Fiscal Devaluations

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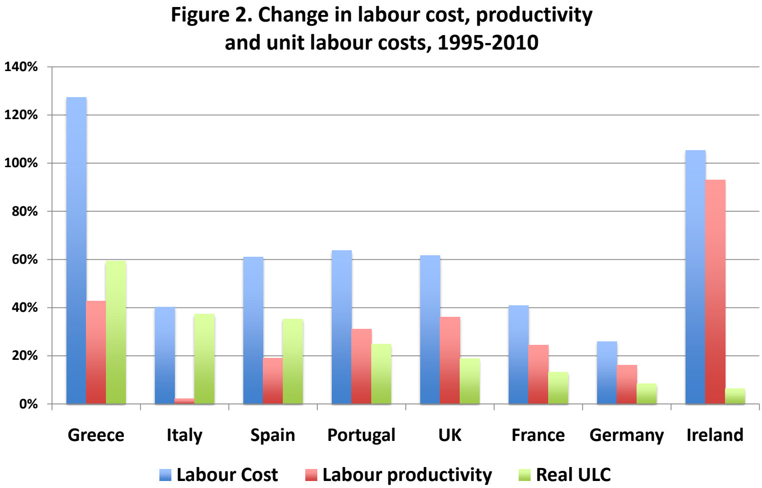
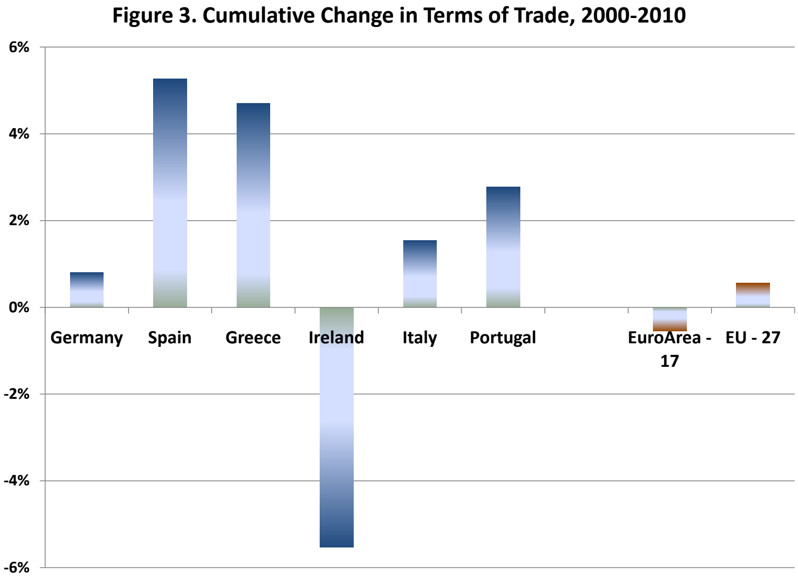
Motivation

- **Currency devaluation**: response to loss of competitiveness
  - New relevance: crisis in the Euro Area
- **Fiscal devaluation**: *set of fiscal policies that lead to the same real outcomes but keeping exchange rate fixed*
  - Old idea (Keynes, 1931): *Uniform tariff cum export subsidy*
  - More recently: *VAT plus payroll subsidy*
    - Cavallo and Cottani (2010), IMF Fiscal Monitor (2011)
- **No longer a theoretical curiosity**
  - France (2012)
  - Germany (2007)

Euro Area: Loss of Competitiveness

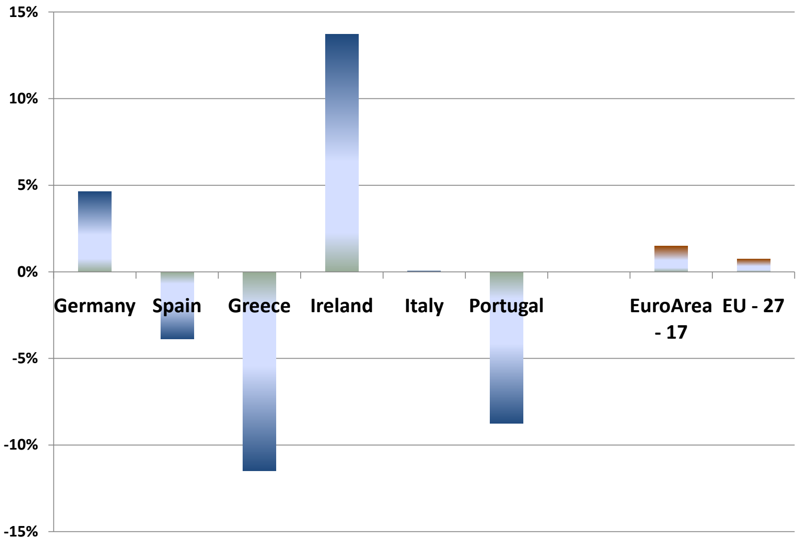


Euro Area: Loss of Competitiveness



Euro Area: Loss of Competitiveness

Figure 1. Trade Deficit as % of GDP, Average over 2000-2010



What we do

- Formal analysis of fiscal devaluations
  - New Keynesian open economy model
  - Dynamic and GE
  - wage and price stickiness (in local or producer currency)
  - arbitrarily rich set of alternative asset market structures
  - general stochastic sequences of devaluations.
  - conventional fiscal instruments
- Example: optimal devaluation, nominal or fiscal ▸ show

