The Twin Ds

Optimal Default and Devaluation

by

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Motivation

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

Reinhart (2002) examines data from 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.**

New Evidence on the Twin Ds Phenomenon

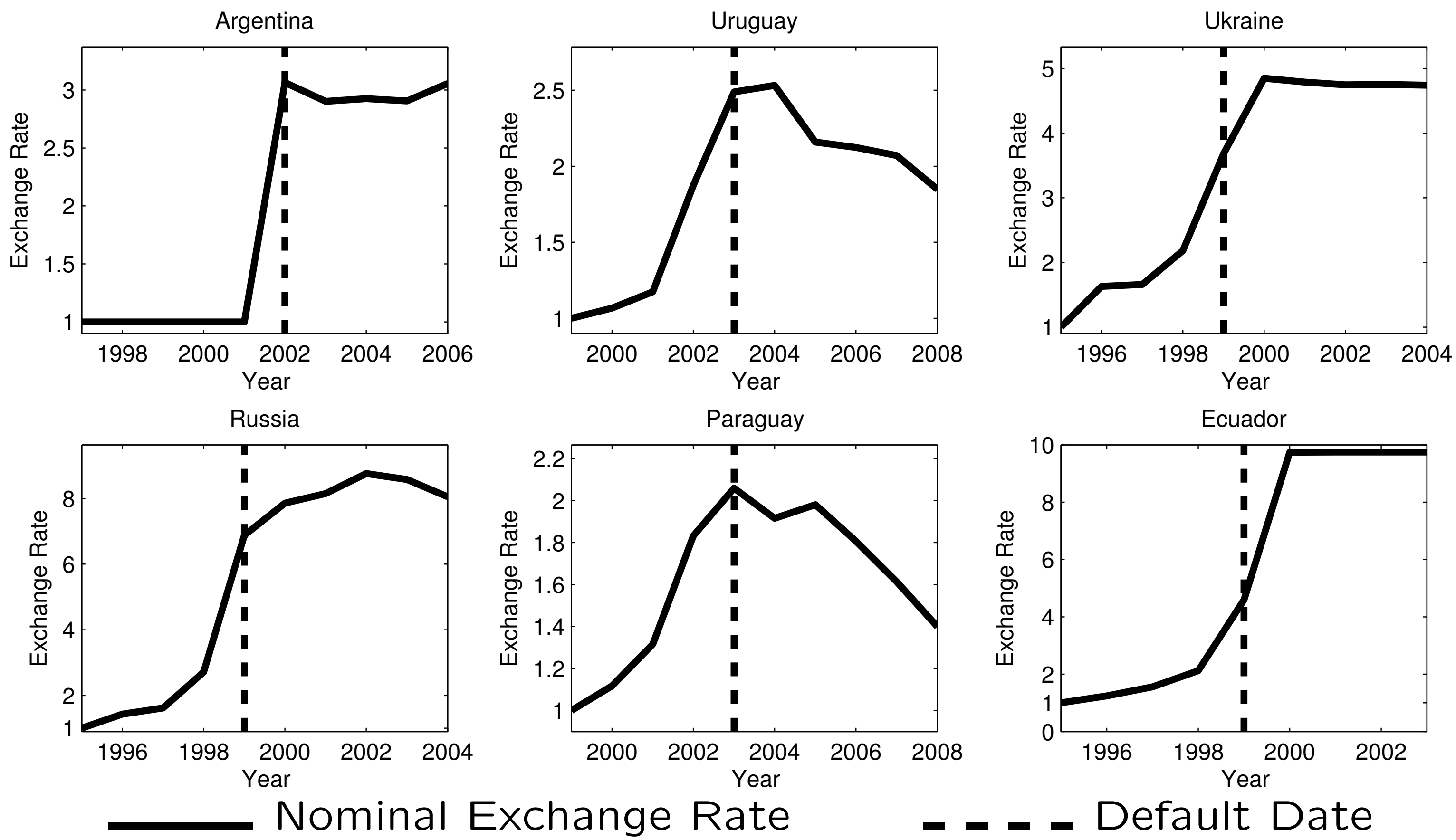
• Expand the Reinhart sample to 2013.

• Produce a dynamic picture of the Twin Ds phenomenon to show the behavior of the exchange rate not only in the year of default but also before and after default.

• Key Findings:
(1) The Twin Ds phenomenon continues to be present in the expanded dataset.

(2) The dynamic perspective shows that devaluations around default are more akin to a change in the *level* of the nominal exchange rate than to a switch to a higher *rate* of depreciation.

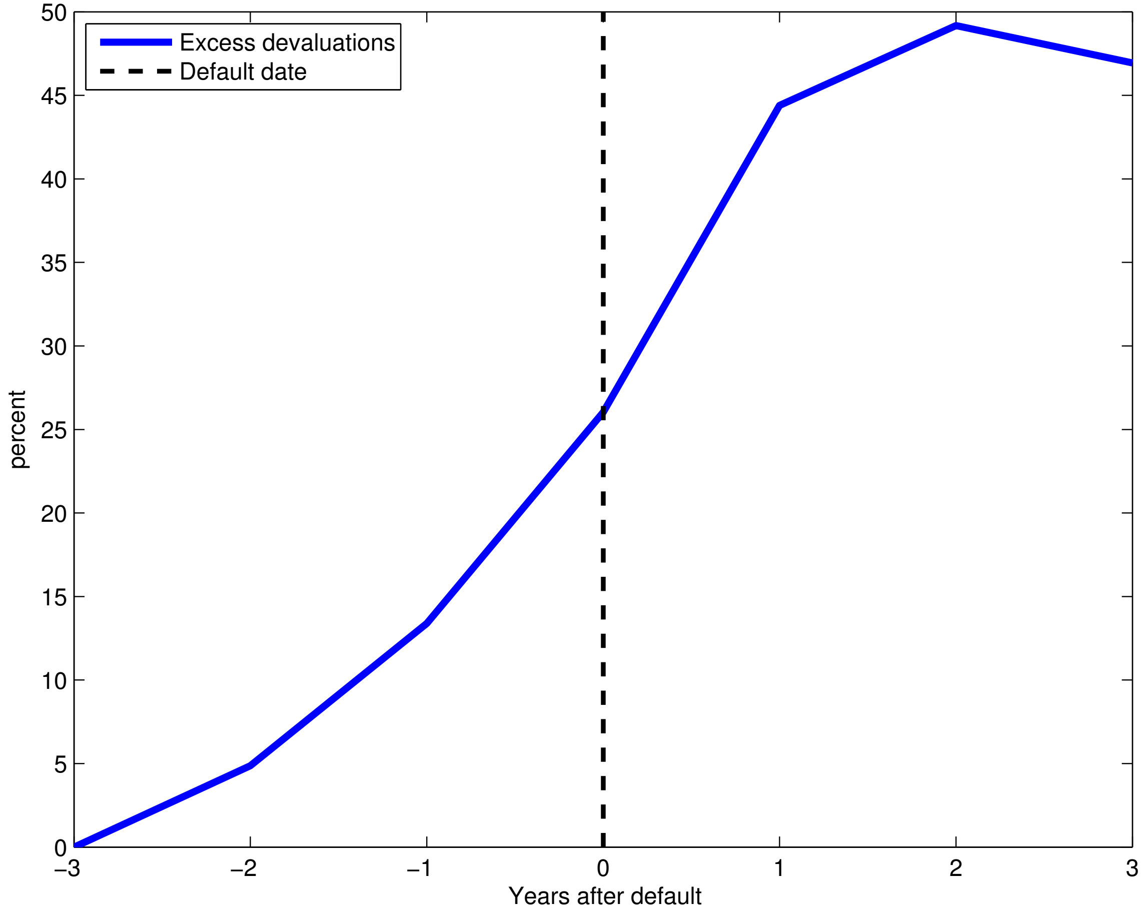
Six Recent Default Episodes



Notes. Exchange rates are nominal dollar exchange rates, annual average, first observation normalized to unity. Data sources: Default dates, Uribe and Schmitt-Grohé (2017, Chapter 13, Table 13.19). Exchange rates, World Development Indicators, (WDI).

Cumulative Excess Devaluation

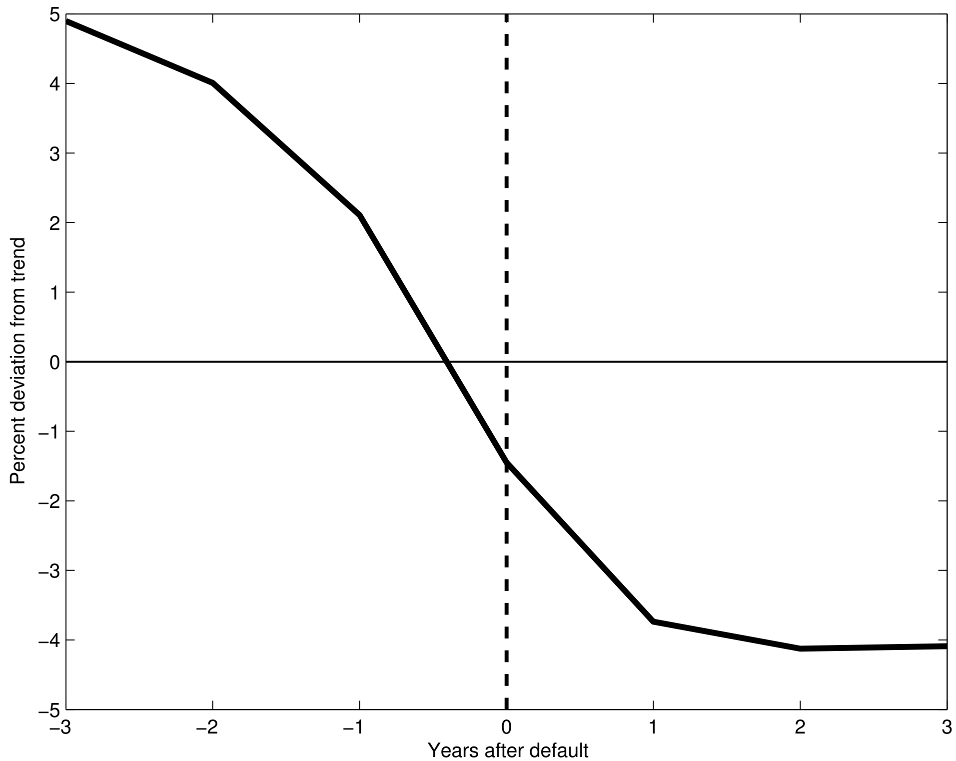
Evidence from 117 Default Episodes: 1975 - 2013



Notes. Median of cumulative devaluations conditional on default in year 0 minus unconditional median. Sample contains 117 default episodes between 1975 and 2013 in 70 countries. Data sources: see notes to previous figure.

Countries Default in Bad Times

Output Around Default Events



Notes. Annual log-quadratically detrended GDP. The year of default is normalized to 0. Median over 105 default episodes between 1975 and 2014.

This Paper

- **Develops a model with two key frictions:**

– Imperfect enforcement of debt contracts (Eaton and Gersovitz, RES 1981).

– Downward nominal wage rigidity (Schmitt-Grohé and Uribe, JPE 2016).

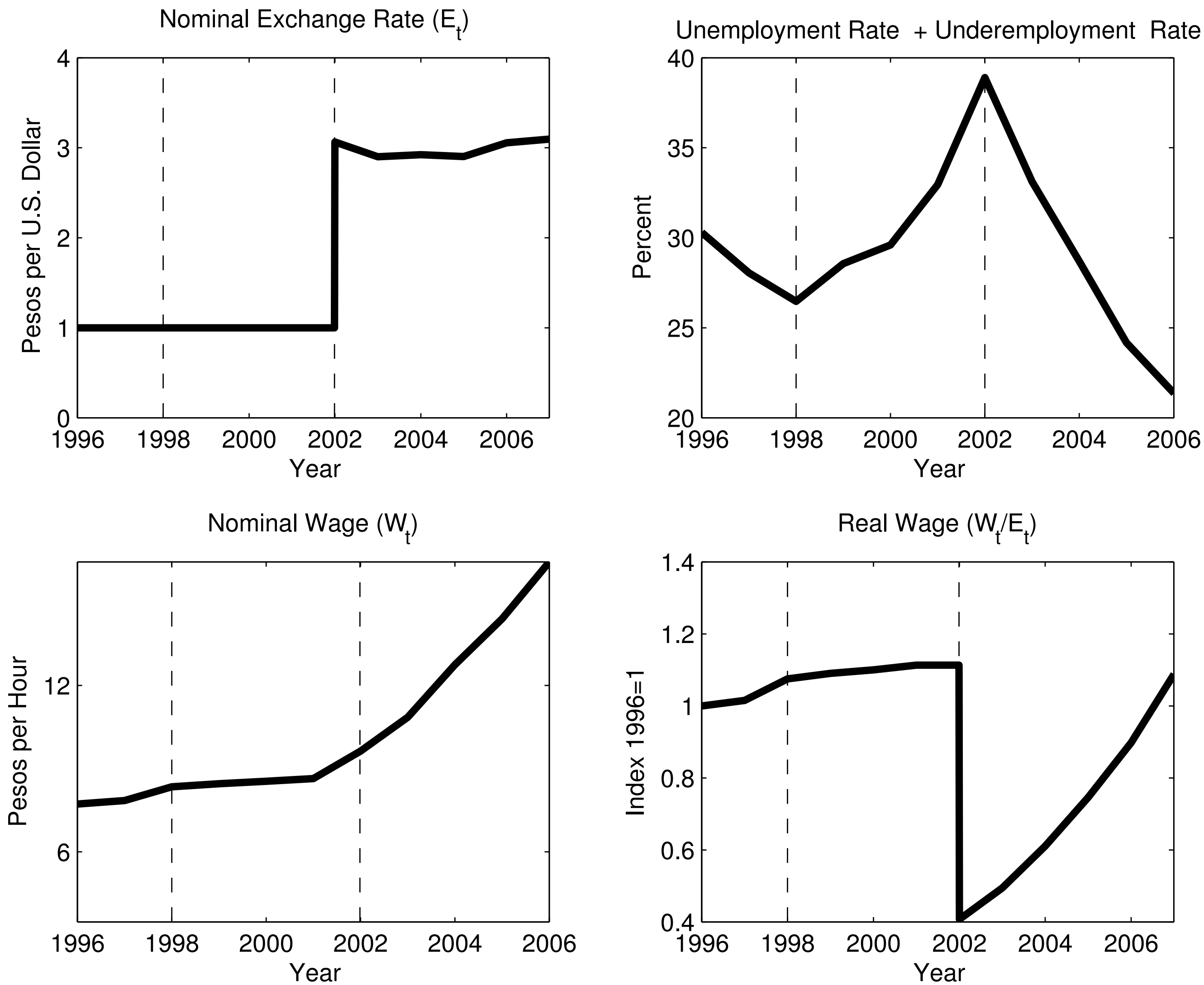
- **Intuition for Why Twin Ds are Optimal in the Present Model**

– In the present model, like in Eaton-Gersovitz-type models, default occurs in the context of highly depressed aggregate demand.

