A Model of the Twin Ds:

Optimal Default and Devaluation

by

S.Na S.Schmitt-Grohé M.Uribe V.Yue

December 14, 2015

Motivation (I)

• There is a strong empirical link between sovereign default and large devaluations.

Reinhart (2002) examines data for 58 countries over the period 1970 to 1999 and finds that:

— The unconditional probability of a large devaluation in any 24-month period is 17%.

— The probability of a large devaluation conditional on the 24-month period containing a default is 84%.

Reinhart refers to this phenomenon as the **Twin Ds.**

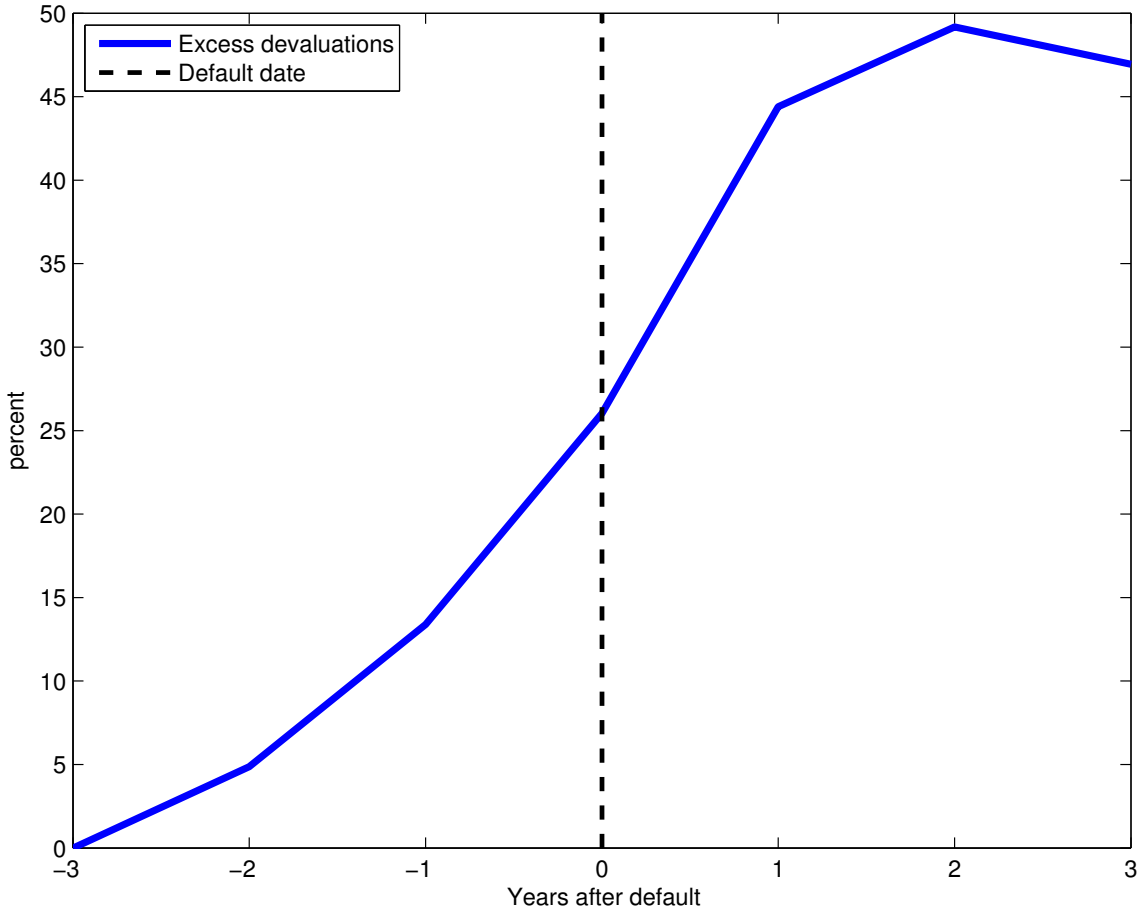
Motivation (II)

• We extend the Twin Ds fact dynamically and find that devaluation around default resembles a step function. That is, is more akin to a change in the *level* of the nominal exchange rate than to a switch to a higher *rate* of depreciation.

— This fact suggests that typically devaluations around default are a one-time event phenomenon and do not mark a switch to a regime of more future devaluations as in first-generation models of BOP crises.

