BANK FOR INTERNATIONAL SETTLEMENTS

An analysis of devaluations and output dynamics in Latin America using an estimated DSGE model

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Motivation

Latin America has a long history of currency devaluations

- These episodes have often been associated with output contractions.
- In fact, it is quite common for economists to argue that devaluations are contractionary.

Are currency devaluations expansionary or contractionary in terms of output?

- The standard macroeconomic literature (i.e. Mundell-Fleming) posits that devaluations are expansionary.
- However, recent financial crises have questioned this outcome.
- In fact, Krugman (1999) argues that the worsening of firms´ balance sheets following a devaluation may lead to a contraction of output.
- As Magendzo (2002) says:

"Given the theoretical disagreement on the effect of a devaluation on output, empirical evidence plays a fundamental role."

Empirically, the relative importance of different transmission channels is open to debate

- Reduced form analysis provides no conclusive answers (Magendzo, 2002; Gupta et al, 2003; Tovar, 2004).

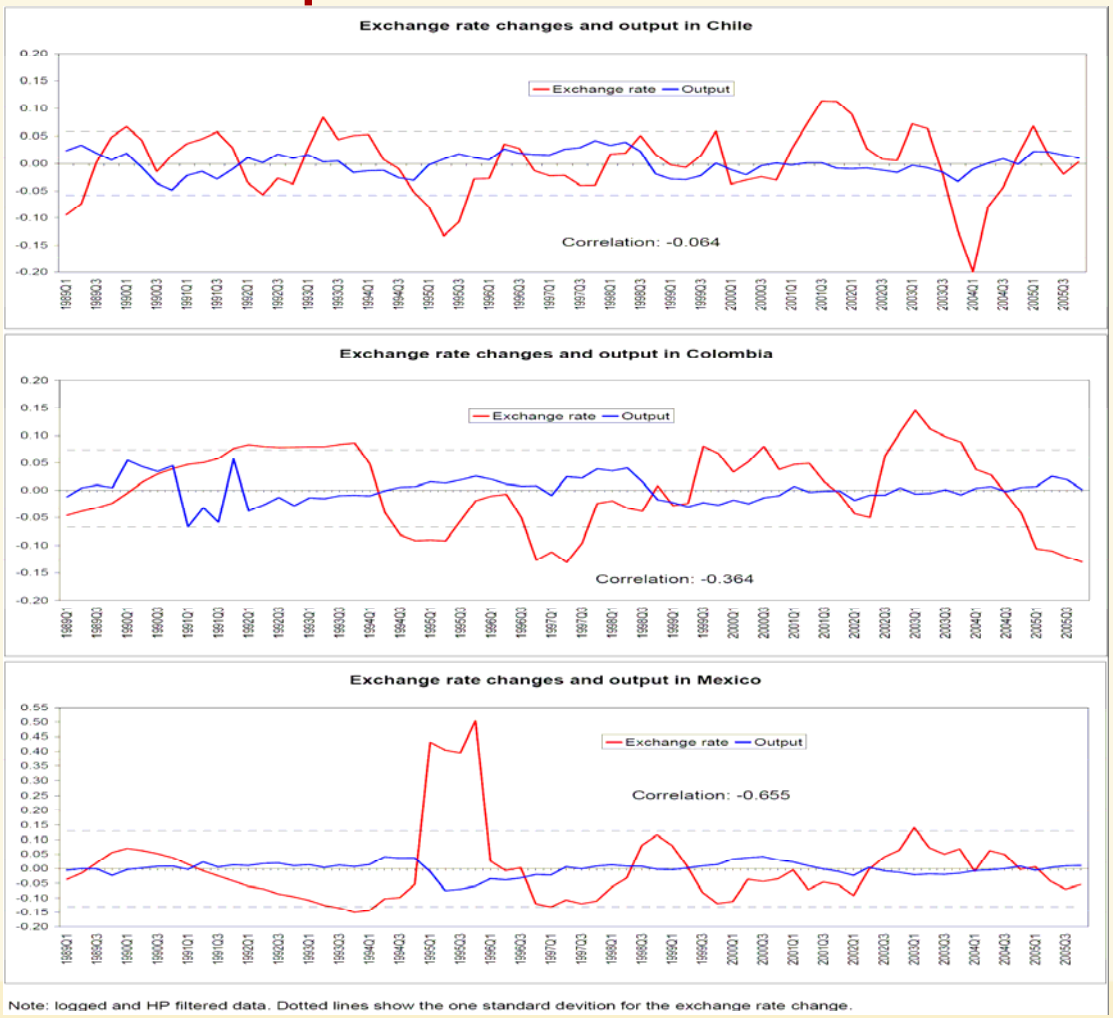
"Without controlling for selection bias I find devaluations to be associated with a growth rate that is 2 percentage points lower than otherwise predicted. However, after controlling for selection bias, the contractionary effect of devaluations disappears. […] These results are robust: devaluations show no statistically significant effect on output growth." *Magendzo, 2002*

- Overall, these empirical studies have limitations in identifying and isolating the relative importance of the different transmission channels involved.