What we do

- Formal analysis of fiscal devaluations
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  - — arbitrarily rich set of alternative asset market structures
  - — general stochastic sequences of devaluations.
  - — conventional fiscal instruments
- Example: optimal devaluation, nominal or fiscal ▸ show
- Relate literature
  1. Partial equilibrium: Staiger and Sykes (2010), Berglas (1974)
  2. Fiscal implementation: Adao, Correia and Teles (2009) ▸ cf
  3. Quantitative studies of the VAT effects
  4. Taxes under sticky prices: Poterba, Rotemberg, Summers (1986)

Main Findings

1. **Robust Policies**: *Small* set of *conventional* fiscal instruments suffices for equivalence across various specifications at all horizons. *Unilateral interventions.*

2. **Sufficient Statistic**: Size of tax adjustments functions only of size of desired devaluation and independent of details of environment.

3. **Revenue Neutrality**
   - If restricted set of taxes then increasing in the trade deficit.

Main Findings

1. Two robust Fiscal Devaluation policies

   (FD′) Uniform increase in import tariff and export subsidy

   OR

   (FD″) Uniform increase in value-added tax (with border adjustment) and reduction in payroll tax

2. In general, (FD′) and (FD″) need to be complemented with a reduction in consumption tax and increase in income tax

   — dispensed with if devaluation is unanticipated

3. If debt denominated in home currency, equivalence requires partial default (forgiveness)

Outline

1. Static (one-period) model
2. Full dynamic model
3. Extensions
   - Monetary union
   - Capital
   - Labor mobility
   - Differential short-run tax pass-through
4. Optimal devaluation: an example

Static Model
Setup

- Two countries:
  - Home: Unilateral fiscal and monetary policies.
  - Foreign: Passive

- Households:
  - Preferences: $U(C, N)$ and $C = C_H^{\gamma} C_F^{1-\gamma}$, $\gamma \geq 1/2$
  - Budget constraint

$$\frac{PC}{1+\varsigma^c} + M + T \leq \frac{WN}{1+\tau^n} + \frac{\Pi}{1+\tau^d} + B$$

  - Cash in advance: $PC/(1+\varsigma^c) \leq M$

- Firms: $Y = AN$

$$\Pi = (1-\tau^{v})P_H C_H + (1+\varsigma^{x})\mathcal{E}P_H^{*}C_H^{*} - (1-\varsigma^{p})WN$$

- Government: balanced budget

$$M + T + TR = 0,$$

$$TR = \left(\frac{\tau^{n}}{1+\tau^{n}}WN + \frac{\tau^{d}}{1+\tau^{d}}\Pi - \frac{\varsigma^{c}}{1+\varsigma^{c}}PC\right) + (\tau^{v}P_H C_H - \varsigma^{p}WN) + \left(\frac{\tau^{v}+\tau^{m}}{1+\tau^{m}}P_F C_F - \varsigma^{x}\mathcal{E}P_H^{*}C_H^{*}\right)$$

Equilibrium relationships I

PCP case

1. International relative prices:

$$P_H^* = P_H \frac{1}{\mathcal{E}} \frac{1-\tau^v}{1+\varsigma^x}$$

$$P_F = P_F^* \mathcal{E} \frac{1+\tau^m}{1-\tau^v} \qquad \Rightarrow \qquad \mathcal{S} = \frac{P_F^*}{P_H^*} = \frac{P_F^*}{P_H} \mathcal{E} \frac{1+\varsigma^x}{1-\tau^v}$$

2. Wage and Price setting:

$$P_H = \bar{P}_H^{\theta_p} \left[\mu_p \frac{1-\varsigma^p}{1-\tau^v} \frac{W}{A} \right]^{1-\theta_p}$$

$$W = \bar{W}^{\theta_w} \left[\mu_w \frac{1+\tau^n}{1+\varsigma^c} P C^\sigma N^\varphi \right]^{1-\theta_w},$$

