^A \\ \eta_t^A &\sim N(0, \sigma_A^2)\end{aligned}\tag{28}$$

The gross real world interest rate has the following process:

$$\begin{aligned}\ln(R_t) &= \rho_R \ln(R_{t-1}) + (1 - \rho_R) \ln(\bar{R}) + \eta_t^R + \rho_{RA} \cdot \eta_t^A \\ \eta_t^R &\sim N(0, \sigma_R^2)\end{aligned}\tag{29}$$

For the case of an exogenous risk premium, we specify the following process:

$$\begin{aligned}\mu_t &= \rho_\mu \mu_{t-1} + \eta_t^\mu \\ \eta_t^\mu &\sim N(0, \sigma_\mu^2)\end{aligned}\tag{30}$$

The logarithm of the gross world interest rate is driven by an innovation term which is in part idiosyncratic, represented by η_t^R and in part correlated with the innovation term to total factor productivity, η_t^A , given by the correlation parameter ρ_{RA} . We follow Mendoza (2010) in assuming a negative correlation between real world interest rate and productivity shocks for a small open economy. Finally, for the risk premium, we assume that it is exogenous, and unrelated to domestic shocks.

Mendoza (2010) also specifies a stochastic process for the relative price of imported goods. We do not take this approach here in order to limit the size of the model (for computational reasons) and because it is not clear that shocks to intermediate goods prices have played a significant role in the Euro Area crisis or in Hong Kong during the Asian financial crisis. Thus, in our specification, this price grows at the constant annual inflation rate of two percent.

2.7 General Equilibrium under Collateral Constraints

The competitive equilibrium is defined by the sequence $\{c_t, L_t, k_{t+1}, b_{t+1}, v_r, i_t\}_0^\infty$ and prices $\{q_t, w_t\}_0^\infty$

such that the representative household maximizes the intertemporal stationary cardinal utility function, given by 1, subject to constraints 5, 7, and 6, taking as given the price vector $\{w_t, q_t, R_t\}$ and the initial conditions $\{k_0, b_0\}$. In the case of DNWR the first order condition for labor (14) is replaced by the wage-setting condition (26).

Wages and the price of capital must satisfy the following conditions:

$$w_t = \frac{\partial N(\bar{L}_t)}{\partial \bar{L}_t} \quad (31)$$

$$= \left(\psi_w(s) \left(\frac{w_{t-1}}{1+\pi} \right)^{1-\theta_w} + (1-\psi_w(s)) \left(\frac{\theta_w}{\theta_w-1} \frac{w_t^{num}}{w_t^{den}} \right)^{1-\theta_w} \right)^{\frac{1}{1-\theta_w}}$$

$$q_t = \frac{\partial i(\bar{k}_{t+1}, \bar{k}_t)}{\partial \bar{k}_{t+1}} \quad (32)$$

$$\bar{L}_t = L_t \quad (33)$$

$$\bar{k}_t = k_t \quad (34)$$

When the collateral constraint binds, ($\mu_t > 0$), a wedge, in the form of an external financing premium on debt, emerges (19). There is also an external financing premium on working capital

3. Calibration and Solution Method

3.1 Parameter Values

The period of the model is annual. The parameters we use in our analysis follow closely those used in Mendoza (2010) and appear in Table 1⁵. The additional parameters, beyond those specified by Mendoza, are for the Calvo wage setting and the liquidity facility equations. The intratemporal elasticity of substitution θ_w is usually set at 6. The Calvo coefficient (which measure the percentage of wage setters who are unable to change their wages when wages are falling) is set 0.6 on the basis of estimates reported in Fagan (2013). These parameters generate a deterministic steady state debt/gdp ratio of 86 percent. We also set the annual world inflation rate 2% for the Calvo wage-setting equation. The target or funding facility parameter Φ is set to 0.13. This is based on panel data estimates obtained from a regression of such flows on interest-rate spreads in the Euro Area. Finally, for the risk premium, these estimates are the median values obtained by Lim and McNelis

⁵ See Mendoza (2010), pp. 1951-53 for a fuller discussion of the parameter selections for this model.

(2012).

3.2 Model Solution Method

Solving models with sudden stops is challenging since these models contain important non-linear processes due to borrowing constraints. The current model incorporates the additional non-linearity, in the form of downward nominal wage rigidity. Solution algorithms based on local approximations (perturbation methods) such as log-linearization or quadratic approximation around the deterministic steady state) are not suitable in our case. This is because our primary interest is in what happens when the binding borrowing constraint becomes binding. Such points in the state space are typically far away from the deterministic steady state or even the stochastic mean since the constraint binds only occasionally.

