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Abstract

Why does low central bank independence generate high macroeconomic instability? A government may periodically appoint a subservient central bank chairman to exploit the inflation-output trade-off, which may generate instability. In a New Keynesian framework, time-varying monetary policy is connected with a "chairman effect." To identify departures from full independence, I classify chairmen based on tenure (premature exits), and the type of successor (whether the replacement is a government ally). Bayesian estimation using cross-country data confirms the relationship between policy shifts and central bank independence, explaining approximately 25 (15) percent of inflation volatility in developing (advanced) economies. Theoretical analyses reveal a novel propagation mechanism of the policy shock.

Keywords: Time-varying policy parameters, macroeconomic volatility, central bank independence, type of chairman changes
JEL classification: E30, E42, E43, E52, E58, E61, O11, O23, O57

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1. Introduction

"Argentina's central bank governor Juan Carlos Fabrega has resigned after less than a year in office. He will be replaced by Alejandro Vanoli, who analysts say is more in tune with the economic policies of President Cristina Fernandez."

(BBC, 02 October, 2014)

"President Trump must soon decide whether to renominate Ms. Yellen or pick someone similarly inclined to emphasize economic growth. Or, instead, he could accede to the wishes of many conservatives for a Fed chairman more worried about inflation." (NYT, 24 August, 2017)

The need to delegate monetary policy to a central bank that is both independent and held accountable for price stability was first argued by Rogoff (1985), based on the dynamic inconsistency theory of inflation introduced by Kydland and Prescott (1977) and further elaborated in Barro and Gordon (1983). While several studies have documented a negative relationship between central bank independence (henceforth CBI) and inflation (Cukierman (1992), Grilli et al. (1991), Cukierman et al. (1992)), these findings have been challenged on several grounds. It has been observed that the reduced form specification may omit important variables, such as society's aversion to inflation (Posen (1995a)), preference for delegation (Crowe (2008)), raising reverse causality concerns (Dreher et al. (2008)). These limitations motivate the need for a formal causal mechanism to justify the empirical literature, and separate CBI's role from other channels that generate macroeconomic stability.

I establish this mechanism in two steps. To connect with the empirical literature, I first document the relationship between CBI and macroeconomic stability. I focus on the de facto measure of CBI, which is proxied by the chairman[1] turn over rate (henceforth TOR),[2] and macroeconomic instability. While several reasons may be attributed to chairman TOR, it can be argued that frequent replacement of the central bank chairman may reflect the removal of those who 'challenge' the government, as highlighted in the case of Argentina, or,

[1]Throughout the paper I use the terms "governor" and "chairman" interchangeably to identify the head of central banking systems, for which titles in different countries vary.

[2]The most widely employed legal indicators of central bank independence are (updates of) the indexes of Cukierman et al. (1992) and Grilli et al. (1991). Legal measures of CBI suffer from many issues (Eijffinger et al. (1996), Cukierman (1992) and Vuletin and Zhu (2011)). For example, de jure institutional rules and laws may not reflect the actual degree of independence in many countries, especially in developing ones. Instead, "de facto" measures of independence, such as the frequency of changes in central bank governors suggest that, at least above some threshold, a more rapid turnover of central bank governors indicates less CBI.

given the recent Trump-Yellen dynamic, maybe even in the United States.[3] A government may frequently fire or pressure the highest monetary authority to quit when he/she does not pursue expansionary monetary policy to exploit the short-run trade-off between output and inflation, which may be achieved through a readjustment in the policy objectives.[4] I model these shifts using time-varying policy parameters in a New Keynesian framework. By introducing a "chairman dummy" in the estimation process, I present a novel technique to quantify what I term the "chairman effect", which connects the frequency of changes in the policy preferences with the TOR of central bank chairman. Using quarterly data on 42 advanced and developing economies, I find this channel to be a source of significant macroeconomic volatility. "Executive capture" of the central bank is identified by disaggregating chairman turnover into (i) premature exits and (ii) whether the replacement was an ally of the government. The results show that executive capture explains approximately 25 percent of the volatility in inflation in developing economies, and 15 percent of the volatility in inflation in advanced economies.

The use of the new panel data set developed by Vuletin and Zhu (2011) confirms the positive and significant relationship between TOR and inflation volatility. The additional controls are robust to a variety of channels that effect this relationship: the inclusion of country fixed effects, degree of trade openness, alternative exchange and monetary agreements, such as fixed exchange rate and inflation targeting regimes, and output volatility. Notable contributions include robustness for the monetary policy transmission mechanism (Laurens (2005), Mishra et al. (2012) and Mishra and Montiel (2013)), and to the type of government regimes (Aisen and Veiga (2006), Aisen and Veiga (2008)).

In the second half of the paper, I introduce time-varying monetary policy parameters to capture shifts in policy preferences using a New Keynesian model. As Clarida et al. (1998a) note, this specification for the policy rule implies that the policy reaction function is stable during the tenure of the chairmen in charge at the time, but may vary across Chairmen.[5] The model is generalized to include positive trend inflation along the lines of Ascari and Ropele (2009) and Ascari and Sbordone (2014). I use Bayesian estimation techniques to quantify the contribution of the policy shock (the shock to the Taylor parameter) to the

[3] Cukierman et al. (1992) conjecture that the frequent changes of the central bank governor give political authorities the "opportunity to pick those who will do their will.

[4] The theoretical motivation for modeling the chairman effect using a time-varying parameter approach is based on the analysis offered by Cukierman (1992), who uses a simple central bank loss function to capture shifts in the relative emphasis on employment and price stability, and where the stochastic policy variable follows an AR(1) process. These shocks may represent readjustments in policy objectives and characterize policymakers who place different relative weights on given policy objectives as being of different "types".

[5] The premise that the emphasis of policy on alternative objectives is time invariant does not seem very realistic in any case (see Lakdawala (2016) for a recent discussion).

historical macroeconomic volatility in the United States.[6] This shock is estimated to be highly persistent and volatile, explaining a large proportion of volatility in inflation and interest rates. Since the change in policy is implemented gradually, giving expectations time to adjust, the output effects are much smaller.

Two exercises connect the independence mechanism to the theoretical model. As a benchmark, I first introduce a "chairman dummy" in the model. The dummy is identified using an additional data series in the model's estimation procedure that includes appointment dates of Federal Reserve chairmen. This enables me to identify the "chairman effect" and separate the variability in policy attributed to changes in the chairman from the aggregate volatility in policy. The "chairman effect" amounts to approximately 18 percent of the variability in inflation and to 32 percent of the variability in the interest rates. Counterfactual analysis finds a positive relationship between chairman TOR and inflation volatility via the time-varying parameter mechanism. I apply this empirical strategy to extract the "chairman effect" for all countries considered in my panel specification.

To identify the *type* of governors from the aggregate series, I distinguish between changes that were premature, and whether the incoming chairman was an ally of the government. Classifying chairmen in this manner purges regular changes from those that may point to an executive capture of the central bank. Estimating the model with the "independence effect" identifies those shifts in the policy parameter that occurred specifically due to a government seeking to exploit the inflation-output trade-off. The independence effect is found to be quantitatively important: approximately 60 percent (25 percent) of total chairman changes result in a parameter shift in the policy rule, explaining on average 25 percent (15 percent) of inflation volatility in developing (advanced) economies. Across countries there exist significant heterogeneity. As expected, in certain advanced economies, such as in the United Kingdom, the United States, Austria and the Netherlands, there is no evidence of the independence effect even though policy varies across chairmen. This mechanism is more prevalent in Argentina, as compared to Bulgaria or Malaysia, where a one-to-one relationship emerges between changes in leadership and policy parameters, generating additional inflation volatility. Therefore, executive capture of the central bank via the appointment of a subservient chairman is found to generate significant macroeconomic volatility.

In the final part of the paper, I examine the theoretical implications of the policy shock. Several interesting results are worth highlighting. First, the shock to policy propagates at higher trend inflation, and when the mean weight on the response to inflation is large.

[6] I focus only on the weight attached to inflation in the policy rule. In an earlier version of the paper, all policy coefficients including the coefficient on interest smoothing were allowed to vary. These were subsequently excluded since they did not contribute to the macroeconomic dynamics.

Conversely, the effect of this shock disappears at zero trend inflation, suggesting that positive trend inflation serves as a crucial propagation mechanism in the model. This may imply that the policy shock may be destabilizing at higher levels of trend inflation and when the monetary authority is highly inflation averse. Second, the degree of persistence of the policy shock determines the direction of the movement in interest rates; at larger degrees of persistence, this shock leads to a rise in inflation despite a fall in interest rates. Despite the lower nominal rate, the change in parameter has a contractionary effect (see, for example, Galí (2009)). Finally, the effect of a shock to this parameter is observationally equivalent to a shock to the inflation target, generating significant welfare effects.

This paper presents a number of important contributions. The primary contribution of this paper is in highlighting and presenting a causal framework that justifies the relationship between CBI and macroeconomic stability observed in the panel data.

The mechanism connecting CBI and policy shifts is based on a New-Keynesian framework model with time varying monetary policy parameters. The use of a novel technique to extract the "chairman effect" and the "independence effect" successfully addresses the issue of causality – executive capture of the central bank via the appointment of a subservient chairman is found to generate significant macroeconomic volatility. This result contributes to a broad literature: the classic relationship between CBI and macroeconomic volatility (Cukierman (1992), Grilli et al. (1991), Cukierman et al. (1992)), reasons for governor dismissal (Dreher et al. (2008), Dreher et al. (2010), Klomp and de Haan (2010)), political milieu and central bank TOR (Keefer and Stasavage (2003), Alesina and Stella (2010), Ehrmann and Fratzscher (2011), Masciandaro (2014), Ennser-Jedenastik (2014), Artha and Haan (2015)), and on governor type (Moser-Boehm (2006), Vuletin and Zhu (2011), Adolph (2013), Fernández-Albertos (2015)). The current paper extends the policy literature (Eijffinger and Hoeberichts (2008), Bernanke (2010), Adolph (2013), Taylor (2013), Levieuge and Lucotte (2014)) by suggesting that the nature of appointment of central bank chairmen may need to be further investigated. Klomp and de Haan (2010) reach similar conclusions.