3. Demand — cash in advance:

$$PC \leq M(1+\varsigma^c)$$

Equilibrium relationships II

4. Goods market clearing: $Y = C_H + C_H^*$

5. Exchange rate determination:

   - Budget constraint (allowing for partial default)

$$P^* C^* = P_F^* Y^* - \frac{1-d}{\mathcal{E}} B^h - B^{f*}$$

$$\Rightarrow \qquad \mathcal{E} = \frac{\frac{1-\tau^v}{1+\tau^m} M(1+\varsigma^c) - \frac{1-d}{1-\gamma} B^h}{M^* + \frac{1}{1-\gamma} B^{f*}}$$

Equilibrium relationships II

4. Perfect risk-sharing:

$$\left(\frac{C}{C^*}\right)^{\sigma} = \frac{P^*\mathcal{E}}{P/(1+\varsigma^c)} \equiv \mathcal{Q} \qquad \Rightarrow \qquad \mathcal{E} = \frac{M}{M^*}\mathcal{Q}^{\frac{\sigma-1}{\sigma}}$$

Results I

Proposition

The following policies constitute a fiscal δ-devaluation

1. *under balanced trade or foreign-currency debt:*

$$\left.\begin{array}{ll} (\text{FD}') & \tau^m = \varsigma^x = \delta \\ (\text{FD}'') & \tau^v = \varsigma^p = \frac{\delta}{1+\delta} \end{array}\right\} \quad \textit{and} \quad \varsigma^c = \tau^n = \epsilon, \quad \frac{\Delta M}{M} = \frac{\delta - \epsilon}{1+\epsilon} \quad \forall \epsilon$$

2. *under home-currency debt supplement with partial default:*

$$d = \delta/1 + \delta$$

3. *under complete international risk-sharing need to set:*

$$\epsilon = \delta \qquad \textit{and} \qquad \frac{\Delta M}{M} = -\frac{\sigma - 1}{\sigma}\frac{\Delta \mathcal{Q}}{\mathcal{Q}}$$

Results II

- Local currency pricing: Same fiscal instruments for equivalence
- Law of one price does not hold
- Price setting in consumer currency

- Terms of trade appreciates

$$\mathcal{S} = \frac{P_F}{P_H^*}\frac{1-\tau^v}{\mathcal{E}}$$

- Foreign firm profit margins decline

$$\Pi^* = P_F^* C_F^* + P_F C_F \frac{1-\tau^v}{\mathcal{E}} - W^* N^*$$

- Price setting in consumer currency

$$P_H^* = \bar{P}_H^{*\theta_p}\left[\mu_p \frac{1-\varsigma^p}{1+\varsigma^x}\frac{1}{\mathcal{E}}\frac{W}{A}\right]^{1-\theta_p},$$

- Real effects differ under PCP and LCP

Results III

5. Revenue neutrality

- Revenue neutrality is relative to the fiscal effect of a nominal devaluation
- Result: (FD′) *and* (FD″) *are fiscal revenue-neutral.*

$$
\begin{aligned}
TR &= \frac{\delta}{1+\delta}\left(WN - PC\right) + \frac{\delta}{1+\delta}\left(P_H C_H - WN\right) + \frac{\delta}{1+\delta} P_F C_F \\
&= \left[\frac{\delta}{1+\delta} - \frac{\delta}{1+\delta}\right]\left(PC - WN\right).
\end{aligned}
$$

- If use all four taxes: VAT + payroll, consumption + income
- If use only two: VAT +payroll, TR increasing in the trade deficit.

Features

1. Taxes required for equivalence similar under PCP and LCP
2. Equivalence in real variables *and* nominal prices
   - Redistribution
3. Only a function of size of desired devaluation δ
   - Independent of details of micro frictions

Dynamic model

- Endogenous savings and portfolio decisions
- Dynamic (interest-elastic) money demand
- Arbitrary degrees of asset market completeness

- **Consumers**

$$\max \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U(C_t, N_t, m_t),$$

$$\frac{P_t C_t}{1+\varsigma_t^c} + M_t + \sum_{j \in J_t} Q_t^j B_{t+1}^j \leq \sum_{j \in J_{t-1}} (Q_t^j + D_t^j) B_t^j + M_{t-1} + \frac{W_t N_t}{1+\tau_t^n} + \frac{\Pi_t}{1+\tau_t^d} + T_t.$$

- Nested CES aggregators: $C(C_H, C_F)$, $C_H(\{C_{hi}\})$, $C_F(\{C_{fi}\})$
- Generalizable to: Variable mark-ups, strategic complementarities in pricing, non-homothetic demand

Dynamic model

- **Producers**
- firm i produces according to

$$Y_t(i) = A_t Z_t(i) N_t(i)^\alpha, \qquad 0 < \alpha \leq 1,$$

- Dynamic Calvo price setting ▸ show

$$\sum_{s=t}^{\infty} \theta_p^{s-t} \mathbb{E}_t \left\{ \Theta_{t,s} \frac{\Pi_s^i}{1+\tau_s^d} \right\},$$

- Generalizable to: Menu cost pricing with real menu cost (labor).