This paper estimates a DSGE model

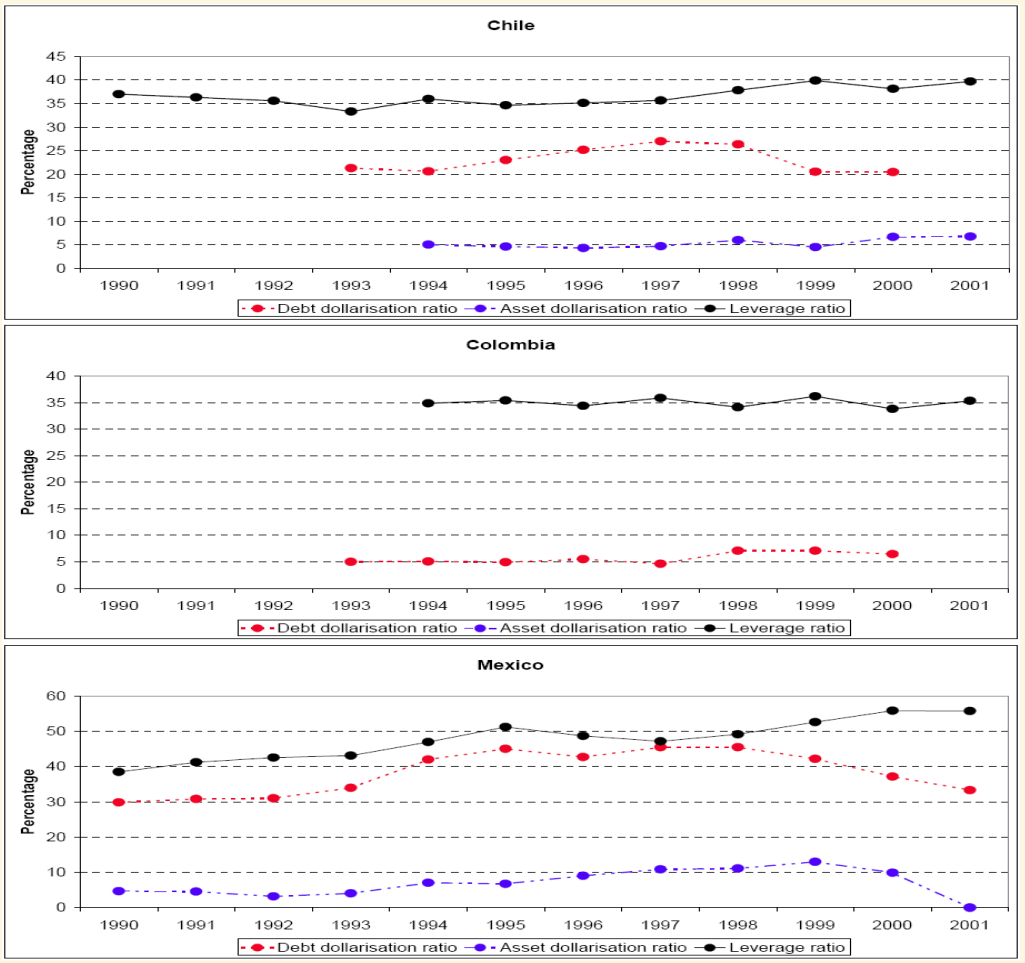
- Its main objective is:
  - To assess empirically the impact of currency devaluations on output in three Latin American economies: Chile, Colombia and Mexico.
  - Disentangle the relative importance of key transmission channels. In particular, the expenditure-switching effect and the balance sheet effect.
  - And shed some light on whether one should blame policy-induced devaluations or sudden stops for the sharp contraction of output.

What is the relationship between currency fluctuations and output in Latin America?



Note: logged and HP filtered data. Dotted lines show the one standard devition for the exchange rate change.

How relevant is the balance sheet effect? Evidence on currency mismatches



Source: Kamil (2004)

Taking a DSGE model to the data is no easy task in general …

...but even more complicated is to estimate a model of this kind for a Latin American economy

Modelling considerations

- To answer the main question of the paper it is essential to ask: What are the most relevant transmission channels through which devaluations affect output?
- Agénor and Montiel (1999) survey the literature and highlight the different channels that may operate:
  - Aggregate demand (relative price effects, real income effects, imported input costs effects, real tax effects, etc).
  - Aggregate supply (wages, use of imported inputs, or the cost of working capital).
- The idea is to focus on the most relevant channels highlighted in the recent literature: expenditure switching and balance sheet effects.

Some considerations on modelling Latin American economies

- During the last two decades the economies in the region have gone through deep structural transformations, including major shifts in:
  - The degree of trade and financial openness.
  - Monetary and exchange rate regimes (key concern in this paper).
- The economies in the region have also been affected by large shocks:
  - This has meant sharp cycles. Is the business cycle the trend? (Aguiar and Gopinath, 2004).
  - Some series have experienced trending behaviour which are not easily modelled (eg inflation).

Changes in monetary and exchange rate regimes

- Chile:
  - 1990s: Inflation target (set in 1990) and an exchange rate target (1984-1999) achieved through a crawling band. Current account target.
  - 1999-2006: IT regime. Floating exchange rate (No fear of floating).
- Colombia:
  - 1990s: Inflation target (set in 1991) and an exchange rate target (1991-1999).
  - 1999-2006: IT regime. Floating exchange rate (fear of floating).
- Mexico:
  - 1990- early 1994: Inflation target and moving band.
  - 1994: Inflation target and moving band. However the exchange rate remained in the ceiling of the band so it was effectively a fixed rate regime.
  - 1995-2006: Floating exchange rate. From 1999 on, an IT regime.

Some considerations on modelling Latin American economies

- Estimating a DSGE for different economies in the region is another challenge because each economy is likely to have a different structure.

- As a result, the model has to be flexible enough to capture key features of all economies.

The model

Framework

- Céspedes, Chang and Velasco's (2004, 2003) model is extended by Tovar (2005).
- Key features are:
  - Fully dynamic model.
  - Endogenous nominal rigidities → Quadratic adjustment costs
  - Endogenous monetary policy → Interest rate rule
  - To avoid the stochastic singularity problems arising in the estimation of DSGE models two approaches are followed:
    - 8 structural shocks are incorporated (preferences, technology, cost-push, international interest rates, export demand, inflation target, output target and nominal exchange rate target).
    - Measurement errors are included as a robustness check.

Framework

- There are two mechanisms through which devaluations affect output:
  - Expenditure-switching effect: a devaluation affects relative prices and therefore the demand for domestically produced goods.
  - Balance sheet effect: if debts are denominated in dollars while firms' revenues are denominated in domestic currency, unexpected changes in the exchange rate will affect firms' balance sheets. The deterioration of balance sheets has two implications:
    - It limits firms' capacity to borrow and invest.
    - Borrowing becomes more expensive endogenously as the risk premium increases.

Framework

Households

•Consume, borrow and supply labour in a monopolistically competitive manner (set wages)

•Face wage adjustment cost.

•Subject to a preference shock.

Firms

•Rent capital and hire labour.

•Produce in a monopolistically competitive market (set prices).

•Subject to a technology and cost-push shock.

Entrepreneurs

•Own firms and rent capital to them.

•Decide how much to invest. So they borrow in international capital markets by issuing foreign currency denominated debt contracts.

•Due to imperfections in international capital markets entrepreneurs face a risk premium over the international risk free interest rate.

Monetary authority

•Conducts monetary policy through an interest rate rule.

•There are three time-varying targets:

- •Expected inflation
- •Output
- •Nominal exchange rate

Firms´ problem

$$\underset{L_{jt},K_{jt}}{Max}\ E_o \sum_{t=0}^{\infty} \Delta_t \left(P_{jt}Y_{jt} - \int_0^1 W_{ijt}L_{ijt}di - R_tK_{jt} - P_tAC_t^P \right) \tag{1}$$

$$Y_{jt} = A_t K_{jt}^{\alpha} L_{jt}^{1-\alpha}, \quad 0 < \alpha < 1 \tag{2}$$

$$P_{jt} = \left[\frac{Y_{jt}}{Y_t} \right]^{-\frac{1}{\theta_t}} P_t, \quad \theta_t > 1 \tag{3}$$

$$AC_t^P = \frac{\psi_p}{2} \left[\frac{P_{jt}}{P_{jt-1}} - \bar{f}^p \right]^2 Y_t \tag{4}$$

$$L_{jt} = \left[\int_0^1 L_{ijt}^{\frac{\sigma-1}{\sigma}} di \right]^{\frac{\sigma}{\sigma-1}}, \quad \sigma > 1 \tag{5}$$