The modeling exercise in itself extends the literature on two fronts. First, it contributes to the literature that has thus far focused solely on the effect of changes in these parameters on determinacy and on policy activeness (Taylor (1999), Clarida et al. (1998a), Orphanides (2002), Boivin (2005), Lubik and Schorfheide (2004a), Coibion and Gorodnichenko (2011), and Foerster (2016)), and has yet to connect shocks to the policy parameter and macroeconomic volatility along the lines of Roberts (2006), and Canova et al. (2010). Second, the analytical results, such as the crucial role of positive trend inflation and the average weight on the policy parameter as propagation mechanisms to the policy shock present several interesting insights and areas for future work. For example, combining these theoretical results with the historical evolution of the policy shock may contribute to the extensive research on the changes in the conduct of monetary policy, the transmission mechanism, and the structural and policy shocks in the U.S. (McConnell and Perez-Quiros (2000), Clarida et al. (1998a), Stock and Watson (2002), Cogley and Sbordone (2008), Primiceri (2005b), Cogley and Sargent (2005), Sims and Zha (2006), Smets and Wouters (2007), Justiniano and Primiceri (2008), Coibion and Gorodnichenko (2011), Bhattarai et al. (2016)). The quantitative similarities between shifts in policy parameters and exogenous shocks to interest rates connect with the findings of Lakdawala (2016), offering an alternative perspective on explaining the source of monetary policy shocks.

Estimating the model using Bayesian techniques for the large number of countries contributes to country-specific research work on the subject; for many countries, the present study is a pioneering effort to estimate this model, serving as a benchmark for future work in this area. Devoting more effort to explaining the role of time-varying parameters in medium-to-large scale DSGE models along the lines of Smets and Wouters (2007) with a fiscal aspect (Sargent and Wallace (1984), Aiyagari and Gertler (1985), De Resende (2007), Kumhof et al. (2010), Davig and Leeper (2011), Leeper (1991), Leeper and Walker (2012)) may be of interest to future researchers.

The paper is ordered as follows: I present cross-country evidence on the relationship between chairman turnover and inflation volatility in the next section. Section 3 outlines the structural mechanism, focusing on the estimation procedure, and simulation. Section 4 uses numerical analysis to identify the chairman effect from the data. Section 5 extracts the effect of different types of chairman changes. Section 6 analyzes the shock to the policy parameter. Section 7 concludes.

2. Central Bank Independence and Macroeconomic Stability: Cross-Country Evidence

To connect with the empirical literature, I first document evidence between the turnover rate (TOR) of central bank governors,[7] which serves as a proxy for central bank independence,

[7] Similar to Klomp and de Haan (2010), I calculate the turnover rate (TOR) using a rolling average over four years preceding a central bank governor change. According to Vuletin and Zhu (2011) using rolling windows to calculate average turnover rate of central bank governors allows for a more gradual and continuous institutional change. It is important to remark that because they calculate the rolling average over four years preceding a central bank governor change, they do not include current or future changes of central bank governor in the calculation of TOR. This strategy somewhat purges reverse causality concerns;

and macroeconomic instability, focusing on variability in inflation across countries.[8] To test the relationship between TOR and inflation volatility in a pooled (averaged) data setting, I present a basic analysis of this relationship in section 2.1. In section 2.2, I examine the robustness of this relationship against various control variables.[9] The results presented in this section highlight a positive and significant relationship between chairman turnover and inflation variability. Even though the use of this technique and an increase in the number of controls improve predictability, the limitations, such as those related to the omission of other potentially important controls remain a challenge (Posen (1995a)). While these results highlight an interesting empirical observation, the latter part of the paper focuses on establishing a causal relationship to explain these stylized facts.

2.1. Benchmark Results

I test whether a higher rate of turnover in the governors of a central bank is correlated with greater variability in inflation. I calculate rolling window of four years to calculate standard deviation of inflation (Bowdler and Malik (2005)) to obtain a measure of inflation variability. The results of this section are robust for window length of three and five years. Figure 1 plots the simple correlation between average inflation volatility and average central bank governor turnover rate for each country over the entire sample, and further splitting this relationship into advanced and developing country classifications. In appendix A.3, I list the overall period average turnover ratio and frequency of change in central bank governor.

The three panels in figure 1 capture a positive relationship between the TOR and the variability in inflation. The first panel plots the relationship for all countries with the second and third panels representing this relationship for advanced and developing countries, respectively. Developed countries are characterized both by lower average volatility, and lower TOR, which is bounded from above by 0.30, suggesting a replacement time of three

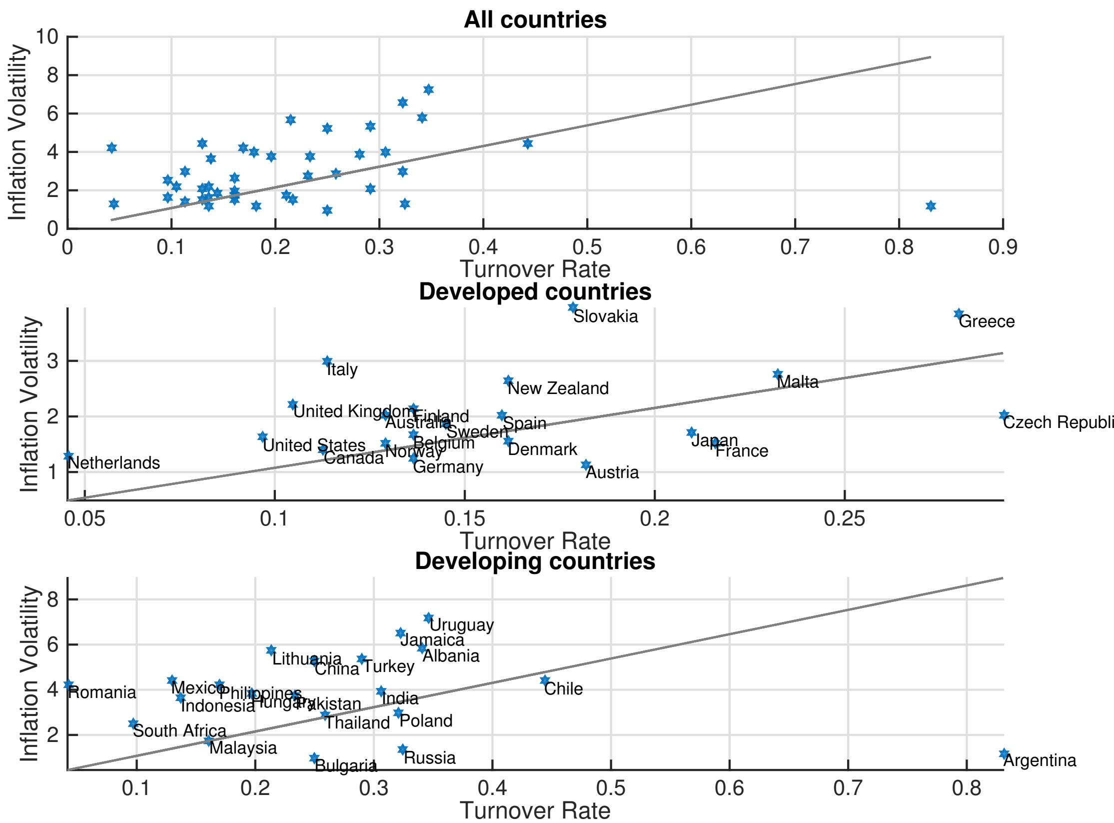
this is a crucial improvement as the existing literature, such as Dreher et al. (2008), has found past inflation to increase the likelihood that a central banker is replaced. Overall, my results are robust when calculating TOR over two, three and five years.

[8] Whereas both the level and the variability of inflation matter from a welfare perspective, I restrict my attention to studying inflation variability. First, under nominal contracts, uncertainty about future prices is likely to entail higher risk premia and unanticipated changes in the distribution of wealth. These costs mean that for a given average inflation rate, higher inflation volatility can depress economic growth (Elder (2004), Fatás and Mihov (2005), Grier and Grier (2006)). I calculate rolling window of four years to calculate standard deviation of inflation (Bowdler and Malik (2005)) to obtain a measure of inflation variability. The results of this section are robust for window length of three and five years.

[9] The baseline data on governor dismissal are compiled by Vuletin and Zhu (2011), and consist of 42 countries (of which 21 are advanced economies and 21 are developing countries) for the period 1972 through to 2006. Detail on the data used in this estimation is available in the appendix.

years. This is in sharp contrast to the developing-country context, which is characterized by both greater TOR and higher average volatility. Chile, for example, has a TOR of approximately 1.5 years, and inflation volatility in excess of 4.0, which is approximately twice the volatility of the upper bound for the developed countries.

Figure 1: Turnover Rate and Inflation Volatility



Note: This figure presents the relationships between the TOR (x-axis) and the variability in inflation (y-axis). The top panel plots the relationship for all countries with the second and third panels representing this relationship in advanced and developing countries, respectively.

