Central Bank Transparency and the Volatility of Exchange Rates

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Motivation

Motivation

Exchange rate volatility and its detrimental effect on the economy:

Empirical evidence suggests that high exchange rate volatility...

- **reduces trade:** Baak et al. (2007), Byrne et al. (2008), Tang (2014), Bahami-Oskooee and Harvey (2016)
- **limits domestic investment:** Goldberg (1993), Servén (2003), Byrne and Davis (2005),…, etc.
- **decreases FDI:** Campa (1993), Kiyota and Urata (2004),…, etc.
- **deters portfolio investment:** Fidora et al. (2007) or Mishra (2011)
- **reduces consumption:** Bahami-Oskooee et al. (2015)
- **lowers growth:** Bagella et al. (2006), Schnabl (2009), …, etc.

Motivation

Literature on the determinants of exchange rate volatility:

OCA theory variables: Bayoumi and Eichengreen (1998)

Financial variables: Devereux and Lane (2003) or Caporale et al. (2015)

Price rigidities in the goods market: Hau (2002) or Bravo-Ortega and Di Giovanni (2006)

Exchange rate regime: Klein and Shambaugh (2008) or Bleaney and Francisco (2010)

Economic development: Hausmann et al. (2006) or Ganguly and Breuer (2010)

Inflation targeting: Rose (2007)

Contribution

1. First to empirically estimate the effect of Central Bank Transparency (CBT) on exchange rate volatility.

2. Combine two theoretical models to derive our hypothesis: CBT lowers the volatility of exchange rates on average.

   However, the effect critically depends on:

   a) interest rate sensitivity of money demand
   b) price adjustment in the goods market and
   c) the “conservatism” of the central bank

3. Employing the Dincer and Eichengreen (2014) index of CBT and its subcomponents, enables us to directly test the theoretical implications of the model(s).

Hypothesis

Theoretical Underpinning

Combining two models:

- Model of exchange rate movement (ERM-Model):

Dornbusch, R., 1976. “Expectations and Exchange Rate Dynamics”, *The Journal of Political Economy* 84:6, 1161-1176.

Frankel, J. A., 1979. “On the Mark: A Theory of Floating Exchange Rates Based on Real Interest Differentials”, *The American Economic Review* 69:4, 610-622.

- Stylized monetary policy model (MP-Model):

Kydland, F. E., Prescott, E. C., 1977. “Rules Rather than Discretion: The Inconsistency of Optimal Plans”, *The Journal of Political Economy* 85:3, 473-492.

The ERM-Model

Solution – Spot rate equation

(1) $$s = m - m^* - \phi(y - y^*) - 1/\theta(i - i^*) + (1/\theta + \lambda)(\pi^e - \pi^{e*})$$

(2) $$\sigma_s^2 = \sigma_m^2 + \sigma_{m^*}^2 + \phi^2\sigma_y^2 + \phi^2\sigma_{y^*}^2 + (1/\theta^2)\sigma_i^2 + (1/\theta^2)\sigma_{i^*}^2 + (1/\theta + \lambda)^2\sigma_{\pi^e}^2 + (1/\theta + \lambda)^2\sigma_{\pi^{e*}}^2 + \sum COV$$

Key insight of the ERM-Model:

- higher volatility of inflation expectations leads to higher exchange rate volatility.

The MP-Model

Monetary policy model in the spirit of Kydland and Prescott (1977)

- **key assumption:** the inflation target τ and the output target κ of the central bank are not known with certainty.
- however, the central bank can reduce this uncertainty by communication/disclosure of information regarding these targets
- **So uncertainty of CB targets depends only on CBT!**

$$(3)\quad \sigma^2_{\pi^e} = \sigma^2_{\tau} + \left(\frac{1-\alpha}{\alpha}\right)^2 \sigma^2_{\kappa} + \left(\frac{1-\alpha}{\alpha}\right)^2 \sigma^2_{\varepsilon_s} + \sigma^2_{\varepsilon_s^u} + \left(\frac{1}{\alpha}\right)^2 \sigma^2_{\varepsilon_d^u}$$

This is central bank opacity!

Appendix

Hypotheses

The model, however, predicts further that the effect of CBT critically depends on:

(4) $$(1/\theta+\lambda)^2\left[\sigma_\tau^2+\left(\frac{1-\alpha}{\alpha}\right)^2\sigma_\kappa^2+\left(\frac{1-\alpha}{\alpha}\right)^2\sigma_{\varepsilon_s}^2+\sigma_{\varepsilon_s^u}^2+\left(\frac{1}{\alpha}\right)^2\sigma_{\varepsilon_d^u}^2\right]$$

The effect of CBT on exchange rate volatility is more pronounced for countries with ...

- a lower flexibility (θ) of prices in the goods market.
- a higher interest rate sensitivity (λ) of money demand.
- central banks that are less conservative (low α).

BACK TO RESULTS

Empirical Strategy

Empirical Strategy

Baseline Approach:

Bilateral exchange rate volatility measure based on weekly historical FX-returns:

(5) $\Delta s_{i,j,t} = \ln(s_{i,j,t}) - \ln(s_{i,j,t-1})$

(6) $VS_{i,j,t} = std(\Delta s_{i,j,t}) \cdot 100$

Alternatively, we use the conditional volatility derived from a GARCH (1, 1) model of daily FX-returns (see, e.g., Servén (2003), Baum et al. (2004) or Edwards and Rigobon (2009)).

Estimation equation – baseline

$$VS_{i,j,t} = \alpha_{i,j} + \beta_0 \cdot \tau_t + \beta_1 \cdot CBT_{i,j,t} + \Gamma X_{i,j,t} + \varepsilon_{i,j,t}$$

$VS_{i,j,t}$: volatility measure
$s_{i,j,t}$: bilateral exchange rate
$X_{i,j,t}$: matrix of control variables
$\varepsilon_{i,j,t}$: error term
τ_t : time fixed effects
$\alpha_{i,j}$: bilateral fixed effect
$CBT_{i,j,t}$: central bank transparency

Conditionality of the effects of CBT → we use a multiplicative interaction model

Summary Stats.

Results

Baseline Results

Table 3a: Historical Exchange Rate Volatility and Direct Central Bank Communication

Dep.Var.: Historical Vola. (weekly)	I	II	III	IV	V
Direct Communication	**-0.136*** **	**-0.143*** **	**-0.141*** **	**-0.138*** **	**-0.521*** **
	(0.037)	(0.038)	(0.038)	(0.037)	(0.068)
Size	-0.270**	-0.403***	-0.331**	-0.364***	-0.669***
	(0.132)	(0.130)	(0.130)	(0.131)	(0.191)
ln Trade	0.005	0.010	0.009	0.006	-0.031
	(0.012)	(0.012)	(0.012)	(0.012)	(0.022)
Gov. Debt	0.001	0.001	0.001	0.000	0.004***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Reserves	-0.005**	-0.004*	-0.004*	-0.005**	-0.002
	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)
FX-Regime	0.457***	0.478***	0.470***	0.480***	0.788***
	(0.052)	(0.054)	(0.054)	(0.052)	(0.068)
FX-Crisis	1.075***	1.069***	1.084***	1.041***	1.112***
	(0.048)	(0.049)	(0.051)	(0.049)	(0.084)
Inflation Volatility	0.361***	0.378***	0.378***	0.361***	0.257***
	(0.014)	(0.013)	(0.013)	(0.014)	(0.013)
M1 Volatility	0.032***	0.032***	0.033***	0.030***	-0.002
	(0.006)	(0.006)	(0.006)	(0.006)	(0.005)
Interest Rate Volatility	0.019***	0.020***	0.021***	0.019***	0.028***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)
Real GDP Shock	0.035***			0.036***	0.052***
	(0.005)			(0.005)	(0.005)
Bank System Shock		0.009***		0.009***	0.012***
		(0.001)		(0.001)	(0.001)
Terms-Of-Trade Shock			0.003**	0.003***	0.003**
			(0.001)	(0.001)	(0.002)
Industrial Production Volatility					0.024***
					(0.007)
Bilateral FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Observations	**10,606**	**10,606**	**10,606**	**10,606**	**5,873**
R-Squared	0.582	0.582	0.577	0.588	0.638

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Baseline Results

Table 3b: Historical Exchange Rate Volatility and Indirect Central Bank Communication

