Inflation Targeting and Inflation Expectations: Evidence for Brazil and Turkey

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Motivation

- Analysing the evolution of inflation expectations for two key emerging economies, Brazil and Turkey
- Constructing a term structure of inflation expectations
- Capture seasonality in the model to use the seasonal information for forecasting
- An econometric model that adapts rapidly to changing conditions

Results:

- Two different experiences for Brazil and Turkey
- While Brazil can anchor the expectations around the target inflation, the same is not the case for Turkey
- Superior OOS performance for Turkey but a more mediocre OOS performance for Brazil

Underlying Econometric Model

- Consider the local linear model

$$
\begin{aligned}
\pi_t - \alpha_t &= \phi(\pi_{t-1} - \alpha_{t-1}) + \varepsilon_t \\
\alpha_t &= \alpha_{t-1} + \mu_{t-1} + \eta_{\alpha,t} \\
\mu_t &= \mu_{t-1} + \eta_{\mu,t}
\end{aligned}
$$

capturing many popular models as a special case

- $\sigma^2_{\eta_\mu} = 0 \rightarrow$ a random walk with a drift, μ.
- $\sigma^2_{\eta_\alpha} = 0 \rightarrow$ a deterministic trend
- Additionally, when the values of the slope become negligibly small, $\rightarrow$ a local level model involving a random walk only for the level
- Setting only $\sigma^2_{\eta_\alpha} = 0$ but allowing $\sigma^2_{\eta_\mu}$ to be $\rightarrow$ integrated random walk and HP filter

Underlying Econometric Model

- Data for emerging markets is usually seasonal **un**adjusted
- We model seasonality together with other components

$$\begin{aligned}
\pi_t - \alpha_t - \gamma_t &= \phi(\pi_{t-1} - \alpha_{t-1} - \gamma_{t-1}) + \varepsilon_t \\
\alpha_t &= \alpha_{t-1} + \mu_{t-1} + \eta_{\alpha,t} \\
\mu_t &= \mu_{t-1} + \eta_{\mu,t} \\
\gamma_t &= -\sum_{j=1}^{11} \gamma_{t-j} + \eta_{\gamma,t}
\end{aligned}$$

Consider the 1-period ahead forecasts

$$E_t^M[\pi_{t+1}] = \phi\pi_t + \alpha_{t+1|t} + \gamma_{t+1|t} - \phi\alpha_{t|t} - \phi\gamma_{t|t},$$

Consider the k-period ahead forecasts

$$E_t^M[\pi_{t+k}] = (1-\phi^k)\alpha_{t|t} + \phi^k\pi_t + k\mu_{t|t} - \phi^k\gamma_{t|t} + \gamma_{t-12+k|t}.$$

Econometric Model - Matching Survey Predictions

- We match model based forecasts with survey based inflation expectations

$$
\begin{aligned}
E_t^S[\pi_{t+k}] &= \sum_{j=1}^{k} E_t^M[\pi_{t+j}] + \upsilon_{k,t} \\
&= \sum_{j=1}^{k} \phi^j \pi_t + \left(j - \sum_{j=1}^{k} \phi^j\right) \alpha_{t|t} \\
&+ \frac{j(j+1)}{2} \mu_{t|t} - \sum_{j=1}^{k} \phi^j \gamma_{t|t} + \upsilon_{k,t}
\end{aligned}
$$

- Using this we add survey based inflation expectations as additional measurement equations
- For Turkey we have $k = 2$ and 12 (1-month ahead expectations only start after 2006)
- For Brazil we have $k = 12$

Econometric Model - Incorporating Target Inflation

- Usually central banks set an annual inflation target for the next year at the end of each year
- Target inflation implies a twelve-month ahead inflation projection in December of each year.
- $\pi^T_{t,A}$ where the superscript T denotes the **T**arget inflation and subscript A denotes its **A**nnual frequency

$$\begin{aligned}\pi^T_{t,A} &= \delta_0 + \left(\sum_{j=1}^{k} E_t^M[\pi_{t+j}]\right) + \upsilon_t^T, \\ &= \delta_0 + \big(\sum_{j=1}^{12} \phi^j \pi_t + \big(12 - \sum_{j=1}^{12} \phi^k\big)\alpha_{t|t} \\ &+ 78\mu_{t|t} - \sum_{k=1}^{12} \phi^k \gamma_{t|t}\big) + \upsilon_t^T\end{aligned}$$

- We extend the model to measure a time-varying bias by specifying a random walk process for the potential bias