Households´ problem

$$\underset{C_{it},L_{it},B_{it},B_{it}^{*}}{Max} E_o \sum_{t=0}^{\infty} \beta^t a_t \left(lnC_{it} - \left(\frac{\sigma - 1}{\sigma} \right) \frac{1}{\nu} L_{it}^{\nu} \right)$$

$$C_{it} = \kappa \left(C_{it}^{H} \right)^{\gamma} \left(C_{it}^{F} \right)^{1-\gamma}, \; 0 < \gamma < 1 \tag{6}$$

$$P_t C_{it}^{H} + S_t C_{it}^{F} = Q_t C_{it} \tag{7}$$

$$B_{it} - B_{it-1} + S_t \left(B_{it}^{*} - B_{it-1}^{*} \right) = i_{t-1} B_{it-1} + S_t i_{t-1}^{*} B_{t-1}^{*} + W_{it} L_{it} - AC_t^{w} - Q_t C_{it} \tag{8}$$

$$W_{it} = \left(\frac{L_{it}}{L_t} \right)^{-\frac{1}{\sigma}} W_t \tag{9}$$

$$AC_t^{w} = \frac{\psi_w}{2} \left[\frac{W_{it}}{W_{it-1}} - \bar{\Omega}\bar{\pi} \right]^2 W_t \tag{10}$$

Entrepreneurs' problem

- The entrepreneurs own firms and rent capital to them. Their main activity is to finance investment, which they do by issuing dollar denominated debt in international markets.

- Formally, entrepreneurs engage in an optimal debt contract with costly state verification (à la Bernanke, Gertler and Gilchrist, 1999 and extended to open economies by Céspedes, Chang and Velasco, 2004).

- The full microeconomic problem is derived in Tovar (2005). In what follows, and for simplicity, I only report the optimality conditions derived from this debt problem with costly state verification.

Entrepreneurs' problem

- Any investment in excess of net worth is financed in international markets:

$$Q_t K_{t+1} = P_t N_t + S_t D_{t+1} \qquad (11)$$

- Due to costly state verification, entrepreneurs borrow abroad at a risk premium above the world risk free interest rate. The risk premium is an increasing concave function of the ratio of investment to net worth:

$$1 + \eta_t = \left(\frac{Q_t K_{t+1}}{P_t N_t} \right)^{\mu} \qquad (12)$$

Entrepreneurs' problem

- In equilibrium, the expected yield of capital in foreign currency must equal the cost of borrowing in international capital markets to finance capital investment:

$$\frac{E_t\left(R_{t+1}K_{t+1}/S_{t+1}\right)}{Q_tK_{t+1}/S_t} = \left(1+\rho_t\right)\left(1+\eta_t\right) \qquad (13)$$

- Net worth is defined as:

$$P_tN_t = R_tK_t + \Pi_t - S_tD_t \qquad (14)$$

Monetary policy

- Monetary policy follows and interest rate rule with partial adjustment. There are three targets: expected inflation, output and the nominal exchange rate.

$$\frac{1+\tilde{i}_t}{1+\bar{i}} = \left(\frac{E_t\pi_{t+1}}{\bar{\pi}_t}\right)^{\omega_\pi} \left(\frac{Y_t}{\bar{Y}_t}\right)^{\omega_y} \left(\frac{S_t}{\bar{S}_t}\right)^{\frac{\omega_s}{1-\omega_s}} \tag{15}$$

where $\omega_\pi,\ \omega_y,\ \omega_s$ and $\omega_i \in [0,1]$.

$$\frac{1+i_t}{1+\bar{i}} = \left(\frac{1+i_{t-1}}{1+\bar{i}}\right)^{\omega_i} \left(\frac{1+\tilde{i}_t}{1+\bar{i}}\right)^{1-\omega_i} \tag{16}$$

- KEY: A devaluation is defined as an increase in: $\bar{S}_t$

Market clearing

$$P_t Y_t = \gamma Q_t \left(K_{t+1} + C_t\right) + \frac{\psi_p}{2}\left(f_t^p - \bar{f}^p\right)^2 P_t Y_t + S_t X_t \qquad (18)$$

Estimation method

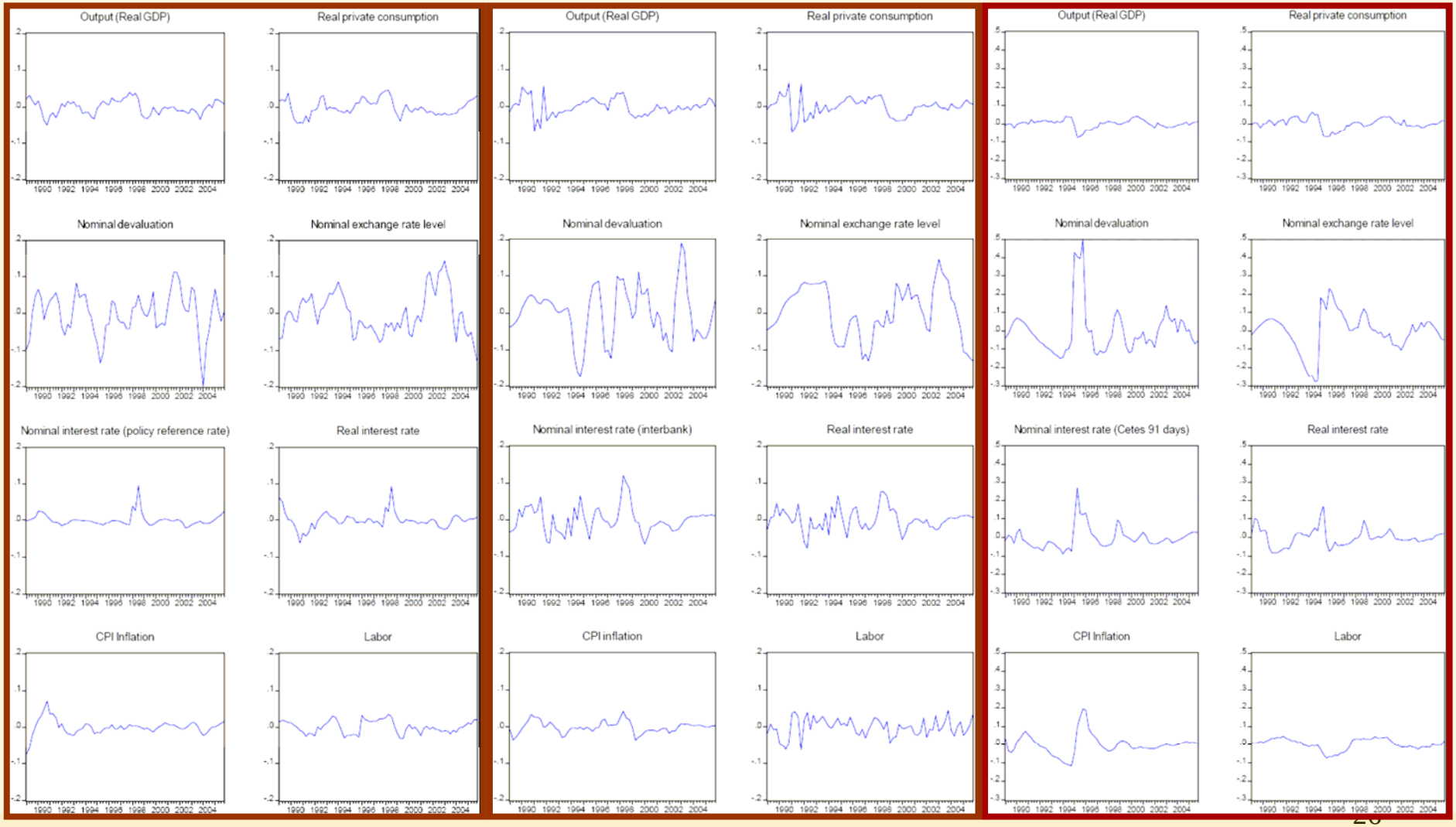
- The model is log-linearised around the non-stochastic symmetric steady-state and solved using the method of undetermined coefficients.