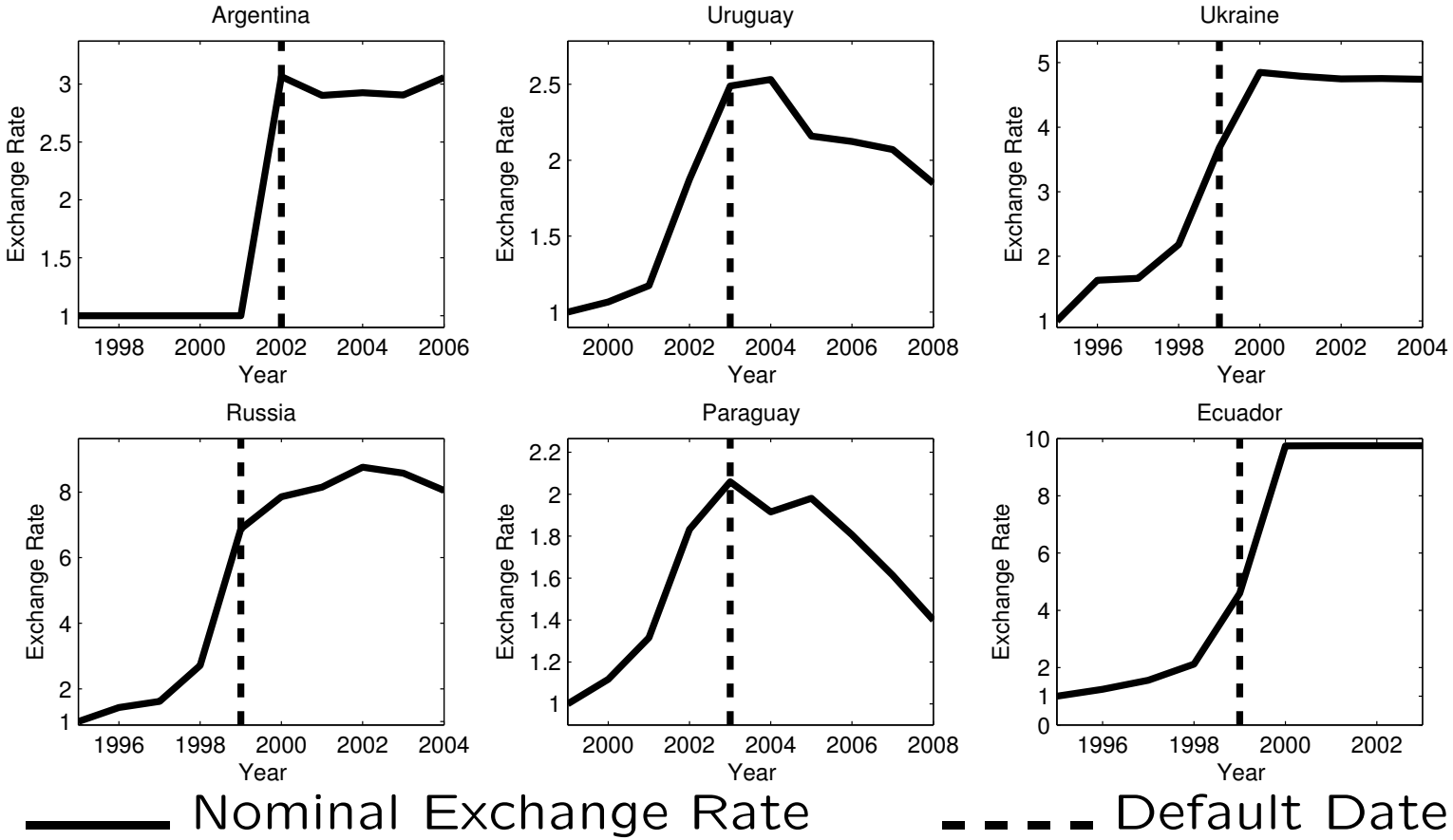
— The fact that virtually of of public debt in the panel is either dollarized or indexed (original sin), suggests that the observed one-time devaluations around default do not aim at inflating away the debt burden.

Excess Devaluation, Evidence from 116 Default Episodes



Median of cumulative devaluations conditional on default in year 0 minus unconditional median. Sample contains 116 default episodes between 1975 and 2013 in 70 countries. Data sources: Default dates, Uribe and Schmitt-Grohé (2015). Exchange rates, WDI.

The Twin Ds: Six Recent Examples



Note: Exchange rates are nominal dollar exchange rates, annual average, first observation normalized to unity. Data sources: Default dates, Uribe and Schmitt-Grohé (2015). Exchange rates, WDI.

This Paper

• Develops a model that explains the Twin Ds phenomenon as an optimal policy outcome, aimed at correcting relative-price misalignments.

• Intuition

– Under the optimal policy, default occurs during large recessions.

– A contracting demand for labor puts downward pressure on real wages.

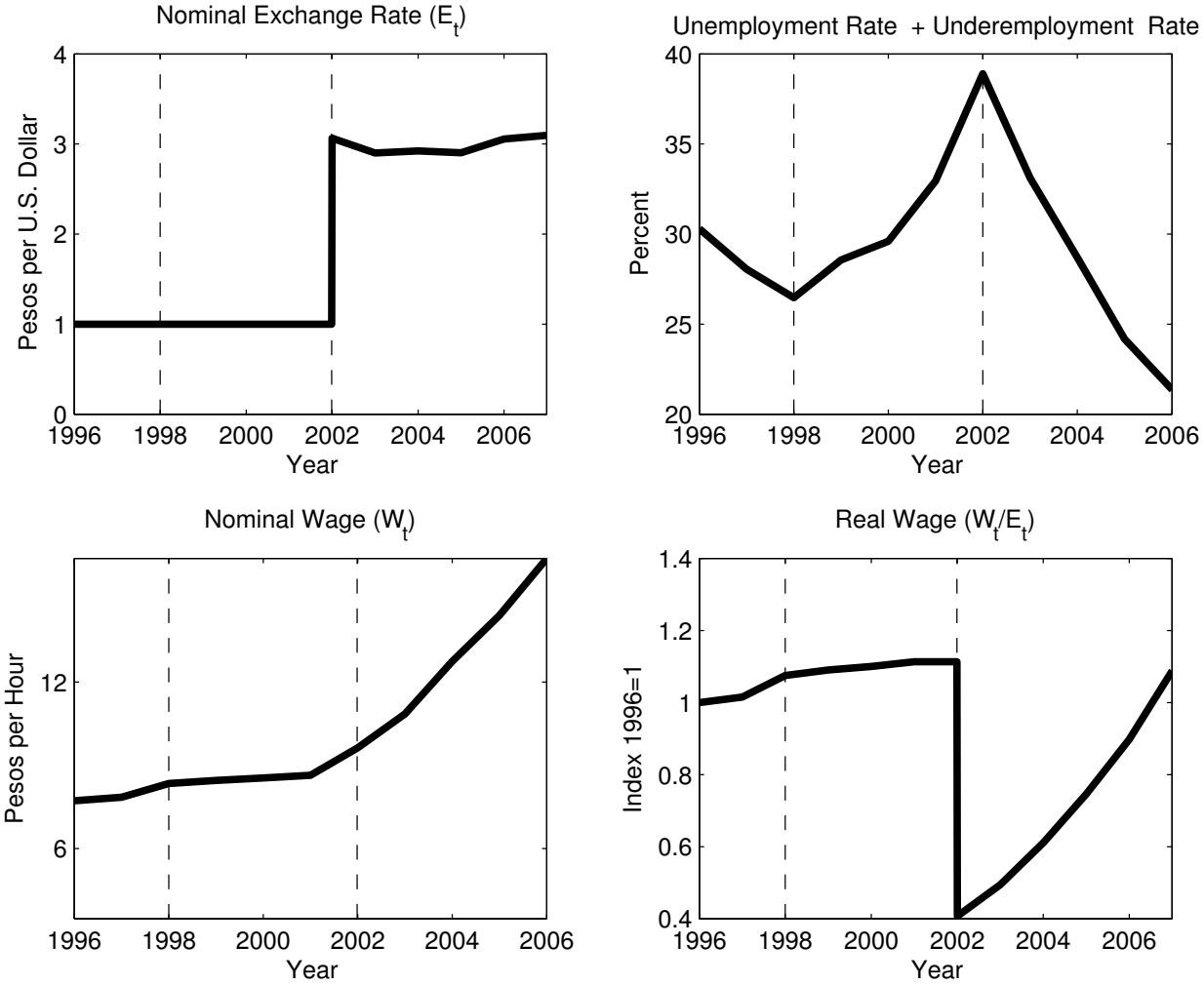
– A large devaluation reduces the real value of wages, thereby preventing unemployment.

