TÜRKİYE CUMHURİYET MERKEZ BANKASI

Asymmetric Behaviour of Inflation around the Target in Inflation-Targeting Emerging Markets

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Motivation

- Short-term inflation forecasts.
- Öğünç et al. (2013)
  - Univariate models, **nonlinear models**, decomposition based models, unobserved component models, VAR, BVAR, dynamic factor models.
  - Out-of-sample forecasting, forecast combination.
  - Kapetanios et al. (2007), Bjørnland et al. (2008), Andersson and Löf (2007).

Öğünç et al. (2013)

RMSEs relative to the traditional random walk benchmark

	Forecast Horizon			
	h=1	h=2	h=3	h=4
Individual Model Forecasts				
RW_T	1.00	1.00	1.00	1.00
RW_D	2.07	1.18	1.20	**0.96**
UM	3.59	2.35	2.50	3.24
AR	1.10	1.37	1.90	2.91
SARIMA	**0.76**	**0.99**	1.27	1.38
VAR	**0.53**	**0.82**	1.02	1.17
mVAR	**0.24**	**0.69**	1.17	1.79
BVAR	**0.30**	**0.60**	**0.61**	**0.58**
eBVAR	**0.36**	**0.66**	**0.60**	**0.85**
TVP	**0.61**	**0.54**	**0.67**	1.11
WAVE	**0.88**	**0.72**	1.08	1.04
UC	**0.93**	1.04	1.00	**0.90**
FM_SE	1.24	**0.75**	1.20	1.19
FAVAR	**0.93**	**0.58**	**0.98**	1.74

RW_T: Traditional Random Walk,
RW_D: Direct Random Walk,
UM: Unconditional Mean,
AR: Autoregressive Model,
SARIMA: Seasonal ARIMA,
VAR: Vector Autoregressive Model,
mVAR: Monetary VAR,
BVAR: Bayesian Vector Autoregressive Model,
eBVAR: Extended BVAR,
TVP: Phillips Curve Motivated Time Varying Parameter Model,
WAVE: Wavelet Filter Approach,
UC: Unobserved Component Model,
FM_SE: Factor Model Single Equation,
FAVAR: Factor-augmented Vector Autoregression Model

Nonlinear modelling

Teräsvirta (2006, *Handbook of Economic Forecasting*)

- Linearity tests
- Model specification
- Estimation
    - Out-of-sample forecasting exercise

Nonlinear modelling

Determinants of the regime change

- unobservable variables
  - Markov-switching models
- observable variables
  - Threshold models
    - Threshold autoregressive (TAR)→ sharp adjustment, (CH, 2001)
    - Smooth transition autoregressive (STAR) → gradual adjustment
      - ESTAR: Exponential STAR, *(KSS, 2006)*

        «A policy mandate of holding inflation at 2%» (KLP, 2007)
      - AESTAR: Asymmetric ESTAR, (Sollis, 2009)

        Inflation targeting?

        Emerging markets?

Asymmetric Response

- Two types of asymmetries:

1. Point target / Target zone (ESTAR)

   "…if the policymaker assigns at least some weight to output stabilization, the output objective will dominate at times when inflation is within the zone but will recede in importance when inflation is outside the zone." Orphanides and Wieland (2000)

2. Upwards / downwards movements (AESTAR)

   - Asymmetric monetary policy response for BOE under IT (Martin and Milas, 2004):
     - Stronger response against positive deviations from the target compared to negative movements.
     - linear-quadratic paradigm?
   - Asymmetry in inflation persistence

Summary of the results

- 14 inflation targeting emerging markets
- 1995-2013, monthly inflation data
- Linearity (ESTAR ve AESTAR) and structural break tests
- AESTAR model estimation
- Out-of-sample forecasting exercise

Results

- AESTAR type nonlinearity for six countries
- Superior forecast performance (especially in long-term) compared to the benchmark naïve random walk model.