- Then, the model is written in state-space form (with and without measurement errors which are incorporated into the observation equations).

- The Kalman filter is used to construct the likelihood function, and the parameters are estimated maximising this function.

- Model is estimated for Chile, Colombia and Mexico using quarterly data from 1989:1 through 2005:4.

Chile | Colombia | Mexico



Logged and HP filtered

Estimation results

Calibrated parameter values

Table 1: **Benchmark parameter values for estimation**

Preferences		Technology	
-Discount factor	$\beta = 0.99$	-Capital share	$\alpha = 0.4$
-Elasticity of labor supply	$\nu = 2$	-Elasticity of labor demand	$\sigma = 2$
-Elasticity of substitution b/w different varieties	$\theta = 6$		

Estimated parameter values

Table 2: **Maximum likelihood estimates: main parameter values**

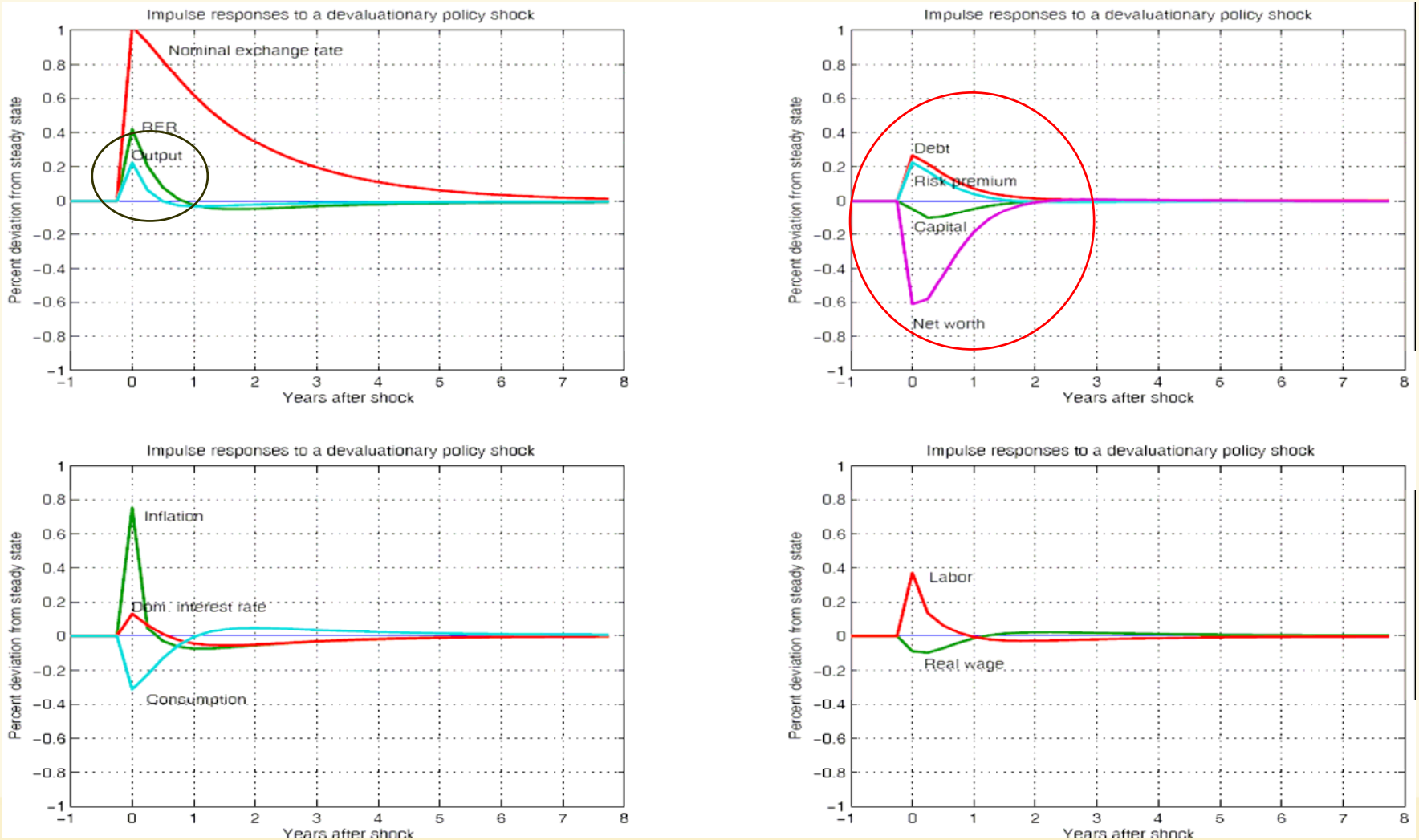
	Chile		Colombia		Mexico	
	Estimate	Std Error	Estimate	Std. Error	Estimate	Std. Error
Transmission channels of devaluations						
- Balance sheet, μ	0.31	0.0019	0.23	0.0021	0.14	0.0030
- Expenditure switching, γ	0.62	0.0012	0.68	0.0046	0.63	0.0034
Interest rate response to:						
- Lagged interest rate, ω_i	0.03	0.0014	0.53	0.0024	0.55	0.0029
- Expected inflation, ω_p	1.93	0.0013	1.98	0.0012	2.50	0.0024
- Output, ω_y	0.04	0.0011	0.16	0.0033	1.14	0.0049
- Nominal exchange rate, ω_s	0.66	0.0007	0.92	0.0028	0.58	0.0029
Nominal rigidities						
- Price rigidities, ψ_p	7.13	0.0050	6.38	0.0024	4.60	0.0024
- Wage rigidities, ψ_w	0.86	0.0010	1.53	0.0030	0.24	0.0043