- **Government**: Same as static.

- **Equilibrium conditions**
- Consolidated country budget constraint

$$\sum_{j \in \Omega_t} \frac{Q_t^{j*}}{P_t^*} B_{t+1}^j - \sum_{j \in \Omega_{t-1}} \frac{Q_t^{j*} + D_t^{j*}}{P_t^*} B_t^j = \frac{P_{Ht}^*}{P_t^*} \left[C_{Ht}^* - C_{Ft} \mathcal{S}_t \right],$$

where $C_{Ht}^* = (P_{Ht}^*/P_t^*)^{-\zeta} C_t^*$ and $C_{Ft} = (P_{Ft}/P_t)^{-\zeta} C_t$

- $\mathcal{S}_t$ Terms of Trade :

$$\mathcal{S}_t = \frac{P_{Ft}}{P_{Ht}^*} \frac{1}{\mathcal{E}_t} \frac{1 - \tau_t^v}{1 + \tau_t^m}$$

Dynamic model

- International risk sharing condition:

$$\mathbb{E}_t \left\{ \frac{Q^{j*}_{t+1} + D^{j*}_{t+1}}{Q^{j*}_t} \frac{P^*_t}{P^*_{t+1}} \left[\left(\frac{C_{t+1}}{C_t} \right)^{-\sigma} \frac{\mathcal{Q}_{t+1}}{\mathcal{Q}_t} - \left(\frac{C^*_{t+1}}{C^*_t} \right)^{-\sigma} \right] \right\} = 0 \quad \forall j \in \Omega_t$$

- $\mathcal{Q}_t$: Real Exchange Rate

$$\mathcal{Q}_t = \frac{P^*_t \mathcal{E}_t}{P_t / (1 + \varsigma^c_t)}$$

- Pricing equation:

$$\bar{P}_{Ht}(i) = \frac{\rho}{\rho - 1} \frac{\mathbb{E}_t \sum_{s \geq t} (\beta\theta_p)^{s-t} C_s^{-\sigma} P_s^{-1} P_{Hs}^{\rho} (C_{Hs} + C_{Hs}^*) \frac{(1+\varsigma_s^c)(1-\varsigma_s^p)}{1+\tau_s^d} \frac{W_s}{A_s Z_s(i)}}{\mathbb{E}_t \sum_{s \geq t} (\beta\theta_p)^{s-t} C_s^{-\sigma} P_s^{-1} P_{Hs}^{\rho} (C_{Hs} + C_{Hs}^*) \frac{(1+\varsigma_s^c)(1-\tau_s^v)}{1+\tau_s^d}}$$

- Interest elastic money demand

$$\chi C_t^{\sigma} \left(\frac{M_t (1 + \varsigma_t^c)}{P_t} \right)^{-\nu} = \frac{i_{t+1}}{1 + i_{t+1}}$$

Dynamic model

- Definition: *Consider an equilibrium path of the economy with*

$$\mathcal{E}_t = \mathcal{E}_0(1 + \delta_t), \qquad \textit{given} \quad \{M_t\}.$$

Fiscal $\{\delta_t\}$-devaluation is a sequence

$$\{M'_t, \tau^m_t, \varsigma^x_t, \tau^v_t, \varsigma^p_t, \varsigma^c_t, \tau^n_t, \tau^d_t\}$$

that leads to the same real allocation, but with $\mathcal{E}'_t \equiv \mathcal{E}_0$.

— Anticipated and unanticipated devaluations

Proposition

Under complete international asset markets a fiscal $\{\delta_t\}$-devaluation can be achieved by one of the two policies:

$$\tau_t^m = \varsigma_t^x = \varsigma_t^c = \tau_t^n = \tau_t^d = \delta_t \qquad \text{for} \quad t \geq 0, \quad \text{or} \qquad (\text{FD}'_F)$$

$$\tau_t^v = \varsigma_t^p = \frac{\delta_t}{1+\delta_t}, \qquad \varsigma_t^c = \tau_t^n = \delta_t \qquad \text{and} \qquad \tau_t^d = 0 \qquad \text{for} \quad t \geq 0; \qquad (\text{FD}''_F)$$

as well as a suitable choice of M'_t for $t \geq 0$.

— analogous to static economy: terms of trade, RER
— interest-elastic money demand: no additional tax instruments

$$\chi C_t^\sigma \left(\frac{M_t(1+\varsigma_t^c)}{P_t} \right)^{-\nu} = \frac{i_{t+1}}{1+i_{t+1}}$$

Result II

Incomplete markets

Lemma

Under arbitrary international asset markets, (FD'_F) and (FD''_F) constitute a fiscal devaluation as long as the foreign-currency payoffs of all assets $\{D_t^{j*}\}_{j,t}$ are unchanged.