– Low demand puts downward pressure on real wages.

– A large devaluation reduces the real value of downwardly rigid nominal wages, thereby preventing potentially large involuntary unemployment.

Illustration of Narrative: Argentina 1996-2006



Vertical Line 1998, beginning of recession.
Vertical Line 2002, **default and devaluation.**

Related Literature

• Fiscal consequence of devaluations, flow effects: Balance of payment crisis literature. High devaluation rate as a way to create seignorage to finance fiscal deficits (ex: Krugman, 1979).

• Fiscal consequence of devaluations, stock effects: Devaluation as indirect default on stock of local currency denominated debt (ex: Calvo, 1988; Corsetti and Dedola, 2014; Aguiar et al., 2013; Da Rocha, Gimenéz, and Lores, 2013; Kriwoluzky, Müller, and Wolf, 2014; Moussa, 2013; Du and Schreger, 2015).

• Real models of default à la Eaton and Gersovitz. (ex: Arellano, 2008; Aguiar and Gopinath, 2006; Hatchondo, Martinez, and Sapriza, 2010; Kim and Zhang, 2012; Martinez and Sapriza, 2010; Chatterjee and Eyigungor, 2012; Mendoza and Yue, 2012.)

The Model

Households Choose c_t, 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

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

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

$$h_t \leq \bar{h} \text{ and } d_{t+1} \leq \bar{d}$$

where c_t=consumption; c_t^T, c_t^N=consumption of tradables,nontradables; d_t debt due in t; q_t= inverse of gross interest rate; $\tilde{y}_t^T$ exogenous and stochastic endowment of tradables; h_t= hours worked; P_t^T, P_t^N=nominal price of tradables, nontradables; $\mathcal{E}_t$= nominal exchange rate (domestic-currency price of foreign currency); W_t=nominal wage; τ_t^d= capital control tax; ϕ_t, f_t=profits and government transfer.

- Law of one price: $P_t^T = P_t^{T*} \mathcal{E}_t$, where $P_t^{T*} = 1$ = foreign price of tradables.
- Households take h_t as given.
- Debt is denominated in foreign currency (original sin).

The Demand for Nontradables

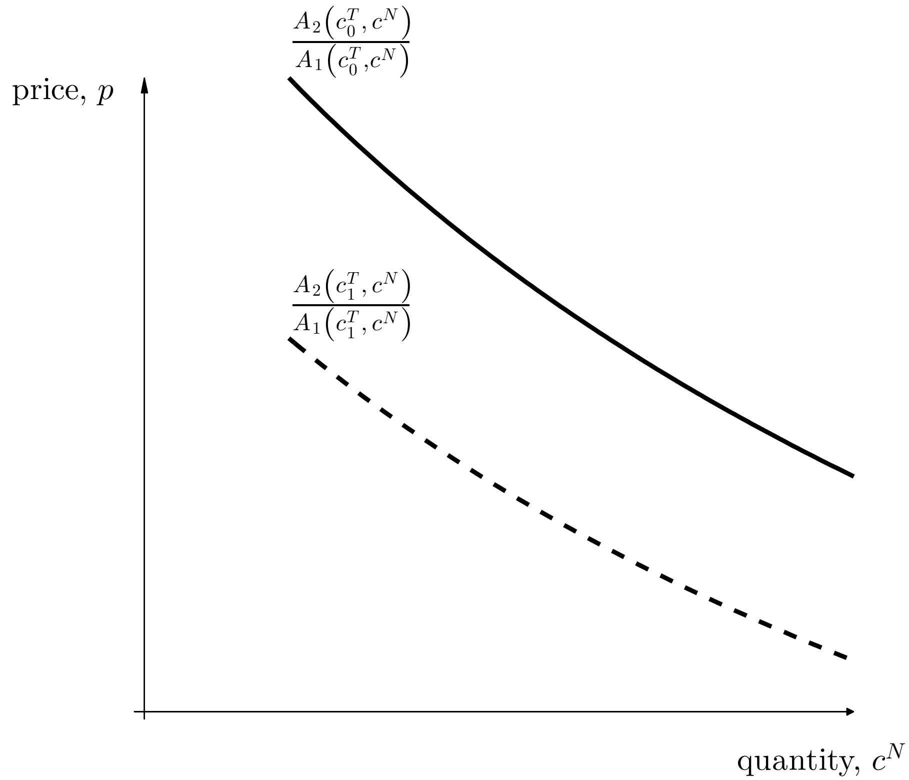
One first-order condition associated with the household's optimization problem is

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

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

This expression defines a demand for nontradables, c_t^N, as a decreasing function of the relative price p_t, holding constant the desired consumption of tradables, c_t^T.

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

Produce nontradables using labor. They choose h_t to maximize profits:

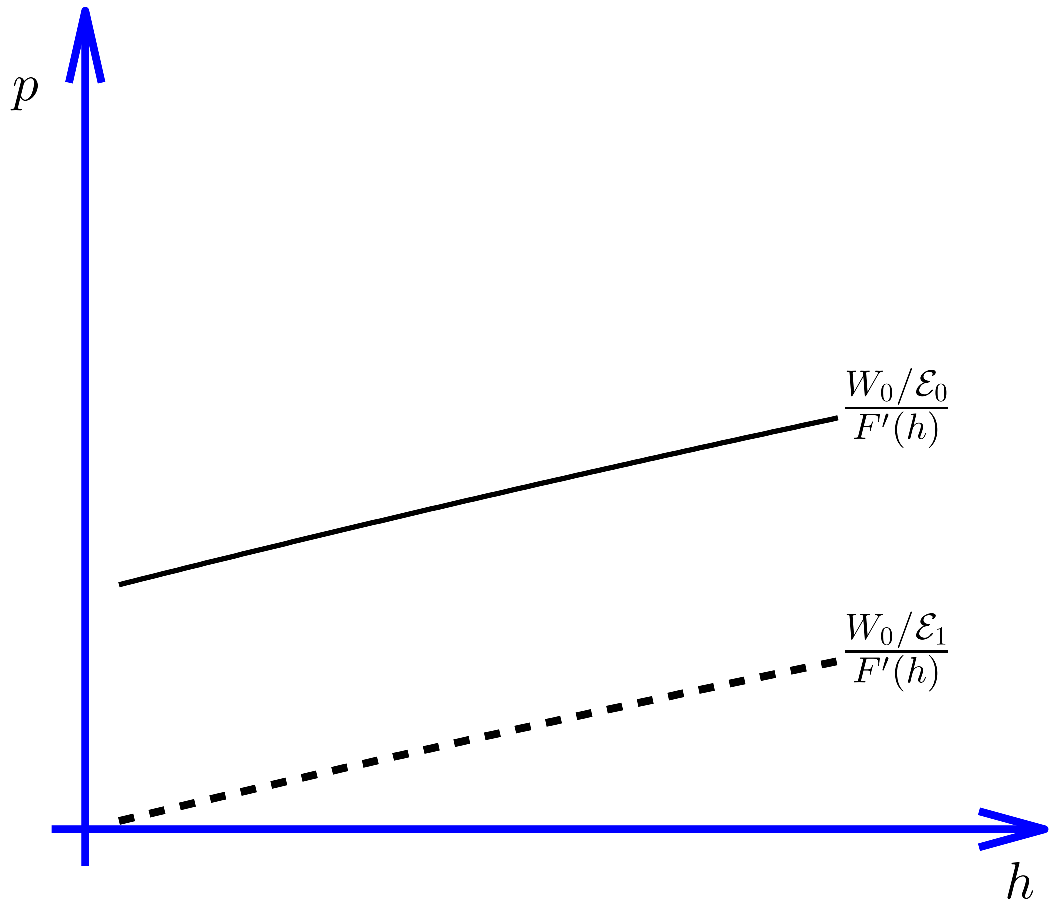
$$p_t F(h_t) - \frac{W_t}{\mathcal{E}_t} h_t$$

First-order condition:

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

can be interpreted as **the supply schedule for nontradables** given real wages, $W_t/\mathcal{E}_t$

The Supply of Nontradables



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

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

Downward Nominal Wage Rigidity

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

W_t = nominal wage in period t.

γ = degree of downward wage rigidity.

Think of γ as being around 1. Schmitt-Grohé and Uribe (JPE, 2016) estimate $\gamma = 0.99$ at quarterly frequency.

Closing of the Labor Market

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

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

Express in real terms

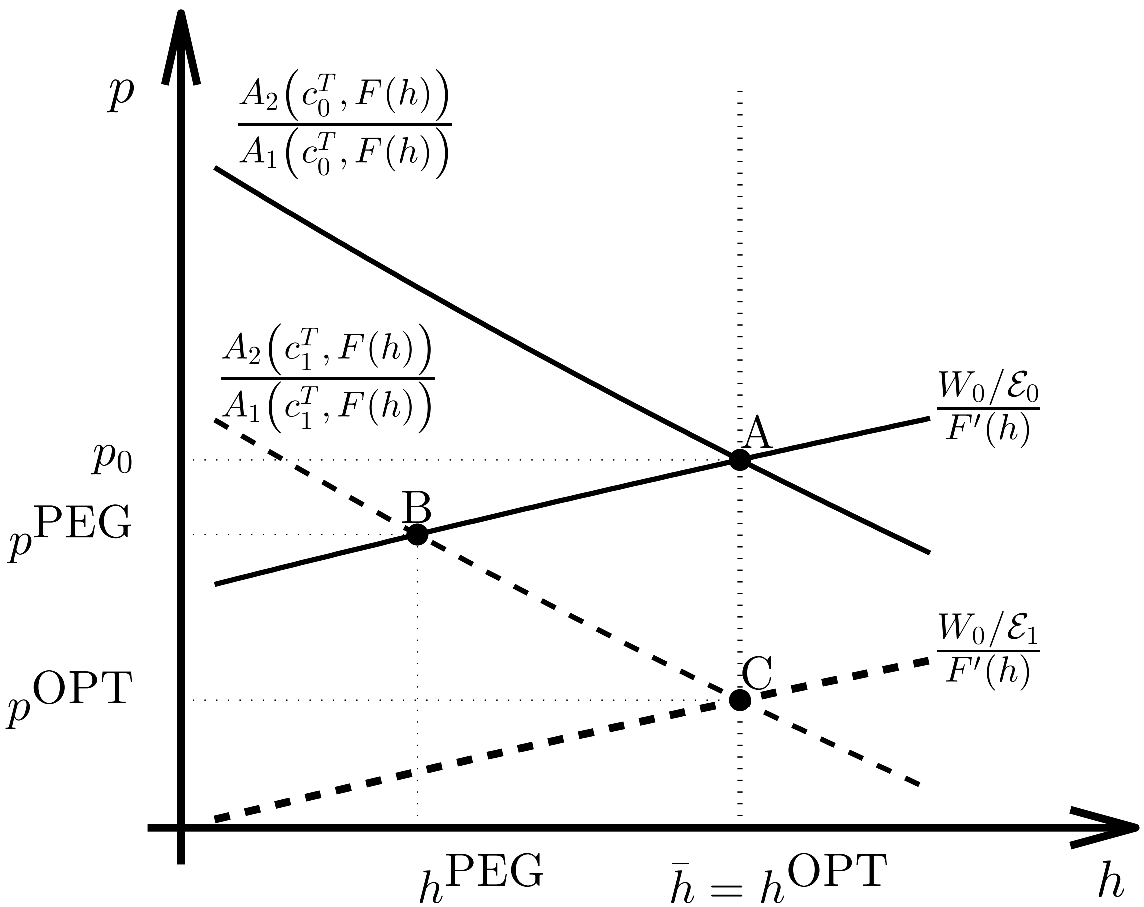
$$(\bar{h} - h_t)\left(w_t - \gamma \frac{w_{t-1}}{\epsilon_t}\right) = 0,$$

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



$c_1^T < c_0^T$ (caused by, e.g., negative endowment shock, $y_t^T \downarrow$)
$\mathcal{E}_1 > \mathcal{E}_0$ (optimal devaluation)

$\Rightarrow$ negative external shock, $y_t^T \downarrow$, calls for a devaluation.