To be more precise, I consider the following specification:

$$\sigma_{\pi_{i,t}} = \alpha_1 + \beta_1 TOR_{i,t} + \sum_{h=1}^{H} \Xi_h x_{i,t}^k + \epsilon_i + \eta_{i,t} \tag{1}$$

Here σ_{π_i} is inflation volatility, $TOR_{i,t}$ is the central bank governor turnover rate, $x_{i,t}^k$ are k control variables and ϵ_i represent country fixed effects. The results of the baseline case with no controls are presented in table 1. Columns 1 - 3 in table 1 report the baseline OLS regressions for all, advanced and developing countries. In this regression, I exclude control variables or fixed effects, and the residuals $\eta_{i,t}$ are set to be homoscedastic and are not autocorrelated. Moreover, outliers due to high inflation observations are included in this regression. These regressions formalize the relationship plotted in figure 1, and suggest that higher rates of changes governors are correlated with greater variability in inflation for each type of country. Quantitatively speaking, the results are significantly large, especially for developing countries, a finding that is consistent with the previous literature, and which may be interpreted to imply that the TOR channel has a larger effect on developing countries.

The results reported in columns 4 - 6 allow for homoscedasticity by estimating robust standard errors and error autocorrelation within countries. The statistical significance of TOR falls for advanced economies but remains strong for developing countries. These findings coincide with the existing literature (see, for example, Cukierman (1992), Cukierman et al. (1992), De Haan and Siermann (1996) and Klomp and de Haan (2010)) and confirm that TOR is highly correlated with macroeconomic stability in developing countries.

Next, I exclude the 10 percent of observations with the largest inflation variability and highest levels of inflation. The turnover rate remains pertinent when all countries are pooled (column 7), and when countries are separated in groups (columns 8 and 9). These results differ from the findings of De Haan and Kooi (2000), Sturm and De Haan (2001), Dreher et al. (2008) and Klomp and de Haan (2010), since this relationship is estimated to be quite strong for developing countries. However, consistent with their findings, the relationship between TOR and inflation volatility weakens for developed countries when high inflation observations are excluded.

Last, in order to control for within-country variability as opposed to cross-country variability, I verify the robustness of my results by including a country fixed effect ϵ_i. Examples of within-country effects include a society's preferences toward low inflation, fiscal conduct and differences in historical experience with inflation, or time-varying institutional effects such as law and order, corruption and bureaucratic quality. The statistical significance of the effect of changes of governor fades for advanced economies but remains robust for developing countries. Overall, my baseline results support previous findings, and confirm that the turnover rate of central bank governors produces more pronounced results in developing countries than in advanced economies (see, for example, Vuletin and Zhu (2011)). By using rolling window estimates of TOR, my results contribute to the literature by extending this relationship to inflation variability as well.[10]

[10]Following Cukierman et al. (1992), I investigated the causality between inflation and the TOR by using a

Table 1: Baseline Results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
$\sigma_{\pi_{i,t}}$	All countries	Advanced countries	Developing countries	All countries	Advanced countries	Developing countries	All countries	Advanced countries	Developing countries	All countries	Advanced countries	Developing countries
TOR	206.894***	1.291***	264.420***	206.894*	1.291*	264.420*	5.576***	1.291*	6.244***	3.485***	0.753	5.454***
	[17.237]	[0.401]	[28.192]	[115.709]	[0.715]	[129.346]	[1.266]	[0.715]	[1.590]	[3.397]	[0.888]	[3.678]
Standard errors	standard	standard	standard	Robust & cluster	Robust & cluster	Robust & cluster	Robust & cluster	Robust & cluster	Robust & cluster	Robust & cluster	Robust & cluster	Robust & cluster
High-inflation obs.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effect	No	No	No	No	No	No	No	No	No	Yes	Yes	Yes
Obs.	1,058	524	534	1058	524	534	957	524	433	957	524	433
R^2	0.120	0.019	0.142	0.120	0.019	0.142	0.105	0.019	0.108	0.059	0.007	0.099
Number of countries	42	21	21	42	21	21	42	21	21	42	21	21

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

Note: Dependent variable is inflation volatility. Constant coefficients are not reported.

2.2. Including Controls

In table 2, I estimate panel fixed effect regressions via the same estimation techniques used for estimates in columns 10 - 12 of the previous tables. Other than the rolling window estimate of TOR, I build on the existing literature by including additional controls to ameliorate the omitted variable bias. I find a statistically significant positive relationship between the central bank chairman turnover rate and inflation volatility even when controlling for the structure of the economy, alternative exchange and monetary agreements, and after controlling for periods where the chairman might be replaced due to economic distress. Columns 1 - 21 of table 2 study whether the results are robust to the structure of the economy, and, especially, to the institutional autonomy of the central bank. Columns 22 - 27 look at the TOR under crisis times as discussed in Vuletin and Zhu (2011), and columns 28 - 30 are estimated using all controls.

Columns 1 - 3 include controls on the type of regime, indicating whether a government is autocratic or democratic. The inclusion of the type of regime can control for the effect of institutional stability on inflation variability (see, for example, Aisen and Veiga (2006), Aisen and Veiga (2008)). The type of regime does not affect the strength of my benchmark findings regarding the influence of TOR on inflation variability.

The conduct of monetary policy has been shown to depend crucially on the transmission mechanism, and the ability of short-term interest rates to influence the real economy (see, for example, George et al. (1999)). An important component of monetary policy transmission is determined by financial development as discussed in Woodford (2012) and Smets et al. (2013), Laurens (2005), Mishra et al. (2012) and Mishra and Montiel (2013). Columns 4 - 6 present the role of the transmission mechanism of monetary policy by including one measure of financial development: efficiency.[11] This relationship is both negative and significant for developed countries only - suggesting that institutional changes such as de jure independence of the monetary authority may be less important for taming inflation variability in these countries.

Furthermore, Svensson (1997), Ball and Sheridan (2004), Rudebusch and Svensson (1999)

simple Granger causality test. This allowed me to estimate the bivariate autoregressive processes for inflation and turnover rate. The coefficient of lagged turnover in the inflation equation is highly significant, as is the coefficient of lagged inflation in the turnover equation.

[11] This indicator represents the efficiency of financial agents and markets in intermediating resources and facilitating financial transactions. Since a number of variables can further be categorized under efficiency, I take the mean of variety of indicators related to efficiency. My results remain robust to a variety of other indicators representing financial development, such as depth (size of financial institutions and markets), stability (stability of financial institutions and markets), access (degree to which individuals can and do use financial services), and other factors that influence financial development.

Table 2: TOR regressions with Control Variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
$\sigma_{\pi_{i,t}}$	All	Adv.	Dev.	All	Adv.	Dev.	All	Adv.	Dev.	All	Adv.	Dev.	All	Adv.	Dev.
TOR	2.874***	0.743	4.521***	3.754***	0.473	5.810***	3.264***	0.516	5.245***	3.329***	0.754	5.179***	2.393***	0.512	3.978**
	[0.845]	[0.846]	[1.173]	[1.052]	[0.887]	[1.465]	[1.006]	[0.766]	[1.512]	[1.040]	[0.856]	[1.548]	[0.859]	[0.569]	[1.463]
Regime	-1.140	-0.494***	-1.325												
	[0.948]	[0.053]	[1.089]												
Efficiency				-0.021	-0.035**	-0.016									
				[0.025]	[0.014]	[0.040]									
Infl. target							-1.668***	-1.291***	-2.190***						
							[0.412]	[0.373]	[0.699]						
Fixed ERR										-0.415	0.290	-0.895			
										[0.504]	[0.478]	[0.875]			
Trend Inflation													0.187***	0.173***	0.184***
													[0.020]	[0.021]	[0.031]
Output vol.															
Openness															
Bank Crisis															
Default															
Std. errors	Robust & cluster	Robust & cluster	Robust & cluster	Robust & cluster	Robust & cluster	Robust & cluster	Robust & cluster	Robust & cluster	Robust & cluster	Robust & cluster	Robust & cluster	Robust & cluster	Robust & cluster	Robust & cluster	Robust & cluster
Obs.	924	506	418	831	448	383	957	524	433	939	524	415	929	524	405
Country fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
High-infl.	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
R^2	0.049	0.008	0.081	0.082	0.041	0.132	0.096	0.082	0.134	0.058	0.011	0.102	0.209	0.282	0.212
Countries	42	21	21	42	21	21	42	21	21	42	21	21	42	21	21

	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)
$\sigma_{\pi_{i,t}}$	All	Adv.	Dev.	All	Adv.	Dev.	All	Adv.	Dev.	All	Adv.	Dev.	All	Adv.	Dev.
TOR	2.352**	0.738	3.801**	3.516***	0.579	5.638***	3.518***	0.765	5.511***	3.019***	0.753	4.752***	1.530**	-0.132	2.724**
	[0.928]	[0.543]	[1.490]	[1.023]	[0.835]	[1.457]	[1.034]	[0.856]	[1.489]	[0.916]	[0.848]	[1.383]	[0.678]	[0.502]	[1.019]
Regime													-0.496	-0.884***	-0.567
													[0.445]	[0.091]	[0.601]
Efficiency													0.001	0.004	-0.000
													[0.015]	[0.008]	[0.031]
Infl. target													-0.338	-0.439	-0.505
													[0.424]	[0.347]	[0.987]
Fixed ERR													-0.371	-0.165	-0.414
													[0.340]	[0.330]	[0.556]
Trend Inflation													0.157***	0.053*	0.189***
													[0.038]	[0.029]	[0.048]
Output vol.	-0.025	0.109	-0.069										0.029	0.209***	-0.004
	[0.099]	[0.064]	[0.141]										[0.059]	[0.072]	[0.075]
Openness				-3.880***	-3.947***	-4.054***							-2.139**	-2.831***	-2.049
				[1.010]	[0.719]	[1.195]							[0.953]	[0.979]	[1.188]
Bank Crisis							0.460	0.192	0.718				-0.187	-0.021	-0.289
							[0.420]	[0.338]	[0.721]				[0.235]	[0.238]	[0.411]
Default										2.224***		1.946***	0.532		0.145
										[0.677]		[0.642]	[0.595]		[0.715]
Std. errors	Robust & cluster	Robust & cluster	Robust & cluster	Robust & cluster	Robust & cluster	Robust & cluster	Robust & cluster	Robust & cluster	Robust & cluster	Robust & cluster	Robust & cluster	Robust & cluster	Robust & cluster	Robust & cluster	Robust & cluster
Obs.	730	433	297	957	524	433	957	524	433	957	524	433	643	384	259
Country fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
High-infl.	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
R^2	0.035	0.019	0.060	0.110	0.063	0.155	0.060	0.008	0.101	0.089	0.007	0.126	0.226	0.179	0.282
Countries	42	21	21	42	21	21	42	21	21	42	21	21	40	21	19