Estimated parameter values

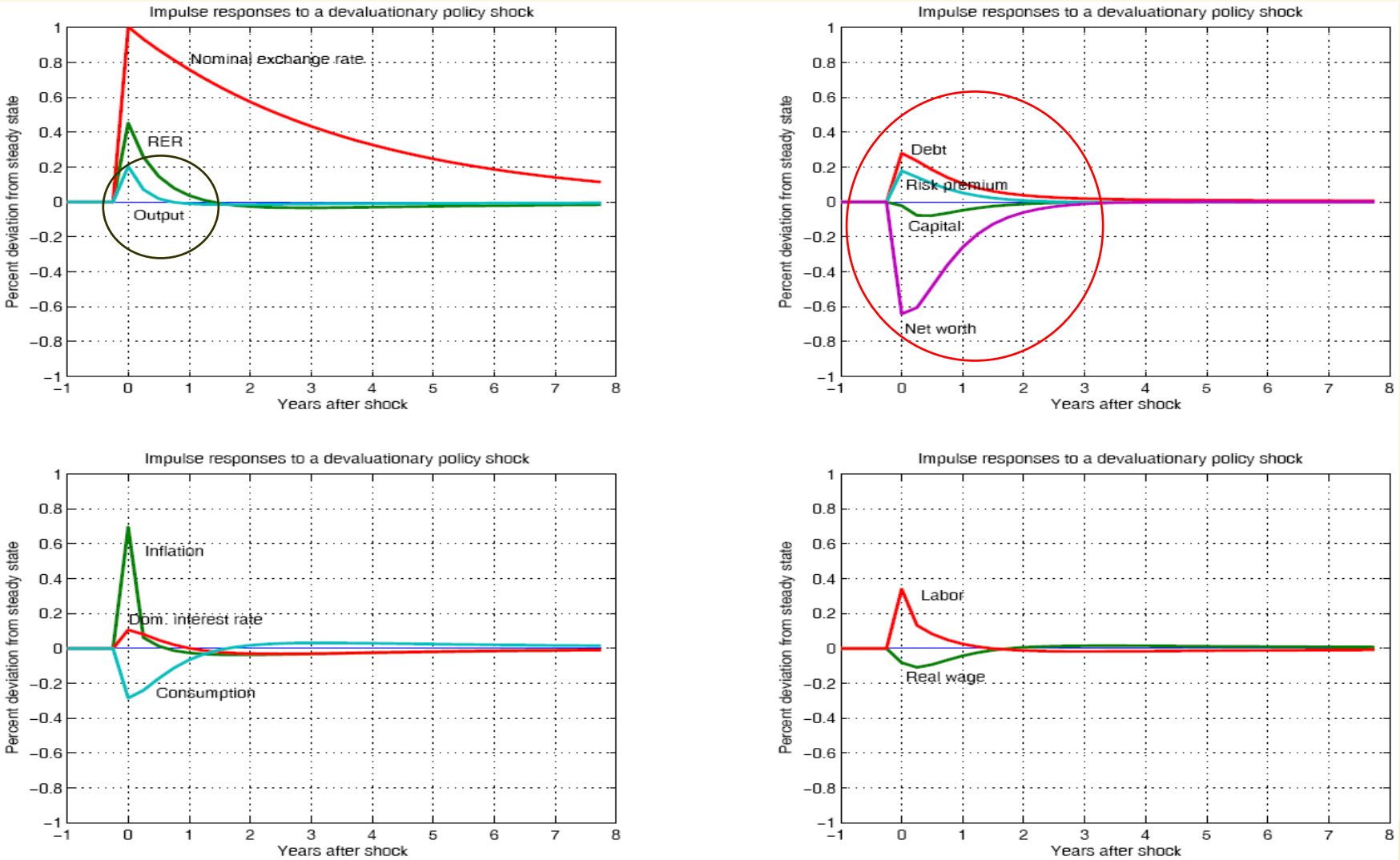
Table 3: **Maximum likelihood estimates: shocks' persistence and standard deviation estimates**

	Chile		Colombia		Mexico	
	Estimate	Std Error	Estimate	Std. Error	Estimate	Std. Error
Persistence parameters						
- Technology, ζ_A	0.68	0.0006	0.86	0.0030	0.96	0.0043
- Mark-up, ζ_θ	0.96	0.0018	0.93	0.0049	0.97	0.0043
- Preferences, ζ_a	0.98	0.0011	0.92	0.0050	0.90	0.0024
- Devaluationary policy, ζ_χ	0.86	0.0015	0.93	0.0014	0.87	0.0028
- International interest rate, ζ_β	0.79	0.0015	0.78	0.0021	0.90	0.0014
- Exports, ζ_x	0.98	0.0013	0.78	0.0023	0.87	0.0034
- Inflation target, $\zeta_\varkappa$	0.74	0.0009	0.85	0.0032	0.50	0.0042
- Output Target, ζ_ϑ	0.87	0.0011	0.86	0.0031	0.77	0.0046
Standard deviations						
- Technology, σ_A	0.01	0.0013	0.06	0.0052	0.10	0.0046
- Mark-up, σ_θ	0.01	0.0019	0.02	0.0023	0.02	0.0032
- Preferences, σ_a	0.23	0.0021	0.08	0.0021	0.02	0.0035
- Devaluationary policy, σ_χ	0.11	0.0016	0.13	0.0021	0.10	0.0023
- International interest rate, σ_ρ	0.03	0.0014	0.02	0.0026	0.13	0.0032
- Exports, σ_x	0.23	0.0015	0.35	0.0020	0.21	0.0028
- Inflation target, $\sigma_\varkappa$	0.15	0.0008	0.21	0.0023	0.11	0.0049
- Output Target, σ_ϑ	0.16	0.0016	0.12	0.0018	0.10	0.0015

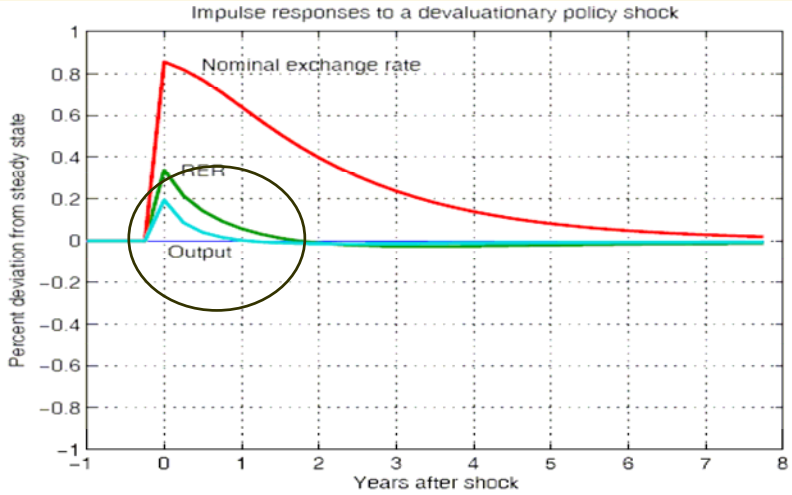
Impulse response to a devaluationary policy shock: Chile