Optimal Default — (Eaton-Gersovitz)

- 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 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 $L(\cdot)$ is an increasing function.

Risk-Neutral Foreign Lenders

The price of debt, q_t, must satisfy

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

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

Competitive Equilibrium: Processes $c_t^T,\ h_t,\ w_t,\ q_t, d_{t+1},\ \lambda_t$ that satisfy

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

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

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

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

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

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

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

given policies $I_t,\ \epsilon_t,\ \tau_t^d$

Optimal Default and Optimal Exchange Rate Policy

Benevolent Government's Problem: Pick policies I_t, ϵ_t, τ_t^d to bring about the best competitive equilibrium subject to the constraint that it lacks commitment.

When the government can choose ϵ_t freely, we can write the competitive equilibrium conditions in a more compact form:

Equilibrium conditions

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

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

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

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

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

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

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

Result: Given processes $\{c_t^T, h_t, d_{t+1}, q_t, I_t\}$ that satisfy the boxed conditions, one can find processes w_t, λ_t, ϵ_t, τ_t^d so that all equilibrium conditions are satisfied.

Lack of Commitment

Restrict attention to Markov perfect equilibira. Period-t government takes default decision of period-$t+1$ government to be a function of pay-off relevant state variables in period $t+1$

$$I_{t+1} = \widehat{I}(y_{t+1}^T, d_{t+1})$$

If $I_t = 1$, then, by participation constraint

$$q_t = \frac{\mathbb{E}_t I_{t+1}}{1+r^*} = \frac{\mathbb{E}_t \widehat{I}(y_{t+1}^T, d_{t+1})}{1+r^*} = q(y_t^T, d_{t+1})$$

Last equality uses the facts that y_t^T is an exogenous first-order Markov process and that d_{t+1} is in the information set of period t.

Optimal Policy

- Value of continuing to service debt:

$$v^c(y_t^T, d_t) = \max_{\{c_t^T, d_{t+1}, h_t\}} \left\{ U\left(A\left(c_t^T, F(h_t)\right)\right) + \beta \mathbb{E}_t v^g(y_{t+1}^T, d_{t+1}) \right\}$$

s.t.

$$\boxed{c_t^T = y_t^T + q(y_t^T, d_{t+1})d_{t+1} - d_t}$$

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

- Value of bad financial standing:

$$v^b(y_t^T) = \max_{\{c_t^T, h_t\}} \left\{ U\left(A\left(c_t^T, F(h_t)\right)\right) + \beta \mathbb{E}_t \left[\theta v^g(y_{t+1}^T, 0) + (1-\theta) v^b(y_{t+1}^T)\right] \right\}$$

s.t.

$$\boxed{c_t^T = y_t^T - L(y_t^T)}$$

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

- Value of good standing:

$$v^g(y_t^T, d_t) = \max\left\{v^c(y_t^T, d_t), v^b(y_t^T)\right\}$$

- Default set:

$$D(d_t) = \left\{y_t^T : v^c(y_t^T, d_t) < v^b(y_t^T)\right\}$$

- Equilibrium participation constraint

$$q(y_t^T, d_{t+1}) = \frac{1\text{-Prob}\left\{y_{t+1}^T \in D(d_{t+1}) | y_t^T\right\}}{1 + r^*}$$

- Under optimal policy: $h_t = \bar{h}$.

- With $h_t = \bar{h}$, problem is identical to Arellano (2008) version of Eaton-Gersovitz model.

The Family of Optimal Devaluation Policies

$$\epsilon_t \geq \gamma \frac{w_{t-1}}{w^f(c_t^T)},$$

where $w^f(c_t^T)$ denotes the full-employment real wage, defined as

$$w^f(c_t^T) \equiv \frac{A_2(c_t^T, F(\bar{h}))}{A_1(c_t^T, F(\bar{h}))} F'(\bar{h}); \qquad \text{with } \frac{\partial w^f(c_t^T)}{\partial c_t^T} > 0.$$

Hence, under optimal policy devaluations go hand in hand with contractions.

$\Rightarrow$ model has the potential to predict the Twin Ds phenomenon because in the Eaton-Gersovitz countries default in bad times.

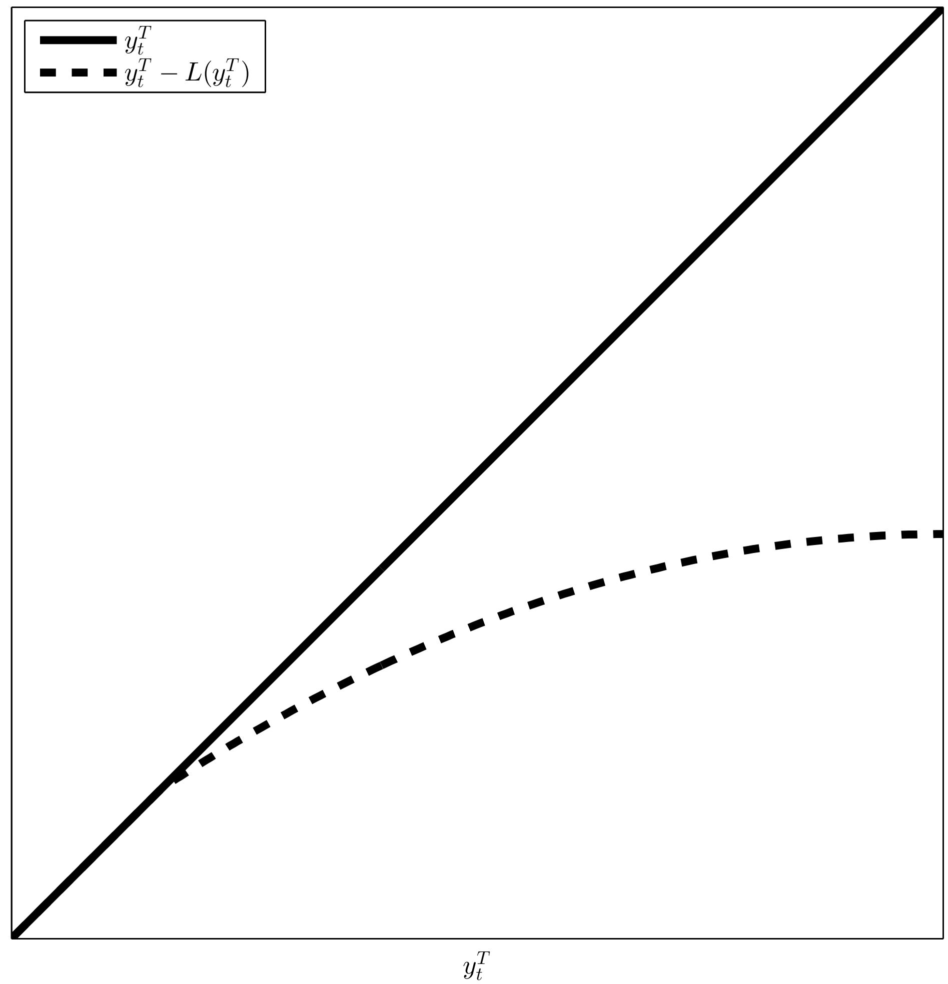
Quantitative Analysis

Functional Forms and Calibration

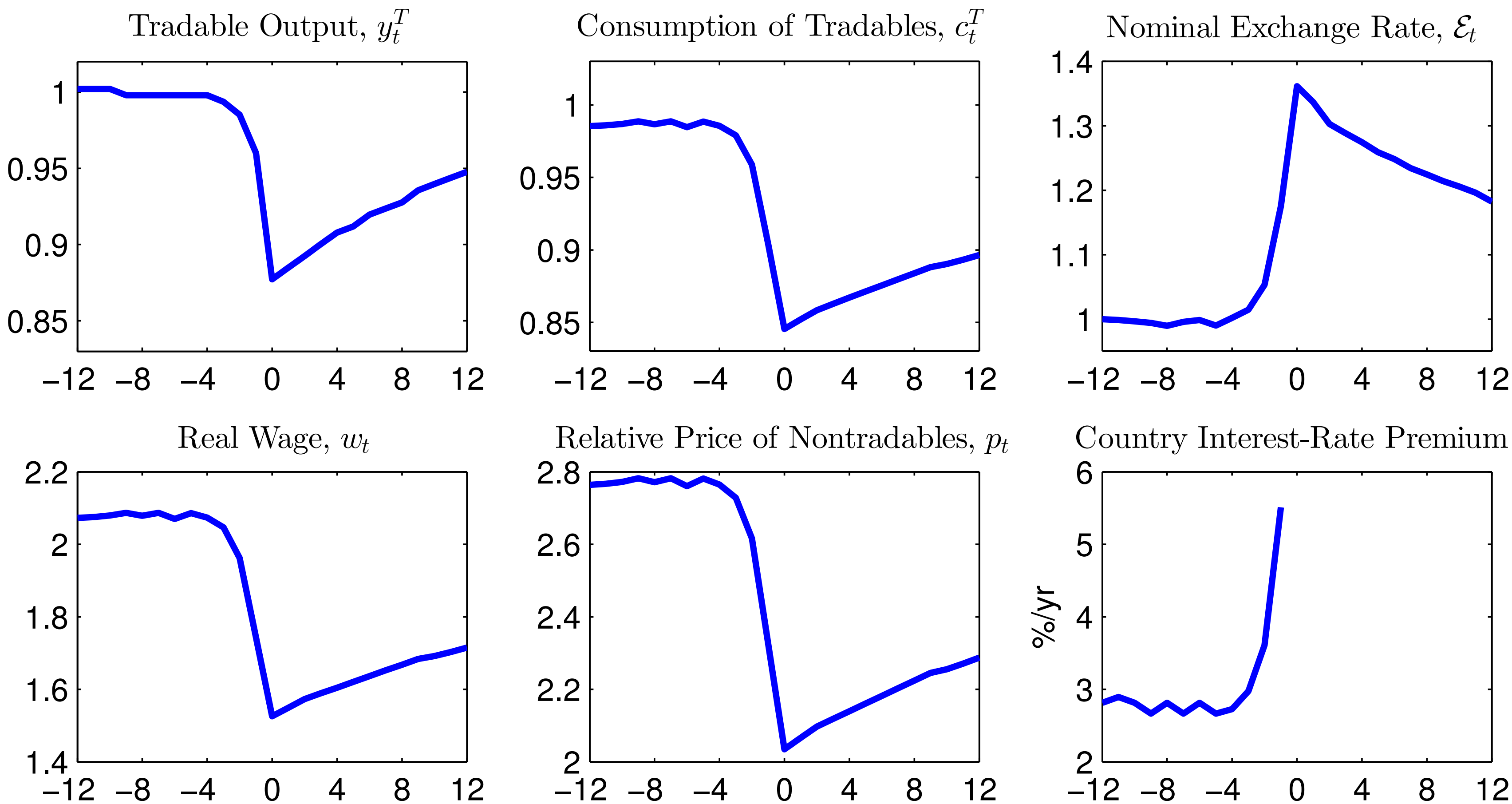
- The time unit is a quarter.
- $U(c) = \frac{c^{1-\sigma}-1}{1-\sigma}$; $\sigma = 2$
- $A(c^T, c^N) = \left[a(c^T)^{1-\frac{1}{\xi}} + (1-a)(c^N)^{1-\frac{1}{\xi}}\right]^{\frac{1}{1-\frac{1}{\xi}}}$; $\xi = 1/\sigma, a = 0.26$
- $F(h_t) = h_t^{\alpha}$; $\alpha = 0.75$
- Output loss, $L(y_t^T) = \max\{0, \delta_1 y_t^T + \delta_2 (y_t^T)^2\}$
- 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.
- $\ln y_t^T = 0.93 \ln y_{t-1}^T + 0.037\mu_t$, $\mu_t \sim N(0,1)$ (Argentina, 1983-2001)

- From the family of optimal policies pick: $\epsilon_t = \frac{w_{t-1}}{w^f(c_t^T)}$

Asymmetric Output Cost of Default



A Typical Default Episode Under Optimal Policy



⇒ Model predicts the Twin Ds Phenomenon

Optimal Default Under Currency Pegs

Suppose the central bank picks

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

Optimal Policy Under a Peg

- Value of continuing to service the debt

$$v^c(y_t^T, d_t, w_{t-1}) = \max_{\{c_t^T, d_{t+1}, w_t, h_t\}} \left\{ U\left(A\left(c_t^T, F(h_t)\right)\right) + \beta \mathbb{E}_t v^g(y_{t+1}^T, d_{t+1}, w_t) \right\}$$

s.t.

$$c_t^T + d_t = y_t^T + q(y_t^T, d_{t+1}, w_t) d_{t+1}$$

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

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

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

- Value of being in bad financial standing

$$v^b(y_t^T, w_{t-1}) = \max_{\{c_t^T, w_t, h_t\}} \left\{ U\left(A\left(c_t^T, F(h_t)\right)\right) + \beta \mathbb{E}_t \left[\theta v^g(y_{t+1}^T, 0, w_t) + (1-\theta) v^b(y_{t+1}^T, w_t) \right] \right\}$$

s.t.