Dep.Var.: Historical Vola. (weekly)	I	II	III	IV	V
Indirect Communication	**-0.149*** **	**-0.136*** **	**-0.143*** **	**-0.139*** **	**-0.089*** **
	(0.018)	(0.018)	(0.018)	(0.018)	(0.021)
Size	-0.303**	-0.436***	-0.365***	-0.392***	-0.565***
	(0.131)	(0.129)	(0.128)	(0.130)	(0.192)
ln Trade	0.006	0.011	0.010	0.006	-0.031
	(0.012)	(0.012)	(0.012)	(0.012)	(0.022)
Gov. Debt	0.002*	0.002	0.002*	0.001	0.006***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Reserves	-0.005**	-0.004*	-0.004*	-0.005**	-0.004
	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)
FX-Regime	0.484***	0.505***	0.496***	0.505***	0.827***
	(0.051)	(0.054)	(0.054)	(0.052)	(0.068)
FX-Crisis	1.067***	1.063***	1.078***	1.036***	1.122***
	(0.048)	(0.049)	(0.050)	(0.048)	(0.085)
Inflation Volatility	0.363***	0.380***	0.380***	0.362***	0.261***
	(0.014)	(0.013)	(0.013)	(0.014)	(0.013)
M1 Volatility	0.033***	0.033***	0.034***	0.032***	0.001
	(0.006)	(0.006)	(0.006)	(0.006)	(0.005)
Interest Rate Volatility	0.017***	0.019***	0.019***	0.017***	0.030***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)
Real GDP Shock	0.036***			0.037***	0.055***
	(0.005)			(0.005)	(0.006)
Bank System Shock		0.009***		0.009***	0.012***
		(0.001)		(0.001)	(0.001)
Terms-Of-Trade Shock			0.002*	0.003**	0.003*
			(0.001)	(0.001)	(0.002)
Industrial Production Volatility					0.009
					(0.007)
Bilateral FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Observations	**10,606**	**10,606**	**10,606**	**10,606**	**5,873**
R-Squared	0.586	0.584	0.580	0.591	0.632

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Appendix

Robustness

Robustness of results:

Different historical Volatility measures

- FX-vola based on daily and monthly FX-returns

Additional controls (for both Vola. measures):

Central Bank Characteristics: introduction of inflation targeting and political independence of the central bank

Financial Market Characteristics: Bank capital to asset ratio, z-score, size of the banking system, financial integration

Institutional quality variables: Polity IV, Economic Freedom (Fraser Institute), WGI ...

Further structural variables: Export Dissimilarity, Economic Development, Capital Controls, Current account balance

Additional shock variables: Inflation shock, Current account shock, Reserve shock, Export shock, Lending rate difference

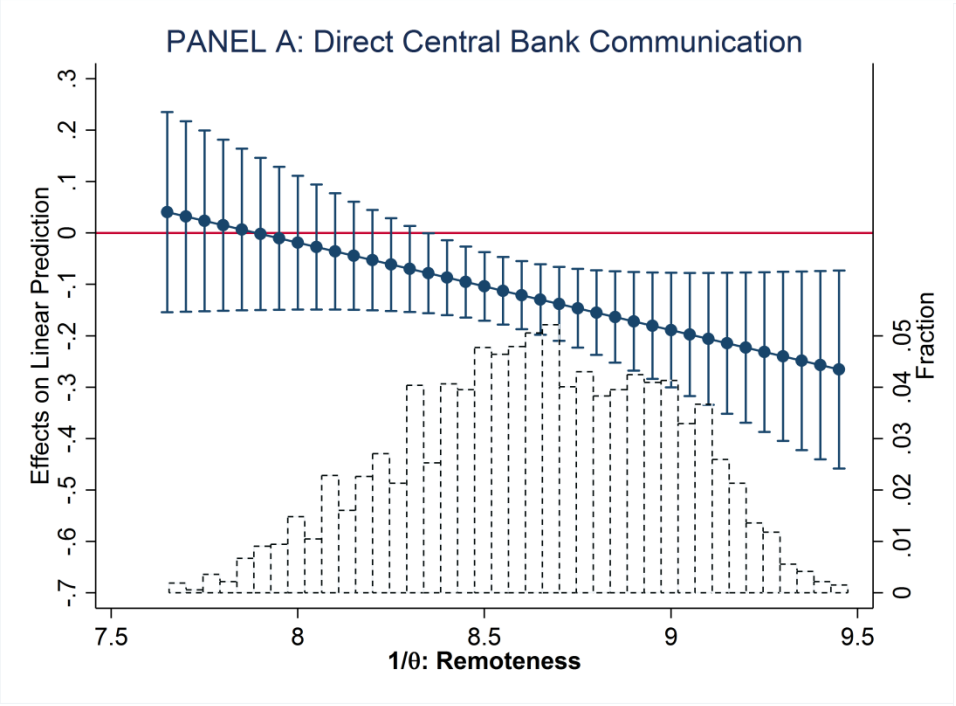
different shock variable definition:

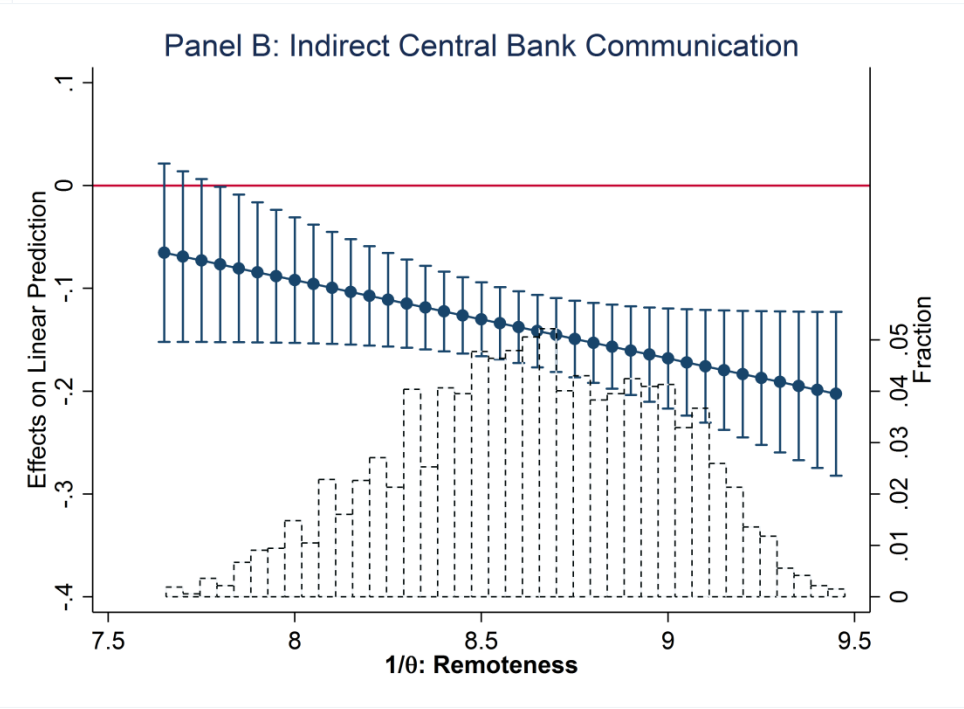
- controlling for average growth rates additionally to the asymmetric shocks.
- using only average growth rates.

Appendix

Interaction Results

The model implies further that the dampening effect of CBT on FX-volatility is increasing in 1/θ!