- (FD'_F) and (FD''_F) replicate changes in all relative prices and price levels
- Require that $\{D_t^{j*}, Q_t^{j*}\}$ are unchanged

$$Q_t^{j*} = \sum_{s \geq t} \mathbb{E}_t\{\Theta_{t,s}^* D_s^{j*}\},$$

- Under no-bubble asset pricing require that the path of foreign-currency nominal asset payoffs $\{D_t^{j*}\}$ is unchanged.

Result II
Incomplete markets

- Foreign-currency risk-free bond
  $D^{f*}_{t+1} \equiv 1$ in foreign currency and its foreign-currency price is

$$Q^{f*}_t = \mathbb{E}_t \left\{ \Theta^*_{t+1} \right\} = \frac{1}{1 + i^*_{t+1}},$$

- Equities

$$\frac{D^e_t}{\mathcal{E}_t} = \frac{\Pi_t}{[1 + \tau^d_t]\mathcal{E}_t} \qquad \text{and} \qquad D^{e*}_t = \Pi^*_t.$$

- No additional instruments required

Result II
Incomplete markets

- Local-currency risk-free bond
  $D_{t+1}^{h} = 1$ in home currency and $D_{t+1}^{h*} = 1/\mathcal{E}_{t+1}$ in foreign-currency.

- Need partial default (haircut, τ_t^h) to make its foreign-currency payoff the same as in a nominal devaluation:

$$D_{t+1}^{h*} = \frac{1 - \tau_{t+1}^{h}}{\mathcal{E}_{t+1}},$$

  and hence price

$$Q_t^{h*} = \mathbb{E}_t \left\{ \Theta_{t+1}^{*} \frac{1 - \tau_{t+1}^{h}}{\mathcal{E}_{t+1}} \right\}.$$

$$\tau_t^h = \frac{\delta_t - \delta_{t-1}}{1 + \delta_t}$$

Result III
Unanticipated devaluation

Proposition

A one-time unanticipated fiscal δ-devaluation in an incomplete markets economy:

$$\left.\begin{array}{ll} (\text{FDD}') & \tau_t^m = \varsigma_t^x = \delta \\ (\text{FDD}'') & \tau_t^v = \varsigma_t^p = \frac{\delta}{1+\delta} \end{array}\right\} \quad \textit{and} \quad M_t' \equiv M_t.$$

— No consumption subsidy needed

— Applies to risk-free bonds and international equities economies

— Home-currency debt: one-time partial default $d = \delta/(1+\delta)$

Extensions: Implementation in a Monetary Union

- Coordination with union central bank:
  - Union-wide money supply:

$$\bar{M}_t = M_t + M_t^*$$

    - M_t / M_t^* is endogenous
  - Division of seigniorage between members:

$$\Delta \bar{M}_t = \Omega_t + \Omega_t^*$$

- Special cases: unilateral fiscal adjustment suffices
  - seigniorage is small ($\Delta \bar{M}_t \to 0$)
  - devaluing country is small ($\Delta \bar{M}_t / \bar{M}_t \to 0$)

Implementation

1. Non-uniform VAT (e.g., non-tradables)
   — match payroll subsidy

2. Multiple variable inputs (e.g., capital)
   — uniform subsidy
   — Model w/capital

3. Tax pass-through assumptions: equivalence of
   — VAT and exchange rate pass-through into foreign prices
   — VAT and payroll tax pass-through into domestic prices
   — Generalization

4. Quantitative investigation show

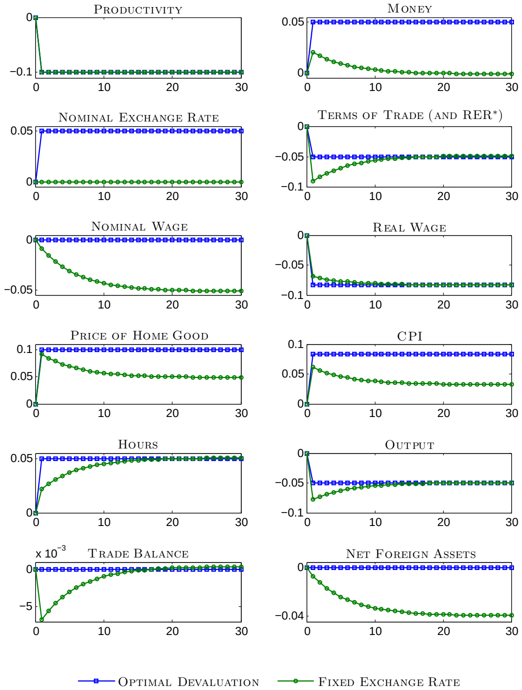
Optimal Devaluation

Setup

- Small open economy
- Flexible prices, sticky wages
- Permanent unexpected negative productivity shock
- Nominal devaluation is optimal
- Fiscal devaluation requires no consumption subsidy (VAT+payroll or tariff+subsidy)