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

Note: Dependent variable is inflation volatility. Constant coefficients are not reported.

and Alpanda and Honig (2014) have argued in favor of the benefits of adopting a fixed exchange rate regime or an explicit inflation target to achieve price stability beyond delegating monetary authority to an independent and credible central banker. In Columns 7 - 9, I include a dummy variable to capture variations in inflation-targeting countries. Specifically this dummy is set to one if the country has an explicit inflation target policy, and set to zero otherwise. Columns 10 - 12 include a fixed exchange rate regime (Fixed ERR), a dummy variable equal to one if I use the Reinhart and Rogoff (2002) de facto exchange-rate-regime coarse classification. My findings support existing empirical evidence by suggesting that inflation-targeting policies are associated with lower variability in inflation; fixed exchange-rate regimes do not seem to influence this relationship.

The existing literature, including work by Katsimbris (1985), Judson and Orphanides (1999) and Cecchetti and Ehrmann (1999), has pointed to a positive relationship between the level the and variability in inflation, as well as between output variability and inflation variability. Columns 13 - 15, which include the level of inflation of the country, suggest that inflation variability is positively related to inflation, but output volatility (as shown in columns 16 to 18) does not influence variability in inflation. However, my results show that these relationships hold only for developed economies thus validating the results found in Blanchard and Simon (2001). Trend inflation is also found to be critical in explaining the variability in inflation.

Romer et al. (1993) has argued that central banks in countries that are more open to trade exercise more restraint than their closed-economy counterparts because deviating from their long-run fundamentals can prove costly. Columns 19 to 21 include trade openness ('Openness'), defined as the percentage ratio of exports plus imports to GDP. My findings support the findings favored by this strand of literature, and indicate that inflation variability indeed decreases with trade openness.

I include the effect of bank crises (columns 22 - 24) and the effect of default episodes (columns 25 - 27) on inflation variability. I find that banking crises as well as default episodes increase inflation volatility in developing countries.[12] Banking crises are not associated with higher inflation variability even at the 10 percent significance level. This suggests that the independence of the monetary authority should not be compromised during periods of economic distress.

Once I include all of these controls simultaneously, the relationship between TOR and inflation holds (columns 28 - 30 in table 2) and which remains significant at the 5 percent level. It is important to note that whether the controls are introduced one at a time or all

[12]In the data, there are no episodes of default in advanced countries for the period analyzed.

together, they do not affect the strength of the benchmark findings regarding the influence of TOR on inflation. Overall, the R-squared of the regression in columns 28 - 30 is close to the benchmark R-squared found in Vuletin and Zhu (2011), and higher than that found in Cukierman et al. (1992).

I also split these controls into "stressful" times and "tranquil" times, designations that are similar to those considered in Vuletin and Zhu (2011). The additional controls capturing the structural mechanism are removed. My results remain robust to their specification as well.[13] Table 3 presents these results.

Table 3: TOR Regressions: 'Stressful' and 'Tranquil' Controls

$\sigma_{\pi_{i,t}}$	(1) All countries	(2) Advanced countries	(3) Developing countries	(4) All countries	(5) Advanced countries	(6) Developing countries
TOR	2.381**	0.389	4.180**	3.093***	0.765	5.125***
	[0.885]	[0.545]	[1.531]	[0.954]	[0.856]	[1.445]
Openess	-2.556***	-2.306**	-2.691**			
	[0.801]	[0.922]	[1.066]			
Infl. target	-0.396	-0.204	-0.660			
	[0.389]	[0.461]	[0.760]			
Fixed ERR	-0.821**	-0.311	-1.119**			
	[0.309]	[0.475]	[0.424]			
Trend Inflation	0.169***	0.160***	0.158***			
	[0.019]	[0.024]	[0.027]			
Bank crisis				0.473	0.192	0.779
				[0.443]	[0.338]	[0.774]
Default				1.927**		1.596**
				[0.716]		[0.672]
Standard errors	Robust & cluster	Robust & cluster	Robust & cluster	Robust & cluster	Robust & cluster	Robust & cluster
Country fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
High-inflation obs.	No	No	No	No	No	No
Obs.	643	384	259	929	524	405
R-squared	0.223	0.179	0.281	0.085	0.008	0.131
Number of countries	40	21	19	42	21	21

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

Note: Dependent variable is inflation volatility. Constant coefficients are not reported.

The results presented in this section highlight a positive and significant relationship between chairman turnover and inflation variability. In particular, these results remain robust when controlling for variables to measure the structure of the economy (e.g., the transmis-

[13]These results are also robust to including the structural controls in this specification.

sion mechanism), the type of regime in place to measure the institutional structure, and "tranquil" and "stressful" time variables that drive the variability in inflation. Interestingly, positive trend inflation plays a significant role in generating additional variability in inflation, a finding that supports the unique theoretical relationship between policy parameters, trend inflation and rational expectation determinacy results in Ascari (2004) and Coibion and Gorodnichenko (2011).

While the use of rolling window estimates of turnover rates, and an increase in the number of controls improves predictability in inflation volatility, the limitations, such as those related to the omission of other potentially important controls remains a challenge. For example, the reduced form regression may omit important variables, such as society's aversion to inflation (Posen (1995a) and Posen (1995b)) or a preference for delegation (Crowe (2008)). This relationship may also suffer from a reverse causality problem (Dreher et al. (2008)). Despite providing important stylized conclusions, the limitations motivate the need for a formal structural mechanism to establish the causal relationship between the macroeconomic stability and CBI.

3. Model and Identification

I employ a New Keynesian DSGE framework to model the impact of time-varying monetary policy parameters on inflation volatility. The particular model considered in this paper is generalized to include positive steady state inflation, which has been empirically shown to be an important determinant of inflation variability and persistence (Benati (2008)). Section 3.1 and 3.2 present the baseline structure of this model. Section 3.3 outlines the modification in the policy rule that allows me to identify the variability in the policy parameters attributed to changes in the chairman, and the procedure to extract this information from the data.

3.1. The Log-Linearized Model

The model consists of the following equations that are micro-founded from the optimality conditions of households and firms. A monetary authority responsible for setting nominal interest rates is introduced later. For a detailed exposition of the positive trend inflation New Keynesian model, the reader is referred to the detailed appendix in Ascari and Sbordone (2014). The key equations of the model can be summarized by the following equations:

$$\pi_t = [\beta\bar{\pi}^{1-\chi} + \eta(\epsilon - 1)]E_t\pi_{t+1} + \kappa y_t + \lambda\varphi a_t - \lambda\varphi s_t + \eta E_t\phi_{t+1} \tag{2}$$

$$\phi_t = (1-\sigma)(1-\theta\beta\bar{\pi}^{(1-\chi)(\epsilon-1)})y_t + \theta\beta\bar{\pi}^{(1-\chi)(\epsilon-1)}[(\epsilon-1)E_t\pi_{t+1} + E_t\phi_{t+1}] \quad (3)$$

$$s_t = \xi\pi_t + \theta\bar{\pi}^{(1-\chi)(\epsilon)}s_{t-1} \quad (4)$$

$$y_t = E_t y_{t+1} - \frac{1}{\sigma}(i_t - E_t\pi_{t+1}) + g_t \quad (5)$$

Here π_t stands for the inflation rate, y_t for de-trended output, a_t is the technology shock, g_t is the demand shock, s_t is price dispersion, ϕ_t is an auxiliary process that participates in the determination of inflation, and i_t is the nominal interest rate.

Equation (5) is the log-linearized Euler condition, which captures the negative relationship between output and the real interest rate. This is determined by the difference in the nominal interest rate, i_t, and expected inflation, π_{t+1}. Due to the inter-temporal substitution effect, higher real returns induce greater savings, depressing aggregate demand. Expectations of positive output expand current output, as economic agents prefer to smooth their consumption. Since the underlying model has no investment, output is proportional to consumption in equilibrium. Aggregate output is subject to a shock g_t that can be interpreted as a shock to government spending, or to the households' preferences.

As suggested by Ascari (2004), Ascari and Ropele (2009) and Ascari et al. (2011), a positive steady state inflation rate, $\bar{\pi}$ effects all coefficients in the Generalized New-Keynesian Phillips Curve (GNKPC), described in equation (2) and (3). It is also influenced by s_t, the process for price dispersion, equation (4). The forward-looking auxiliary process ϕ_t also participates in the determinants of inflation. Since trend inflation leads to a smaller coefficient on current output and a larger coefficient on future expected inflation, the NKPC under positive trend inflation becomes more "forward-looking." The contemporaneous relationship between inflation and output progressively weakens, and the inflation rate becomes less sensitive to variations in output and more forward looking. Price indexation counterbalances some of the effects of trend inflation. The GNKPC under trend inflation nests the text-book version of the NKPC, which can be derived by setting $\bar{\pi} = 1$ or under full price indexation.