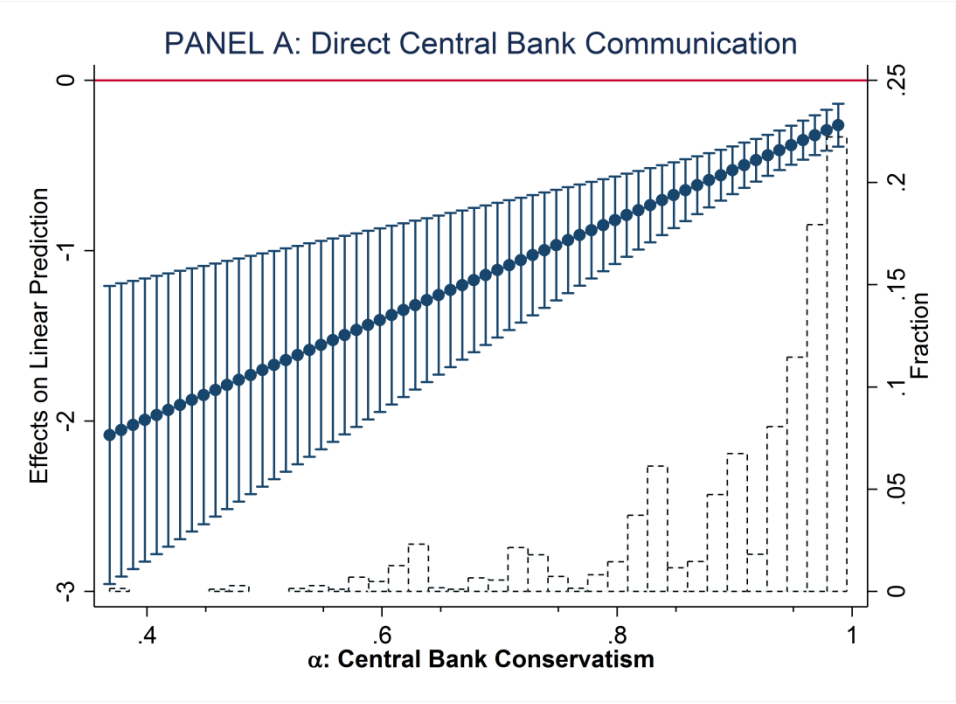


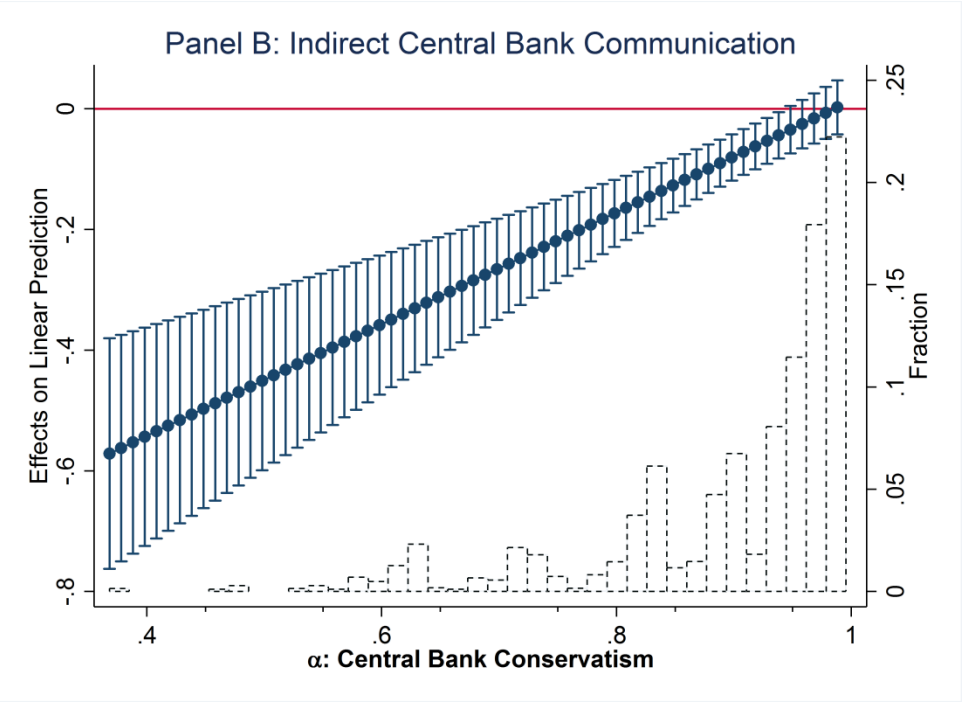


Appendix!

Interaction Results

Finally, the model also implies that the dampening effect of CBT on FX-volatility is decreasing in α!

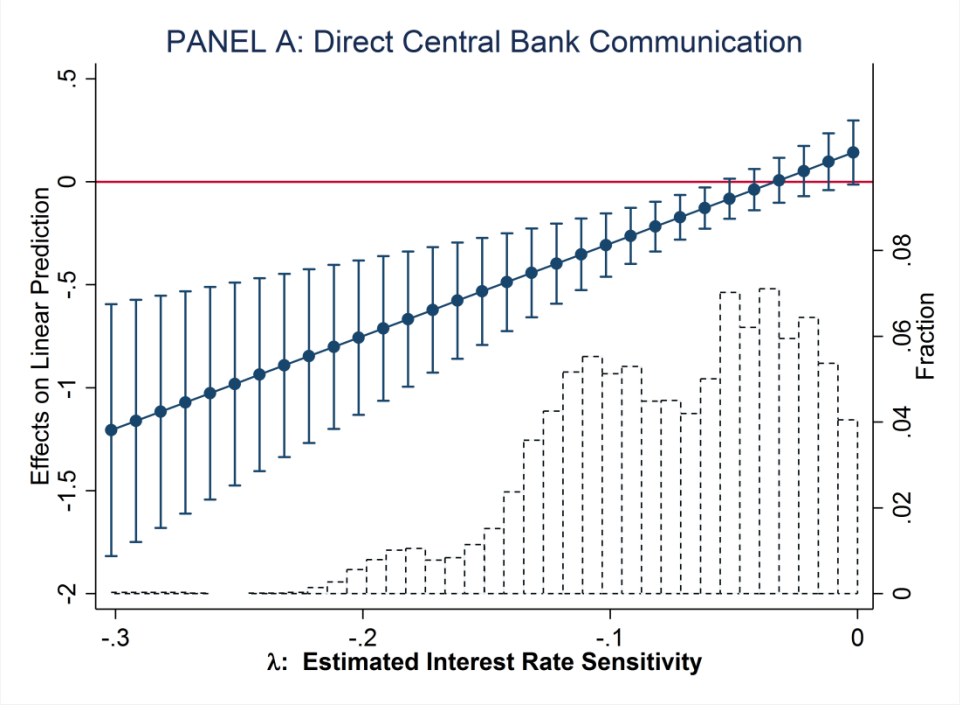


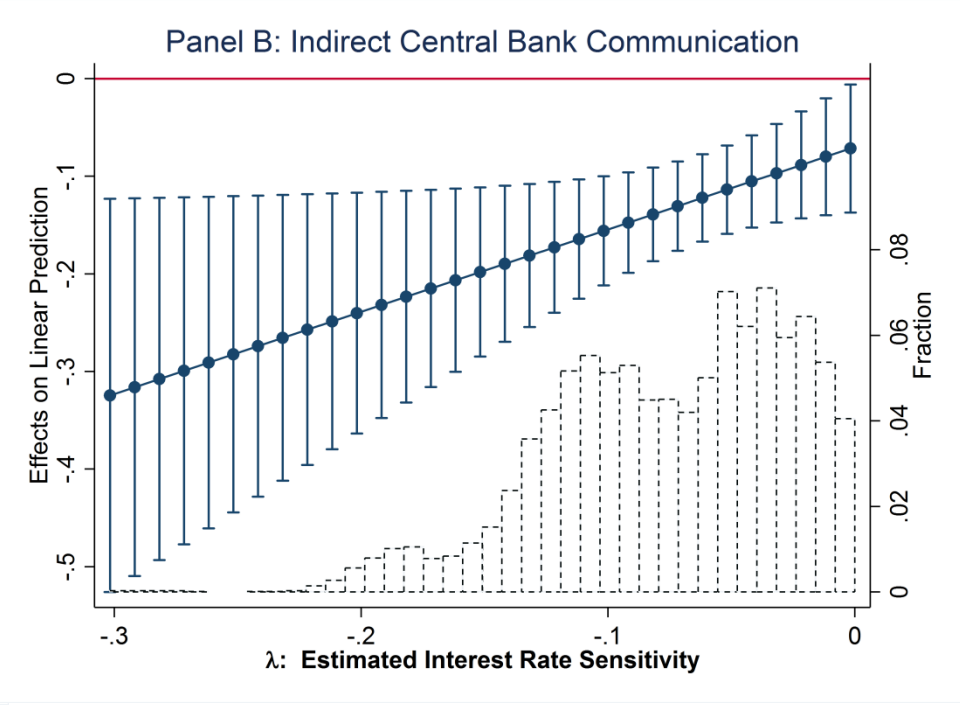


Appendix!

Interaction Results

The model predicts that the dampening effect of CBT on FX-volatility is increasing in (-)λ!





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[Appendix!](#)

Conclusion

- By combining an ERM-Model and a MP-Model, we show that CB communication concerning their monetary policy targets decreases the volatility of the bilateral exchange rate .

- The model implies further that the effect should depend on:
  a) **the interest rate sensitivity of money demand**
  b) **the speed of adjustment of prices in the goods market and**
  c) **the conservatism of the central bank.**

- We find empirical evidence for both the average as well as for the conditional effects.

Thank you for your attention!