We therefore use a global solution technique within a class of global nonlinear methods which takes into account nonlinearities, in the form of zero lower bounds on the interest rate, asymmetries in the DNWR version of the Calvo model, as well as the occasionally binding collateral constraints. This paper uses the extended path method originally developed by Fair and Taylor (1983).

4. Results with Collateral Constraints

We illustrate our model's implications regarding the effects of a monetary union credit facility using a number of different approaches. We take 100000 annual observations generated by our stochastic simulations and, emulating the empirical literature on sudden stops, identify particular sudden stop episodes. Following the definition provided by Calvo et al. (2004a) we specify in that the sudden stop be characterized by a large and unexpected reversal of capital flows and be associated with a contraction in output. We identify a sudden stop episode with two restrictions. First, the change in the net exports to GDP ratio is at least two standard deviations above its mean for at least one year during the episode. Secondly, output is at least one standard deviation below its stochastic mean during the episode.

The results of this exercise are presented in Figure 3. We capture the event dynamics by taking the median values for these episodes, with a normalization factor for each variable at unity one period prior to the sudden stop at time $t = 0$, with the exception of net exports which are normalized at zero.

The solid curves represent the effects of sudden stop with binding collateral constraints in the absence of a monetary union, and the broken curves show the adjustment in a monetary union, when the credit facility is available to members of the union.

We see that the effects on GDP, consumption, investment, Tobin's Q, and of course, the spread, are greatly mitigated. The net export/gdp ratio rises, but less quickly, and is always slightly lower than the net export/gdp ratio without the funding facility.

We varied the specification of the shock processes, with greater volatility in productivity in one set of experiments, greater volatility to world real interest rates in others, but the results were substantially the same.

5. Results: Contagion Effects

Bad news happens to countries, whether in the form of collateral constraints becoming binding, setting off a debt/deflation mechanism, or in the form of contagion effects, even if a country has a large positive net foreign asset position, as in the case of Hong Kong.

We show in this case, using the same event dynamics as above, the the availability of a large reserve fund, to sustain a credible currency board, greatly mitigates the adverse effects of negative shocks, similar to the way the credit facility funds in a monetary union mitigate the effects of the adverse shocks in a monetary union

Figure 4 pictures the adjustment with and without support of reserve financing (as the Hong Kong Monetary Authority provided at the time of the Asian crisis), when the economy is subject to contagion effects. Following the same methodology as above, in Figure 5, we show the process for GDP and the net export/GDP ratio. As before, the base period is $t=-1$. At the time of the crisis, GDP falls over two years, while the net export/GDP ratios start to rise, as a result of the collateral constraint becoming binding, or the contagion effect. The patterns are similar for GDP, but we see that net exports rise faster in the case of the contagion effects.

We see a similar adjustment, even though there is no binding collateral constraint, endogenously triggered by the fall in Tobin's Q . Instead the rise in the spread in Figure 4 is exogenously imposed through regional contagion effects.

We see that the drop in GDP, consumption, investment, Tobin's Q are greatly mitigated, as is, of course, the rise in the spread, with the provision of the credit flows. Unlike the case of the monetary union, where the credit flows are automatic, this credit flows in the currency board arrangement come from a deliberate, discrete policy choice. But the effects are the same as the effects of the endogenous credit facility in the monetary union.

6. Conclusion

This paper compares the adjustment following a sudden stop of two types of countries operating with a fixed exchange rate: a monetary union with an integrated monetary policy and financing system and a pure peg without such a system. We also compared the adjustment of an economy subject to exogenously imposed contagion effects with that of an economy subject to a borrowing constraint triggered by asset-price deflation. We show that a Hong Kong style arrangement with the availability

of large reserves, helps cushion the adverse effects of the contagion effect, much the same way as the monetary union cushions the effects when collateral constraints become binding.

The availability of financing in a monetary union greatly mitigates the adverse effects of a sudden-stop episode on GDP, consumption, and, particularly, investment.

Much of the open-economy macro research has focused on the fixed vs. flexible exchange-rate regime choice. This paper draws attention to the monetary union as an important third option, and highlights the similarities between sudden stop adjustment with collateral constraints and adjustment due to contagion effects, under a monetary union and currency board.

The example of the Hong Kong Monetary Authority intervention, of course, is not the only one case when a monetary authority, with large reserves, was able to ameliorate the rise in borrowing costs due to an external negative shock. Since Hong Kong operated under a currency board, the intervention was in equity markets, and for that reason can be followed in a literal manner. However, it represents the use of a non-traditional monetary policy at a time of crisis. Another example from East Asia would be the use of foreign currency reserves by the Bank of Korea to provide liquidity to the banking sector in 2008-2009, which was later supplemented by U.S. dollar swaps by the Federal Reserve System. However, unlike the Eastern European countries, Korea operates on a flexible exchange rate system with inflation targeting. This example, like the Hong Kong one, is not meant to be literally interpreted. Both the Hong Kong and Korean central bank interventions represent important lessons, *mutatis mutandis*, for the transition economies of Eastern Europe on the verge of entering the Euro zone.