The parameters β is the discount factor from the consumer's utility problem, φ is the labor elasticity, σ is the relative risk-aversion parameter, ϵ is the Dixit-Stiglitz elasticity of substitution among goods, θ is the Calvo (1983) parameter, χ is the degree of price indexation, and $\bar{\pi}$ is the steady state inflation. Finally, λ, η, κ and ξ are all convolutions of the structural parameters and take on the following form:

$$\lambda = \frac{(1-\theta\bar{\pi}^{(\epsilon-1)(1-\chi)})(1-\theta\bar{\pi}^{\epsilon(1-\chi)})}{\theta\bar{\pi}^{(\epsilon-1)(1-\chi)}} \qquad \eta = \beta(\bar{\pi}^{(1-\chi)}-1)(1-\theta\bar{\pi}^{(\epsilon-1)(1-\chi)})$$

$$\kappa = \lambda_{\bar{\pi},\epsilon}(\sigma+\varphi) - \eta_{\bar{\pi},\epsilon}(1-\sigma) \qquad \xi = \frac{\epsilon\theta\bar{\pi}^{(\epsilon-1)(1-\chi)}(\bar{\pi}^{1-\chi}-1)}{1-\theta\bar{\pi}^{(\epsilon-1)(1-\chi)}}$$

3.2. The Monetary Authority

The model is closed by introducing a monetary authority that sets the interest rates. Similar to Fernández-Villaverde and Rubio-Ramirez (2007), I allow the policy coefficient on inflation to vary over time. Both the variables and the corresponding policy parameters in the following specification of the policy rule are expressed in gross terms:

$$I_t = V_t(I_{t-1})^{\Phi_i}[\Pi_t^{\Phi_{\pi,t}} Y_t^{\Phi_y}]^{1-\Phi_i} \tag{6}$$

In an earlier version of the paper, all policy coefficients including the coefficient on interest smoothing were allowed to vary. These were subsequently excluded since they did not contribute to the macroeconomic dynamics.[14] The equation can be log-linearized to obtain the time-varying rule in the following form:[15]

$$i_t = \Phi_i i_{t-1} + (1-\Phi_i)[\Phi_\pi(\bar{\pi}^{ss}\phi_{\pi,t} + \pi_t) + \Phi_y y_t] + v_t \tag{7}$$

Since equation (6) expresses the variables and the parameters in the policy rule in gross terms, log-linearization returns a time-varying rule where the natural logarithm of the gross steady state price level ($\bar{\pi}$) and rescales the time-varying parameter. $v_{r,t}$ captures the exogenous component in the nominal interest rate. The policy parameter is assumed to follow an AR(1) process: $\phi_{\pi,t} = \rho_p\phi_{\pi,t-1} + \epsilon_t$ where the error term ϵ_t is assumed to be iid with zero mean and variance σ_p^2. Notice that setting either $\bar{\pi}^{ss}$ or $\phi_{\pi,t}$ to zero in equation (7) returns a standard, Taylor-type monetary policy rule considered in the literature.

This set-up allows me to distinguish between short-run changes in the policy parameters from those that occur in the long run. The monetary authority systematically responds to contemporaneous long run changes in inflation and output captured by the parameters, Φ_π and Φ_y.[16] Short-run changes in policy, $\phi_{\pi,t}$, may represent departures from the stan-

[14] The model was also estimated using various levels of trend inflation, but that did not change the underlying quantitative results. Similarly, the results remain unchanged when the model is adjusted to allow for cross-country differences in trend inflation, as shown in section 4.3.

[15] Derivation of the log-linearization is available in the appendix A.2.

[16] Moreover, as long as $\Phi_i > 0$, the monetary policy rule accounts for some degree of interest rate smoothing,

dard policy rule. Therefore, the policy framework may be interpreted as follows: central banks follow policy that is consistent with the central bank's specific framework (such as an inflation-targeting central bank), which is represented by the long run parameters, while deviations in policy are captured using the short run variable $\phi_{\pi,t}$.[17] Clarida et al. (1998a) present one reason why this may be so; the time-varying specification in the policy rule may imply that the policy reaction function is stable during the tenure of the chairman in charge at the time, but may vary across chairmen.

How do shifts in the inflation coefficient represent a reasonable mapping of the chairman effect? The current framework suggests that shifts in policy may represent readjustments in objectives, characterizing policymakers who place different relative weights on given policy objectives as being of different "types". Shifts in the policy parameters enter as an additional shock in the monetary policy rule, leading to a shift in the nominal interest rates and affecting inflation and output through the transmission mechanism comprising equations (2) – (5).

The theoretical motivation for modeling the chairman effect using a time-varying parameter approach is based on the analysis offered by Cukierman (1992), chapter 9, who uses a simple central bank loss function to capture shifts in the relative emphasis on employment and price stability, and where the stochastic policy variable follows an AR(1) process. Furthermore, Adolph (2013) shows that left- and right-wing governments tend to appoint central bankers with different monetary preferences. Fernández-Albertos (2015) surveying 24 central banks find that even the most independent central bank does not operate in a political vacuum. Ehrmann and Fratzscher (2011) uses data on the partisan back-ground of 195 central bank governors in 30 European countries between 1945 and 2012 to test whether partisan congruence between governors and the executive (the government or the president) is associated with a higher probability of governor turnover. The author finds that partisan ties to the government strongly increase a governor's odds of survival vis-à-vis nonpartisan and opposition-affiliated individuals.

Finally, in the complete model comprising equations (2) – (5) and (7), the structural shocks, a_t, and g_t and the exogenous policy shock v_t are all assumed to follow a mean zero AR(1) process, and are serially uncorrelated and normally distributed with mean zero, persistence ρ, and standard deviation σ.

as observed from central banks' tendency to smooth interest rate adjustments.

[17] For example an inflation-targeting central bank may have a consistent long-run aversion to inflation and which will be captured as a high long-run value of Φ_π.

3.3. Identification of Chairman and Independence Effect

In this framework time-varying policy parameters capture shifts in central bank preferences due to changes in the chairman. However, since changes in the policy parameters may occur due to reasons beyond those limited to changes in the chairmanship, estimates of the variance of this shock as captured by the policy rule (7) may be contaminated.[18] Furthermore, not all changes in chairmanship represent executive capture of the central bank.

To resolve this issue, I proceed in two steps. Including a "chairman dummy" in the estimation procedure allows me separate the variability in the policy parameters attributed specifically to the appointment of the chairman from changes in policy due to institutional or welfare related reasons.[19] In the second step, I differentiate voluntary exits that are part of the naturally occurring process of the labor supply/attachment decisions of central bank governors from the involuntary departures associated with central bank governors who are perceived as challengers by the government, and I identify whether the incoming central bank governor replacements have strong ties with the government. The first step identifies the "chairman effect", while the second step isolates the "independence effect" from the total chairman effect.

Estimating the complete model using the three observables (inflation, output and interest rates) allows me to capture the persistence and standard deviation, $\phi_{\pi,t} = \rho_p \phi_{\pi,t-1} + \epsilon_t$. To capture the "chairman effect" from this equation, I introduce a "chairman dummy" in the estimation process. I introduce data consisting of values zero and one, with one specified against the quarters corresponding to changes in the chairman of the central bank. For example, in the U.S. version of the model, the data series contains five changes in the chairman; therefore the dummy series has five observations equal to one at 1970:I (Martin – Burns), 1978:I (Burns – Miller), 1979:III (Miller – Volcker), 1987:III (Volcker – Greenspan) and 2006:I (Greenspan – Bernanke). Observations at other points in this series are set to zero. The dummy enters in the variance component of the AR(1) process for policy. Therefore, the estimated model returns ρ_p and σ_p^t, where σ_p^t captures the aggregate standard deviation of changes in policy. Then σ_p^d, which captures the "chairman effect" is extracted by taking the difference between the total shift in policy parameters and the without dummy estimation,

[18] These factors may include pressure from the Treasury (Cukierman (1992)), the chairman's own preferences regarding inflation levels (Cecchetti and Ehrmann (1999)), the policymakers' learning about the right mechanism of the economy (Primiceri (2005a)), or the aim of achieving greater welfare (Taylor (1993)).

[19] In the model, U.S. data are treated as the benchmark to connect with the existing literature that has modeled time-invariant rules in this set-up, and connect with the vast literature available that describes the suitability of this model for the underlying data. In section 4.2 this exercise is extended to the other countries included in the panel specification.

using $\sigma_p^d = \sigma_p^t - \sigma_p$.[20] This specification connects with the work of Clarida et al. (1998a) and Boivin (2005), who use dummy variables to estimate changes in policy parameters.[21]

In the second step, I extract the "independence effect" from the total "chairman effect." To identify the type of governor changes I distinguish between a change that was premature, as defined by whether a central bank governor completed his/her tenure, and a change that led to a successor chairman who was an ally of the government. Excluding these changes in the chairman from the aggregate turnover represent executive branch capture of the central bank. This idea builds on work by Vuletin and Zhu (2011) who argue that governments may frequently fire or pressure the highest monetary authority to quit when he/she does not pursue expansionary monetary policy to exploit the short-run trade-off between output and inflation. Other literature has also distinguished between the types of governors (see, for example, Fernández-Albertos (2015), Moser-Boehm (2006), Adolph (2013)).

Re-estimating the model with the series that contains these type of governors enables me to track those shifts in the policy parameters that occur when the government appoints a subservient central bank governor to exploit the inflation-output trade-off. The model is then used to decompose the volatility that results due to explicit executive capture of the central bank due to the appointment of a specific "type" of chairman. In this manner, the theoretical mechanism allows me to explain the relationship between macroeconomic stability and central bank independence, which can be applied to a broad set of countries.