$$c_t^T = y_t^T - L(y_t^T)$$

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

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

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

- Value of being in good standing

$$v^g(y_t^T, d_t, w_{t-1}) = \max\left\{v^c(y_t^T, d_t, w_{t-1}), v^b(y_t^T, w_{t-1})\right\}.$$

- Default set

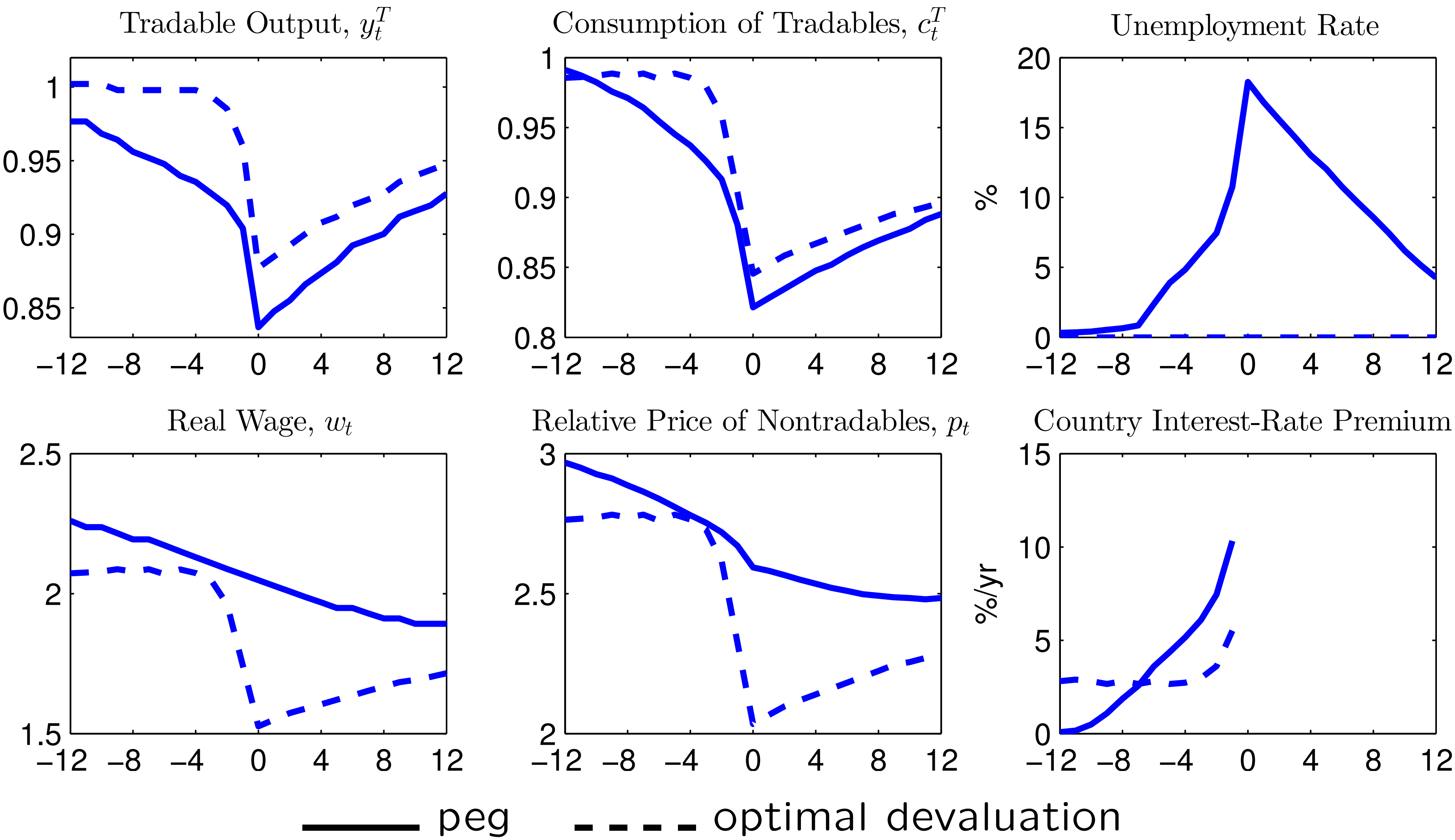
$$D(d_t, w_{t-1}) = \left\{y_t^T : v^b(y_t^T, w_{t-1}) > v^c(y_t^T, d_t, w_{t-1})\right\}.$$

- Equilibrium participation constraint

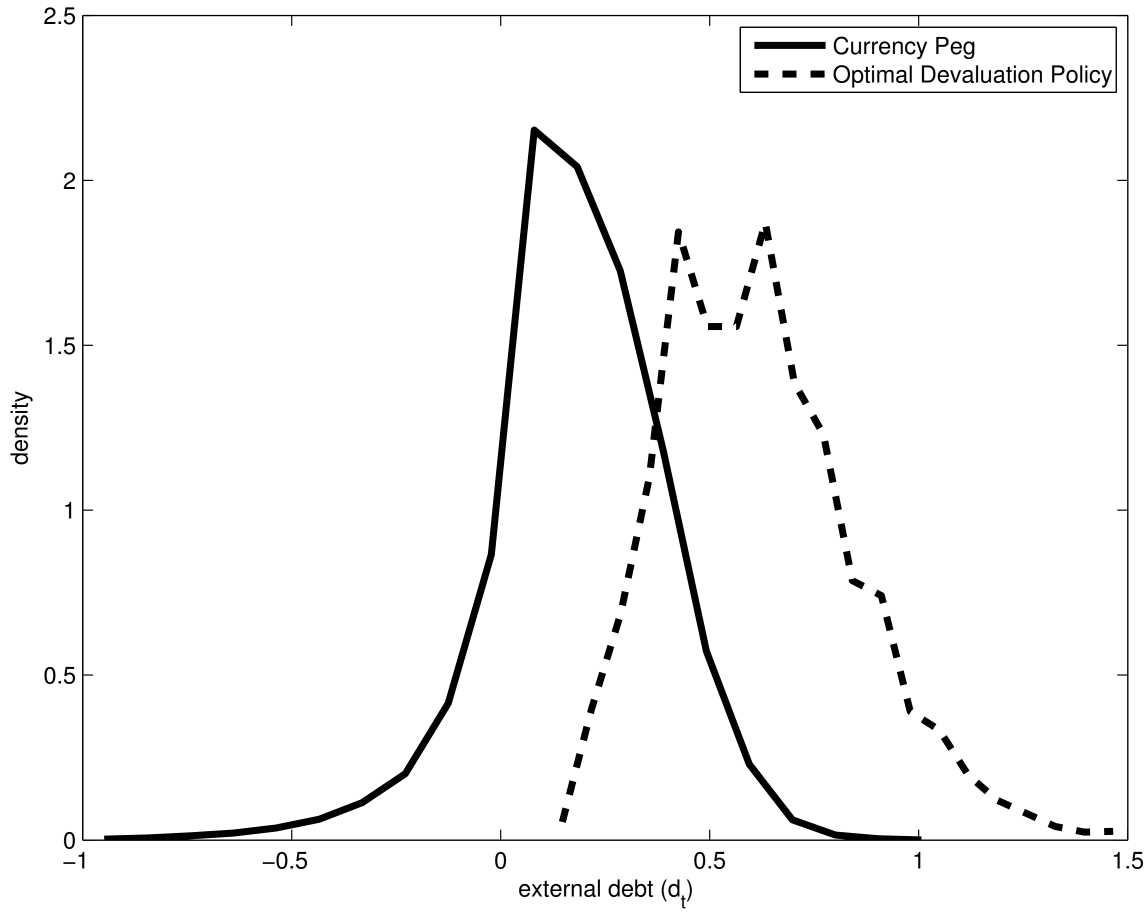
$$q(y_t^T, d_{t+1}, w_t) = \frac{\text{1-Prob}\left\{y_{t+1}^T \in D(d_{t+1}, w_t)\right\}}{1 + r^*}$$

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

Under Fixed Exchange Rates Defaults are Accompanied by Massive Unemployment

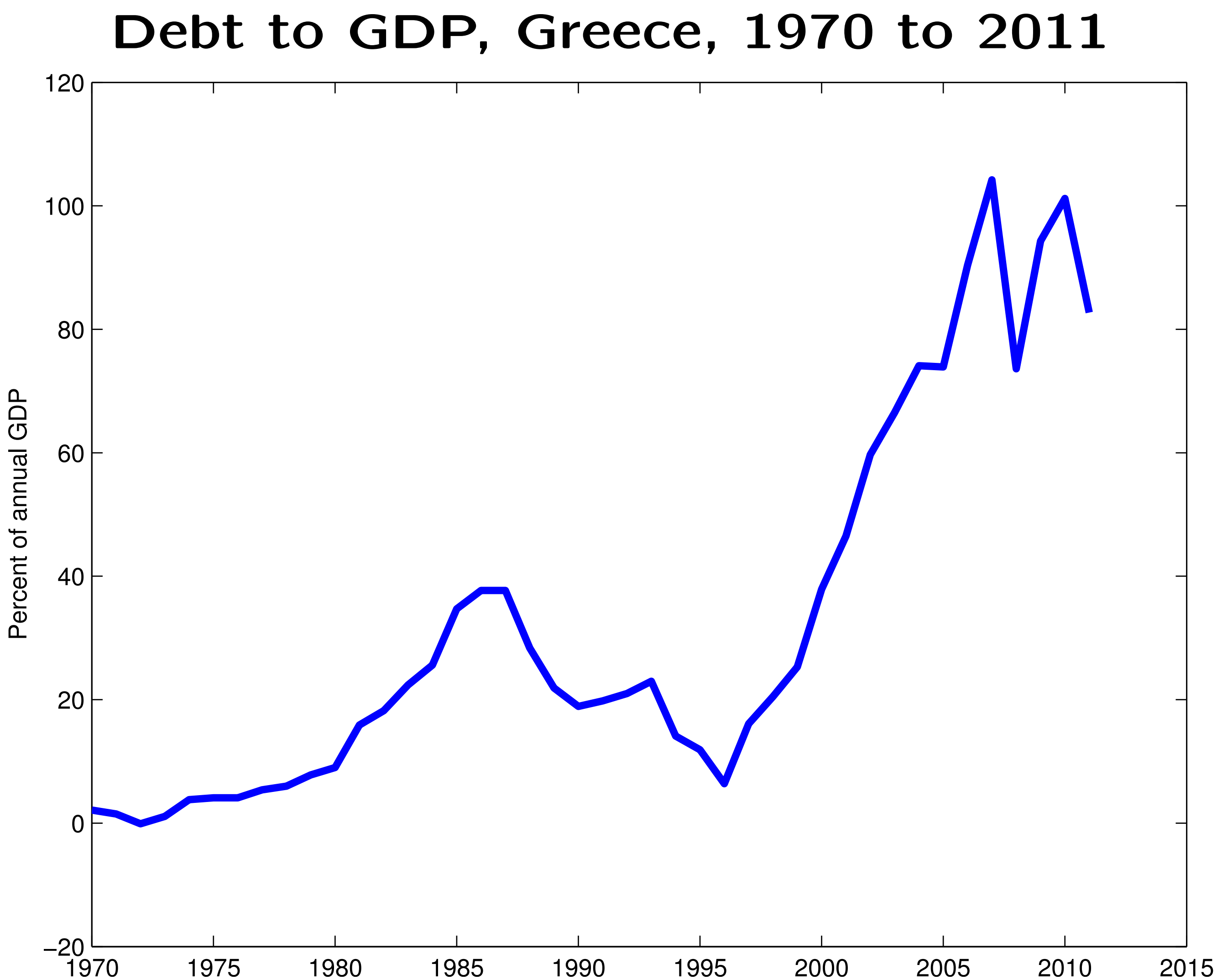


Peggers Can Support Less External Debt



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

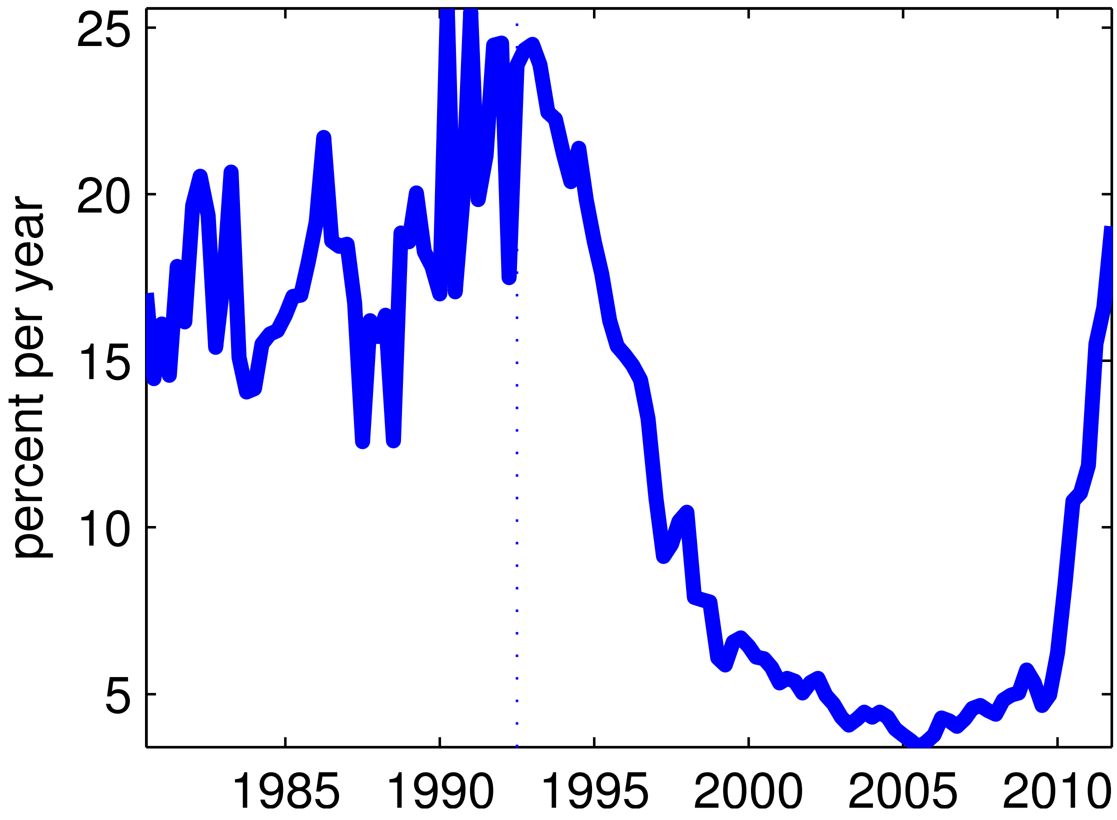
Bailouts, Pegs, and Debt Sustainability



- low debt prior to accession to Eurozone, in 1995, just 11.9 percent.
- thereafter debt explodes reaching more than 100 percent by 2007.