Appendix

Central Bank Transparency

Def. : CBT is “...defined as the absence of asymmetric information between monetary policy makers and other economic agents.” (Geraats, 2002)

Central Bank Transparency

Measurement of CBT: Dincer/Eichengreen (2014)

Taxonomy of Geraats (2002): 5 aspects of CBT

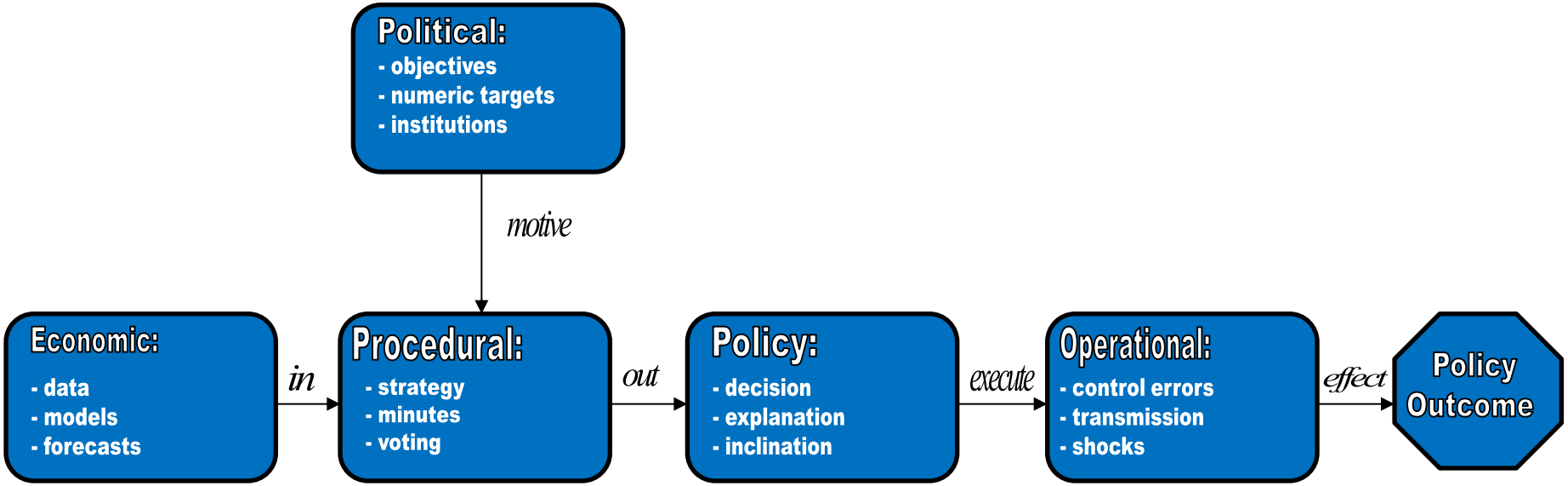


Figure 1: A Conceptual Framework for CBT (Source: Geraats (2002))

Central Bank Transparency

direct central bank communication:

openness of policy objectives:

- formal statement about monetary policy objectives (multiple objectives: prioritization): Yes, but multiple without prioritization? → 0.5 ; Yes → 1
- quantification of primary objective: YES → 1

indirect central bank communication:

openness of economic information that is used for monetary policy:

- at least quarterly time series information of most important data: between 3 or 4 out of 5 variables → 0.5; 5 out of 5 → 1
- disclosure of models applied for monetary policy: YES → 1
- numeric forecasts: inflation and/or output less than quarterly frequency →0.5 ; inflation and output for the medium term (1-2 years ahead, info: if conditional fc)
- does the central bank discuss unexpected shocks that had an impact on the transmission mechanism