4. Benchmark Results

In this section, I present estimates of the parameters that describe the structural model (section 4.1), as well as investigate the contribution of changes in chairman of the central bank on macroeconomic volatility (section 4.2). Using the results from the models estimation procedure, I extract the chairman effect by simulating the model in section 4.3.

[20] One may argue that the appointment of a new chairman should be reflected more in expected inflation than realized inflation in the policy rule. My results are robust to estimating the policy rule on expected inflation instead of realized inflation.

[21] Notice that the exogenous timing of U.S. chairman's appointment permits me to separately identify the "chairman effect" from the data. However, even if the timing of appointment is exogenous, one may argue that the "type" of chairman (e.g. one who is particularly aggressive on inflation) may not be exogenous. Chairman Volcker, for example, has acquired a reputation for having been harsher on inflation than his predecessors. This can be identified using the dummy approach by only allowing for the "Volcker dummy" in the data series. Other factors, such as those related to the central banks' learning mechanism are best captured by gradual changes in policy, rather than by large shifts during the periods corresponding to changes in the chairman. In this sense, welfare-based changes in the long run parameter would be better reflected in the evolution of the composition and structure of the FOMC rather than by the appointment of a new chairman (see, for example, Tootell (1999)).

4.1. Bayesian Estimation

The linear model, comprising equations (2) – (5) and the policy rule in equation (7), is first solved using standard Blanchard-Kahn techniques, and then estimated using Bayesian estimation techniques, setting the U.S. economy as a benchmark.

I calibrate a subset of the model's parameters, a standard methodology in the literature. The discount factor β is set to 0.99, the elasticity of substitution among goods ϵ is set equal to six, and the inverse of the labor elasticity φ is calibrated to one. μ, which represents the relative weight of indexation to past inflation versus trend inflation, is set to zero. Trend inflation is kept fixed to the average of the sample for the benchmark case. Varying this average does not change the main conclusions of the paper. Using the priors presented in Ascari et al. (2011), the model is estimated over the full sample from 1966:I through to 2008:II.[22] The end-of-the-sample dates are chosen to avoid dealing with the Federal Reserve's unconventional monetary policy that began in September 2008. The posterior distribution of the parameters is characterized using the methods outlined in An and Schorfheide (2007) and are described in the appendix.

I use three quarterly U.S. time series: log of quarterly gross rate of the GDP deflator, the log deviation of real GDP with respect to its long run trend, and the federal funds rate. A fourth series, which contains information pertaining to the chairman dummy is added. Specifically, this series consists of values zero and one, with one specified against the quarters corresponding to changes in the chairman. For the U.S., there are five changes in the chairman therefore the dummy series has five observations equal to one at 1970:I (Martin – Burns), 1978:I (Burns – Miller), 1979:III (Miller – Volcker), 1987:III (Volcker – Greenspan) and 2006:I (Greenspan – Bernanke). Observations at other points in this series are set to zero.

I estimate three versions of the model. First, I constrain the time-varying policy parameter to zero. In this case, the model is similar to the one presented in Ascari et al. (2011), but estimated over the entire data sample. Second, I estimate the mode, including the time-varying monetary policy rule. Third, I include the policy rule including the chairman dummy. Table 4 reports the prior and posterior densities for the estimated parameters, the mean, and the 10th, and 90th percentiles of the posterior distributions for each version of the model. Details on the priors are included in appendix A.5.

[22]The model is also estimated over the sample 1955:I - 1965:IV to establish the validity of their priors, and establish priors for the time-varying policy parameters.

Table 4: Full Sample Estimation Results

Parameter	Description	Baseline (I) Posterior Mean [10th; 90th]	Extended (II) Posterior Mean [10th; 90th]	Dummy (III) Posterior Mean [10th; 90th]
χ	Indexation	0.82	0.51	0.50
		[0.66; 0.99]	[0.11; 0.99]	[0.11; 0.99]
θ	Calvo	0.92	0.58	0.64
		[0.91; 0.94]	[0.47; 0.69]	[0.52; 0.74]
σ	Risk aversion	2.89	2.24	2.36
		[2.51; 3.25]	[1.86; 2.64]	[1.94; 2.79]
Φ_π	T. rule inflation	1.34	3.41	3.36
		[1.07; 1.60]	[2.87; 3.92]	[2.82; 3.88]
Φ_y	T. rule output	0.43	0.08	0.08
		[0.31; 0.55]	[0.03; 0.13]	[0.03; 0.13]
Φ_i	T. rule smooth	0.78	0.52	0.63
		[0.73; 0.83]	[0.37; 0.66]	[0.50; 0.75]
ρ_a	Tech. pers.	0.89	0.98	0.98
		[0.86; 0.93]	[0.98; 0.99]	[0.96; 0.99]
ρ_v	Policy pers.	0.23	0.28	0.22
		[0.10; 0.34]	[0.16; 0.39]	[0.11; 0.34]
ρ_g	IS pers.	0.82	0.92	0.90
		[0.78; 0.86]	[0.88; 0.96]	[0.85; 0.95]
ρ_p	Policy (II) pers.	–	0.96	0.99
		–	[0.93; 0.98]	[0.98; 0.99]
σ_a	Tech. std.	0.0348	0.0129	0.012
		[0.0278; 0.0424]	[0.011; 0.0148]	[0.01; 0.014]
σ_v	Policy std.	0.0024	0.0043	0.0033
		[0.0022; 0.0027]	[0.0031; 0.0055]	[0.0025; 0.0041]
σ_g	IS shock std.	0.0024	0.0011	0.0012
		[0.0020; 0.0028]	[0.0008; 0.0013]	[0.0009; 0.0015]
σ_p	Policy (II) std.	–	0.1424	0.09
		–	[0.1198; 0.1652]	[0.07; 0.10]
σ_p^t	Total St. Dev	–	–	0.17
	(incl. chairman dummy)		–	[0.16; 0.19]
LL		−296	−284	−163

Note: I use 200,000 draws from the posterior to compute the model. Acceptance rates on average were between 30% to 33%. The log-marginal likelihoods are computed with the harmonic mean estimator presented in Geweke (1999). " – " Indicates that the parameter is constrained to equal zero.

For the baseline model without the time-varying policy parameter, the indexation parameter is high compared to the estimates provided by Justiniano et al. (2011). Estimates of the Calvo parameter and the degree of relative risk aversion are also on the higher side compared to the standard literature, but they are in line with the estimates provided by Ascari et al. (2011). The parameters for Calvo and the relative risk aversion are precisely estimated, and their distributions appear to cover a narrow range of available estimates using macro data. The results of the estimated model with the time-varying monetary policy rule match the broader evidence considered in the literature. The estimated values of the other structural parameters are also close to what have been proposed in the literature. The evidence suggests that the model with the time-varying parameter better explains the data.

The estimated policy parameters suggest an aggressive, gradually implemented, long-run reaction of the Federal Reserve to fluctuations in inflation, which is close to existing literature (Benati and Surico (2009), Boivin and Giannoni (2006), Clarida et al. (1998b) and Lubik and Schorfheide (2004b)). However, the model without trend inflation in the policy rule is unable to capture the high long-run response to inflation. This could possibly be due to the inclusion of trend inflation in explaining the dynamics during the Great Moderation (Qureshi (2015)), and due to the conditions imposed on determinacy (Coibion and Gorodnichenko (2011)). The policy parameter indicates a high degree of persistence, and a standard deviation three times larger than the exogenous policy shock.[23] As in Smets and Wouters (2007), the estimated persistence of the structural shocks is very large in both models. Shocks to output and the nominal interest rate are relatively less volatile, but shocks to the IS curve are persistent in all three models.

Estimates of the model with the dummy variable provide an interesting insight into the behavior of policy parameters during the quarters corresponding to changes of the chairmen. The results of the estimation attribute a little under half of the total volatility in policy parameters to changes in the chairmen. This suggests that while the policy parameters may have shifted due to reasons other than due to changes of the chairmen, volatility specifically due to the appointment of a new chairman is an important source of changes in the policy parameter.

Finally, the modified harmonic mean estimator is used to calculate the Bayesian Information Criterion (BIC) and the Akaike Information Criterion (AIC), and to identify the model that best fits the data. My results suggest that a model with a time-varying parameter rule fits the data better than a model without this shock, even when penalizing the additional information present in a time-varying model. Interestingly, the model that takes into consid-

[23]Excluding the sample from 1979 to 1982 reduces the difference between the two models presenting evidence related to time-varying monetary policy and the Great Moderation (see, for example, Qureshi (2015)). This highlights the fact that the framework's inclusion of shocks to the policy parameter is able capture major changes in monetary policy, implying that major changes in monetary policy can be captured in this framework that includes shocks to the policy parameter. However, the main quantitative results of my paper do not change significantly even when explicitly accounting for this break.

eration changes in preferences of the chairman by including a dummy variable fits the data better than the simple time-varying model. One possible justification for this result may be due to the fact that the inclusion of both the time-varying parameters in the policy rule and trend inflation in the model better captures the dynamics of inflation. Table 5 presents this evidence.

Table 5: Model Fit

Model	Parameters	LL	BIC	AIC
Fixed	12	−296	653	616
Bias	14	−284	639	596
Bias (D)	15	−163	253	296

Note: The table presents the fit of the three model. The row "Fixed" represents the likelihood of the model with a constant monetary policy rule, the row "Bias" presents the model with no dummy, while the row "Bias (D)" presents the fit of the model which includes the dummy variable.

4.2. Numerical Analysis

What are the numerical properties of the policy shock? These properties are best explained by looking at the basic workings of the model, illustrated by tracing out impulse response functions generated by the estimated model. To explain the contribution of changes in the policy parameter relative to the other structural shocks in the economy, I later focus on the variance decomposition of these shocks. For the purposes of this section, I use the estimated parameters generated by the 'extended model' (Model - II).