The rise in debt occurs at a time when interest rates in Greece reach record lows.

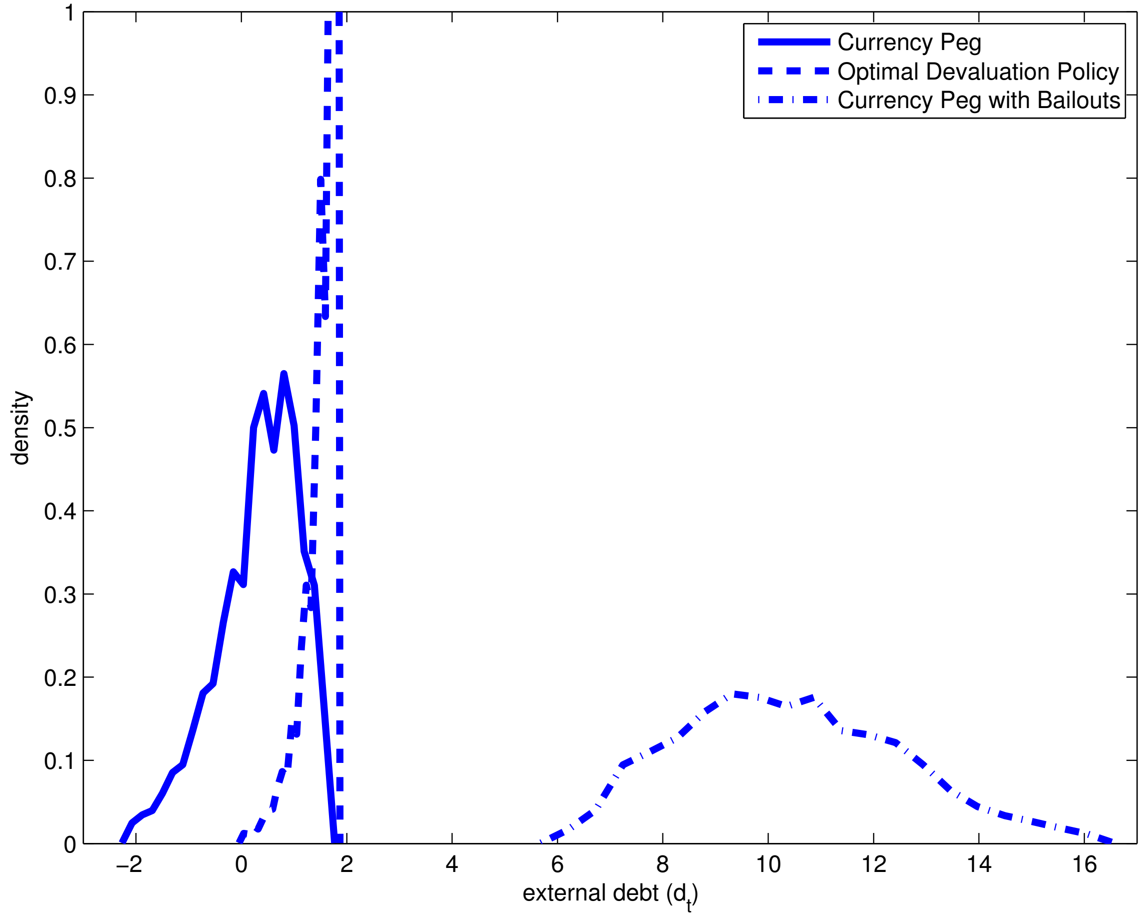
Interest Rate, Greece, 1980Q3-2011Q4



Notes. 1980Q3 to 1992Q2, overnight rate; 1992Q3-2011Q4 10-year government bond rate. Data sources: Bank of Greece and Eurostat.

This suggests that accession to the Eurozone was interpreted by markets as being accompanied to some degree with implicit bailout guarantees...

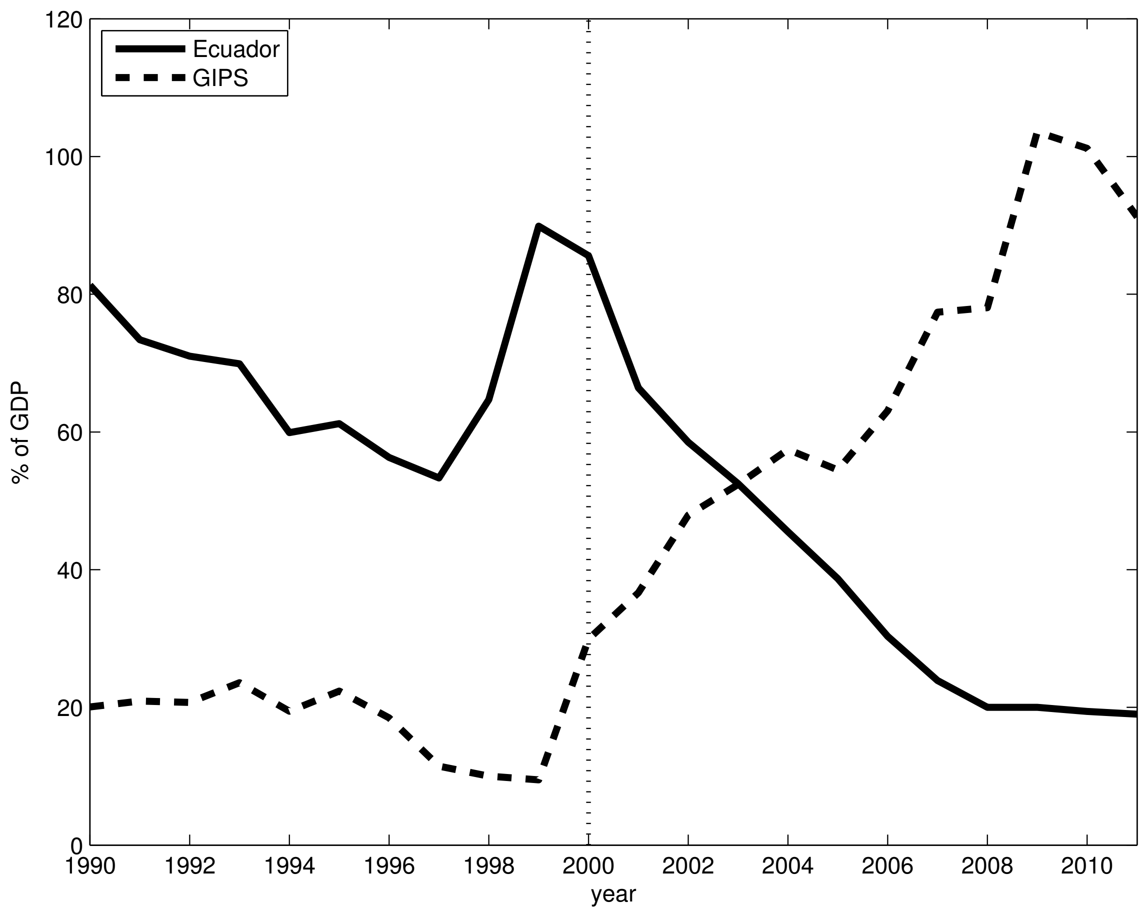
The prospect of bailouts (or ability to commit to repay) increases eqm level of debt



Note. Debt distributions are conditional on being in good financial standing. The distribution under the optimal float is truncated at 1 to preserve a comparable scale across the three densities. Model calibrated to the Greek economy.

Absent an implicit bailout guarantee, debt declines after adoption of peg:

**External Debt to GDP Ratios:
GIPS versus Ecuador, 1990 to 2011**



Conclusions

- The paper provides new empirical evidence of the Twin Ds: defaults are typically accompanied by large one-time devaluations.

- It introduces nominal rigidities and exchange-rate policy into models with default risk à la Eaton-Gersovitz.

- The resulting model predicts that under the optimal policy defaults are accompanied by large devaluations, thus, capturing the Twin Ds phenomenon.

- The incentives to devalue around default are large. Under a currency peg, defaults are predicted to be accompanied by massive unemployment of around 20 percent.