Central Bank Transparency

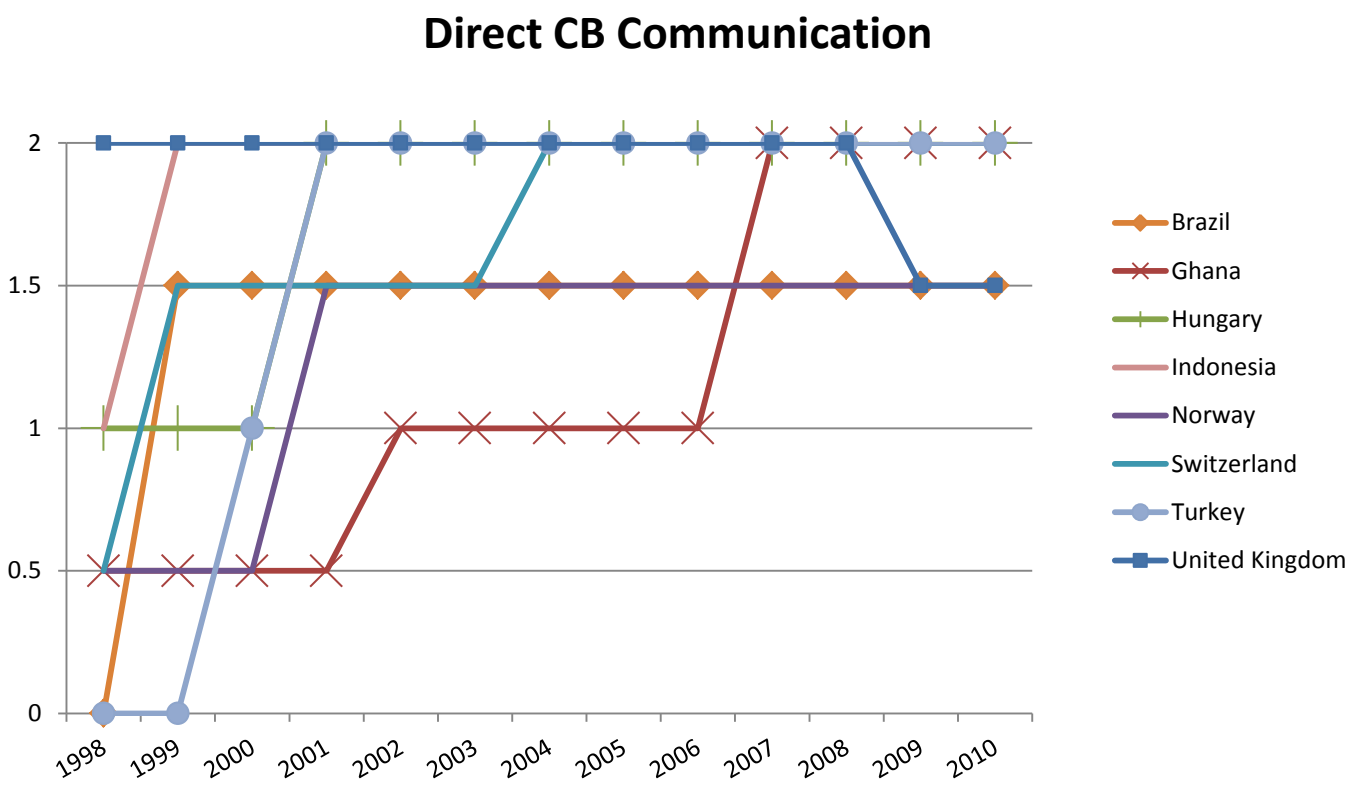


Figure 4: The Evolution of Direct CB Communication for Selected Countries

Central Bank Transparency

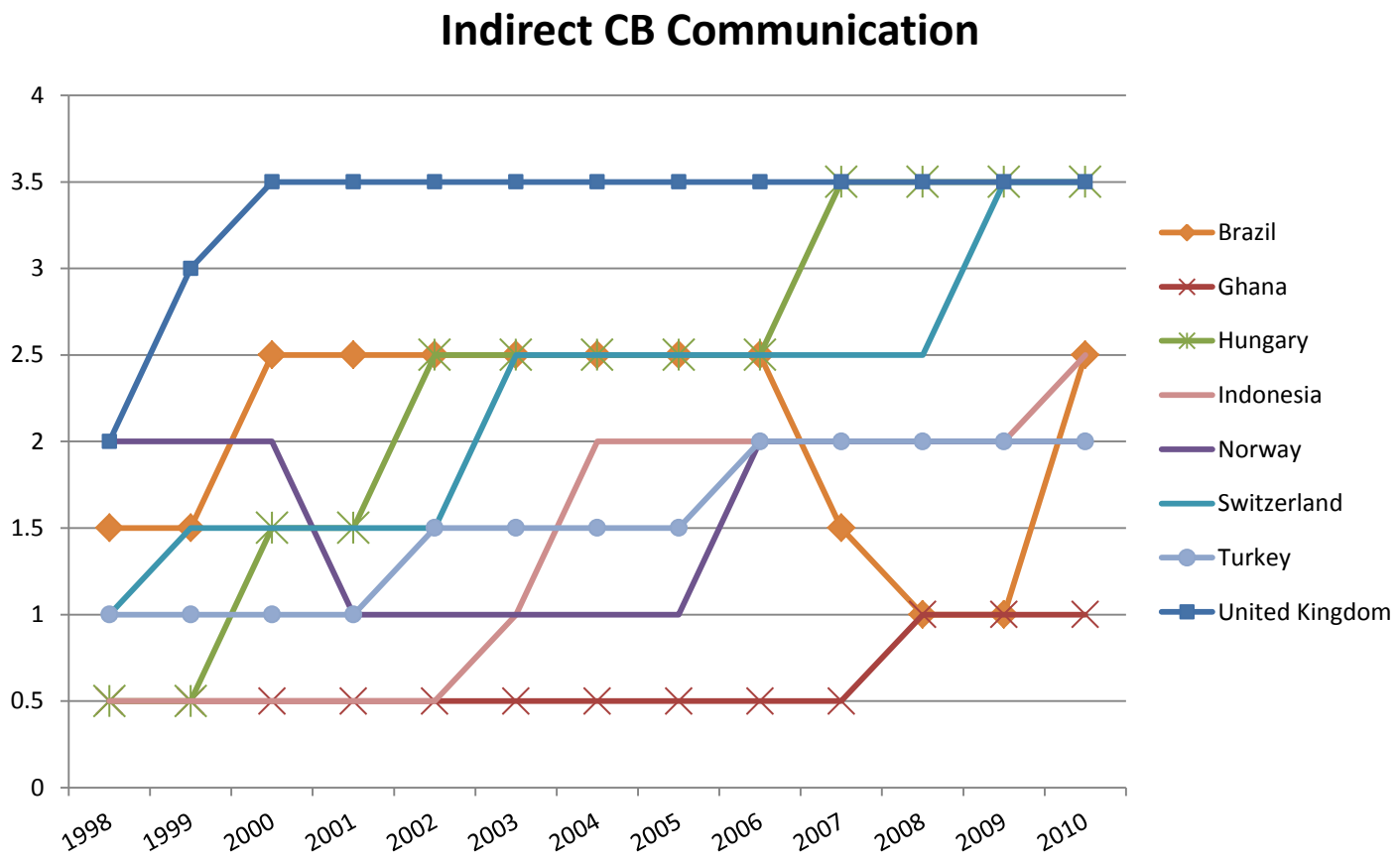


Figure 5: The Evolution of Indirect CB Communication for Selected Countries

BACK!

Summary Statistics

Table 2: Summary Statistics

Variable	mean	sdv.	within sdv.	min	max
Historical Volatility	1.68	1.12	0.92	0.01	10.80
Conditional Volatility	0.83	0.29	0.12	0.11	2.98
Direct Communication	3.07	0.78	0.23	0.5	4
Indirect Communication	3.11	1.56	0.55	0	7.5
Bilateral Trade (in 2005 mm USD)	2436.67	17821.55	2155.20	0.00	532069.40
Government Debt per GDP	53.46	23.32	9.75	7.02	171.94
Real GDP (in 2005 mm USD)	668085.30	1399612.00	83956.26	1743.47	9216162.00
Reserves	18.42	11.38	3.17	1.62	95.68
FX-Regime	1.68	0.47	0.19	1	4
FX-Crisis	0.09	0.29	0.27	0	1
Inflation Volatility	1.30	1.00	0.82	0.08	12.58
M1 Volatility	4.37	2.67	2.02	0.51	28.55
Interest Rate Volatility	6.32	4.82	3.31	0.00	41.72

Table 2 continued..

Variable	mean	sdv.	within sdv.	min	max
Real GDP Shock	3.08	2.63	2.19	0.00	18.70
Bank System Shock	6.56	10.46	7.72	0.00	110.89
Terms-Of-Trade Shock	7.14	7.39	6.06	0.00	65.85
Industrial Production Volatility	4.68	2.42	1.82	0.42	18.40
Inflation Targeting (Soft Def.)	0.43	0.34	0.13	0	1
Inflation Targeting (Strict Def.)	0.43	0.34	0.13	0	1
Central Bank Independence	0.57	0.14	0.03	0.13	0.90
Bank Capital Asset Ratio	9.22	2.37	1.02	3.1	18.98
Size of Banking System	65.38	32.02	8.92	8.06	223.94
Financial Integration	2.70	3.88	2.58	0.51	46.49
Z-Score	14.04	6.86	2.26	0	49.49812
Current Account Balance	-1.88	5.31	2.37	-27.78	21.04
Capital Account Controls	0.41	0.27	0.07	0	1
Economic Development	16.80	2.17	0.17	10.37	22.01
Export Dissimilarity	80.10	48.75	11.30	1.28	198.65

Table 2 continued...

Variable	mean	sdv.	within sdv.	min	max
POLITY IV	6.57	3.06	0.89	-6	10
FSI - Summary Index	7.00	0.56	0.16	5.12	8.71
FSI - Freedom to Trade	7.21	0.76	0.22	4.72	9.26
FSI - Size of Government	6.61	0.82	0.31	3.45	9.15
FSI - Sound Money	8.18	0.95	0.38	3.97	9.81
FSI - Legal System	6.16	1.21	0.27	2.50	9.24
FSI - Regulation	6.84	0.62	0.26	4.48	8.63
Inflation Shock	3.57	4.07	3.43	0	42.89
Current Account Shock	3.56	3.30	2.42	0.001	24.13
Reserve Shock	3.49	3.88	3.20	0.000242	50.35
Export Shock	3.89	4.12	3.29	0.000043	42.65
Lending Rate Shock	9.74	11.99	7.01	0	116.52

BACK!

Appendix

Currencies in Baseline: 62

Albanian Lek, Argentinian Peso, Australian Dollar, Bangladeshi Taka, Brazilian Real, Botswana Pula, Belarusian Ruble, Canadian Dollar, Chinese Yuan Renmimbi, Colombian Peso, Czech Koruna, Egyptian Pound, Ethiopian Birr, Fijian Dollar, Georgian Lari, Ghanan Cedi, Guatemalan Quetzal, Croatian Kuna, Hungarian Forint, Indonesian Rupiah, Israeli Shekel, Indian Rupee, Icelandic Krona, Jamaican Dollar, Japanese Yen, Kenyan Shilling, Kuwaiti Dinar, Latvian Lat, Lithuanian Litas, Macedonian Denar, Maltese Lira, Malawian Kwacha, Malaysian Ringgit, Mauritian Rupee, Mexican Peso, Moldovan Leu, Mozambican Meticail, New Zealand Dollar, Nigerian Naira, Pakistani Rupee, Peruvian Sol, Philippine Peso, Polish Zloty, Russian Ruble, Rwandan Franc, Seychellois Rupee, Singapore Dollar, Slovak Koruna, South Korean Won, Sri Lankan Rupee, Swedish Krona, Swiss Franc, Tanzanian Shilling, Thai Baht, Tunisian Dinar, Turkish Lira, UK Pound, Ugandan Shilling, US Dollar, Uruguayan Peso, Vanuatu Vatu, South African Rand, Zambian Kwacha

Robustness

Table 4 a: Conditional Volatility and Direct Central Bank Communication

Dep.Var.: Conditional Vola. (daily)	I	II	III	IV	V
Direct Communication	-0.035***	-0.037***	-0.037***	-0.035***	-0.107***
	(0.006)	(0.007)	(0.007)	(0.006)	(0.013)
Size	0.076***	0.057**	0.062***	0.063***	-0.075***
	(0.023)	(0.024)	(0.023)	(0.024)	(0.029)
ln Trade	0.000	0.001	0.001	0.000	-0.001
	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)
Gov. Debt	0.002***	0.002***	0.002***	0.002***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Reserves	-0.000	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
FX-Regime	0.073***	0.077***	0.078***	0.077***	0.094***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.010)
FX-Crisis	0.108***	0.108***	0.109***	0.102***	0.157***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.010)
Inflation Volatility	0.035***	0.037***	0.038***	0.035***	0.037***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
M1 Volatility	0.003***	0.003***	0.003***	0.003***	0.003***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Interest Rate Volatility	0.003***	0.003***	0.003***	0.003***	0.004***
	(0.000)	(0.001)	(0.001)	(0.000)	(0.001)
Real GDP Shock	0.007***			0.007***	0.007***
	(0.001)			(0.001)	(0.001)
Bank System Shock		0.001***		0.001***	0.001***
		(0.000)		(0.000)	(0.000)
Terms-Of-Trade Shock			0.001***	0.001***	0.001***
			(0.000)	(0.000)	(0.000)
Industrial Production Volatility					0.005***
					(0.001)
Bilateral FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Observations	10,681	10,681	10,681	10,681	5,768
R-Squared	0.540	0.533	0.530	0.546	0.662

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table 4 b: Conditional Volatility and Indirect Central Bank Communication

Dep.Var.: Conditional Vola. (daily)	I	II	III	IV	V
Indirect Communication	-0.025***	-0.024***	-0.024***	-0.024***	-0.020***
	(0.003)	(0.003)	(0.003)	(0.002)	(0.003)
Size	0.072***	0.054**	0.059**	0.061***	-0.052*
	(0.023)	(0.024)	(0.023)	(0.024)	(0.029)
ln Trade	0.000	0.001	0.001	0.000	-0.001
	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)
Gov. Debt	0.002***	0.002***	0.002***	0.002***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Reserves	-0.000	-0.000	-0.000	-0.000	-0.001
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
FX-Regime	0.081***	0.085***	0.085***	0.084***	0.102***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.011)
FX-Crisis	0.106***	0.107***	0.108***	0.101***	0.159***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.010)
Inflation Volatility	0.035***	0.038***	0.038***	0.035***	0.038***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
M1 Volatility	0.003***	0.003***	0.003***	0.003***	0.003***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Interest Rate Volatility	0.003***	0.003***	0.003***	0.003***	0.004***
	(0.000)	(0.001)	(0.001)	(0.000)	(0.001)
Real GDP Shock	0.007***			0.007***	0.008***
	(0.001)			(0.001)	(0.001)
Bank System Shock		0.001***		0.001***	0.001***
		(0.000)		(0.000)	(0.000)
Terms-Of-Trade Shock			0.001***	0.001***	0.001**
			(0.000)	(0.000)	(0.000)
Industrial Production Volatility					0.002*
					(0.001)
Bilateral FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Observations	10,681	10,681	10,681	10,681	5,768
R-Squared	0.544	0.535	0.533	0.549	0.650

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

BACK!