- Parameters:

$$\beta = 0.99, \quad \theta_w = 0.75, \quad \gamma = 2/3, \quad \sigma = 4, \quad \varphi = \kappa = 1, \quad \eta = 3$$


Productivity
Money
Nominal Exchange Rate
Terms of Trade (and RER*)
Nominal Wage
Real Wage
Price of Home Good
CPI
Hours
Output
x 10^−3
Trade Balance
Net Foreign Assets
Optimal Devaluation
Fixed Exchange Rate

Summary

- **Robust Policies**: *Small* set of *conventional* fiscal instruments suffices for equivalence.
  - — uniform import tariff and export subsidy
  - — uniform increase in VAT and reduction in payroll tax
- Unanticipated devaluation: no additional instruments
- More generally does not suffice: Anticipated devaluations
  - Replicate savings/portfolio decisions
  - Exact equivalence in reset prices.
- **Sufficient Statistic**: $\tau_t^v = \dfrac{\bar{\tau}_0^v + \delta_t}{1 + \delta_t}$
- **Revenue Neutrality**
- Sidesteps the trilemma in international macro

Quotes

- Popular arguments for abandoning Euro and devaluation:
  - Feldstein (FT 02/2010):

    If Greece still had its own currency, it could, in parallel, devalue the drachma to reduce imports and raise exports... The rest of the eurozone could allow Greece to take a temporary leave of absence with the right and the obligation to return at a more competitive exchange rate.

  - Krugman (NYT): *Why devalue? The Euro Trap, Pain in Spain*

    Now, if Greece had its own currency, it could try to offset this contraction with an expansionary monetary policy – including a devaluation to gain export competitiveness. As long as its in the euro, however, Greece can do nothing to limit the macroeconomic costs of fiscal contraction.

  - Roubini (FT 06/2011): *The Eurozone Heads for Break Up*

    ...there is really only one other way to restore competitiveness and growth on the periphery: leave the euro, go back to national currencies and achieve a massive nominal and real depreciation.

- Keynes (1931) in the context of Gold standard

  Precisely the same effects as those produced by a devaluation of sterling by a given percentage could be brought about by a tariff of the same percentage on all imports together with an equal subsidy on all exports, except that this measure would leave sterling international obligations unchanged in terms of gold.

back to slides

Related Literature

Comparison to ACT (Adao, Correia and Teles, JET, 2009)

	ACT (2009)	FGI (2011)	
Allocation	Flexible-price (first best)	Nominal devaluation	— one-time unexpected
Implementation	General non-constructive fiscal implementation principle	Specific implementation: — simplicity, robustness, feasibility	
Environment			
– Nominal frictions	Sticky prices (PCP or LCP)	Sticky prices (PCP and LCP) and sticky wages	
– Int'l asset markets	Risk-free nominal bonds	Arbitrary degree of completeness	Arbitrary incomplete markets
Instruments	Separate consumption taxes by origin of the good and income taxes in both countries; additional instruments in other cases	VAT, payroll, consumption and income tax in one country	VAT and payroll tax only in one country
Implementability			
– Analytical characterization of taxes	No	Yes, simple characterization and expressions	
– Int'l coordination of taxes	Yes	No, unilateral policy	
– Tax dependence on microenvironment	In general, yes	No, robust to any changes in environment	
– Tax dynamics	In general, complex dynamic path	Path of taxes follows the path of devaluation	Only one-time tax change

back to slides

Local currency pricing

- Law of one price does not hold

- Price setting in consumer currency

$$P_H^* = \bar{P}_H^{*\theta_p} \left[\mu_p \frac{1-\varsigma^p}{1+\varsigma^x} \frac{1}{\mathcal{E}} \frac{W}{A} \right]^{1-\theta_p},$$

$$P_F = \bar{P}_F^{\theta_p} \left[\mu_p \frac{1+\tau^m}{1-\tau^v} \mathcal{E} \frac{W^*}{A^*} \right]^{1-\theta_p}$$

- Terms of trade appreciates

$$\mathcal{S} = \frac{P_F}{P_H^*} \frac{1}{\mathcal{E}} \frac{1-\tau^v}{1+\tau^m}$$