• **Main Elements of the Model**

– Imperfect enforcement of debt contracts.

– Downward nominal wage rigidity.

Argentina 1996-2006



Vertical Line 1998, beginning of recession.

Vertical Line 2002, default and devaluation.

The Model

Households choose c_t^T, c_t^N, d_{t+1} to maximize

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

subject to

$$c_t = A(c_t^T, c_t^N),$$

$$P_t^T c_t^T + P_t^N c_t^N + \mathcal{E}_t d_t = P_t^T \tilde{y}_t^T + W_t h_t + \mathcal{E}_t (1 - \tau_t^d) q_t d_{t+1} + \mathcal{E}_t \phi_t + \mathcal{E}_t f_t,$$

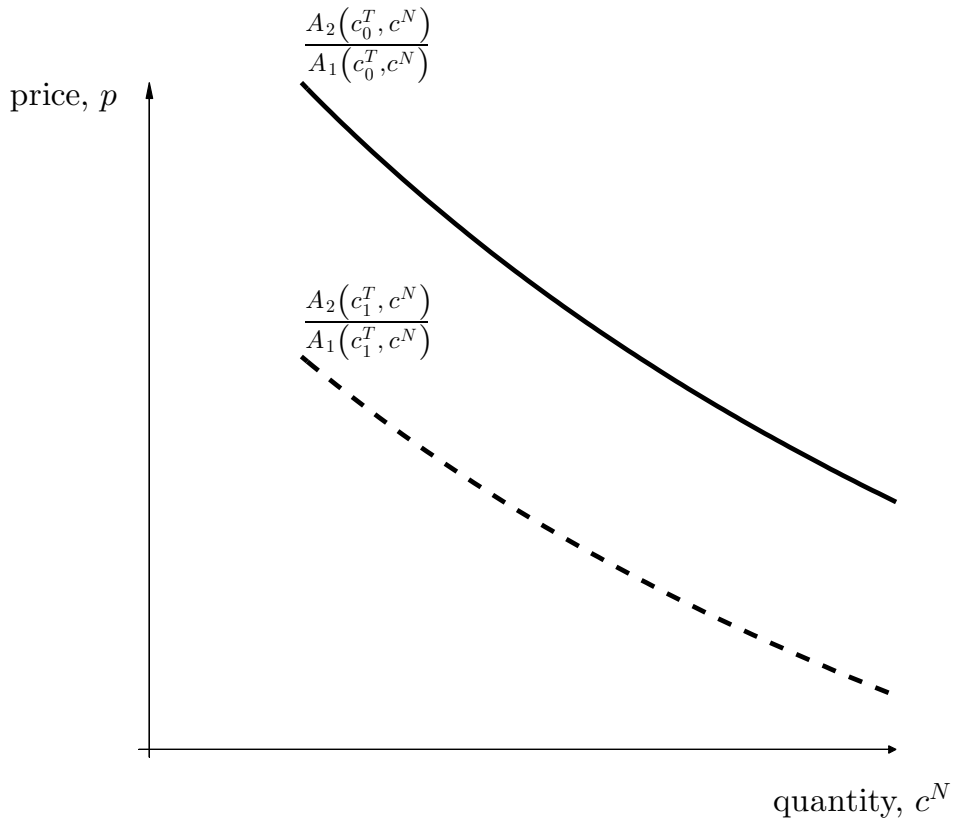
$$h_t \leq \bar{h}.$$

Households take h_t as given.
Debt is denominated in foreign currency (original sin).
The Demand for Nontradables

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

where $p_t \equiv P_t^N / \mathcal{E}_t$ is the relative price of nontradables in terms of tradables (the foreign price of tradables is normalized to 1).