Dep. Var.: historical FX-Vola (daily)	I	II	III	IV	V
Direct Communication	-0.032**	-0.035**	-0.035**	-0.033**	-0.212***
	(0.014)	(0.015)	(0.015)	(0.014)	(0.027)
Size	-0.145***	-0.200***	-0.167***	-0.182***	-0.243***
	(0.053)	(0.052)	(0.052)	(0.053)	(0.077)
ln Trade	0.005	0.007	0.006	0.005	-0.007
	(0.005)	(0.005)	(0.005)	(0.005)	(0.009)
Gov. Debt	0.002***	0.001***	0.002***	0.001***	0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Reserves	-0.002***	-0.002**	-0.002**	-0.002***	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
FX-Regime	0.159***	0.168***	0.163***	0.167***	0.297***
	(0.020)	(0.021)	(0.021)	(0.020)	(0.026)
FX-Crisis	0.470***	0.468***	0.476***	0.458***	0.538***
	(0.018)	(0.018)	(0.018)	(0.018)	(0.029)
Inflation Volatility	0.129***	0.136***	0.136***	0.128***	0.085***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
M1 Volatility	0.014***	0.014***	0.014***	0.013***	0.003*
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Interest Rate Volatility	0.009***	0.009***	0.009***	0.009***	0.011***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Real GDP Shock	0.015***			0.015***	0.019***
	(0.002)			(0.002)	(0.002)
Bank System Shock		0.004***		0.004***	0.005***
		(0.000)		(0.000)	(0.000)
Terms-Of-Trade Shock			0.000	0.001	0.000
			(0.000)	(0.000)	(0.001)
Industrial Production Volatility					0.011***
					(0.003)
Observations	10,606	10,606	10,606	10,606	5,873
R-squared	0.615	0.614	0.609	0.621	0.688
Number of bilatid	1,735	1,735	1,735	1,735	915

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Dep.Var.: historical FX-Vola (daily)	**I**	**II**	**III**	**IV**	**V**
Indirect Communication	-0.067***	-0.061***	-0.065***	-0.063***	-0.047***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.008)
Size	-0.153***	-0.209***	-0.176***	-0.188***	-0.198**
	(0.053)	(0.052)	(0.052)	(0.053)	(0.077)
ln Trade	0.005	0.007	0.007	0.006	-0.006
	(0.005)	(0.005)	(0.005)	(0.005)	(0.009)
Gov. Debt	0.002***	0.002***	0.002***	0.002***	0.003***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Reserves	-0.002***	-0.002**	-0.002**	-0.002***	-0.002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
FX-Regime	0.166***	0.175***	0.169***	0.173***	0.312***
	(0.020)	(0.021)	(0.021)	(0.020)	(0.026)
FX-Crisis	0.467***	0.465***	0.474***	0.456***	0.541***
	(0.017)	(0.018)	(0.018)	(0.017)	(0.030)
Inflation Volatility	0.130***	0.137***	0.137***	0.129***	0.087***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
M1 Volatility	0.015***	0.015***	0.015***	0.014***	0.004**
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Interest Rate Volatility	0.008***	0.008***	0.008***	0.008***	0.011***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Real GDP Shock	0.015***			0.015***	0.021***
	(0.002)			(0.002)	(0.002)
Bank System Shock		0.004***		0.004***	0.005***
		(0.000)		(0.000)	(0.000)
Terms-Of-Trade Shock			0.000	0.000	0.000
			(0.000)	(0.000)	(0.001)
Industrial Production Volatility					0.005*
					(0.003)
Observations	10,606	10,606	10,606	10,606	5,873
R-squared	0.620	0.619	0.614	0.626	0.683
Number of bilatid	1,735	1,735	1,735	1,735	915

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Dep.Var.: historical FX-Vola (monthly)	**I**	**II**	**III**	**IV**	**V**
Direct Communication	-0.418***	-0.431***	-0.429***	-0.420***	-1.632***
	(0.095)	(0.099)	(0.098)	(0.096)	(0.204)
Size	-0.568*	-0.769***	-0.664**	-0.639**	-1.792***
	(0.295)	(0.291)	(0.291)	(0.295)	(0.440)
ln Trade	0.014	0.024	0.024	0.016	-0.030
	(0.027)	(0.027)	(0.027)	(0.027)	(0.047)
Gov. Debt	-0.004	-0.004	-0.003	-0.005*	0.002
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Reserves	-0.007	-0.005	-0.005	-0.007	-0.000
	(0.005)	(0.005)	(0.005)	(0.005)	(0.008)
FX-Regime	1.481***	1.510***	1.480***	1.484***	1.930***
	(0.117)	(0.123)	(0.122)	(0.117)	(0.151)
FX-Crisis	1.991***	2.005***	2.045***	1.980***	2.084***
	(0.088)	(0.090)	(0.091)	(0.088)	(0.145)
Inflation Volatility	0.728***	0.764***	0.764***	0.726***	0.491***
	(0.031)	(0.030)	(0.029)	(0.031)	(0.029)
M1 Volatility	0.108***	0.109***	0.111***	0.108***	0.060***
	(0.013)	(0.013)	(0.013)	(0.013)	(0.012)
Interest Rate Volatility	0.037***	0.040***	0.040***	0.036***	0.055***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.008)
Real GDP Shock	0.078***			0.079***	0.117***
	(0.011)			(0.011)	(0.013)
Bank System Shock		0.009***		0.010***	0.015***
		(0.002)		(0.002)	(0.003)
Terms-Of-Trade Shock			-0.005*	-0.005*	-0.001
			(0.003)	(0.003)	(0.004)
Industrial Production Volatility					0.054***
					(0.020)
Observations	10,606	10,606	10,606	10,606	5,873
R-squared	0.542	0.537	0.536	0.543	0.607
Number of bilatid	1,735	1,735	1,735	1,735	915

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Dep.Var.: historical FX-Vola (monthly)	I	II	III	IV	V
Indirect Communication	-0.163***	-0.145***	-0.157***	-0.158***	-0.085*
	(0.042)	(0.042)	(0.042)	(0.042)	(0.051)
Size	-0.663**	-0.865***	-0.763***	-0.728**	-1.511***
	(0.295)	(0.291)	(0.291)	(0.296)	(0.436)
ln Trade	0.012	0.021	0.022	0.013	-0.031
	(0.027)	(0.027)	(0.027)	(0.027)	(0.048)
Gov. Debt	-0.003	-0.003	-0.002	-0.003	0.007**
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Reserves	-0.007	-0.005	-0.005	-0.007	-0.007
	(0.005)	(0.005)	(0.005)	(0.005)	(0.008)
FX-Regime	1.559***	1.590***	1.559***	1.560***	2.064***
	(0.123)	(0.130)	(0.129)	(0.123)	(0.165)
FX-Crisis	1.979***	1.995***	2.036***	1.971***	2.123***
	(0.088)	(0.090)	(0.091)	(0.088)	(0.151)
Inflation Volatility	0.729***	0.766***	0.766***	0.727***	0.500***
	(0.031)	(0.030)	(0.030)	(0.031)	(0.029)
M1 Volatility	0.109***	0.110***	0.112***	0.109***	0.063***
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
Interest Rate Volatility	0.037***	0.040***	0.040***	0.036***	0.064***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.008)
Real GDP Shock	0.080***			0.081***	0.129***
	(0.011)			(0.011)	(0.015)
Bank System Shock		0.009***		0.009***	0.015***
		(0.002)		(0.002)	(0.003)
Terms-Of-Trade Shock			-0.006**	-0.005*	-0.001
			(0.003)	(0.003)	(0.004)
Industrial Production Volatility					0.011
					(0.019)
Observations	10,606	10,606	10,606	10,606	5,873
R-squared	0.541	0.536	0.535	0.542	0.590
Number of bilatid	1,735	1,735	1,735	1,735	915

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 5 a: Robustness - Central Bank Characteristics