- Foreign firm profit margins decline

$$\Pi^* = P_F^* C_F^* + P_F C_F \frac{1}{\mathcal{E}} \frac{1-\tau^v}{1+\tau^m} - W^* N^*$$

back to slides

Price setting

$$\bar{P}_{Ht} = \frac{\mathbb{E}_t \sum_{s \geq t} (\beta\theta_p)^{s-t} C_s^{-\sigma} P_s^{-1} P_{Hs}^{\rho} Y_s \frac{\rho}{\rho-1} \frac{(1+\varsigma_s^c)(1-\varsigma_s^p)}{1+\tau_s^d} W_s / A_s}{\mathbb{E}_t \sum_{s \geq t} (\beta\theta_p)^{s-t} C_s^{-\sigma} P_s^{-1} \frac{(1+\varsigma_s^c)(1-\tau_s^v)}{1+\tau_s^d}},$$

- Under (FDD″), $(1+\varsigma_s^c)(1-\tau_s^v) = (1+\varsigma_s^c)(1-\varsigma_s^p) = 1$, therefore the reset price $\bar{P}_{Ht}$ stays the same, and hence so does P_{Ht}
- (FDD′) additionally requires compensating with $\tau_s^d = \delta_t$, unless devaluation is unanticipated

back to slides

Home-currency Bond

- Partial defaults on home-currency bonds: contingent sequence $\{d_t\}$
- The international risk sharing condition becomes

$$\begin{aligned} Q_t &= \beta \mathbb{E}_t \left\{ \left(\frac{C^*_{t+1}}{C^*_t} \right)^{-\sigma} \frac{P^*_t \mathcal{E}_t}{P^*_{t+1} \mathcal{E}_{t+1}} (1 - d_{t+1}) \right\} \\ &= \beta \mathbb{E}_t \left\{ \left(\frac{C_{t+1}}{C_t} \right)^{-\sigma} \frac{P_t}{P_{t+1}} \frac{1 + \varsigma^c_{t+1}}{1 + \varsigma^c_t} (1 - d_{t+1}) \right\}, \end{aligned}$$

- Country budget constraint can now be written as

$$Q_t \frac{1}{\mathcal{E}_t} B^h_{t+1} - (1 - d_t) \frac{\mathcal{E}_{t-1}}{\mathcal{E}_t} \frac{1}{\mathcal{E}_{t-1}} B^h_t = (1 - \gamma) \left[P^*_t C^*_t - P_t C_t \frac{1}{\mathcal{E}_t} \frac{1 - \tau^v_t}{1 + \tau^m_t} \right]$$

back to slides

International trade in equities

- Budget constraint

$$\frac{P_t C_t}{1+\varsigma_t^c} + M_t + (\omega_{t+1} - \omega_t)\,\mathbb{E}_t\left\{\Theta_{t+1} V_{t+1}\right\} - (\omega_{t+1}^* - \omega_t^*)\,\mathbb{E}_t\left\{\Theta_{t+1}\mathcal{E}_{t+1} V_{t+1}^*\right\}$$
$$\leq \frac{W_t N_t}{1+\tau_t^n} + \omega_t \frac{\Pi_t}{1+\tau_t^d} + (1-\omega_t^*)\mathcal{E}_t \Pi_t^* + M_{t-1} - T_t,$$

- Value of the firm:

$$V_t = \mathbb{E}_t \sum_{s=t}^{\infty} \Theta_{t,s} \frac{\Pi_s}{1+\tau_s^d}, \qquad \Theta_{t,s} = \prod_{\ell=t+1}^{s} \Theta_\ell, \;\; \Theta_\ell = \beta \left(\frac{C_{t+1}}{C_t}\right)^{-\sigma} \frac{P_t}{P_{t+1}} \frac{1+\varsigma_{t+1}^c}{1+\varsigma_t^c},$$
$$V_t^* = \mathbb{E}_t \sum_{s=t}^{\infty} \Theta_{t,s}^* \Pi_s^*$$

- Risk-sharing conditions

$$\mathbb{E}_t \sum_{s=t}^{\infty} \left(\Theta_{t,s} - \Theta_{t,s}^* \frac{\mathcal{E}_t}{\mathcal{E}_s}\right) \frac{\Pi_s}{1+\tau_s^d} = 0 \quad \text{and} \quad \mathbb{E}_t \sum_{s=t}^{\infty} \left(\Theta_{t,s} \frac{\mathcal{E}_s}{\mathcal{E}_t} - \Theta_{t,s}^*\right) \Pi_s^* = 0.$$

back to slides

Model with capital

- Choice of capital input by firms:

$$\frac{L_t}{K_t} = \frac{\alpha}{1-\alpha} \frac{(1-\varsigma_t^r)}{(1-\varsigma_t^p)} \frac{R_t}{W_t}$$

- Choice of capital investment by households:

$$U_{c,t} \frac{(1+\varsigma_t^c)}{(1+\varsigma_t^i)} = \beta \mathbb{E}_t U_{c,t+1} \left[\frac{R_{t+1}}{P_{t+1}} \frac{(1+\varsigma_{t+1}^c)}{(1+\tau_{t+1}^k)} + (1-\delta) \frac{(1+\varsigma_{t+1}^c)}{(1+\varsigma_{t+1}^i)} \right]$$