ESTAR model and linearity test

- Kapetanios, Shin and Snell (2003)

$$\Delta\pi_t = a_1\pi_{t-1} + a_2\pi_{t-1}G\{1 - exp[-\theta(\pi_{t-d} - \lambda)^2]\} + \varepsilon_t$$

G : transition function

θ: speed parameter

π_{t-d} : threshold variable

λ : threshold value

$\lambda=0,\ a_1=0,\ d=1$

$$\Delta\pi_t = a_2\pi_{t-1}G\{1 - exp[-\theta(\pi_{t-1})^2]\} + \varepsilon_t$$

- Joint test for linearity and unit root

H_o: $\theta = 0$

H_1: $\theta > 0$

ESTAR model and linearity test

- Identification problem under H_o →Taylor Series approximation

$$\Delta\pi_{t=}\gamma\pi_{t-1}{}^{3} + \sum_{j=1}^{p}\Delta\pi_{t-j} + error$$

- One-sided t-test

$H_o: \gamma = 0$

$H_1: \gamma > 0$

AESTAR model and linearity test

$$\Delta\pi_t = G(\theta_1, \pi_{t-1})[S(\theta_2, \pi_{t-1})a_1 + \{1 - S(\theta_2, \pi_{t-1})\}a_2] + \varepsilon_t$$

$$G(\theta_1, \pi_{t-1}) = 1 - exp[-\theta_1(\pi_{t-1})^2] \qquad \theta_1 > 0$$

$$S(\theta_2, \pi_{t-1}) = [1 + exp(-\theta_2\pi_{t-1})]^{-1} \qquad \theta_2 > 0$$

- Identification problem under H_o →Taylor Series approximation

$$\Delta\pi_t = \emptyset_1(\pi_{t-1})^3 + \emptyset_2(\pi_{t-1})^4 + \sum_{i=1}^{k} \kappa_i \Delta\pi_{t-i} + \mu_t$$