Dep.Var.: Historical Vola. (weekly)	I	II	III	IV
Direct Communication	-0.123***	-0.118**	-0.131***	-0.116**
	(0.046)	(0.046)	(0.037)	(0.046)
...				
Controls	YES	YES	YES	YES
...				
Soft IT	-0.145**			-0.142*
	(0.072)			(0.073)
Strict IT		-0.175**		
		(0.070)		
Central Bank Independence			-0.333	-0.312
			(0.351)	(0.368)
Bilateral FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Observations	10,354	10,354	10,478	10,226
R-Squared	0.589	0.589	0.589	0.590

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table 5 b: Robustness - Central Bank Characteristics

Dep.Var.: Historical Vola. (weekly)	I	II	III	IV
Indirect Communication	-0.138***	-0.136***	-0.140***	-0.140***
	(0.019)	(0.019)	(0.018)	(0.019)
...				
Controls	YES	YES	YES	YES
...				
Soft IT	-0.073			-0.069
	(0.063)			(0.063)
Strict IT		-0.099		
		(0.062)		
Central Bank Independence			-0.636*	-0.579
			(0.345)	(0.361)
Bilateral FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Observations	10,354	10,354	10,478	10,226
R-Squared	0.592	0.592	0.592	0.593

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table 6 a: Robustness - Financial System Variables

Dep.Var.: Historical Vola. (weekly)	I	II	III	IV	V
Direct Communication	-0.183***	-0.132***	-0.133***	-0.153***	-0.187***
	(0.058)	(0.037)	(0.037)	(0.035)	(0.059)
...					
Controls	YES	YES	YES	YES	YES
...					
Bank Capital Asset Ratio	-0.056***				-0.060***
	(0.011)				(0.012)
Size of the Banking System		0.003***			0.000
		(0.001)			(0.002)
Financial Integration			0.009***		-0.040
			(0.002)		(0.027)
Z-Score				0.001	0.006
				(0.003)	(0.005)
Bilateral FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Observations	5,274	10,606	10,606	10,239	5,274
R-Squared	0.550	0.589	0.588	0.592	0.551

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table 6 b: Robustness - Financial System Variables

Dep.Var.: Historical Vola. (weekly)	I	II	III	IV	V
Indirect Communication	-0.171***	-0.136***	-0.137***	-0.132***	-0.179***
	(0.027)	(0.018)	(0.018)	(0.018)	(0.028)
...					
Controls	YES	YES	YES	YES	YES
...					
Bank Capital Asset Ratio	-0.058***				-0.067***
	(0.012)				(0.013)
Size of the Banking System		0.003***			-0.001
		(0.001)			(0.002)
Financial Integration			0.008***		-0.031
			(0.002)		(0.027)
Z-Score				0.002	0.011**
				(0.003)	(0.006)
Bilateral FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Observations	5,274	10,606	10,606	10,239	5,274
R-Squared	0.555	0.591	0.591	0.594	0.556

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table 7 a: Robustness - Other Structural Variables

Dep.Var.: Historical Vola. (weekly)	I	II	III	IV	V
Direct Communication	-0.120***	-0.170***	-0.139***	-0.124***	-0.153***
	(0.037)	(0.039)	(0.037)	(0.038)	(0.041)
...					
Controls	YES	YES	YES	YES	YES
...					
Current Account Balance	-0.017***				-0.005
	(0.004)				(0.004)
Capital Account Controls		-1.496***			-1.634***
		(0.126)			(0.134)
Economic Development			-0.537*		-0.232
			(0.281)		(0.345)
Export Dissimilarity				-0.006***	-0.004***
				(0.001)	(0.001)
Bilateral FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Observations	10,606	7,982	10,557	10,425	10,533
R-Squared	0.589	0.628	0.590	0.583	0.592

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table 7 b: Robustness - Other Structural Variables

Dep.Var.: Historical Vola. (weekly)	I	II	III	IV	V
Indirect Communication	-0.141***	-0.097***	-0.139***	-0.144***	-0.104***
	(0.018)	(0.017)	(0.018)	(0.018)	(0.016)
...					
Controls	YES	YES	YES	YES	YES
...					
Current Account Balance	-0.019***				-0.008*
	(0.004)				(0.004)
Capital Account Controls		-1.331***			-1.451***
		(0.119)			(0.125)
Economic Development			-0.220		0.223
			(0.271)		(0.327)
Export Dissimilarity				-0.006***	-0.004***
				(0.001)	(0.001)
Bilateral FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Observations	10,606	7,982	10,557	10,425	10,533
R-Squared	0.593	0.629	0.593	0.586	0.596

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table 8 a: Robustness - Institutional Quality

Dep.Var.: Historical Vola. (weekly)	I	II	III	IV	V	VI	VII	VIII
Direct Communication	-0.097***	-0.216***	-0.214***	-0.228***	-0.214***	-0.217***	-0.214***	-0.233***
	(0.037)	(0.043)	(0.043)	(0.044)	(0.043)	(0.044)	(0.043)	(0.044)
...								
Controls	YES	YES	YES	YES	YES	YES	YES	YES
...								
Polity IV	-0.039***							
	(0.007)							
FSI - Summary Index		0.051						
		(0.071)						
FSI - Freedom to Trade			-0.023					0.004
			(0.035)					(0.039)
FSI - Size of Government				0.090***				0.105***
				(0.026)				(0.030)
FSI - Sound Money					0.031			0.046
					(0.032)			(0.035)
FSI - Legal System						-0.150***		-0.159***
						(0.034)		(0.036)
FSI - Regulation							-0.013	-0.031
							(0.043)	(0.049)
Bilateral FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Observations	9,569	8,976	8,948	8,976	8,976	8,976	8,976	8,948
R-Squared	0.589	0.608	0.608	0.609	0.608	0.609	0.608	0.610

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table 8 b: Robustness - Institutional Quality

Dep.Var.: Historical Vola. (weekly)	I	II	III	IV	V	VI	VII	VIII
Indirect Communication	-0.065***	-0.112***	-0.116***	-0.109***	-0.115***	-0.111***	-0.113***	-0.110***
	(0.016)	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)
...								
Controls	YES	YES	YES	YES	YES	YES	YES	YES
...								
Polity IV	-0.039***							
	(0.007)							
FSI - Summary Index		0.024						
		(0.069)						
FSI - Freedom to Trade			-0.055					-0.028
			(0.034)					(0.037)
FSI - Size of Government				0.050**				0.063**
				(0.025)				(0.028)
FSI - Sound Money					0.041			0.051
					(0.031)			(0.034)
FSI - Legal System						-0.139***		-0.139***
						(0.034)		(0.036)
FSI - Regulation							0.006	-0.001
							(0.042)	(0.048)
Bilateral FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Observations	9,569	8,976	8,948	8,976	8,976	8,976	8,976	8,948
R-Squared	0.590	0.609	0.609	0.609	0.609	0.610	0.609	0.610

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table 9 a: Robustness Additional Shock Variables

Dep.Var.: Historical Vola. (weekly)	I	II	III	IV	V	VI
Direct Communication	-0.137***	-0.140***	-0.138***	-0.135***	-0.323***	-0.359***
	(0.037)	(0.037)	(0.037)	(0.036)	(0.043)	(0.041)
...						
Controls	YES	YES	YES	YES	YES	YES
...						
Inflation Shock	0.026***					0.057***
	(0.005)					(0.006)
Current Account Shock		0.007*				-0.003
		(0.004)				(0.003)
Reserve Shock			0.002			-0.000
			(0.002)			(0.002)
Export Shock				0.014***		0.009***
				(0.003)		(0.003)
Lending Rate Shock					0.011***	0.010***
					(0.001)	(0.001)
Bilateral FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Observations	10,606	10,606	10,606	10,606	8,811	8,811
R-Squared	0.595	0.588	0.588	0.590	0.609	0.640

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table 9 b: Robustness Additional Shock Variables

Dep.Var.: Historical Vola. (weekly)	I	II	III	IV	V	VI
Indirect Communication	-0.134***	-0.140***	-0.140***	-0.135***	-0.150***	-0.141***
	(0.017)	(0.018)	(0.018)	(0.018)	(0.019)	(0.017)
...						
Controls	YES	YES	YES	YES	YES	YES
...						
Inflation Shock	0.025***					0.056***
	(0.005)					(0.005)
Current Account Shock		0.007**				-0.003
		(0.004)				(0.003)
Reserve Shock			0.002			-0.000
			(0.002)			(0.002)
Export Shock				0.013***		0.009***
				(0.003)		(0.003)
Lending Rate Shock					0.012***	0.011***
					(0.002)	(0.001)
Bilateral FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Observations	10,606	10,606	10,606	10,606	8,811	8,811
R-Squared	0.597	0.591	0.591	0.593	0.609	0.638