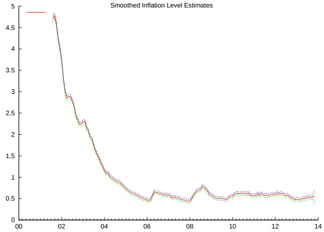
$$\delta_{0,t} = \delta_{0,t-1} + \eta_{\delta,t}.$$

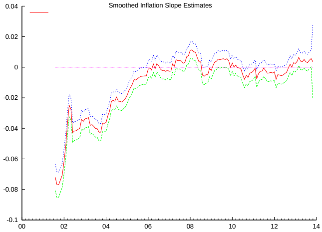
Final Model

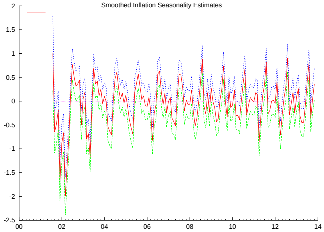
$$
\begin{aligned}
\pi_t &= \alpha_t + \gamma_t + \phi(\pi_{t-1} - \alpha_{t-1} - \gamma_{t-1}) + \varepsilon_t \\
E_t^S[\pi_{t+k}] &= \sum_{j=1}^{k} \phi^j \pi_t + \left(j - \sum_{j=1}^{k} \phi^j\right)\alpha_t + \frac{j(j+1)}{2}\mu_t - \sum_{j=1}^{k} \phi^j \gamma_t + \upsilon_{k,t} \\
\pi_{t,A}^T &= \delta_{0,t} + \left(\sum_{j=1}^{12} \phi^j \pi_t + \left(12 - \sum_{j=1}^{12} \phi^k\right)\alpha_t + 78\mu_t - \sum_{k=1}^{12} \phi^k \gamma_t\right) + \upsilon_t^T \\
\alpha_t &= \alpha_{t-1} + \mu_{t-1} + \eta_{\alpha,t} \\
\mu_t &= \mu_{t-1} + \eta_{\mu,t} \\
\gamma_t &= -\sum_{j=1}^{11} \gamma_{t-j} + \eta_{\gamma,t} \\
\delta_{0,t} &= \delta_{0,t-1} + \eta_{\delta,t}.
\end{aligned}
$$

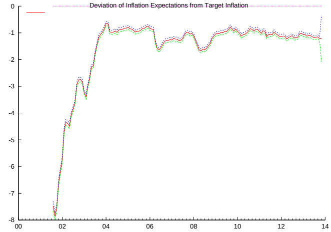
- We use Kalman filter/smoother together with quasi-Newton optimization techniques.

Turkey: Inflation level, slope and seasonality, deviation from target inflation









Turkey: Parameter Estimates

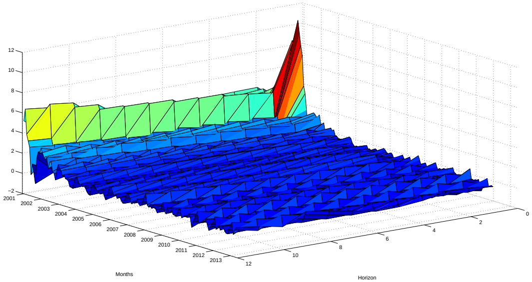
	ϕ	$\sigma^2_{\eta_\alpha}$	$\sigma^2_{\eta_\mu}$	$\sigma^2_{\eta_\gamma}$	$\sigma_{\eta_\alpha,\eta_\mu}$	$\sigma_{\eta_\alpha,\eta_\gamma}$	$\sigma_{\eta_\mu,\eta_\gamma}$
Estimate	0.371	0.002	0.000	0.023	-0.0001	0.005	-0.0007
St. dev	(0.034)	(0.001)	(0.000)	(0.006)	(0.00008)	(0.001)	(0.0002)

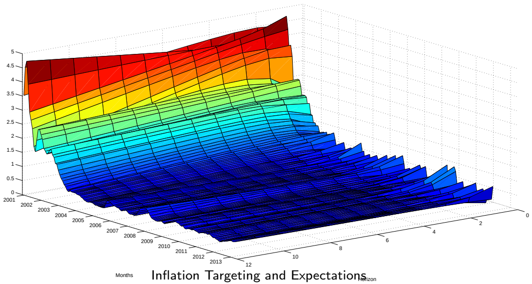
	$\sigma^2_{\eta_\delta}$	$\sigma_{\eta_\delta,\eta_\alpha}$	$\sigma_{\eta_\delta,\eta_\mu}$	$\sigma_{\eta_\delta,\eta_\gamma}$
Estimate	0.021	-0.003	-0.00025	0.008
St. dev	(0.016)	(0.004)	(0.00006)	(0.021)