$$H_0 = \emptyset_1 = \emptyset_2 = 0$$

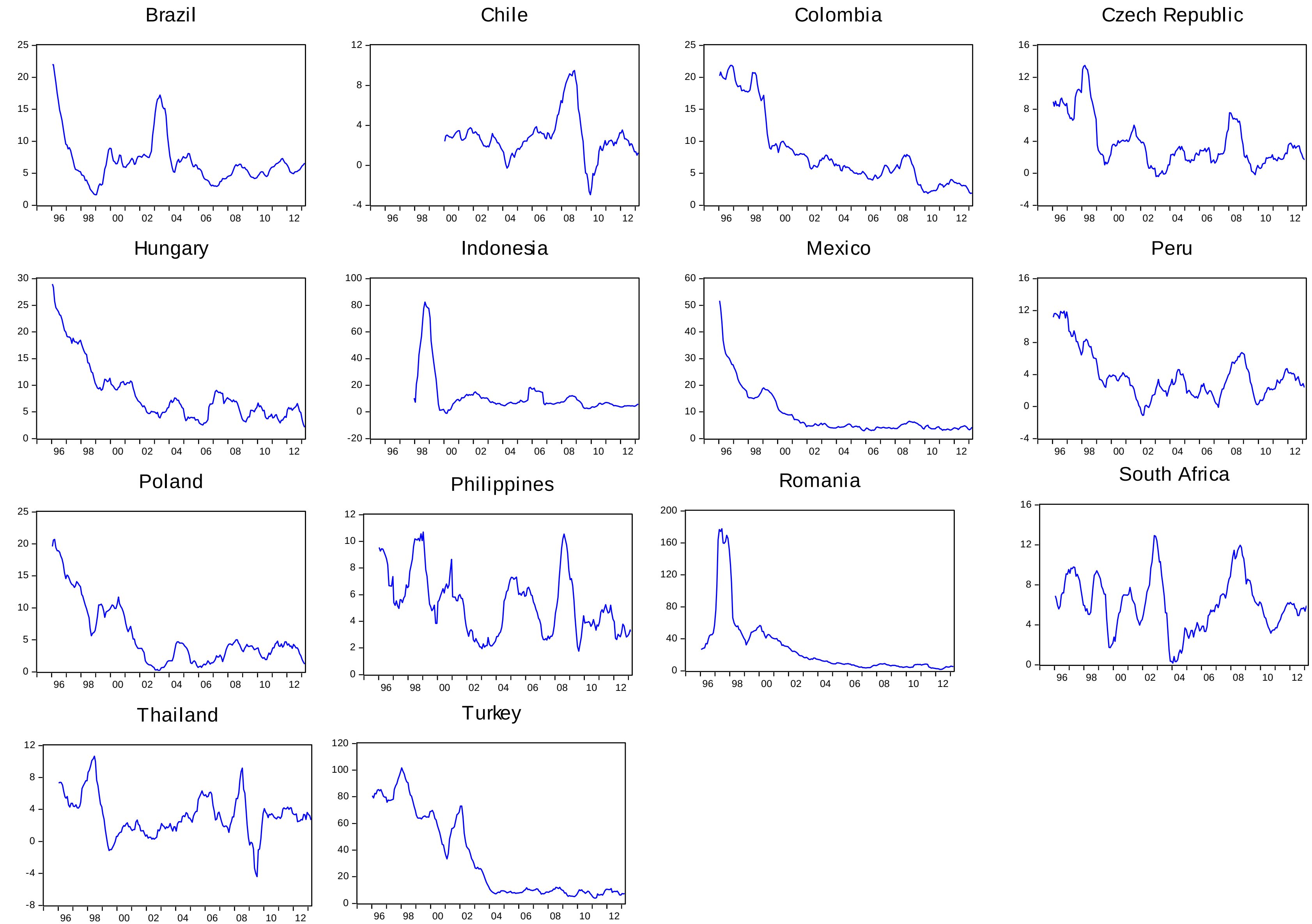
- *Sollis (2009)*

Inflation Targeting: Emerging Markets

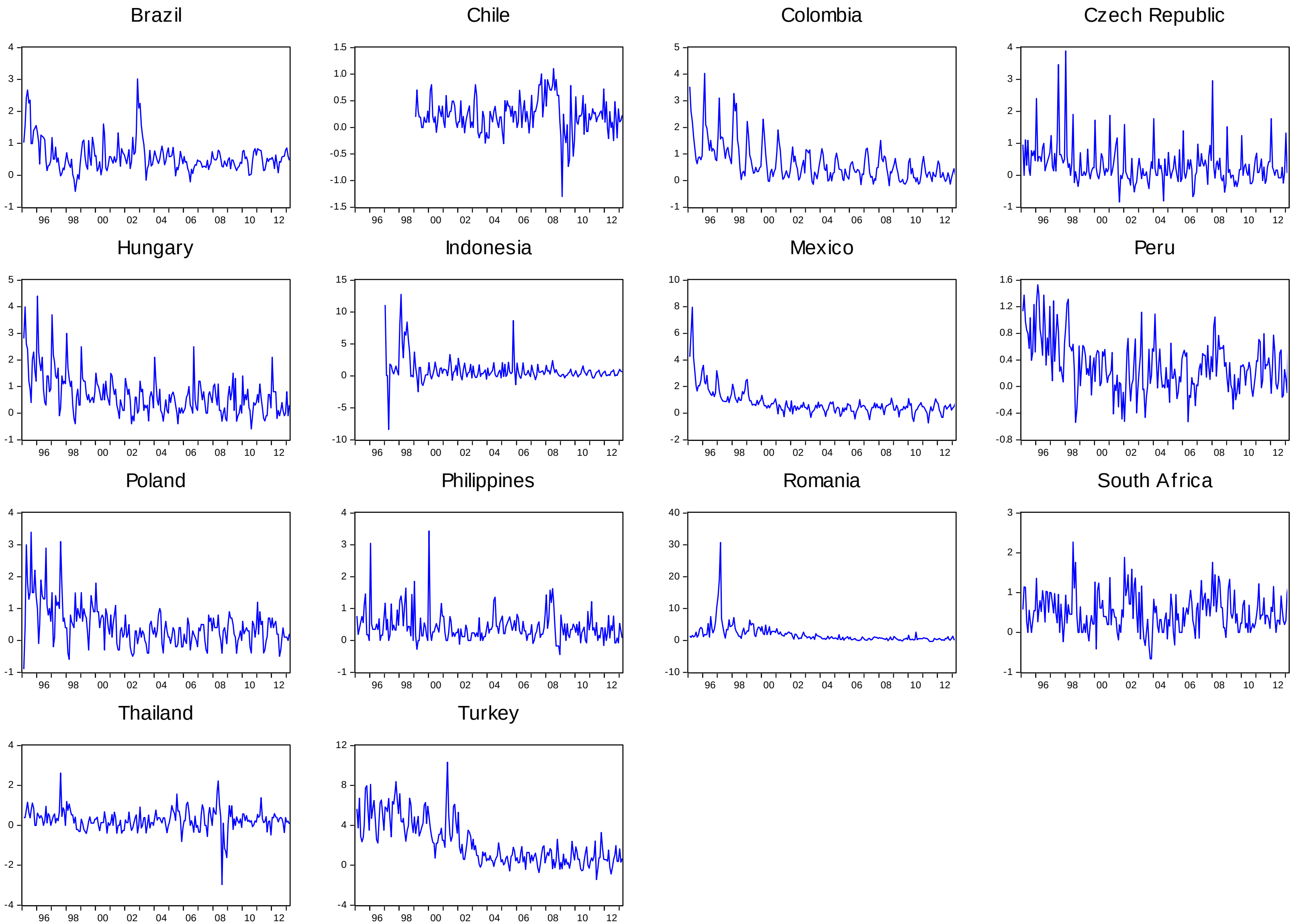
Country	IT Adoption
Brazil	1999
Chile	1999
Colombia	1999
Czech Republic	1997
Hungary	2001
Indonesia	2005
Mexico	2001
Peru	2002
Philippines	2002
Poland	1998
Romania	2005
South Africa	2000
Thailand	2000
Turkey	2006

Source: Mukherjee and Bhattacharya (2011).

CPI Inflation (y-o-y)



CPI Inflation (monthly)



Structural break test

Multiple Structural Break Test (Bai-Perron, 2003)

	Udmax	Wdmax	F(1/0)	F(2/0)	F(3/0)	F(4/0)	F(5/0)	Break Dates
Brazil	3.63	9.06	0.46	0.81	0.08	2.39	3.63 *	
Chile	63.81 ***	159.72 ***	1.08	14.22 ***	2.15	5.77 **	63.81 ***	Jan-97, Feb-99, Dec-01, Jan-04, Feb-07
Colombia	4.07	8.08	0.60	0.77	1.07	4.07	0.79	
Czech Republic	57.21 ***	143.21 ***	0.67	3.67	16.08 ***	4.67 *	57.21 ***	Aug-97, Dec-00, Jan-05, Sep-08, Jul-10