The Demand For Nontradables



$$c_1^T < c_0^T$$

A Contraction in Traded Absorption, $\mathbf{c_t^T \downarrow}$, Shifts the Demand for Nontradables Down and to the Left

Firms

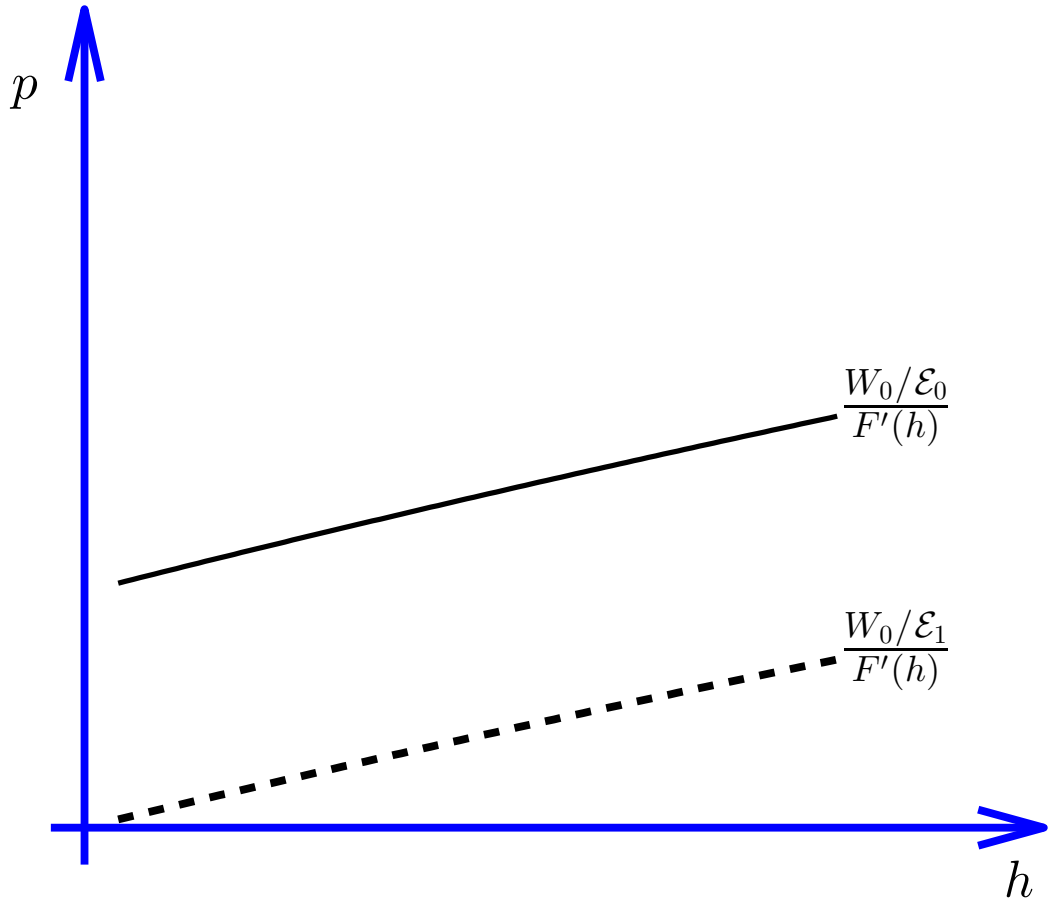
Choose h_t to

$$\max\left\{P_t^N F(h_t) - W_t h_t\right\}$$

The Supply of Nontradables

$$p_t = \frac{W_t/\mathcal{E}_t}{F'(ht)}$$

The Supply of Nontradabels



$(\mathcal{E}_1 > \mathcal{E}_0)$

A Devaluation ($\mathcal{E}_t \uparrow$) Shifts The Supply Schedule Down

Nominal Wages are Downwardly Rigid

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

$W_t =$ nominal wage in period t.

$\gamma =$ degree of downward wage rigidity.

$\gamma = 0 \Rightarrow$ fully flexible wages.

Think of γ as being around 1. Schmitt-Grohé and Uribe (2013) estimate $\gamma = 0.99$ at quarterly frequency.

Closing of the Labor Market

The following slackness condition is assumed to hold at all times:

$$(\bar{h} - h_t)\,(W_t - \gamma W_{t-1}) = 0.$$

Express in real terms

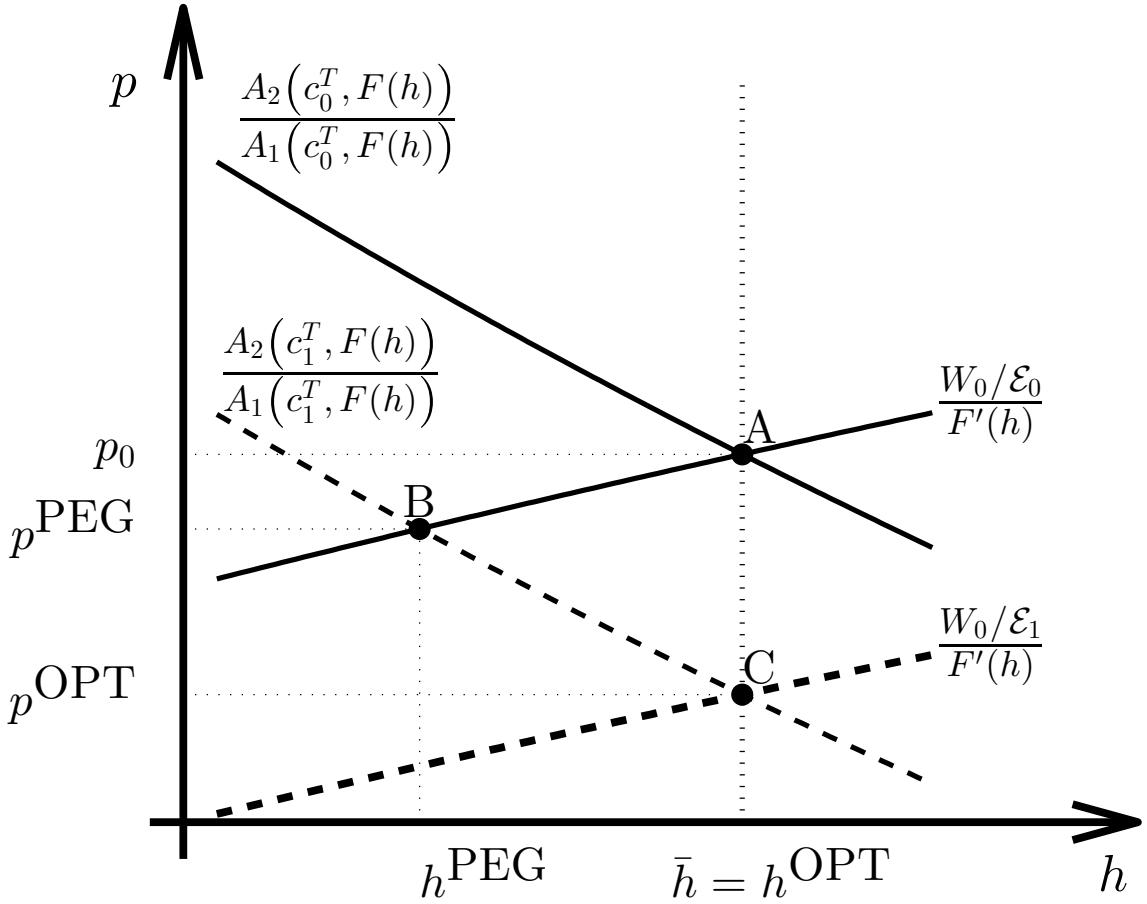
$$(\bar{h} - h_t)\left(w_t - \gamma \frac{w_{t-1}}{\epsilon_t}\right) = 0,$$