Based on the estimated model, an exogenous innovation to the interest rate works to increase the annualized short-term nominal interest rate by about 10 basis points, and keeps the interest rate above its steady-state level for six quarters. This generates a fall in inflation and output by 25 and 13 basis points, respectively.

The monetary authority accommodates productivity shocks, thereby allowing a large variation in output, and effectively insulating the effect of this shock on inflation. This works to reduce interest rates by 4.2 basis points upon impact, leading to a decline of 4.3 basis points in inflation and a rise of 78 basis points in output. The persistent nature of this shock prevents the macroeconomy from returning to steady state in the three years considered.

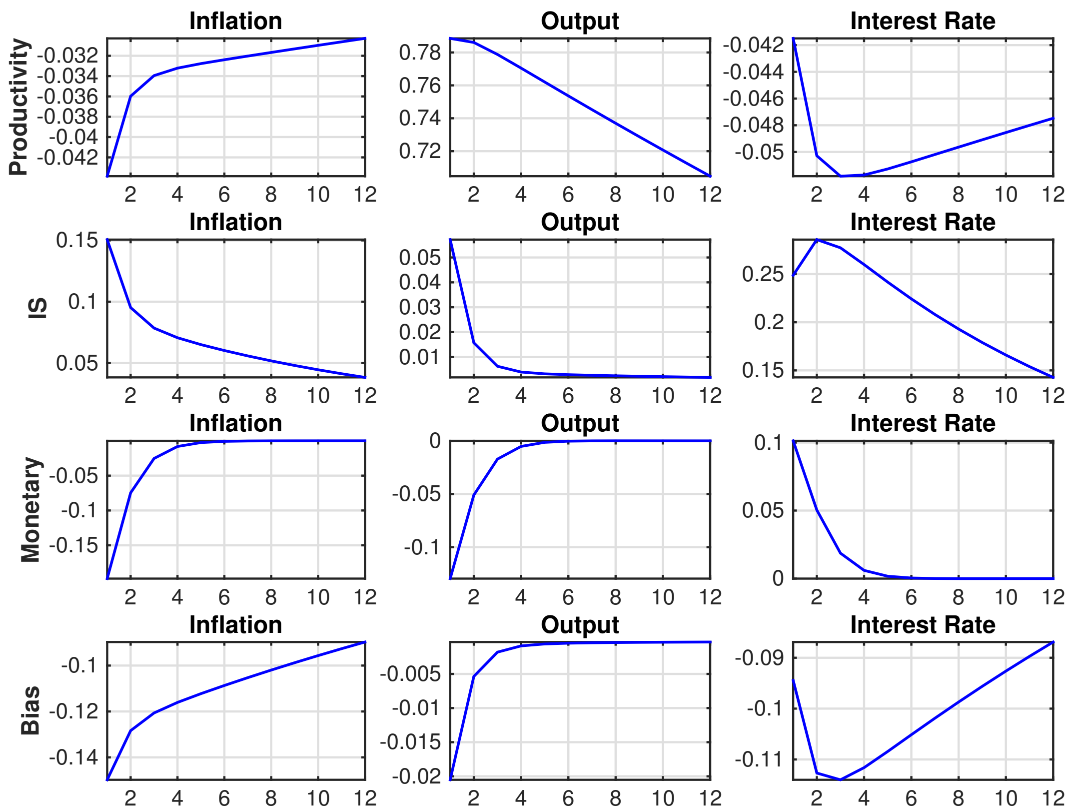
Shocks to aggregate demand work to increase output by 5.7 basis points, causing inflation to jump up by 15 basis points. This induces a sharp response by the monetary authority that hikes up interest rates by 24 basis points upon impact, and continues to do so for about five periods. Inflation peaks in the third period before gradually returning to steady state, while the fall in output is larger, and quicker, and returns to steady state in only two periods preceding the hike in interest rates.

Finally, a positive shock to policy parameter leads to a permanent 9.4-basis-point decline in nominal interest rates, a 15-basis-point decline in inflation, and a 2-basis-point decline in output. The mechanism is similar to that of an exogenous policy shock; shocks to the policy parameter generate changes in the interest rates, which generate fluctuations in inflation and output. In this particular case, a positive shock makes policy more anti-inflationary but since the effects of the shock are symmetric, the volatility of inflation will be quantitatively similar.

However, notice that because the persistence of this shock is sufficiently high, the nominal rate declines in response to a rise in the policy parameter. This is a result of the downward adjustment in the nominal rate induced by the decline in inflation. In that case, and despite the lower nominal rate, the policy shock still has a contractionary effect, though it is absorbed in this model by the extremely forward-looking Phillips curve. Interest rates continue to fall for about three periods before gradually returning to steady state. Inflation and output gradually return to steady state as the effect of this shock returns to steady state. Given the intuition outlined in Galí (2009) the quantitative similarities between the change in policy parameter and an exogenous shock to interest rates connect with the findings of Lakdawala (2016) and offer an alternative perspective on explaining the source of monetary policy shocks.

The baseline impulse responses are plotted in figure 2. Further details related to the role of the stochastic process governing policy are explored in section 6.

Figure 2: Impulse Response: Baseline Estimation



Note: This figure presents impulse response of each of the model's four shocks using the parameterization based on the baseline estimated model. The x-axis and y-axis present the quarterly time period and the percentage deviations from steady state, respectively.

The effects of these shocks are further elaborated by looking at the forecast variance decomposition over the short and long horizons, and are summarized in table 6. In both model variants, both aggregate demand and monetary policy shocks play a minor supporting role in driving short-run output fluctuations, with the dominant source of movements in output resulting from technology shocks.[24] Monetary policy shocks and changes in the policy parameter become more important in accounting for movements in the nominal interest rate. Consequently, aggregate demand and the policy parameter explain the low-frequency

[24]In the Smets and Wouters (2007) model, other shocks, such as to government spending, consumption preference and investment shocks are the main drivers of output. These shocks are not separately included in this model. However, and similar to the findings of Ascari et al. (2011), shocks to government spending, or IS shocks, are estimated to be less volatile than productivity shocks and therefore do not contribute to the movements in output in this model.

movements in inflation; however, the contribution toward macroeconomic variability depends on the forecast horizons, as expected. Given the persistent nature of shocks to the policy parameter, it is not surprising that they represent the dominant source of fluctuations in inflation in the long run. Moreover, since the change in policy is implemented gradually and expectations have time to adjust, the output effects of the change in interest rates are much smaller.

Table 6: Forecast Error Variance Decompositions

	Interest Rate				Inflation				Output			
Q	Tech.	Mon.	IS	Bias	Tech.	Mon.	IS	Bias	Tech.	Mon.	IS	Bias
1	2.59	21.31	72.03	4.07	3.86	35.50	45.99	14.65	93.51	4.06	2.35	0.07
4	3.78	6.37	83.75	6.11	5.67	24.26	44.67	25.40	97.91	1.33	0.74	0.02
8	4.89	3.89	83.05	8.17	7.03	18.41	40.25	34.31	98.88	0.71	0.40	0.01
20	7.66	2.76	75.62	13.95	8.85	12.32	30.00	48.83	99.45	0.35	0.20	0.01
40	10.12	2.39	66.76	20.73	9.44	9.05	22.26	59.25	99.63	0.23	0.13	0.00
∞	11.12	1.96	54.80	32.12	8.08	5.93	14.60	71.39	99.72	0.17	0.1	0.00

Note: The table decomposes the forecast error variance at each horizon into percentages due to each of the models four shocks.

4.3. Volatility attributed to the Chairman Dummy

In this section, I extract the macroeconomic volatility generated by the policy parameter due to changes in chairman of the Federal Reserve. To be consistent with the intuition outlined in sections 3.2 - 3.3, which discuss how the "chairman effect" is extracted from the data, I focus on version-III of the estimated model for the remainder of this section.

In a simple linear specification, the contribution of a dummy variable is extracted by subtracting the coefficient on the dummy variable with the coefficient without the dummy variable. The same technique applies here as well. In the model, the volatility generated by the policy parameter is tabulated by simulating the model using σ_p^t (the total variation in the policy parameter) from table 4 in the first step. In the second step, I calculate the volatility in inflation implied by the model with the time-varying policy parameter, using the value corresponding to σ_p in table 4. This then gives estimates of the variance of the shock without the chairman channel. Finally, I calculate the difference in inflation volatility between these two parameterizations of the policy shock. This technique yields the additional volatility attributed to chairman of the central bank.[25] Table 7 summarizes these results.

[25] As argued earlier, the "chairman effect" is extracted using the following relationship $\sigma_p^d = \sigma_p^t - \sigma_p$.

Table 7: Additional Macroeconomic Volatility

Model	Interest Rate	Inflation	Output
Bias	32.12	71.39	0.00
Bias (D)	63.53	90.18	0.02
Difference	32.41	18.79	0.02

Note: The table presents the additional volatility generated due to changes in the chairman. The row "Bias" presents the forecast variance decompositions by the model with no dummy (σ_p), while the row "Bias (D)" (σ_p^t) presents the forecast variance decompositions including the dummy variable. The additional volatility is the calculation based on σ_p^d in model-III.

Focusing first on the model without the chairman dummy, changes in the policy parameter explain approximately 71.39 percent of the volatility in inflation, 32.12 percent of the volatility in the interest rate. Looking at the total volatility, including that generated by the chairman dummy, amounts to 90.18 percent of the volatility in inflation, 63.53 percent of the volatility in the interest rate, and 0.02 percent of the volatility in output. Therefore, the additional volatility generated by the shocks to the policy parameter due to changes in the chairman of the Federal Reserve explains approximately 18.79 percent of the volatility in inflation, 32.41 percent of the volatility in the interest rate and 0.02 percent of the volatility in output. In the context of my framework, the chairman effect is found to generate significant macroeconomic variability.