Extras

Sensitivity Analysis

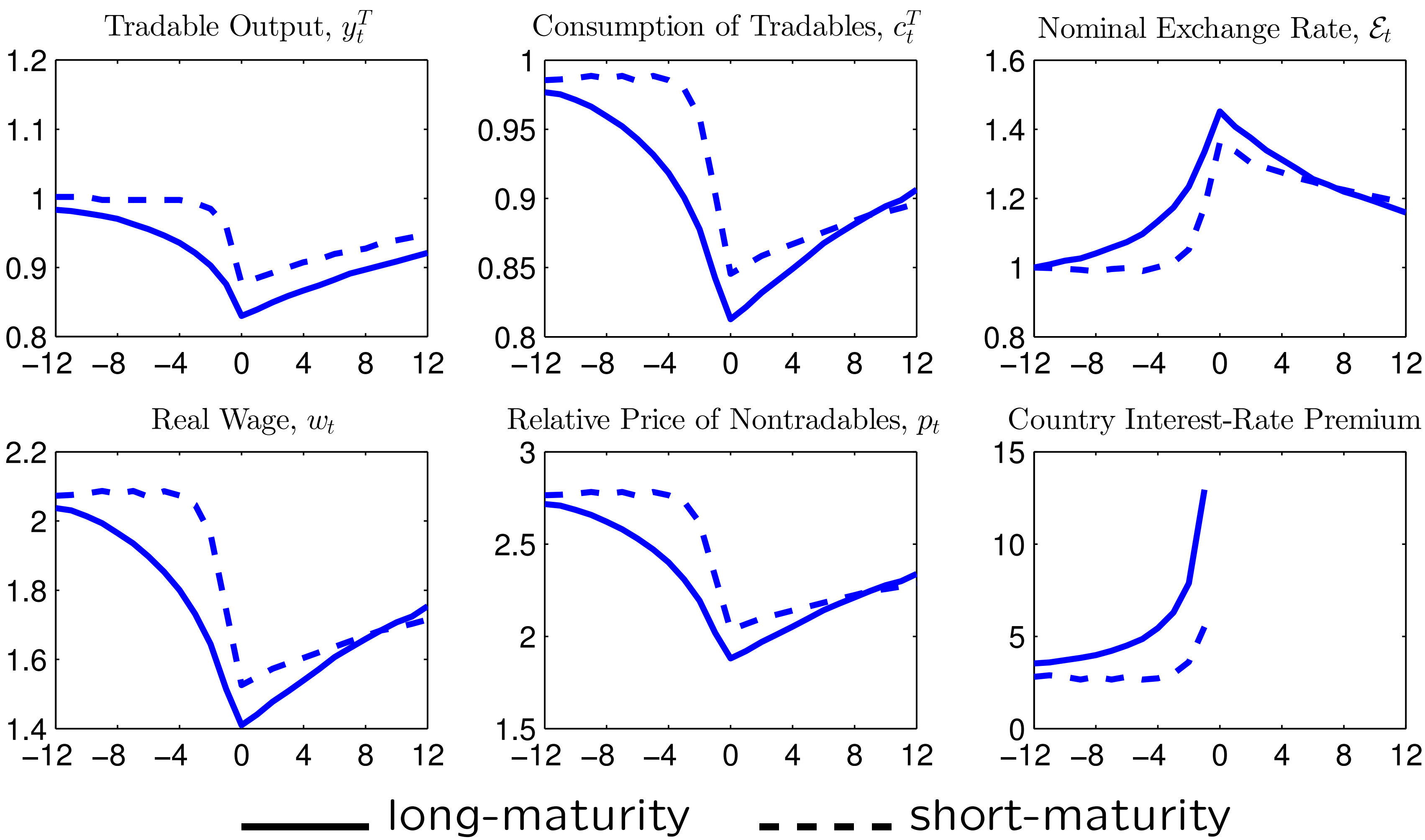
1. Long-Maturity Debt

2. Incomplete Exchange Rate Pass Through

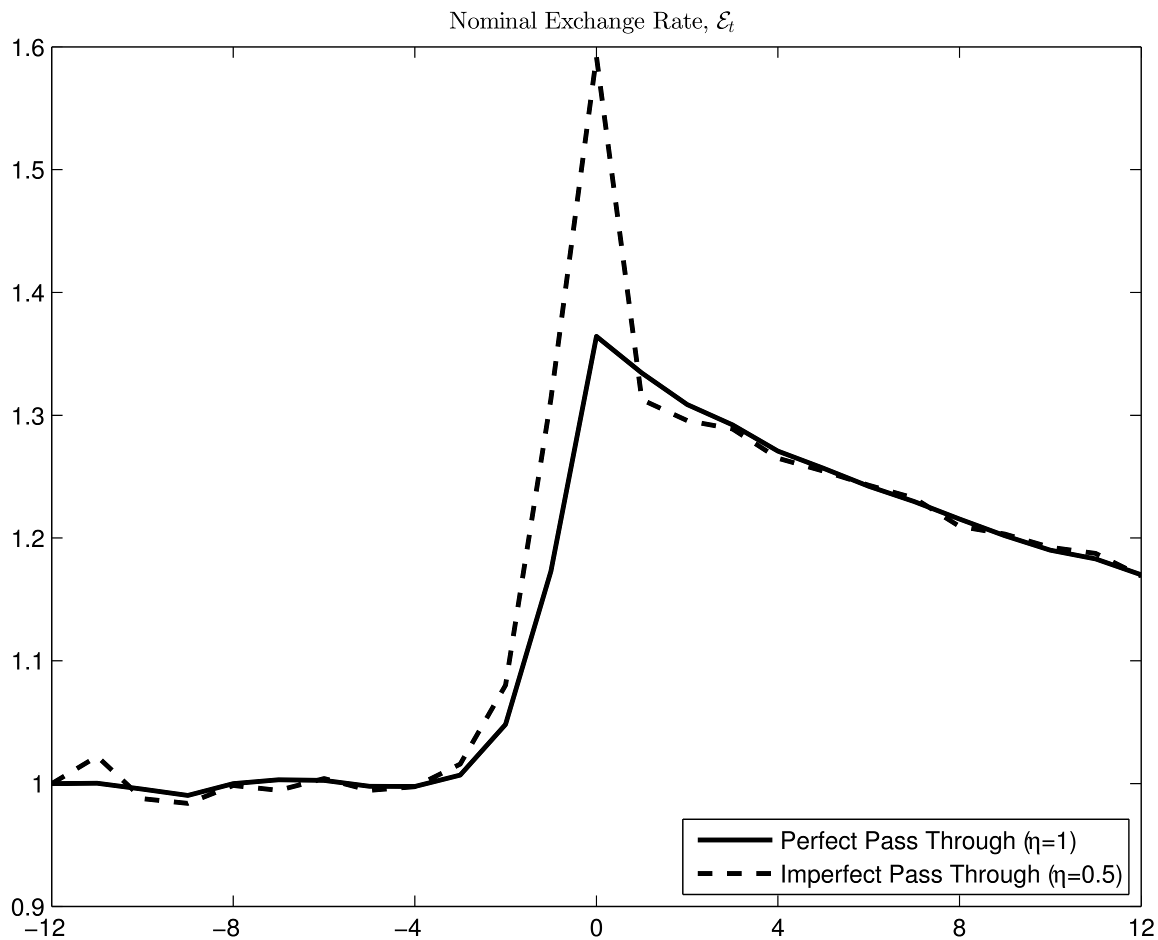
3. Patience and the Twin Ds (higher β)

1.) Long-Maturity Debt: model continues to predict Twin Ds phenomenon

Optimal Devaluation Around the Typical Default Episode

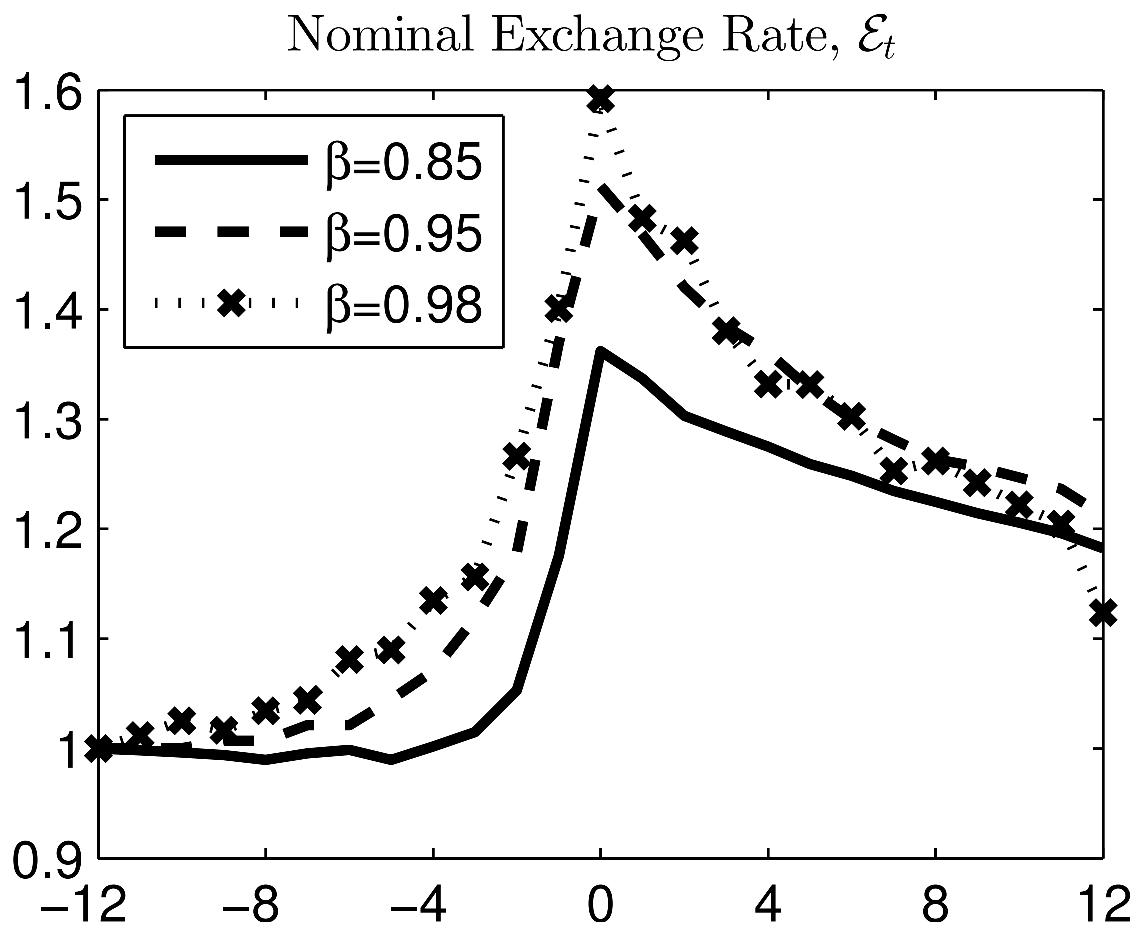


2.) Incomplete Exchange Rate Pass Through
Optimal Devaluation Around the Typical Default Episode



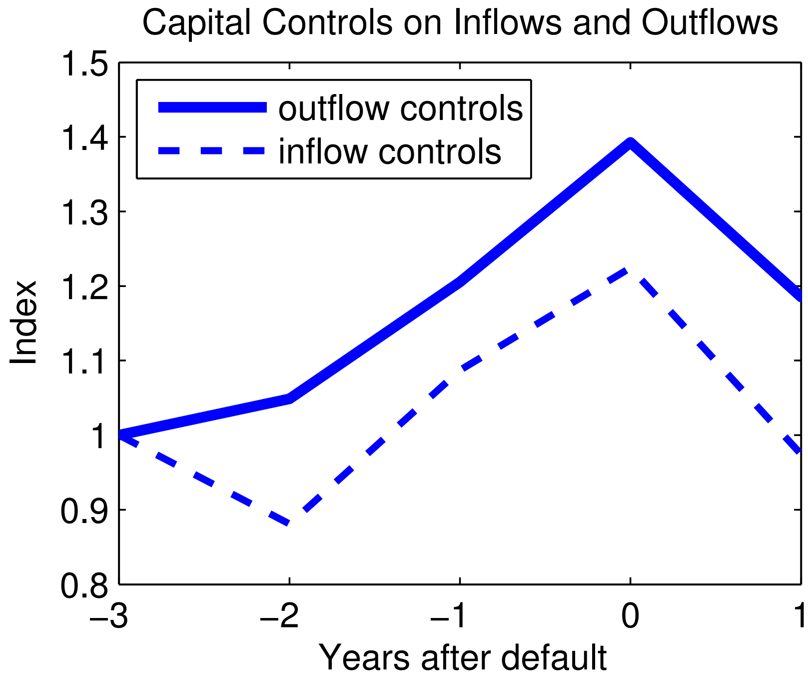
3.) Patience and the Twin Ds (higher β)

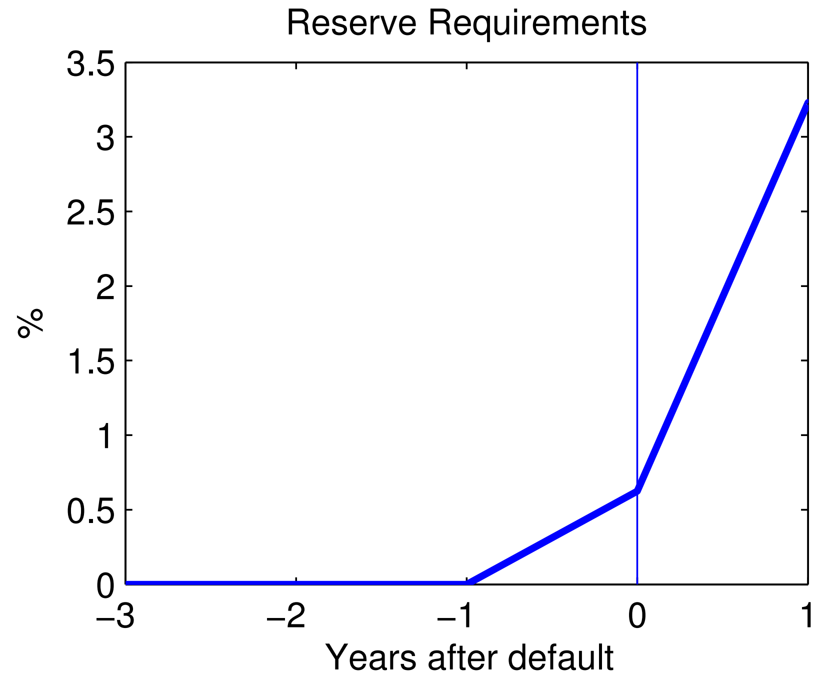
Optimal Devaluation Around the Typical Default Episode



Empirical Evidence on the Behavior of Capital Controls and Reserve Requirements Around Default

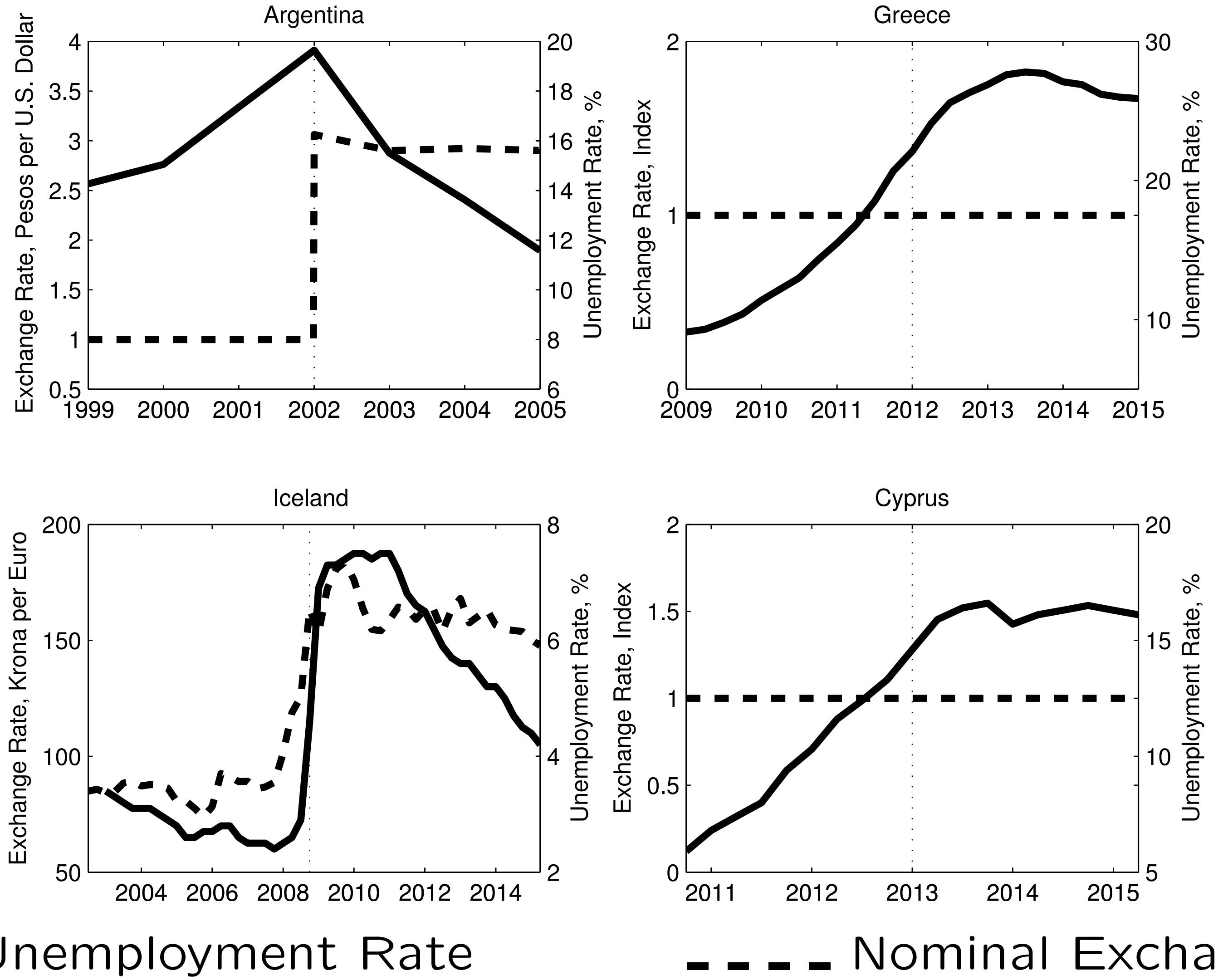
The model predicts that debt taxes increase as the economy approaches default. Is this prediction of the model supported in the data? Take a look at the next two plots. The first shows that capital control measures increase and the second shows that reserve requirements increase.