Hungary	3.94	9.85	0.00	1.60	1.38	2.67	3.94 *	
Indonesia	12.59 ***	31.51 ***	0.25	2.22	4.53	7.13 ***	12.59 ***	May-97,Jan-00, Oct-03, Mar-06, Aug-08
Mexico	2.24	5.60	0.73	0.16	0.61	1.37	2.24	
Peru	7.20	18.01 ***	1.61	0.78	1.54	2.14	7.20 ***	Aug-97, Apr-00, Jan-04, Sep-08, Jul-10
Philippines	21.31 ***	53.35 ***	0.54	0.73	0.86	2.44	21.31 ***	Jan-98, Oct-00, Nov-04, Sep-08, Jul-10
Poland	18.96 ***	47.45 ***	0.23	2.12	1.24	3.48	18.96 ***	Aug-97, Apr-00, Mar-04, Nov-07, Jul-10
Romania	10.45 **	26.16 ***	2.56	1.63	2.92	1.79	10.45 ***	Feb-99, Oct-01, Jun-04, Aug-08, Jul-10
South Africa	5.11	12.78	0.11	0.40	2.00	4.87 *	5.11 ***	
Thailand	34.06 ***	85.27 ***	1.42	0.55	1.13	7.96 ***	34.06 ***	Aug-97, Mar-98, Mar-05, Oct-08, Jul-10
Turkey	17.63 ***	44.12 ***	1.19	4.99	5.59 *	8.51 ***	17.63 ***	Feb-99, Oct-01, Sep-04, Oct-07, Jul-10