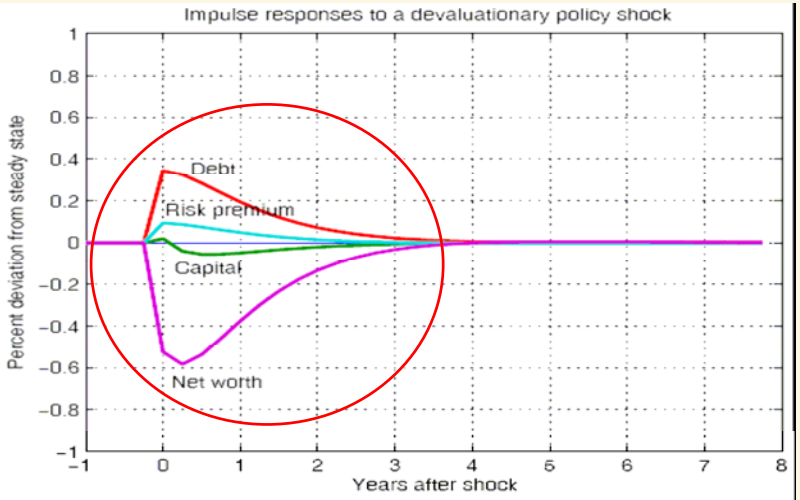


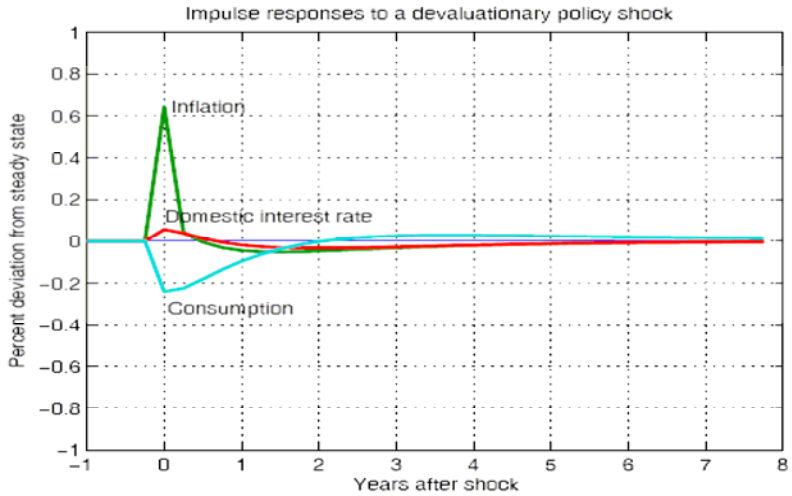
Impulse response to a devaluationary policy shock: Colombia

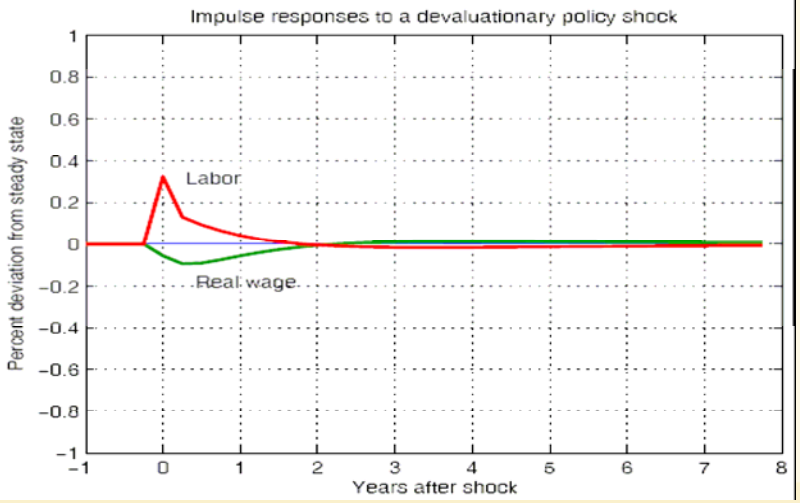


Impulse response to a devaluationary policy shock: Mexico









Forecast error variance decompositions: Chile

	Technology		Mark-up		Preference		Devaluation		Intl. Interest		Export		Inflation target		Output target	
Q	coef.	s.e.	coef.	s.e	coef.	s.e	coef.	s.e.	coef.	s.e.	coef.	s.e	coef.	s.e	coef.	s.e
								Output								
1	1.01	0.082	5.62	0.796	19.50	0.845	19.05	0.325	0.23	0.002	17.40	0.276	37.17	0.497	0.02	0.000
4	1.16	0.114	10.47	1.562	37.73	1.623	9.09	0.234	0.62	0.011	24.91	0.524	16.02	0.129	0.01	0.000
8	0.65	0.070	12.42	1.908	47.41	1.840	3.85	0.120	0.47	0.008	28.12	0.704	7.07	0.080	0.00	0.000
20	0.29	0.031	11.59	1.809	50.84	1.468	1.69	0.051	0.22	0.003	32.27	0.780	3.11	0.050	0.00	0.000
								Nominal exchange rate change								
1	0.02	0.001	5.90	0.833	20.41	0.870	25.49	0.453	0.03	0.001	0.21	0.027	47.92	0.489	0.02	0.000
4	0.06	0.006	11.31	1.644	38.52	1.739	19.66	0.533	0.18	0.002	0.35	0.038	29.90	0.437	0.02	0.001
8	0.03	0.004	17.21	2.527	58.47	2.702	9.29	0.381	0.81	0.021	3.04	0.244	11.14	0.312	0.01	0.000
20	0.00	0.001	19.11	2.751	69.98	2.952	1.39	0.063	0.78	0.025	7.33	0.451	1.40	0.045	0.00	0.000