Notes. Own calculations based on data on capital controls from Fernández et al. (2016), left panel, and on data on reserve requirements from Federico, Végh, and Vuletin (2014), right panel.

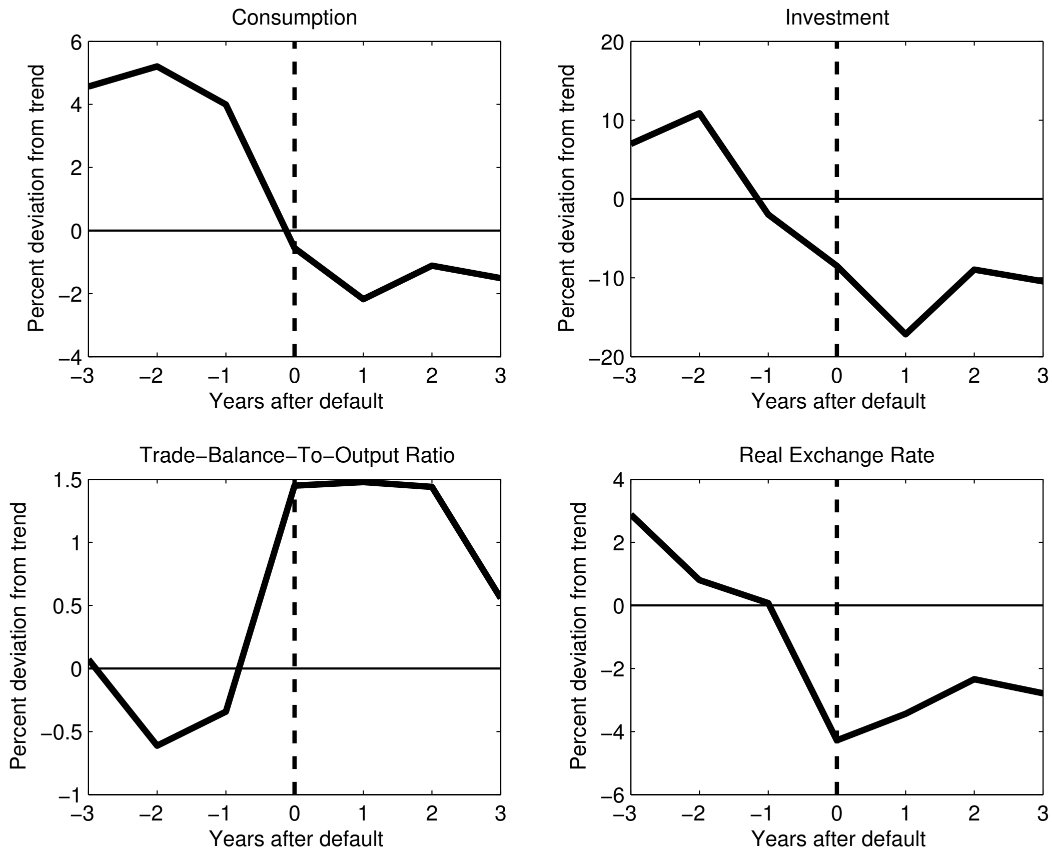
Default, Devaluation, and Unemployment:



Note. Vertical line indicates the year of default. Own calculations based on data from INDEC (Argentina), EuroStat, and the Central Bank of Iceland.

Other Macro Indicators Around Defaults

support view that countries default in bad times



Note: Annual log-quadratically detrended variables. The year of default is normalized to 0. Median over 105 default episodes between 1975 and 2014.

Observations

• Consumption contracts by as much as output in the run up to default (about 6 percent).

• The contraction of investment leading up to default is 3 times as large as that of output.

• The trade balance is below average up until the year of default. And in the year of default it experiences a reversal of about 2%.

• The real exchange rate depreciates significantly in the default year (by over 4%), and then begins to gradually appreciate.

Calibration

Parameter	Value	Description
γ	0.99	Degree of downward nominal wage rigidity
σ	2	Inverse of intertemporal elasticity of consumption
y^T	1	Steady-state tradable output
$\bar{h}$	1	Labor endowment
a	0.26	Share of tradables
ξ	0.5	Elasticity of substitution between tradables and nontradables
α	0.75	Labor share in nontraded sector
β	0.85	Quarterly subjective discount factor
r^*	0.01	World interest rate (quarterly)
θ	0.0385	Probability of reentry
δ_1	-0.35	parameter of output loss function
δ_2	0.4403	parameter of output loss function
ρ	0.9317	serial correlation of $\ln y_t^T$
σ_μ	0.037	std. dev. of innovation μ_t
		Discretization of State Space
n_y	200	Number of output grid points (equally spaced in logs)
n_d	200	Number of debt grid points (equally spaced)
n_w	125	Number of wage grid points (equally spaced in logs)
$[\underline{y}^T, \overline{y}^T]$	[0.6523,1.5330]	traded output range
$[\underline{d}, \overline{d}]^{float}$	[0,1.5]	debt range under optimal float
$[\underline{d}, \overline{d}]^{peg}$	[-1,1.25]	debt range under peg
$[\underline{w}, \overline{w}]^{peg}$	[1.25,4.25]	wage range under peg

Data and Model Predictions: Optimal Devaluation Policy

	$E(r-r^*)$	$\sigma(r-r^*)$	corr$(r-r^*,y)$	corr$(r-r^*,tb/y)$
Data	7.4	2.9	-0.64	0.72
Model	3.5	3.2	-0.54	0.81

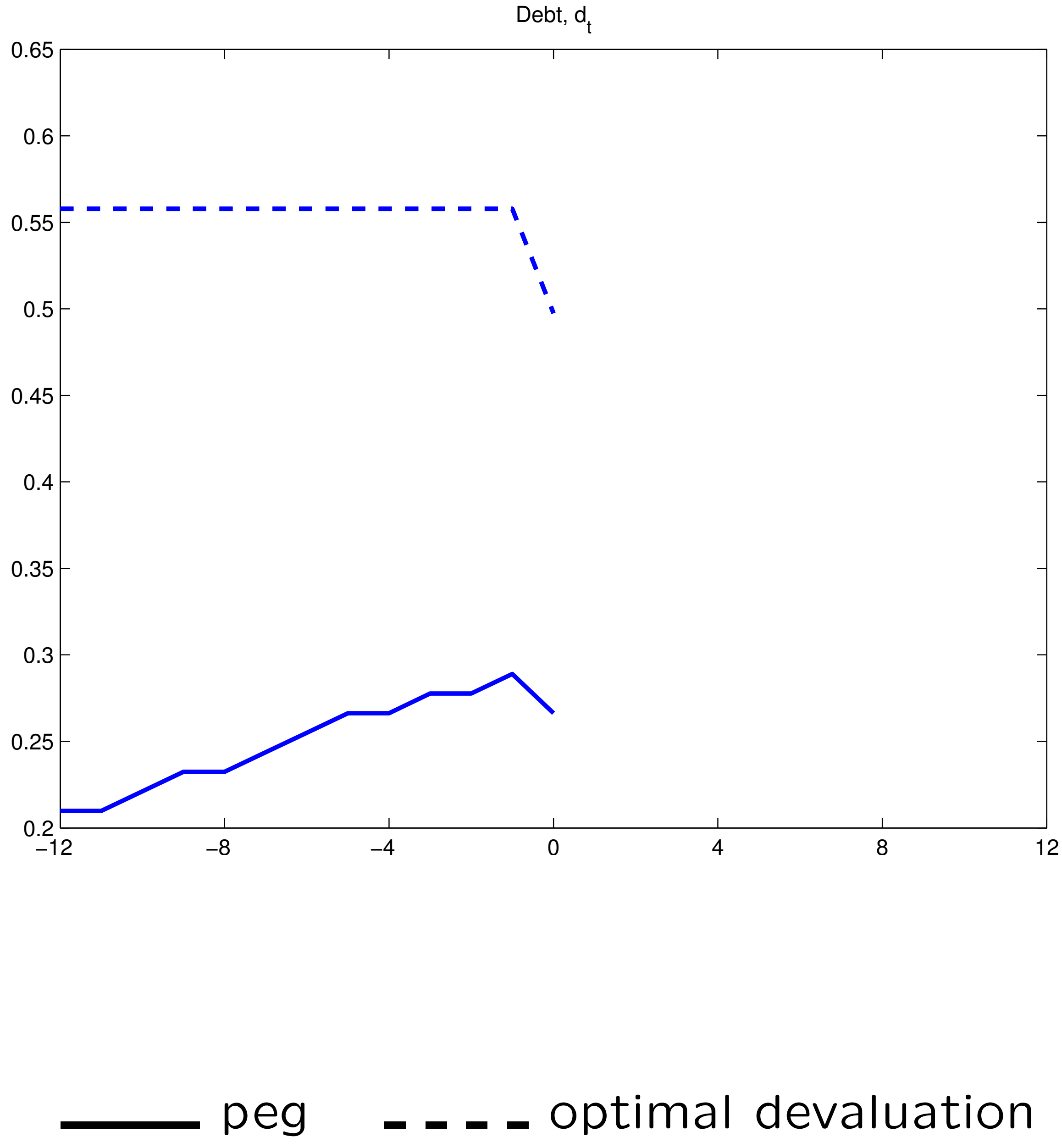
Note. Data moments are from Argentina over the inter-default period 1994:1 to 2001:3, except for the default frequency, which is calculated over the period 1824 to 2013. In the theoretical model, all moments are conditional on the country being in good financial standing.

Business-Cycle Statistics:

Data and Model Predictions Under Optimal Exchange Rate Policy

	$\sigma(c)/\sigma(y)$	$\sigma(tb/y)/\sigma(y)$	corr(c, y)	corr$(tb/y, y)$
Data				
Emerging Countries	1.23	0.69	0.72	-0.51
Argentina	1.11	0.48	0.75	-0.87
Model	1.22	0.57	0.88	-0.14

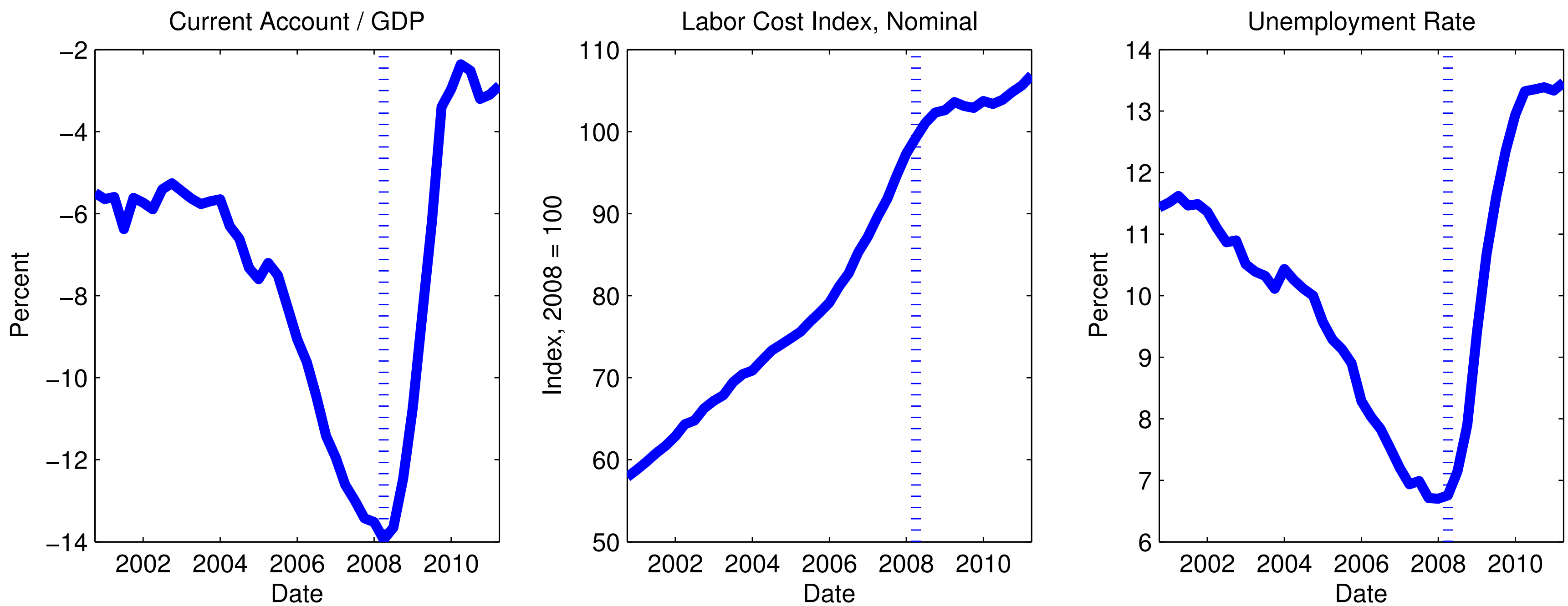
Typical Default Episodes With Fixed Exchange Rates



Is there wage restraint during booms?