Structural Break: Problems

- Linearity tests
  - Carrasco (2002)
    - Nonlinear structure → tests with a threshold alternative have more power against parameter instability that stems from structural change.
    - tests including threshold model identify *parameter instability* in time series regardless of its nature.
- Robustness of forecasts
  - bias-variance tradeoff
    - Pesaran and Timmermann (2002)
    - Terasvirta (2005)

Linear unit root tests

	ADF		PP		ERS		P					
							bi		bt		bb	
Brazil	1.15		1.50		1489.27		-2.79		-3.04		-3.81	
d(Brazil)	-6.25	***	-6.27	***	0.47	***	-7.52	***	-6.85	***	-7.56	***
Chile	-0.11		-0.07		291.08							
d(Chile)	-4.46	***	-9.57	***	-0.84	***						
Colombia	-2.36		-4.12	***	4520.20		-2.36		-2.66		-2.77	
d(Colombia)	-1.96		-5.46	***	34.23		-9.17	***	-8.80	***	-9.36	***
Czech Republic	-1.45		-2.16		605.84		-3.32		-2.70		-2.79	
c(Czech)	-2.78	*	-12.97	***	5.94		-14.19	***	-13.40	***	-14.22	***
Hungary	-1.18		-1.63		3891.17		-3.97		-3.39		-4.25	
d(Hungary)	-3.24	**	-11.18	***	2.98	**	-8.92	***	-8.90	***	-8.17	***
Indonesia	-0.23		-0.56		921.40		-4.35		-3.93		-4.59	
d(Indonesia)	-10.83	***	-11.02	***	1.67	***	-6.48	***	-5.54	***	-7.49	***
Mexico	-0.59		-4.38	***	2000.65		-4.51		-4.08		-5.15	
d(Mexico)	-2.78	*	-6.98	***	29.85		-8.36	***	-8.41	***	-8.41	***
Peru	-1.86		-2.17		1428.63		-4.33		-3.07		-3.51	
d(Peru)	-9.28	***	-9.23	***	0.66	***	-7.58	***	-7.48	***	-7.69	***
Philippines	0.47		0.48		2427.13		-4.18		-2.62		-3.84	
d(Philliphines)	-11.91		-11.89	***	0.25	***	-12.58	***	-12.03	***	-12.53	***
Poland	-1.52		-3.82		776.45		-3.97		-3.17		-3.36	
d(Poland)	-1.90		-9.40	***	56.37		-7.51	***	-7.21	***	-7.83	***
Romania	-0.50		-0.31		3036.26		-3.90		-3.44		-3.97	
d(Romania)	-9.72	***	-10.10	***	0.55	***	-10.92	***	-11.41	***	-11.69	***
S. Africa	2.95		2.77		2104.52		-2.27		-2.65		-3.56	
d(S. Africa)	-9.79	***	-10.35	***	0.64	***	-10.94	***	-10.64	***	-10.94	***
Thailand	-0.54		-0.51		430.91		-3.94		-3.44		-3.78	
d(Thailand)	-10.20	***	-10.27	***	0.26	***	-11.51	***	-10.42	***	-11.34	***
Turkey	1.41		1.79		1347.00		-4.58		-2.70		-4.48	
d(Turkey)	-9.64	***	-9.78	***	0.43	***	-6.06	***	-5.74	***	-7.18	***