Forecast error variance decompositions: Colombia

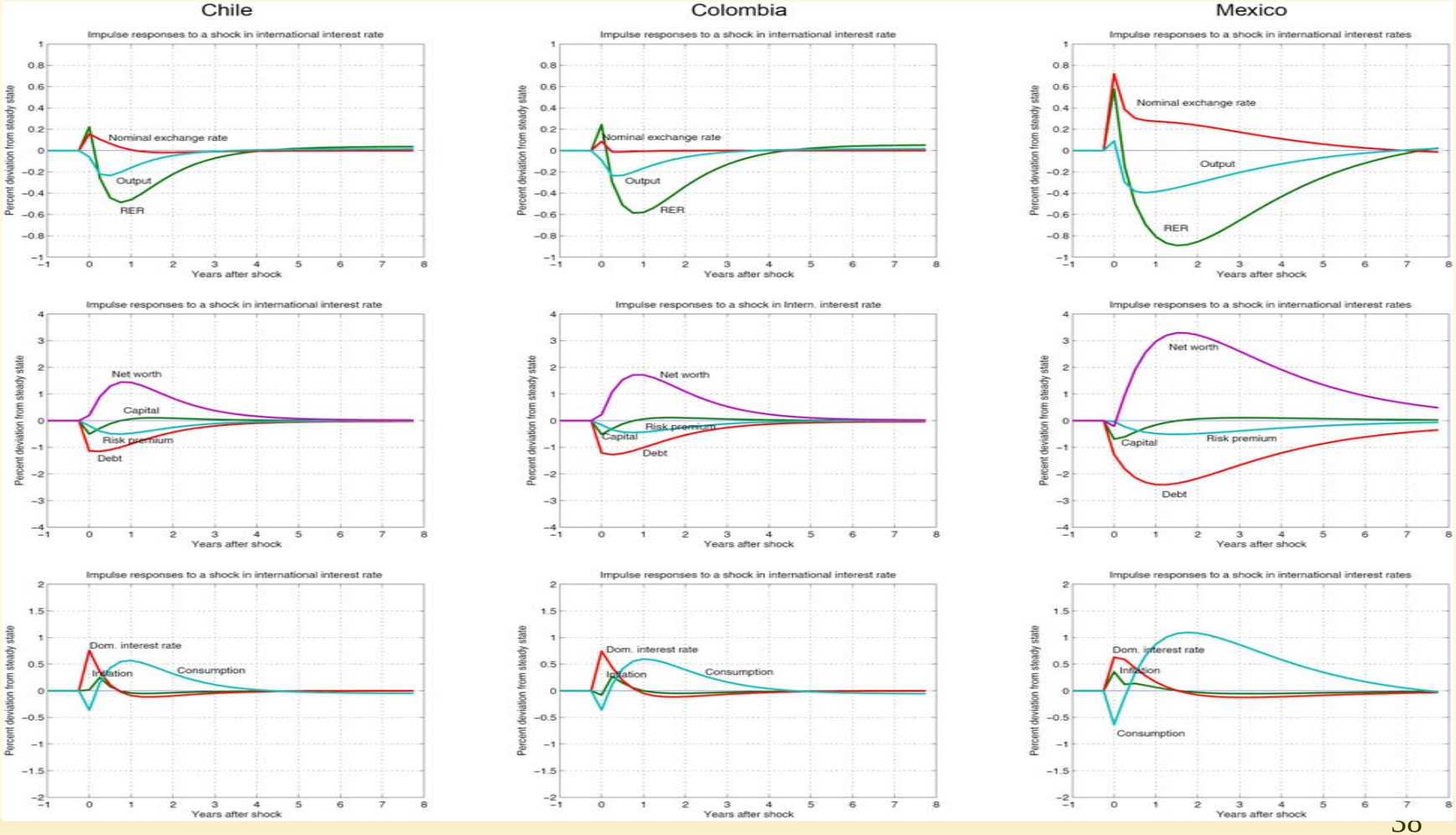
	Technology		Mark-up		Preference		Devaluation		Intl. Interest		Export		Inflation target		Output target	
Q	coef.	s.e.	coef.	s.e	coef.	s.e	coef.	s.e.	coef.	s.e.	coef.	s.e	coef.	s.e	coef.	s.e
								Output								
1	27.07	3.120	5.58	0.932	6.57	0.554	29.38	2.327	0.04	0.008	29.37	1.509	1.99	0.264	0.00	0.000
4	38.84	3.117	9.14	1.195	10.79	1.266	13.36	1.497	0.14	0.027	26.91	2.233	0.82	0.131	0.00	0.000
8	41.58	2.682	12.77	1.728	14.67	2.071	7.81	0.989	0.14	0.028	22.57	2.166	0.45	0.077	0.00	0.000
20	39.93	2.316	16.56	2.865	18.10	3.064	6.14	0.823	0.12	0.024	18.80	1.893	0.35	0.061	0.00	0.000
								Change in nominal exchange rate								
1	1.12	0.162	9.62	2.096	11.17	0.426	66.65	2.440	0.08	0.013	6.85	0.739	4.51	0.464	0.01	0.001
4	2.06	0.260	16.53	3.298	17.40	1.080	44.82	2.776	0.23	0.041	16.28	0.893	2.67	0.318	0.01	0.001
8	1.68	0.174	25.32	4.695	23.60	2.183	26.50	2.275	0.96	0.159	20.61	0.778	1.33	0.185	0.00	0.000
20	0.52	0.028	40.90	7.183	32.89	5.011	9.62	1.195	1.90	0.315	13.79	0.688	0.38	0.066	0.00	0.000