	σ^2_ε	$\sigma^2_{\upsilon_2}$	$\sigma^2_{\upsilon_{12}}$	$\sigma^2_{\upsilon^T}$	$\sigma_{\varepsilon,\upsilon_2}$	$\sigma_{\varepsilon,\upsilon_{12}}$	$\sigma_{\varepsilon,\upsilon^T}$
Estimate	0.388	0.063	0.140	1.106	-0.098	-0.231	-0.395
St. dev	(0.051)	(0.017)	(0.038)	(0.806)	(0.031)	(0.040)	(0.331)

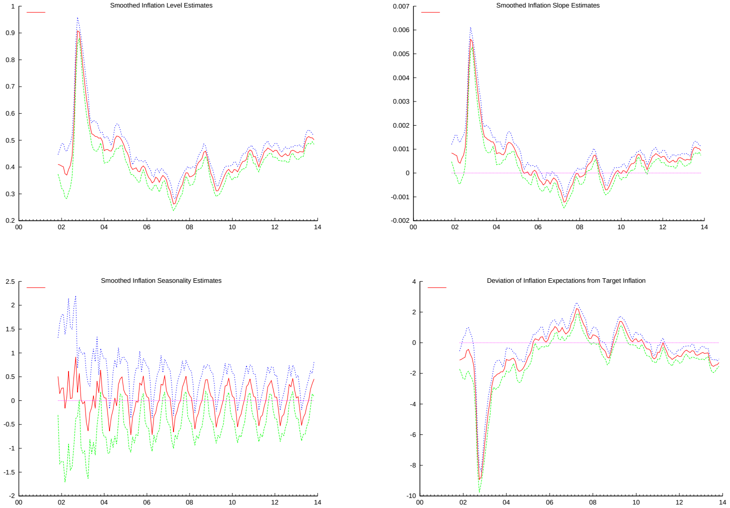
	$\sigma_{\upsilon_2,\upsilon_{12}}$	$\sigma_{\upsilon_2,\upsilon^T}$	$\sigma_{\upsilon_{12},\upsilon^T}$
Estimate	0.067	0.075	0.230
St. dev	(0.024)	(0.029)	(0.190)

Turkey: Term Structure of Inflation Expectations





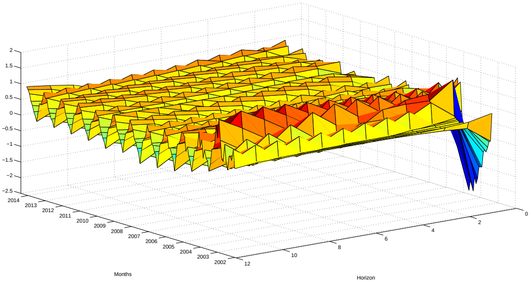
Brazil: Inflation level, slope and seasonality, deviation from target inflation

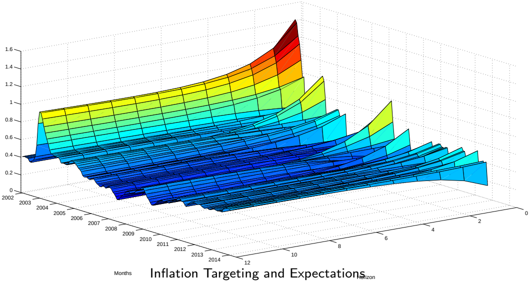


Brazil: Parameter Estimates

	ϕ	$\sigma^2_{\eta_\alpha}$	$\sigma^2_{\eta_\mu}$	$\sigma^2_{\eta_\gamma}$	$\sigma_{\eta_\alpha,\eta_\mu}$	$\sigma_{\eta_\alpha,\eta_\gamma}$	$\sigma_{\eta_\mu,\eta_\gamma}$
Estimate	0.559	0.009	0.000	0.006	0.00009	0.007	0.00007
St. dev	(0.031)	(0.003)	(0.000)	(0.024)	(0.00004)	(0.016)	(0.0001)
	$\sigma^2_{\eta_\delta}$	$\sigma_{\eta_\delta,\eta_\alpha}$	$\sigma_{\eta_\delta,\eta_\mu}$	$\sigma_{\eta_\delta,\eta_\gamma}$			
Estimate	2.349	-0.146	-0.001	-0.118			
St. dev	(0.873)	(0.054)	(0.000)	(0.249)			
	σ^2_{ε}	$\sigma^2_{\upsilon_{12}}$	$\sigma^2_{\upsilon^T}$	$\sigma_{\varepsilon,\upsilon_{12}}$	$\sigma_{\varepsilon,\upsilon^T}$	$\sigma_{\upsilon_{12},\upsilon^T}$	
Estimate	0.672	0.554	0.295	-0.608	-0.420	0.370	
St. dev.	(0.260)	(0.446)	(0.324)	(0.306)	(0.302)	(0.308)	