More to the point, the East Asian interventions offer important lessons for the benefits of a credible monetary union. Sudden stops can take their toll even on economies which are not highly indebted, and where collateral constraints are not binding, as Hong Kong shows. This paper argues that the transition economies of Eastern Europe fixed to the Euro, Bosnia and Herzegovina, Bulgaria, Latvia and Lithuania, can reap the benefits of the wider union credit facilities, much as Hong Kong reaped the benefits of the currency board and ample reserves during the Asian crisis, and later, Korea accrued the benefits of an ample stock of reserves during the more recent crisis of 2008.

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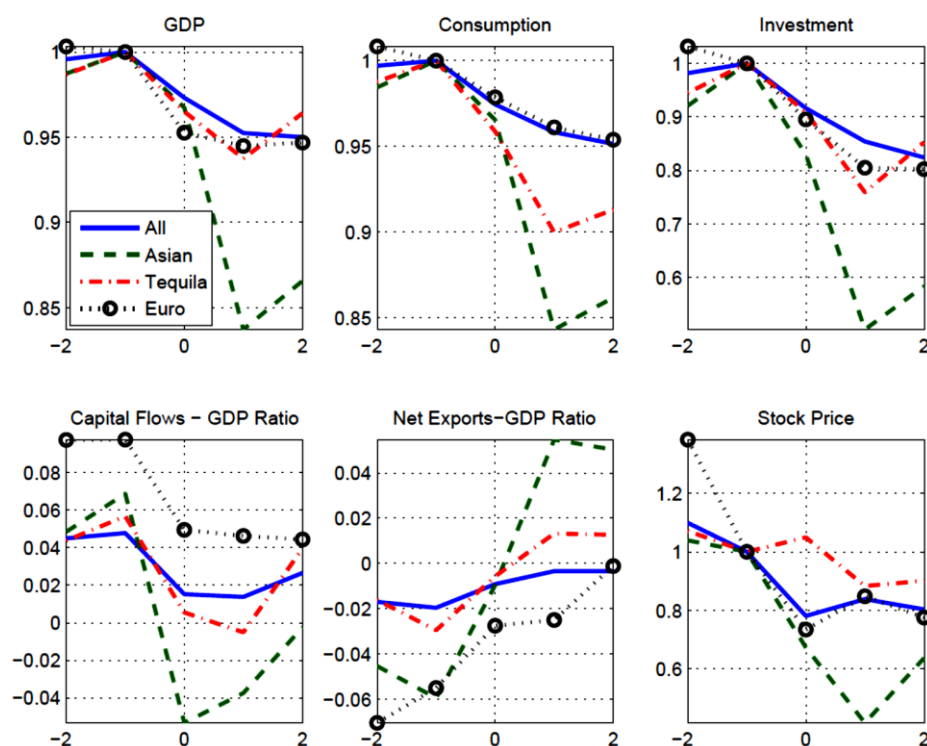
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Table 1. Parameters

Utility		
	σ_c	2.0
	ω	1.846
	γ	0.16
Production		
	α	0.592
	β	0.305
	η	0.102
	A	7.389
Investment		
	δ	0.088
	a	2.750
Borrowing constraint and Govt.		
	κ	0.225
	ϕ	0.258
	tc	0.168
	tc	0.168
Wage Setting		
	ψ_w	0.60
	θ_w	6.0
Stochastic Processes		
	ρ_A	0.57
	ρ_R	0.57
	ρ_{RA}	-0.98
	ρ_μ	0.5
	σ_A	0.011
	σ_R	0.012
	σ_μ	0.038
TARGET system		
	Φ	0.13

Figure 1. Macro Dynamics with Sudden Stops (Annual)



Source: IMF Balance of Payments Statistics, World Development Indicators, AMECO, Bloomberg. The year in which the sudden stop starts is denoted 0. All series except net trade and capital flows are deviations from a Hodrick-Prescott filter indexed to 1 for $t=-1$.