Forecast error variance decompositions: Mexico

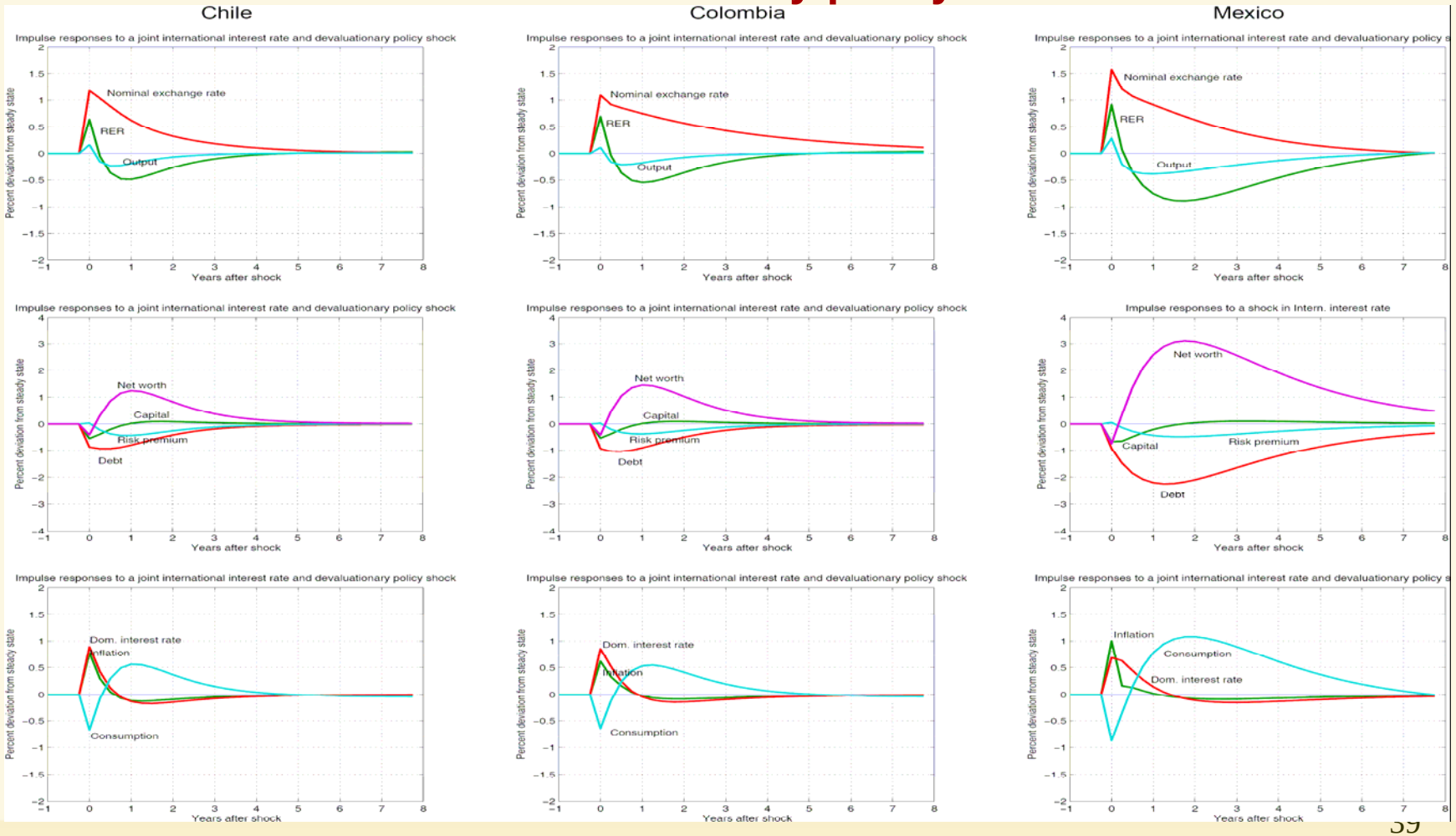
	Technology		Mark-up		Preference		Devaluation		Intl. Interest		Export		Inflation target		Output target	
Q	coef.	s.e.	coef.	s.e	coef.	s.e	coef.	s.e.	coef.	s.e.	coef.	s.e	coef.	s.e	coef.	s.e
							Output									
1	38.73	2.737	14.61	1.321	0.42	0.194	3.81	0.209	0.76	0.177	23.40	0.779	15.46	1.652	2.81	0.135
4	56.96	2.764	13.97	1.375	0.37	0.161	1.17	0.070	10.93	1.109	11.66	0.437	4.12	0.505	0.82	0.043
8	63.26	2.630	13.43	1.536	0.28	0.125	0.46	0.026	14.12	1.223	6.41	0.186	1.71	0.210	0.33	0.018
20	69.25	2.739	13.75	2.215	0.19	0.089	0.24	0.012	11.86	0.771	3.67	0.148	0.87	0.092	0.17	0.008
							Change in nominal exchange rate									
1	6.14	0.986	12.64	0.806	0.34	0.182	12.17	0.580	15.01	0.598	0.01	0.037	44.97	2.443	8.72	0.240
4	13.88	1.841	27.89	1.723	0.65	0.321	12.28	0.598	4.75	0.201	1.59	0.097	31.03	2.225	7.95	0.262
8	14.01	1.784	41.95	2.020	0.77	0.364	6.85	0.359	18.34	0.862	3.13	0.176	11.18	0.832	3.78	0.195
20	2.80	0.426	35.23	2.206	0.39	0.192	1.02	0.053	57.22	1.803	1.47	0.110	1.37	0.054	0.49	0.037

Is it then sudden stops rather than contractionary devaluations?

Impulse response to an adverse external shock: an increase in international interest rates



Impulse response to a joint adverse external shock and devaluationary policy



Robustness check

Estimated parameter values

No measurement errors

Table 2: **Maximum likelihood estimates: main parameter values**

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- Output, ω_y	0.04	0.0011	0.16	0.0033	1.14	0.0049
- Nominal exchange rate, ω_s	0.66	0.0007	0.92	0.0028	0.58	0.0029
Nominal rigidities						
- Price rigidities, ψ_p	7.13	0.0050	6.38	0.0024	4.60	0.0024
- Wage rigidities, ψ_w	0.86	0.0010	1.53	0.0030	0.24	0.0043

With measurement errors

Table 15: **Maximum likelihood estimates with measurement erros: main parameter values**

	Chile		Colombia		Mexico	
	Estimate	Std Error	Estimate	Std. Error	Estimate	Std. Error
Transmission channels of devaluations						
- Balance sheet, μ	0.24	0.003	0.30	0.0151	0.18	0.002
- Expenditure switching, γ	0.59	0.018	0.68	0.013	0.63	0.002
Interest rate response to:						
- Lagged interest rate, ω_i	0.49	0.036	0.71	0.034	0.74	0.006
- Expected inflation, ω_p	1.60	0.012	2.15	0.084	1.50	0.070
- Output, ω_y	0.70	0.201	0.53	0.410	1.14	0.036
- Nominal exchange rate, ω_s	0.71	0.001	0.89	0.005	0.67	0.007
Nominal rigidities						
- Price rigidities, ψ_p	5.10	0.53	6.37	1.212	4.78	0.125
- Wage rigidities, ψ_w	1.60	0.012	1.74	0.436	1.14	0.036

Concluding remarks

- A stylised structural DSGE model is used to answer two main questions:
  - Are currency devaluations expansionary or contractionary in terms of output?
  - What is the relative importance of the different mechanisms involved?
- Estimates show that during the last two decades in three Latin American countries:
  - the contractionary balance sheet transmission mechanism is dominated by the expenditure switching effect.
  - exogenous devaluationary policy shocks, ceteris paribus, have been on average expansionary.
  - Also that all else equal, balance sheet effects are on average weaker in Mexico than in Chile or Colombia.

Concluding remarks

- Overall, it was argued that prevalence of negative correlations between exchange rate changes and output did not support the claim that devaluations were contractionary.
- The sign of the correlation between exchange rate changes and output depends on the nature of the shock that hits the economy.
- In other words, it is not contractionary devaluations but sudden stops that lead to sharp output contractions.
- An important implication is that isolating the exchange rate fluctuations associated with different shocks can be a difficult task to accomplish in reduced form models. Therefore, this explains the difficulties faced by the existing empirical literature in assessing the effects of devaluations on output. At the same time, it shows the advantages of employing a structural model, such as the one presented here.

Lines of future research

- Model the balance sheet in a richer setting (eg with non-tradables, fiscal policy). Also allowing for more transmission channels (competitiveness effects).

- Allow monetary targets to react to different shocks (eg exchange rate target may respond to the volatility of the risk premium).

- Explore alternatives of PTM. In emerging markets, if one considers original sin to be binding then LCP might not be a good assumption.

- Estimate the model using Bayesian methods.

Thank you!

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