Brazil: Term Structure of Inflation Expectations





OOS Comparison-Benchmark models

(i) A naive MA model: $\hat{\pi}_{t+h|t} = \frac{1}{12}(\pi_t + \pi_{t-1} + \ldots + \pi_{t-12})$

(ii) An AR(p) model:$\hat{\pi}_{t+h|t} - \pi_t = \alpha_0 + \alpha(L)\Delta\pi_t + \epsilon_t^h$

(iii) A backward-looking Phillips curve:

$$\hat{\pi}_{t+h|t} - \pi_t = \alpha_0 + \alpha(L)\Delta\pi_t + \lambda\hat{z}_t + \delta(L)\Delta z_t,$$

(iv) A backward-looking Philips curve without the current output gap:

(v) A hybrid New Keynesian Philips Curve (NKPC) with survey expectations:

$$\hat{\pi}_{t+h|t} = \gamma\pi_t + (1-\gamma)\pi_t^S + \alpha_0 + \alpha(L)\Delta\pi_t + \lambda\hat{z}_t + \delta(L)\Delta z_t,$$

(vi) A hybrid New Keynesian Philips curve with survey expectations and without the current output gap

Turkey: OOS forecast results

		1	2	3	4	5	6
(i)	State space model (survey expec.)	**0.709**	**0.733**	**0.726**	**0.735**	**0.732**	**0.736**
(ii)	State space model	0.723	0.778	0.807	0.849	0.782	0.843
(iii)	MA (AO)	0.873	0.888	0.893	0.897	0.892	0.899
(iv)	AR	0.999	1.497	1.985	1.994	1.726	1.523
(v)	PC - IP gap	1.010	1.523	1.977	1.989	1.699	1.514
(vi)	PC - lagged IP gap	0.993	1.515	1.987	1.979	1.688	1.525
(vii)	Hybrid NK-PC - IP gap	0.827	1.020	1.062	1.183	1.081	1.056
(viii)	Hybrid NK-PC - lagged IP gap	0.857	1.078	0.989	0.937	0.923	0.871

		7	8	9	10	11	12
(i)	State space model (survey expec.)	**0.733**	**0.735**	**0.741**	**0.742**	**0.731**	**0.733**
(ii)	State space model	0.868	0.895	1.018	1.003	0.966	0.982
(iii)	MA (AO)	0.896	0.881	0.880	0.876	0.855	0.841
(iv)	AR	1.534	1.779	2.124	2.130	1.552	1.154
(v)	PC - IP gap	1.541	1.696	2.048	1.976	1.538	1.062
(vi)	PC - lagged IP gap	1.544	1.671	2.015	1.952	1.497	1.014
(vii)	Hybrid NK-PC - IP gap	0.994	1.098	1.284	1.308	1.146	0.975
(viii)	Hybrid NK-PC - lagged IP gap	0.899	0.959	1.112	0.999	0.903	0.823

Brazil: OOS forecast results

		1	2	3	4	5	6
(i)	State space model (survey expec.)	0.225	0.263	0.283	0.284	0.278	0.270
(ii)	State space model	**0.189**	0.264	0.287	0.307	0.331	0.332
(iii)	MA (AO)	0.219	**0.228**	**0.235**	**0.240**	**0.244**	**0.244**
(iv)	AR	0.194	0.249	0.365	0.447	0.548	0.598
(v)	PC - IP gap	0.194	0.360	0.424	0.486	0.569	0.629
(vi)	PC - lagged IP gap	0.190	0.352	0.421	0.488	0.566	0.625
(vii)	Hybrid NK-PC - IP gap	0.215	0.253	0.342	0.366	0.364	0.411
(viii)	Hybrid NK-PC - lagged IP gap	0.206	0.244	0.307	0.312	0.376	0.416

		7	8	9	10	11	12
(i)	State space model (survey expec.)	0.270	0.275	0.284	0.296	0.304	0.305
(ii)	State space model	0.340	0.317	0.301	0.294	0.281	0.257
(iii)	MA (AO)	**0.245**	**0.245**	**0.244**	**0.236**	**0.235**	**0.236**
(iv)	AR	0.580	0.496	0.407	0.374	0.366	0.361
(v)	PC - IP gap	0.617	0.547	0.504	0.511	0.459	0.466
(vi)	PC - lagged IP gap	0.616	0.547	0.497	0.494	0.458	0.460
(vii)	Hybrid NK-PC - IP gap	0.416	0.389	0.377	0.593	0.344	0.383
(viii)	Hybrid NK-PC - lagged IP gap	0.419	0.441	0.366	1.399	0.699	0.468