Figure 2. Hong Kong Macroeconomic Indicators

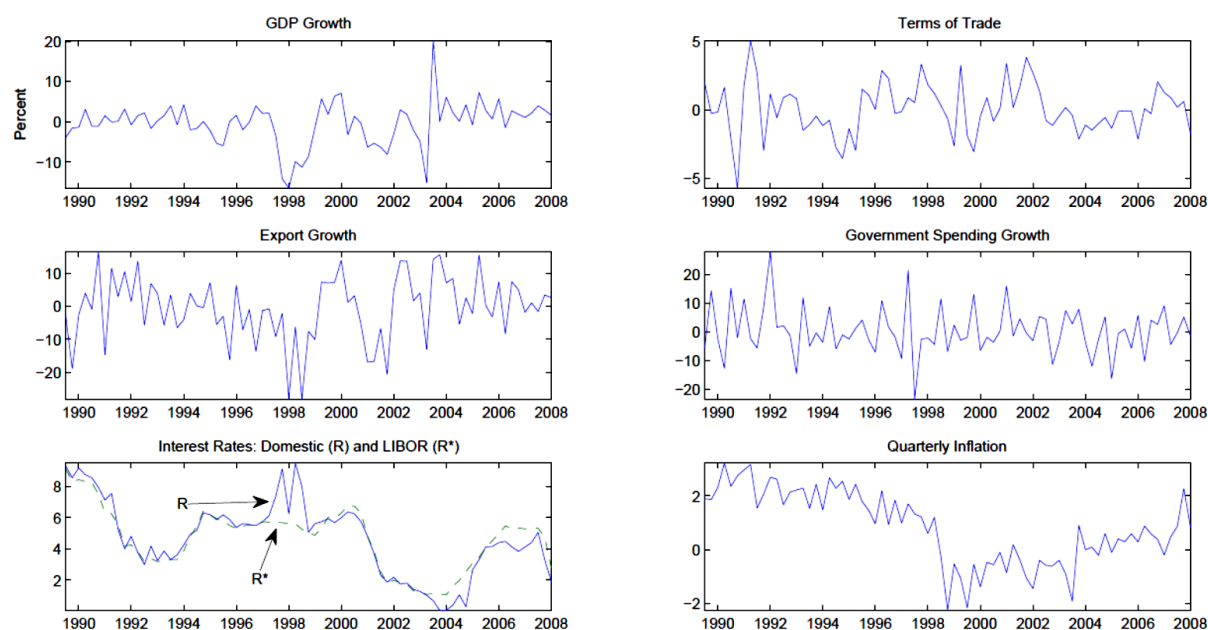


Figure 3. Adjustment to a Sudden Stop with Binding Collateral Constraints

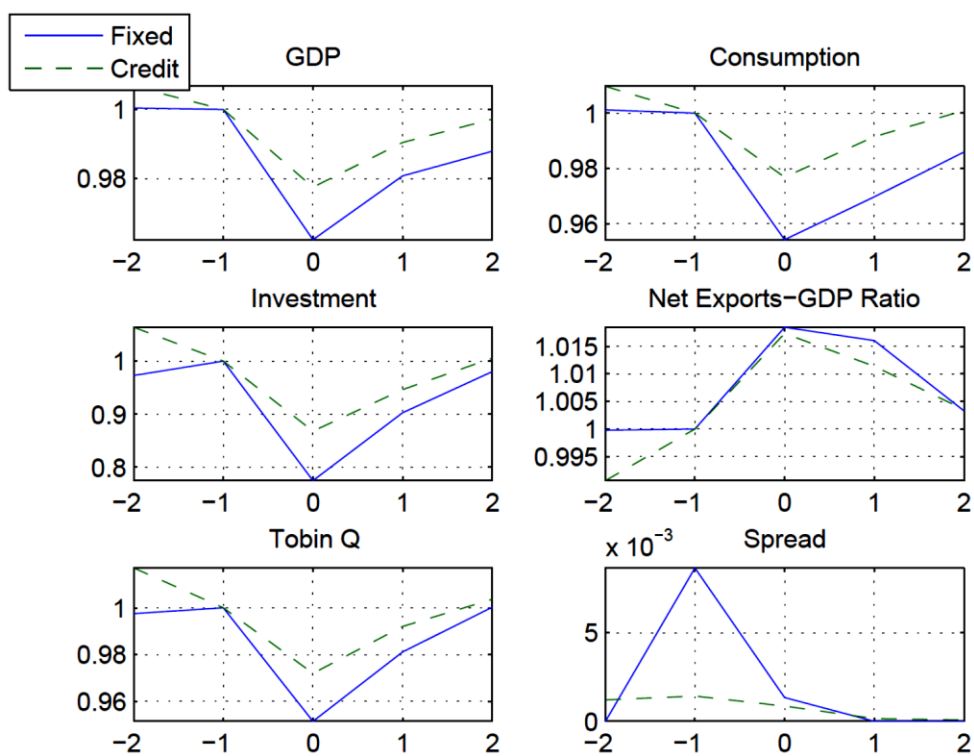


Figure 4. Adjustment to Sudden Stops with Contagion Effects