where

$w_t \equiv \frac{W_t}{\mathcal{E}_t}$ = real wage in units of tradables.

$\epsilon_t \equiv \frac{\mathcal{E}_t}{\mathcal{E}_{t-1}}$ =the gross devaluation rate in period t

Optimal Exchange-Rate Policy



$c_1^T < c_0^T$ (negative endowment shock, $y_t^T \downarrow$)

$\mathcal{E}_1 > \mathcal{E}_0$ (optimal devaluation)

The Government

• Each period t, the government can be either in good financial standing or in bad financial standing.

• If the government is in good financial standing, it can choose to either honor its debt (indicated by $I_t = 1$) or default. If it defaults, it immediately acquires bad financial standing (indicated by $I_t = 0$).

• If the government is in bad financial standing in t, then it regains good financial standing in $t+1$ with exogenous probability θ, and maintains bad standing with probability $1 - \theta$.

Two Exogenous Costs of Default

(1) Financial Exclusion: While the country is in bad financial standing ($I_t = 0$), it cannot participate in international credit markets,

$$(1 - I_t)d_{t+1} = 0.$$

(2) Output Loss: The endowment received by households is given by

$$\tilde{y}_t^T = \begin{cases} y_t^T & \text{if } I_t = 1 \text{ (good standing)} \\ y_t^T - L(y_t^T) & \text{if } I_t = 0 \text{ (bad standing)} \end{cases}$$

where y_t^T is an exogenous stochastic process, and $L(\cdot)$ is an increasing function.

Risk-Neutral Foreign Lenders

The price of debt, q_t, is given by

$$q_t = \frac{\text{Prob}\{I_{t+1} = 1 | I_t = 1\}}{1 + r^*}$$

where r^* is the risk-free interest rate.

Competitive Equilibrium

$$c_t^T = y_t^T - (1 - I_t)L(y_t^T) + I_t[q_t d_{t+1} - d_t]$$

$$(1 - I_t)d_{t+1} = 0$$

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

$$I_t \left[(1 - \tau_t^d)q_t\lambda_t - \beta\mathbb{E}_t\lambda_{t+1}\right] = 0$$

$$\frac{A_2(c_t^T, F(h_t))}{A_1(c_t^T, F(h_t))}F'(h_t) = w_t$$

$$w_t \geq \gamma\frac{w_{t-1}}{\epsilon_t}; \quad (h_t - \bar{h})\left(w_t - \gamma\frac{w_{t-1}}{\epsilon_t}\right) = 0; \quad \text{and } h_t \leq \bar{h}$$

$$I_t \left[q_t - \frac{\mathbb{E}_t I_{t+1}}{1+r^*}\right] = 0$$

given policies $\{I_t, \epsilon_t, \tau_t^d\}$.

Competitive equilibrium with unrestricted τ_t^d & ϵ_t

$$\boxed{c_t^T = y_t^T - (1 - I_t)L(y_t^T) + I_t[q_t d_{t+1} - d_t]}$$

$$\boxed{(1 - I_t)d_{t+1} = 0}$$

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

$$I_t \left[(1 - \tau_t^d)q_t\lambda_t - \beta\mathbb{E}_t\lambda_{t+1}\right] = 0$$

$$\frac{A_2(c_t^T, F(h_t))}{A_1(c_t^T, F(h_t))}F'(h_t) = w_t$$

$$w_t \geq \gamma\frac{w_{t-1}}{\epsilon_t}; \quad (h_t - \bar{h})\left(w_t - \gamma\frac{w_{t-1}}{\epsilon_t}\right) = 0; \quad \text{and } \boxed{h_t \leq \bar{h}}$$

$$\boxed{I_t \left[q_t - \frac{\mathbb{E}_t I_{t+1}}{1+r^*}\right] = 0}$$

given I_t. Policies $\{\epsilon_t, \tau_t^d\}$ picked to satisfy nonboxed conditions

Optimal Policy Problem

$$\max_{\{c_t^T, h_t, d_{t+1}, I_t, q_t\}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U(A(c_t^T, F(h_t))) \text{ s.t.}$$

$$\boxed{c_t^T = y_t^T - (1 - I_t)L(y_t^T) + I_t[q_t d_{t+1} - d_t]}$$

$$\boxed{(1 - I_t)d_{t+1} = 0}$$

$$\boxed{I_t \left[q_t - \frac{\mathbb{E}_t I_{t+1}}{1+r^*} \right] = 0}$$

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

- States are: y_t^T, d_t (note w_{t-1} is not relevant under optimal exchange-rate policy).
- Full employment is optimal ($h_t = \bar{h}$ for all t).
- After setting $h_t = \bar{h}$, **the above problem is exactly Arellano (2008).**

Summary of Analytical Results

Decentralization of the EG Model: Real models of sovereign default in the tradition of Eaton and Gersovitz (1981) can be interpreted as the centralized version of economies with default risk and downward nominal wage rigidity.