- Results:

  1. When consumption subsidy ς_t^c is not used, only capital expenditure subsidy to firms ς_t^r is required (parallel to payroll subsidy). All variable inputs should be subsidized uniformly
  2. Otherwise, investment subsidy and capital income tax need to be used in addition:

$$\varsigma_t^i = \tau_t^k = \varsigma_t^c = \delta_t$$

back to slides

Pass-through of VAT and payroll tax

- Static model with differential pass-through $\xi_p > \xi_\tau$:

$$P_H = \left[\bar{P}_H \cdot \frac{(1-\varsigma^p)^{\xi_p}}{(1-\tau^v)^{\xi_\tau}}\right]^{\theta_p} \left[\mu_p \frac{1-\varsigma^p}{1-\tau^v} \frac{W}{A}\right]^{1-\theta_p}$$

Proposition

Fiscal devaluation is as characterized in Results I-III, but with payroll subsidy given by

$$\varsigma^p = 1 - \left(\frac{1}{1+\delta}\right)^{\frac{\xi_v \theta_p + 1 - \theta_p}{\xi_p \theta_p + 1 - \theta_p}} .$$

- still $\tau^v = \delta/(1+\delta)$, to mimic international relative prices
- $\xi_v > \xi_p$ implies $\varsigma^p > \tau^v = \delta/(1+\delta)$
- as θ_p decreases towards 0, ς^p decreases towards $\delta/(1+\delta)$

back to slides

Quantitative investigation

Source: Gopinath and Wang (2011)

	Germany	Spain	Portugal	Italy	Greece
Taxes					
— VAT	13%	7%	11%	9%	8%
— payroll contributions	14%	18%	9%	24%	12%
— including employee's SSC	27%	22%	16%	29%	22%
% change, 1995-2010					
– wages	25%	61%	64%	39%	127%
– productivity	17%	19%	28%	3%	42%
Required devaluation*		34%	28%	28%	77%
Maximal fiscal devaluation**		23%	11%	32%	14%
— with German fiscal revaluation		38%	26%	47%	29%
— additionally reducing employee's SSC		43%	34%	56%	43%

- Required devaluation brings unit labor cost (W_t/A_t) relative to Germany to its 1995 ratio
- Maximal fiscal devaluation is constrained by zero lower bound on payroll contributions and 45% maximal VAT rate (which is never binding). A reduction of x in payroll tax and similar increase in VAT is equivalent to a $x/(1-x)$ devaluation
- Maximal German revaluation is an additional decrease in German VAT of 13% and a similar increase in German payroll tax, equivalent to an additional 15% devaluation against Germany

back to slides

Optimal Devaluation

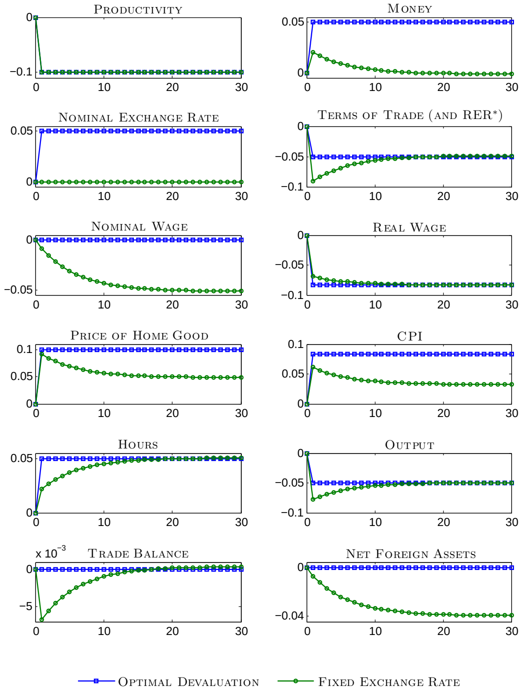
Setup

- Small open economy
- Flexible prices, sticky wages
- Permanent unexpected negative productivity shock
- Nominal devaluation is optimal
- Fiscal devaluation requires no consumption subsidy (VAT+payroll, or tariff+subsidy)

- Parameters:

$$\beta = 0.99, \quad \theta_w = 0.75, \quad \gamma = 2/3, \quad \sigma = 4, \quad \varphi = \kappa = 1, \quad \eta = 3$$

back to slides


Productivity
Money
Nominal Exchange Rate
Terms of Trade (and RER*)
Nominal Wage
Real Wage
Price of Home Good
CPI
Hours
Output
x 10⁻³
Trade Balance
Net Foreign Assets
Optimal Devaluation
Fixed Exchange Rate