Nonlinear Unit Root Tests

	testar	Faestar	
Brazil	2.22	4.91	*
Chile	-1.06	0.99	
Colombia	-2.16	4.46	*
Czech Republic	-1.39	1.91	
Hungary	-1.36	0.92	
Indonesia	-2.00	11.38	***
Mexico	0.33	5.58	*
Peru	-0.95	10.08	***
Philippines	0.02	0.39	
Poland	-1.48	4.18	*
Romania	-0.90	2.97	
South Africa	1.29	3.18	
Thailand	-0.70	0.39	
Turkey	0.38	3.62	

AESTAR Model: Results

	θ_1	θ_2	a_1	a_2	a1 - a2	$W_{a1 - a2}$	
Brazil	0.01	0.12	-0.04	-0.01	-0.03	0.21	
	(0.00)	(0.26)	(0.02)	(0.00)			
Colombia	0.01	0.18	-0.01	-0.10	0.09	3.73	*
	(0.03)	(0.17)	(0.01)	(0.34)			
Indonesia	0.01	0.24	-0.02	-0.01	-0.01	0.00	
	(0.01)	(0.44)	(0.00)	(0.00)			
Mexico	0.01	0.04	-0.07	-0.01	-0.06	1.45	
	(0.00)	(0.02)	(0.01)	(0.04)			
Peru	0.04	0.27	-0.01	-0.13	0.12	1.60	
	(0.31)	(1.11)	(0.05)	(1.21)			
Poland	0.11	0.19	-0.02	-0.01	-0.01	0.03	
	(0.65)	(1.74)	(0.01)	(0.16)			

$$\Delta\pi_t = G(\theta_1, \pi_{t-1})[S(\theta_2, \pi_{t-1})a_1 + \{1 - S(\theta_2, \pi_{t-1})\}a_2] + \varepsilon_t$$

Out-of-sample forecasting

	h=1	h=3	h=6	h=9	h=12
Brazil	0.99	0.94	0.93	0.18	0.22
Colombia	0.88	0.74	0.49	0.21	0.18
Indonesia	0.96	0.84	1.08	0.45	0.35
Mexico	0.99	0.81	0.69	0.59	0.52
Peru	0.90	0.62	0.53	0.27	0.21
Poland	0.94	0.62	0.38	0.25	0.20
average	**0.94**	**0.76**	**0.68**	**0.32**	**0.28**

- Training sample(1995M1: 2011M9), forecasting sample(2011M10:2013M3)

Results-1

James Bullard on "juxtaposition between the *role of forecasting* and the *role of modeling* to try to understand how better policy can be made " (Interview with ED, November 2013):

"We [central banks] do not really forecast anyway. What we do is we track the economy. Most actual forecasting day to day is really just saying: What is the value of GDP last period or last quarter? What is it this quarter? And what is it going to be next quarter? Beyond that we predict that it will ***go back to some mean level*** *which is tied down by* ***longer-run expectations****"*

Results-2

- **First asymmetry:** Policy response against deviations of inflation from the target could be different inside or outside a specific band under IT regime.
- **Second asymmetry:**
  - Policy response could be stronger once the inflation is above the band, compared to a negative deviation.
  - Inflation persistence could be different below or above the band.
- AESTAR model provides us:
  - A framework that captures both of these asymmetries;
  - High predictive power for inflation,especially at long-horizons.

Remarks and Future Work

- A gradually shifting mean in inflation
  - González, A., Hubrich, K., & Teräsvirta, T. (2011). *Forecasting inflation with gradual regime shifts and exogenous information* (No. 1363). European Central Bank.
- Structural breaks
- Misspecification tests