Implied Use of Policy Instruments: Default and devaluation policies are determined jointly, with the latter serving as a means to bring about the full-employment real wage.

Quantitative Analysis

Functional Forms and Calibration

$$U(c) = \frac{c^{1-\sigma} - 1}{1-\sigma}; \quad \sigma = 2$$

$$A(c^T, c^N) = \left[a(c^T)^{1-\frac{1}{\xi}} + (1-a)(c^N)^{1-\frac{1}{\xi}} \right]^{\frac{1}{1-\frac{1}{\xi}}}; \quad \xi = 1/2, a = 0.26$$

$$y_t^N = h_t^{\alpha}; \quad \alpha = 0.75$$

$$L(y_t^T) = \max\{0, \delta_1 y_t^T + \delta_2 (y_t^T)^2\}$$

- Set $\beta = 0.85$, $\delta_1 = -0.35$, and $\delta_2 = 0.44$ to ensure:

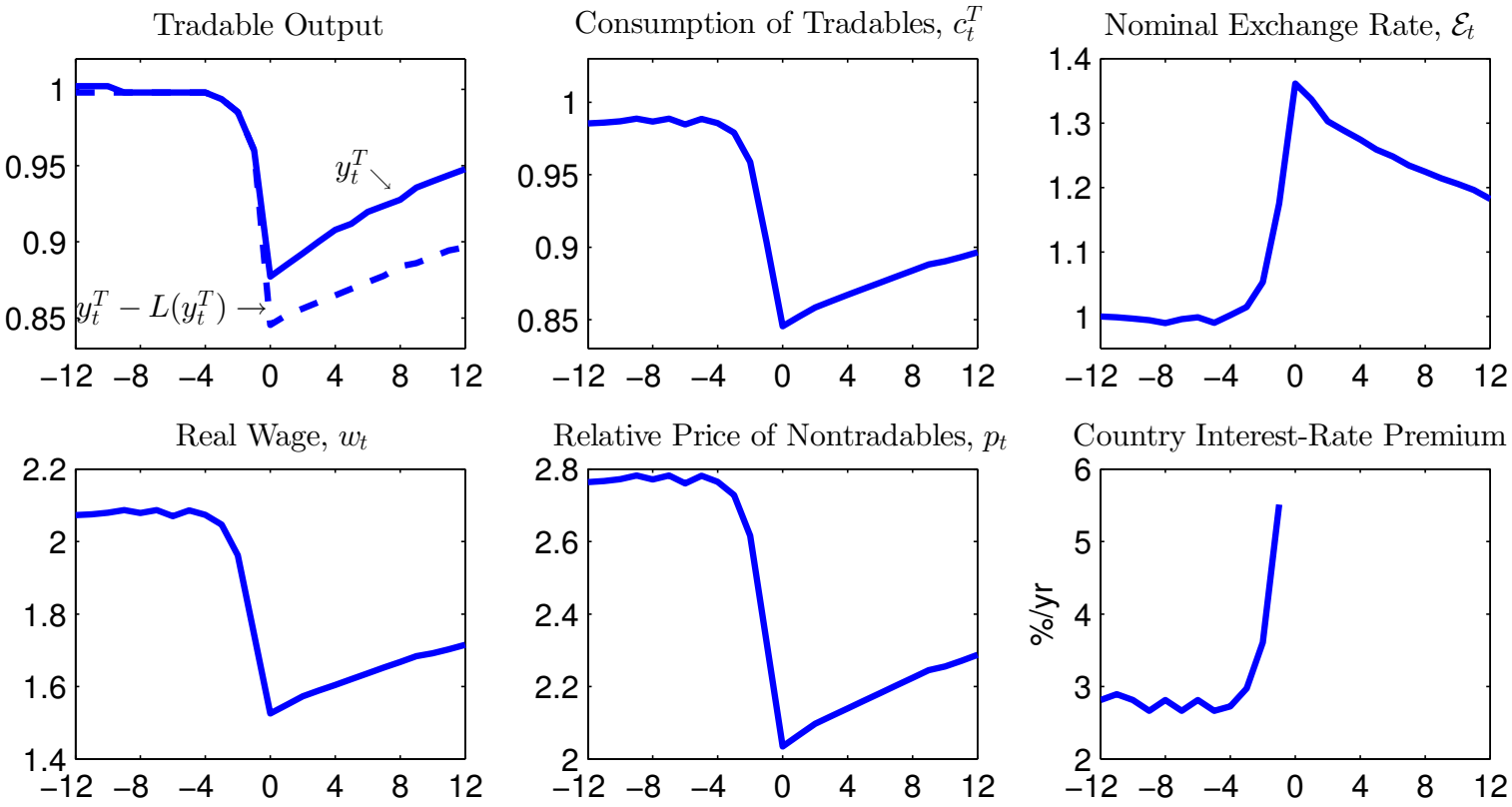
(a) $E(d_t/y_t^T) = 60\%$,

(b) Prob of default equal to 2.6 per century, and

(c) Average output loss in autarky of 7%.