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Interaction Model

Table 10 a: Conditional Effects of Direct Central Bank Communication

Dep.Var.: Historical Vola. (weekly)	I	II	III
Direct Communication	1.343	-3.160***	0.151*
	(0.884)	(0.724)	(0.081)
...			
Controls	YES	YES	YES
...			
Direct Communication X Remoteness	-0.170*		
	(0.103)		
Direct Communication X Conservatism		2.931***	
		(0.757)	
Direct Communication X Interest Rate Sensitivity			4.494***
			(1.234)
Bilateral FE	YES	YES	YES
Year FE	YES	YES	YES
Observations	10,606	6,136	6,908
R-Squared	0.588	0.655	0.611

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table 10 b: Conditional Effects of Indirect Central Bank Communication

Dep.Var.: Historical Vola. (weekly)	I	II	III
Indirect Communication	0.003**	0.002	0.002
	(0.001)	(0.002)	(0.002)
...			
Controls	YES	YES	YES
...			
Indirect Communication X Remoteness	-0.076*		
	(0.043)		
Indirect Communication X Conservatism		0.925***	
		(0.174)	
Indirect Communication X Interest Rate Sensitivity			0.843**
			(0.415)
Bilateral FE	YES	YES	YES
Year FE	YES	YES	YES
Observations	10,606	6,136	6,908
R-Squared	0.591	0.652	0.608

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Interest Rate Sensitivity measure:

Hetzel, R. L. (1984) Table 2 - JMCB

$$\Delta \ln(M1_t / N_t) = \alpha + \beta\pi_t - \lambda\Delta \ln(\iota_t) + [\phi\Delta \ln(Y_t / N_t)] + \varepsilon_t$$

We estimate this equation for each country in order to attain $\hat{\lambda}$ as a proxy for the interest rate sensitivity of money demand for the period from 1998-2010.

This specification is chosen to maximize the numbers of countries available. Unfortunately, adding the industrial production index/growth decreases the numbers of countries.

Hence, we try to find an additional proxy variable for the interest rate sensitivity of money demand.

BACK!

Remoteness (Frankel and Romer (1999) – *AER)*

$$REMOTENESS_i = \sum_{j \neq i} w_j \cdot \ln(DISTANCE_{i,j}),$$

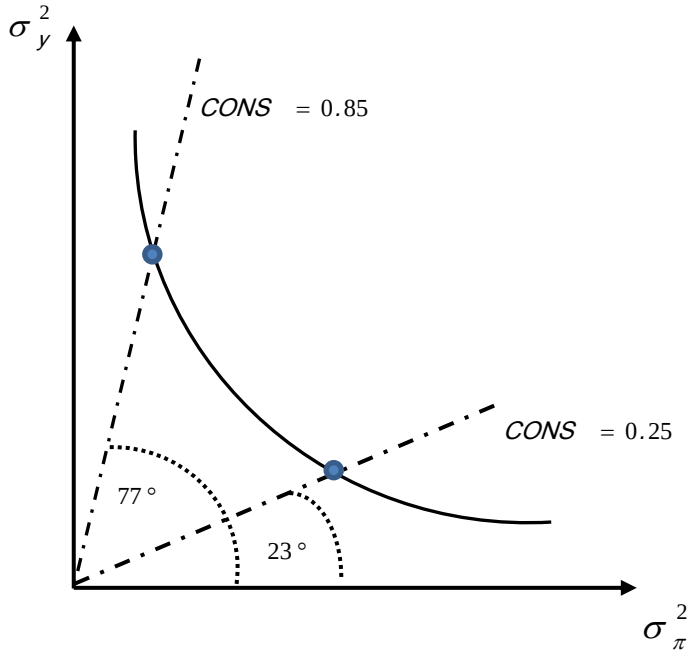
where $w_j = \frac{Trade_j}{\sum_k Trade_k}$; j : trade partner of country i

and k : all countries in the world.

BACK!

CB conservatism (Levieuge and Lucotte (2015))

$$CONS = \frac{1}{90}\left[a\tan\left(\frac{\sigma_y^2}{\sigma_\pi^2}\right) \cdot \frac{180}{pi} \right]$$



BACK!

Theoretical Approach

ERM-Model

LR-equilibrium value of the nominal exchange rate is given by purchasing power parity (PPP)

(1) $\bar{s} = \bar{p} - \bar{p}^*$ | PPP

(2) $m = p + \phi y - \lambda i$ | money demand

(3) $p - p^* = m - m^* - \phi(y - y^*) + \lambda(i - i^*)$ | MM-equilibrium

(4) $\bar{s} = m - m^* - \phi(y - y^*) + \lambda(i - i^*)$ | LR-equilibrium

ERM-Model

Exchange rate in the SR:

(5) $s^e - s = i - i^*$ | UIP

(6) $s^e - s = -\theta(s - \bar{s}) + \pi^e - \pi^{e*}$ | sticky prices in GM

(4‘) $\bar{s} = m - m^* - \phi(y - y^*) + \lambda(\pi^e - \pi^{e*})$ | if $\bar{s} = s$

(7) $s = m - m^* - \phi(y - y^*) - 1/\theta(i - i^*) + (1/\theta + \lambda)(\pi^e - \pi^{e*})$

ERM-Model

SR vs LR effects of inflation expectation uncertainty

$$(7^*)\quad s = m - m^* - \phi(y - y^*) - \underbrace{\frac{1}{\theta}\left[\left(i - \pi^e\right) - \left(i^* - \pi^{e*}\right)\right]}_{= (s - \bar{s})} + \underbrace{\lambda(\pi^e - \pi^{e*})}_{\text{LR uncertainty about } \bar{s}}$$

SR uncertainty of overshooting

The MP-Model

Monetary policy model in the spirit of Kydland and Prescott (1977)

(8) $$W = -\frac{1}{2}\alpha(\pi - \tau)^2 - \frac{1}{2}(1-\alpha)(y-\kappa)^2$$ | Loss-fct.

(9) $$y = \pi - \pi^e + \varepsilon_s$$ | output gap

(10) $$y = -\delta(i - \pi^e) + \varepsilon_d$$ | demand

The model is solved sequentially in three stages:

1st - private agents form rational inflation expectations

2nd - central bank sets the optimal interest rate

3rd - actual shocks realize and actual output/inflation is determined

The MP-Model

Solution

(11) $$i = 1/\delta\left[(\alpha+\delta)\pi^{e} - \alpha\tau - (1-\alpha)\kappa - \alpha\varepsilon_{s}^{a} + \varepsilon_{d}^{a}\right]$$

(12) $$y = -\alpha\pi^{e} + \alpha(\tau+\varepsilon_{s}) + (1-\alpha)\kappa - \alpha\varepsilon_{s}^{u} + \varepsilon_{d}^{u}$$

(13) $$\pi = (1-\alpha)\pi^{e} + \alpha\tau + (1-\alpha)(\kappa-\varepsilon_{s}) - \alpha\varepsilon_{s}^{u} + \varepsilon_{d}^{u}$$

(14) $$\sigma_{\pi^{e}}^{2} = \sigma_{\tau}^{2} + \left(\frac{1-\alpha}{\alpha}\right)^{2}\sigma_{\kappa}^{2} + \left(\frac{1-\alpha}{\alpha}\right)^{2}\sigma_{\varepsilon_{s}}^{2} + \sigma_{\varepsilon_{s}^{u}}^{2} + \left(\frac{1}{\alpha}\right)^{2}\sigma_{\varepsilon_{d}^{u}}^{2}$$

The Variance Equation

Combining both models:

$$\sigma_s^2 = \sigma_m^2 + \sigma_{m^*}^2 + \phi^2\sigma_y^2 + \phi^2\sigma_{y^*}^2 + (1/\theta^2)\sigma_i^2 + (1/\theta^2)\sigma_{i^*}^2 +$$

(2`)

$$(1/\theta+\lambda)^2\left[\sigma_\tau^2 + \left(\frac{1-\alpha}{\alpha}\right)^2\sigma_\kappa^2 + \left(\frac{1-\alpha}{\alpha}\right)^2\sigma_{\varepsilon_s}^2 + \sigma_{\varepsilon_s^u}^2 + \left(\frac{1}{\alpha}\right)^2\sigma_{\varepsilon_d^u}^2\right] +$$

$$(1/\theta+\lambda)^2\left[\sigma_{\tau^*}^2 + \left(\frac{1-\alpha}{\alpha}\right)^2\sigma_{\kappa^*}^2 + \left(\frac{1-\alpha}{\alpha}\right)^2\sigma_{\varepsilon_s^*}^2 + \sigma_{\varepsilon_s^{u*}}^2 + \left(\frac{1}{\alpha}\right)^2\sigma_{\varepsilon_d^{u*}}^2\right] +$$

$$\sum COV$$

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