Example: Periphery of Europe during the 2000-2008 Boom

Boom-Bust Cycle in Peripherical Europe: 2000-2011

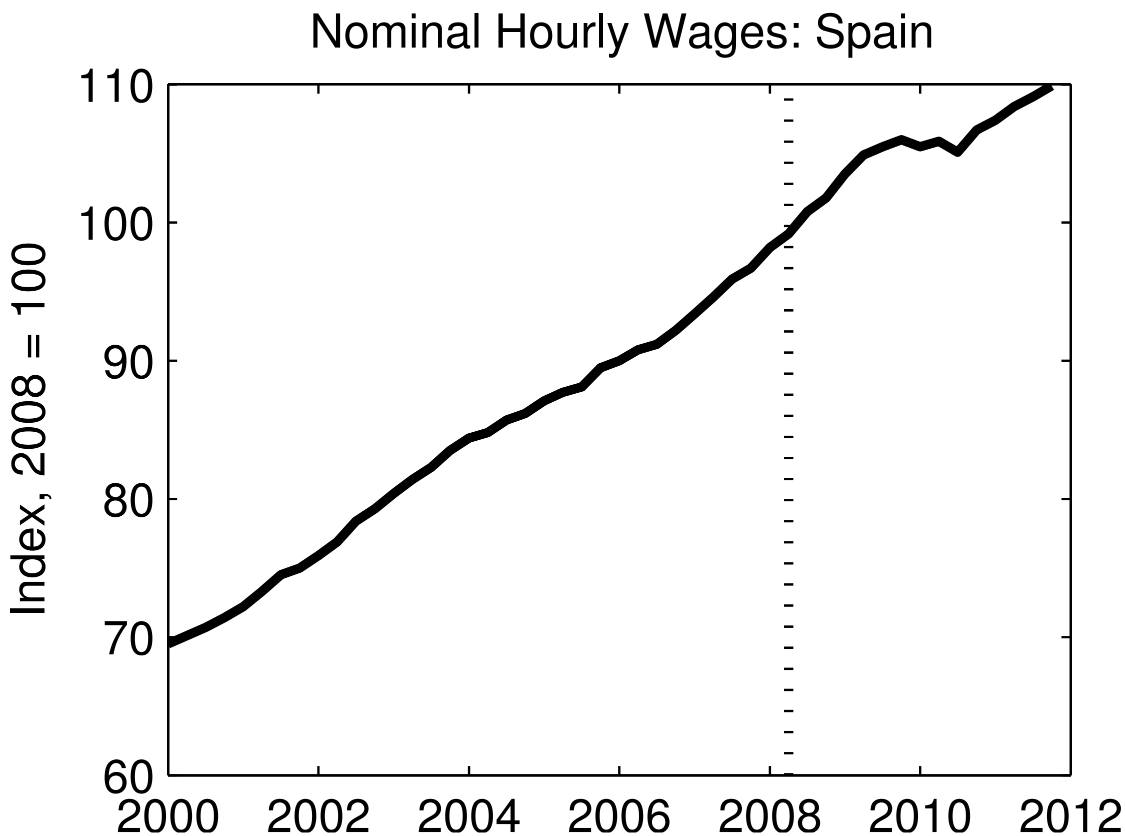


Data Source: Eurostat. Data represents arithmetic mean of Bulgaria, Cyprus, Estonia, Greece, Ireland, Lithuania, Latvia, Portugal, Spain, Slovenia, and Slovakia

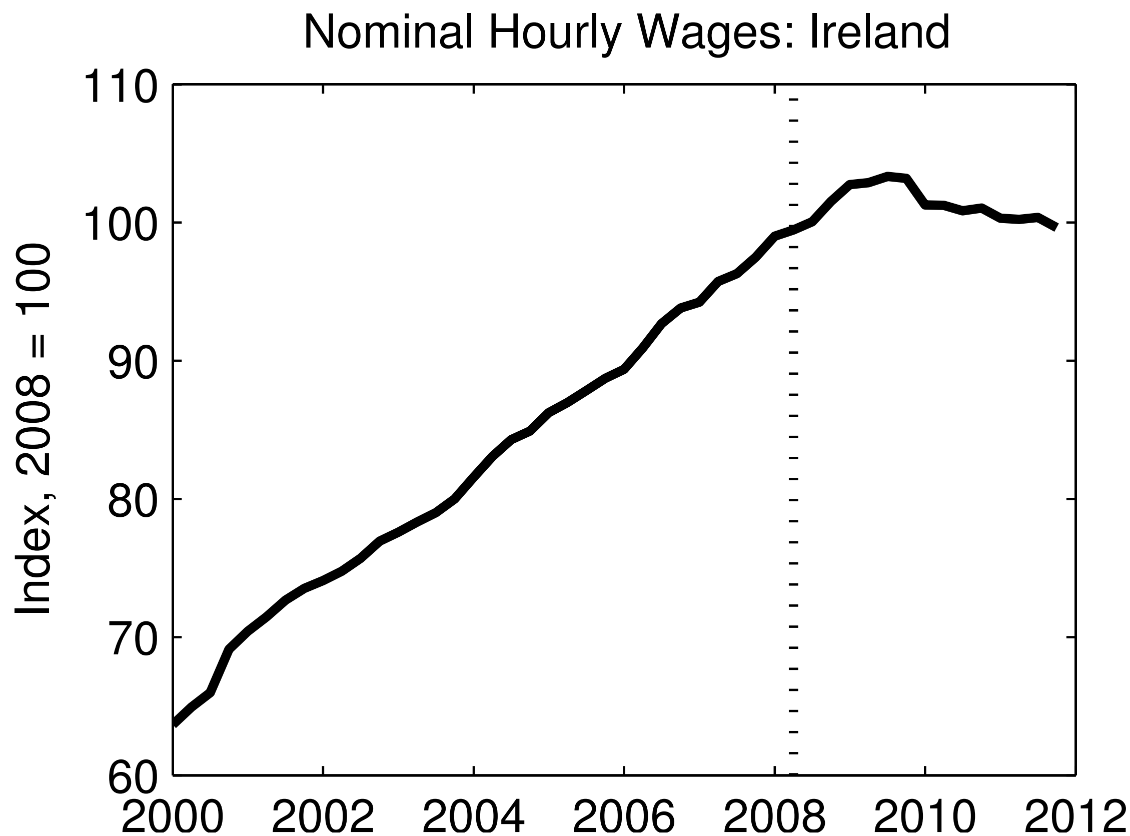
$\Rightarrow$ Wages grew by 70 percent between 2000 and 2008!

Let's take a closer look at Spain and Ireland ...

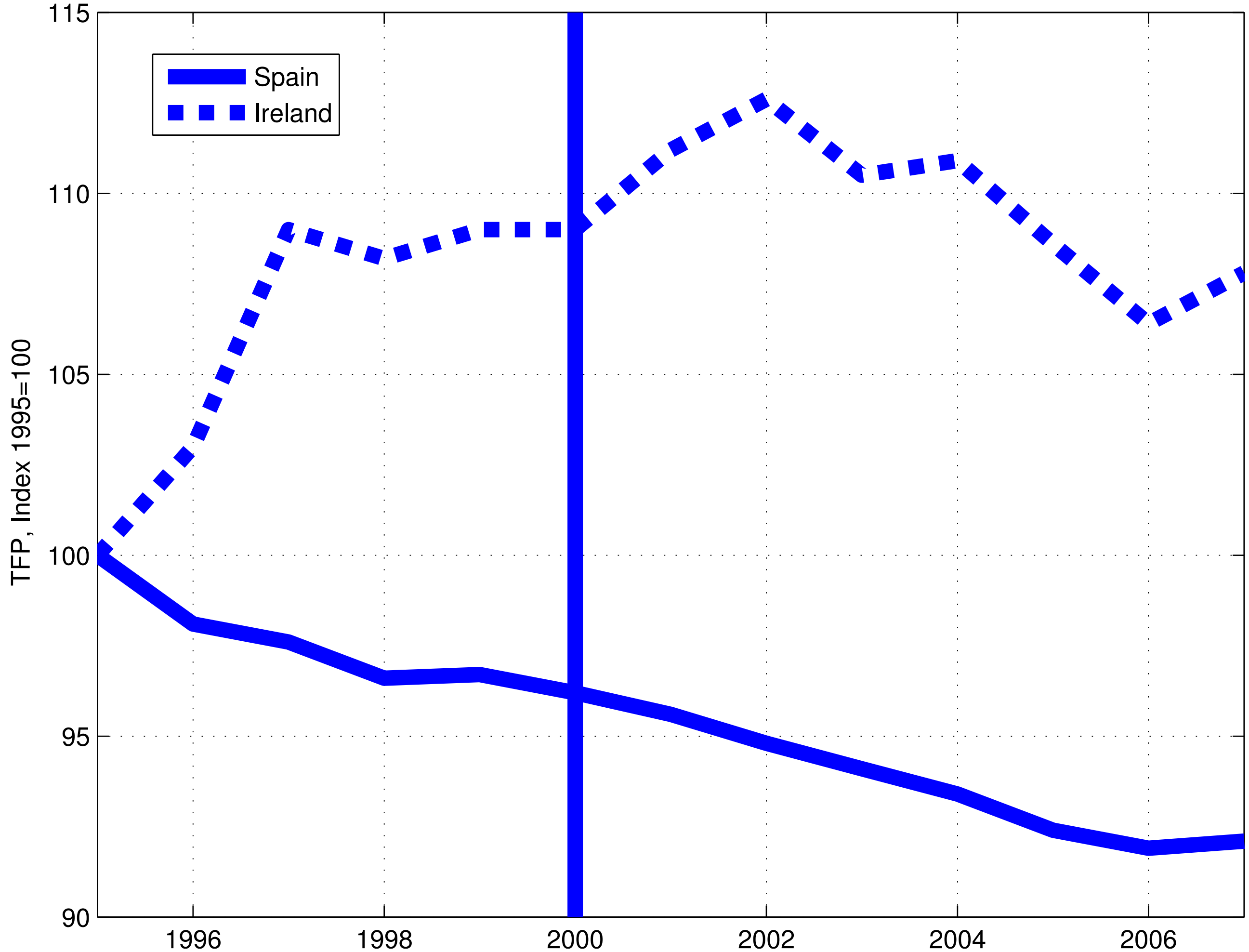
Nominal hourly wages in Spain increase by 44 percent during the 2000-2008 boom



Nominal hourly wages in Ireland increase by 57 percent during the 2000-2008 boom



... Despite No Growth in Total Factor Productivity



Total Factor Productivity: 2000-2007 (value added based), Index (1995=100)

	2000	2001	2002	2003	2004	2005	2006	2007
Spain	96.2	95.6	94.8	94.1	93.4	92.4	91.9	92.1
Ireland	109.0	111.2	112.6	110.5	110.9	108.6	106.4	107.8

Source: EU KLEMS Growth and Productivity Accounts. This database includes measures of output and input growth, and derived variables such as multifactor productivity at the industry level. The input measures include various categories of capital (K), labour (L), energy (E), material (M) and service inputs (S). The measures are developed for 25 individual EU member states, the US and Japan and cover the period from 1970 to 2007. The variables are organized around the growth accounting methodology, a major advantage of which is that it is rooted in neo-classical production theory. It provides a clear conceptual framework within which the interaction between variables can be analyzed in an internally consistent way. The data series are publicly available on http://www.euklems.net. November 2009 release.

Average Debt And Default Probability Across Devaluation Policies

	Optimal Devaluation Policy	Currency Peg
Debt-to-traded-output ratio (qtr)	60%	20%
Number of Defaults per century	2.6	2.0
Country Premium	3.5%	2.5%

Calibration of the Long-Maturity Debt Model

Parameters specific to the long-maturity debt model: $\eta = 0.05$; $z = 0.03$
Parameters common with the short-maturity debt model that take a different value now: Pick $\beta = 0.969$, $\delta_1 = -0.18319$, $\delta_2 = 0.24558$ to match $E(d_t/y_t^T) = 0.6$, 2.6 defaults, and 5 percent output cost of default.

Debt grid: $[\underline{d}, \overline{d}] = [0, 1]$, $nd = 200$, equally spaced

All other parameters are as in the short-maturity debt model, see Table 1.