- Set $\gamma = 0.99 \Rightarrow$ wages can fall by up to 4% per year.
- $y_t^T = 0.93 y_{t-1}^T + 0.037 \mu_t$, $\mu \sim N(0,1)$ (Argentina, 1983-2001)

A Typical Default Episode Under Optimal Policy



Observations On The Dynamics Around A Typical Default Episode Under Optimal Policy

• Default takes place after a short but sharp contraction in tradable output.

• Default coincides with end of contraction and beginning of recovery.

• Contrary to what the intertemporal approach to the BOP would suggest (but consistent with empirical evidence), the contraction of consumption of tradables is more severe than that of output, TB surplus. Reason: the interest rate premium doubles.

• In spite of the severe external crisis, the economy displays full employment at all times.

• Full employment is achieved through large devaluations, > 35 percent, **($\Rightarrow$Twin Ds)** that cause a large reduction in the real wage and a significant real depreciation.

• Real depreciation mainly due to increase in nominal price of tradables, as in actual data.

Optimal Default Under Currency Pegs

Suppose the central bank picks

$$\epsilon_t = 1 \quad \forall t$$

• This case is of interest because of the recent experience in the periphery of Europe where countries choose to stick to currency pegs through severe external crises involving large increases in country spreads and even sovereign defaults.

The Peg-Constrained Optimal Policy Problem:
Pick polices $\{I_t, \tau_t^d\}$ and all endogenous variables of the private-sector equilibrium to maximize

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U(A(c_t^T, F(h_t)))$$

subject to

$$\boxed{c_t^T = y_t^T - (1 - I_t)L(y_t^T) + I_t[q_t d_{t+1} - d_t]}$$

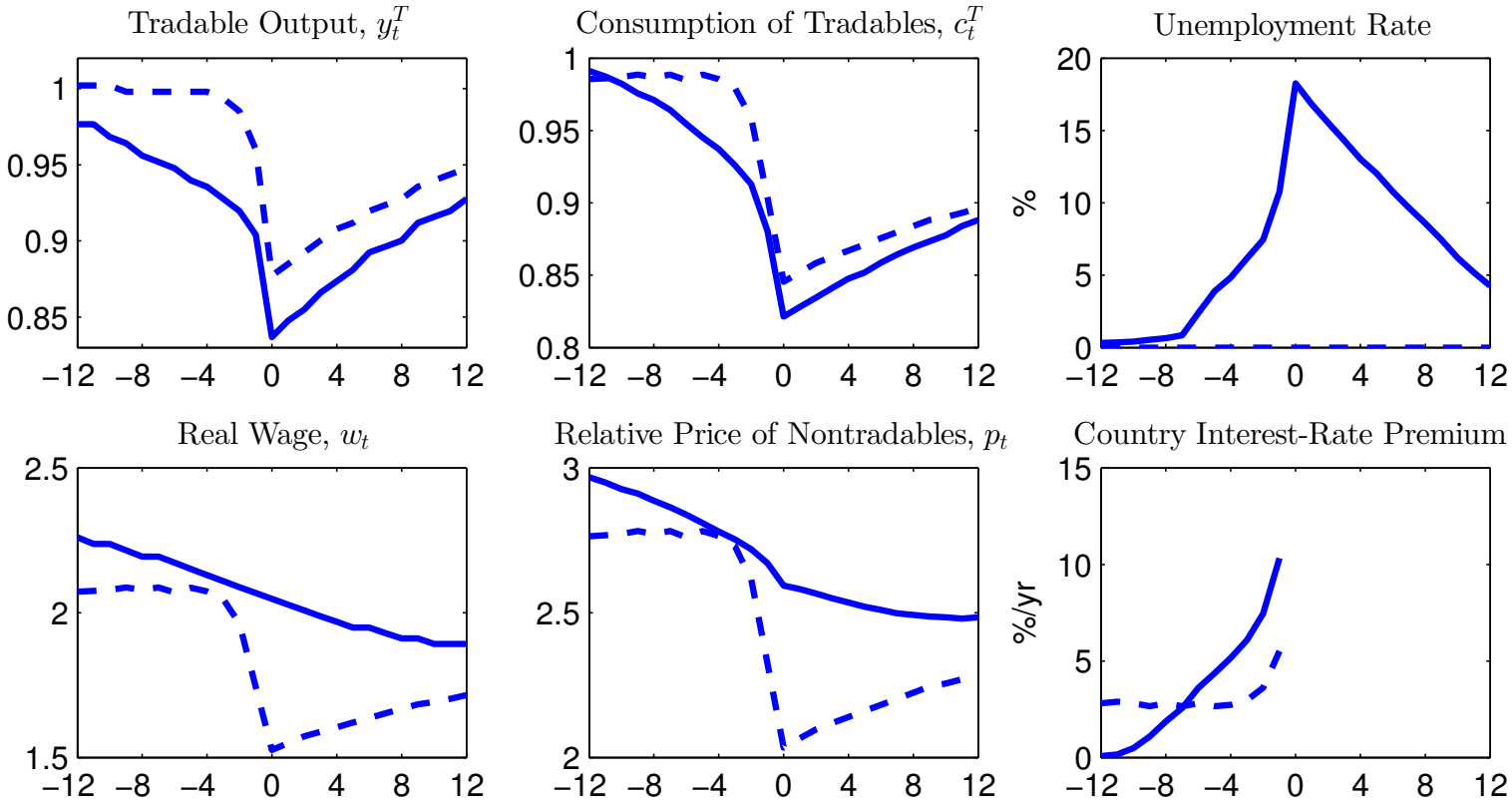
$$\boxed{(1 - I_t)d_{t+1} = 0}$$

$$\frac{A_2(c_t^T, F(h_t))}{A_1(c_t^T, F(h_t))} F'(h_t) = w_t; \quad w_t \geq \gamma w_{t-1}; \quad \boxed{h_t \leq \bar{h}}$$

$$\boxed{I_t \left[q_t - \frac{\mathbb{E}_t I_{t+1}}{1 + r^*} \right] = 0}$$

Note: (1) Impossible to get rid of wage-rigidity constraints (except for slackness); **(2)** States are now: y_t^T, d_t, w_{t-1}

Typical Default Episodes With Fixed Exchange Rates



Observations On Typical Defaults With Fixed Exchange Rates

- Default occurs after protracted contractions in tradable output.

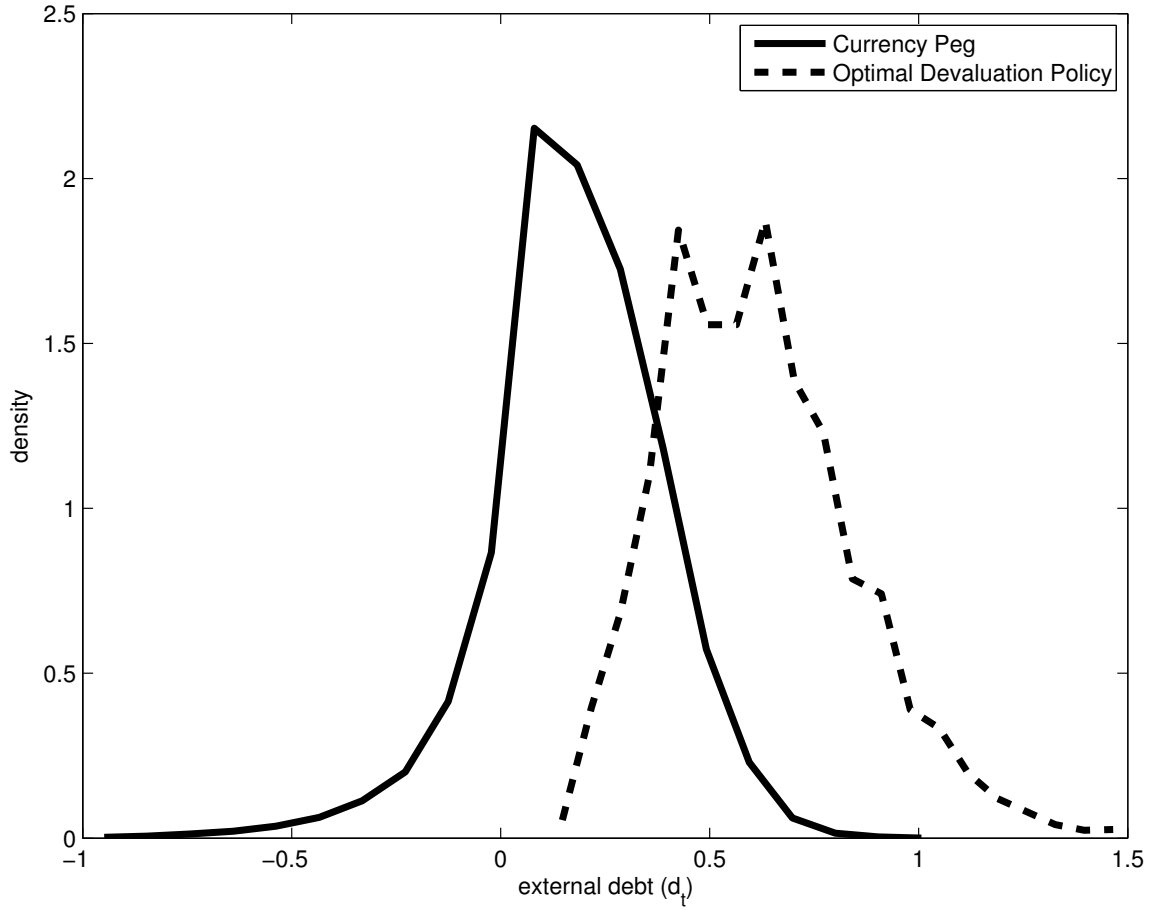
- Defaults occur in the context of massive involuntary unemployment (over 20%) and highly depressed levels of consumption.

- The lack of nominal depreciation causes the real wage to stay above the full employment real wage before, during, and after default.

- Firms do not lower prices because costs (wages) remain high, leading to much less real depreciation relative to optimal exchange rate policy.

Long-Run Debt Sustainability under a Currency Peg

Density Function of External Debt



Note. Debt distributions are conditional on being in good financial standing.

Observations on the figure

• In the long run, economies undergoing currency pegs can sustain less debt than economies with optimal floats (20 vs. 60 percent of tradable output, respectively).

• Reason: *Ex-ante*, stronger incentive to default under a peg, since default, by accelerating the recovery of consumption, helps reduce unemployment. Under optimal devaluation, this channel is not there, because the central bank guarantees full employment at all times, through appropriate movements in the nominal exchange rate.

• However, *ex-post*, the peg economy does not predict a higher default rate than the optimal float economy. The reason, is that the lower level of debt reduces incentives to default.

Conclusions

• Paper presents a model that predicts that under the optimal policy defaults are accompanied by large devaluations, that is, the model can explain the Twin Ds phenomenon.

• Under optimal policy, the central role of devaluations around default episodes is to fend off unemployment.

• In fixed-exchange rate economies defaults are predicted to be accompanied by massive unemployment.

• Fixed-exchange-rate economies are shown to support less debt in the long run than optimal float economies.

• Paper shows that real economies with default risk à la Eaton-Gersovitz can be interpreted as the centralized version of economies with default risk, downward nominal wage rigidity, optimal debt taxes, and optimal devaluation policy.