To study the counterfactual inflation volatility when chairman turnover rates are varied, I simulate the model in which the structural and policy parameters of the model are kept fixed and only the shock to the policy parameter is varied. Intuitively, this reflects higher or lower chairman turnover rate, thereby generating macroeconomic volatility for different levels of CBI. In the limiting case, σ_p^d, which captures the "chairman effect" from the following relationship $\sigma_p^d = \sigma_p^t - \sigma_p$, is restricted to zero. $\sigma_p^d = 0.025$ corresponds to the counterfactual scenario where there is approximately 1 governor change in the data series, $\sigma_p^d = 0.05$ corresponds to the counterfactual scenario where there are approximately 2 governor changes. Finally, $\sigma_p^d = 0.125$ captures approximately 6 changes in chairman. In each case the additional volatility is calculated using the same methodology as done to calculate the volatility presented in table 7.

Table 8 summarises the macroeconomic volatility under each of these counterfactual scenarios. The corresponding relationship suggests that higher frequency of changes in the policy parameter (implying frequent changes in the chairman) would result in additional inflation volatility, holding constant the structure of the model and the composition of shocks. The opposite statement also holds: lower frequency of changes in the policy parameter

Table 8: Counterfactual Volatility (%)

Parameter	Inflation Volatility
Counterfactual ($\sigma_p^d = 0$)	0
Counterfactual ($\sigma_p^d = 0.025$)	8.82
Counterfactual ($\sigma_p^d = 0.05$)	14.3
Counterfactual ($\sigma_p^d = 0.075$)	17.85
Benchmark ($\sigma_p^d = 0.0874$)	**18.79**
Counterfactual ($\sigma_p^d = 0.1$)	20.26
Counterfactual ($\sigma_p^d = 0.125$)	22.96

Note: The table presents the counterfactual volatility generated due to changes in the chairman. The model is simulated keeping fixed the parameters and the shock to the policy parameter is varied to reflect higher or lower chairman turnover rate, and thus taken to imply different levels of CBI.

(implying less frequent changes in the chairman) would result in lower inflation volatility, holding constant the structure of the model and the composition of shocks. The model therefore presents a plausible channel that reveals the effect of different levels of chairman changes on macroeconomic dynamics. Indeed, a higher replacement of governors generates higher volatility, assuming, rather strongly, that each change in leadership causes a change in the parameters. The next section relaxes this assumption and identifies the types of changes that lead to executive capture of the central bank.

5. Counterfactual Analysis

The next section extends the benchmark quarterly estimation procedure and confirms evidence of the chairman effect across countries. In 5.2, I further disaggregate among the type of chairman changes to identify the independence mechanism.

5.1. Cross-Country Investigation

Do the results of the previous section carry over to other countries examined in the panel specification? That is, does the same theoretical model validate the existence of the chairman turnover channel across countries? And, does the model shed light on the relationship between the chairman turnover rate and the frequency of shifts in the policy parameters?

To answer these questions, I re-estimate the model for all countries in the data sample described in section 2.[26] To identify the chairman effect, I limit the estimation procedure to the version of the model with the monetary policy rule and the chairman dummy, i.e., model - III. Following the same methodology detailed in the previous section, I extract the chairman effect by comparing the difference in model-implied standard deviation of the policy shock with and without the dummy variable. This captures the shifts in the policy parameter generated by changes in the chairman of the individual central bank. The theoretical model can then be used to draw inferences about the magnitude of macroeconomic volatility generated by this shock.

The model is estimated using Bayesian estimation techniques using three quarterly country-specific time series: log of gross rate of the GDP deflator/CPI, the log deviation of real GDP/production index with respect to its long run trend, and the key central bank policy rate. As before, I include a fourth series that contains information pertaining to the chairman dummy, and which consists of values zero and one, with one specified against the quarters corresponding to changes in the chairman of the country-specific central bank. Data on chairman appointment dates are constructed using the information available on the websites of the country-specific central bank. The baseline calibration of the model for the fixed parameters, such as for β and trend inflation $\bar{\pi}$, are also adjusted to correspond to country-specific values. To match the relationship between chairman TOR from the data and the model, I recalculate the TOR from the quarterly data used in the country-specific models' Bayesian estimation. Estimation of the parameters of the model using the quarterly data generates the estimated (model-implied) chairman effect.

Table 9 presents evidence to validate the existence of the chairman turnover channel across countries. The estimated frequency of shift in the policy parameters is significantly different from zero, and varies considerably across countries. Second, comparing the estimated chairman effect in advanced countries with developing countries suggests that on average, the frequency of change in the policy parameter is greater in countries with higher turnover rate. As an example, consider France, where the average turnover rate is 0.155, and the estimated chairman effect is 0.0731, and Uruguay, where the average turnover rate is 0.388, and the model-implied chairman effect is 0.2887. A similar pattern is observed across other countries in the data sample. Second, for both advanced and developing economies, the average number of times the policy parameter changes is roughly equal to the turnover rate. The framework is, by construction, unable to distinguish whether each change in governor resulted in a shift in the parameter, or whether a few governors were responsible for the entire estimated volatility in the policy parameter.

[26]Data on the frequency of central bank TOR are consistent with the series described in section 2. Results from the estimation of the complete model for each country are shared in appendix A.6.

Table 9: Cross-Country Estimates of Chairman Effect

	Advanced Countries				Developing Countries		
Country	Baseline turnover ratio of central bank governor	Estimated turnover ratio of central bank governor	Estimated Chairman Effect σ_p^d	Country	Baseline turnover ratio of central bank governor	Estimated turnover ratio of central bank governor	Estimated Chairman Effect σ_p^d
Australia	0.143	0.148	0.1887	Albania	0.333	0.181	0.2075
Austria	0.192	0.164	0.1998	Argentina	0.800	0.421	0.298
Belgium	0.115	0.117	0.167	Bulgaria	0.200	0.203	0.2195
Canada	0.114	0.094	0.0886	Chile	0.429	0.181	0.2068
Czech Republic	0.200	0.181	0.2099	China	0.214	0.181	0.1771
Denmark	0.143	0.174	0.1845	Hungary	0.188	0.216	0.229
Finland	0.115	0.149	0.1511	India	0.286	0.14	0.1845
France	0.192	0.155	0.0731	Indonesia	0.143	0.258	0.246
Germany	0.115	0.242	0.2336	**Jamaica**	0.286	0.000	0.000
Greece	0.276	0.151	0.187	**Lithuania**	0.273	0.000	0.000
Italy	0.115	0.073	0.0758	Malaysia	0.143	0.174	0.2032
Japan	0.200	0.211	0.182	Mexico	0.114	0.064	0.1222
Malta	0.250	0.286	0.2638	Pakistan	0.229	0.248	0.2428
Netherlands	0.077	0.044	0.0969	Philippines	0.171	0.137	0.1731
New Zealand	0.143	0.128	0.1754	Poland	0.313	0.151	0.1863
Norway	0.114	0.136	0.1791	Romania	0.063	0.145	0.2353
Slovak Republic	0.182	0.186	0.2107	Russia	0.286	0.162	0.1968
Spain	0.172	0.151	0.195	South Africa	0.086	0.103	0.0634
Sweden	0.171	0.14	0.183	Thailand	0.257	0.372	0.2973
United Kingdom	0.114	0.092	0.0866	Turkey	0.286	0.289	0.2657
United States	0.114	0.14	0.0842	Uruguay	0.371	0.388	0.2887
Average	0.155	0.151	0.1608	Average	0.255	0.191	0.194

Note: The table summarizes the baseline central bank TOR described in section 2, the estimated TOR computed for the country-specific sample used in the quarterly estimation of the model, and the estimated chairman effect computed from the model. The two countries in bold did not experience any chairmanship changes during the period considered.

The results validate the existence of the chairman effect across countries, and highlight the relationship between chairman turnover rate and frequency of shifts in the policy parameter from the quarterly country specific data. The next section isolates the degree of central bank independence based on types of governor appointments, connecting it with shifts in the policy parameter.

5.2. Types of Governor Changes, Policy Shifts and Macroeconomic Instability

Next, I isolate the "independence effect" from the aggregate "chairman effect". I differentiate voluntary exits that are part of the naturally occurring process of the labor supply/attachment decisions of central bank governors from the involuntary departures associated with central bank governors who are perceived as challengers by the government. I also identify whether central bank governor replacements have strong ties with the government. In the model, a shift in the policy parameters due to this change represents a central bank that has been captured by the executive. A broad literature attempts to distinguish between types of govenors: Adolph (2013) shows that left- and right-wing governments tend to appoint central bankers with different monetary preferences. Fernández-Albertos (2015) surveying 24 central banks find that even the most independent central bank does not operate in a political vacuum. Ehrmann and Fratzscher (2011) uses data on the partisan back-ground of 195 central bank governors in 30 European countries between 1945 and 2012 to test whether partisan congruence between governors and the executive (the government or the president) is associated with a higher probability of governor turnover. The author finds that partisan ties to the government strongly increase a governor's odds of survival vis-à-vis nonpartisan and opposition-affiliated individuals. The classification of the type of chairman in the current paper builds on work by Vuletin and Zhu (2011).

For each of the 42 countries, I discern whether or not each central bank governor was replaced prematurely, that is, before the expiration of his/her official first term in office. Premature changes are more likely to be associated with involuntary departures of central bank governors perceived as challengers by the government. For this purpose, I combine changes in central bank governor data with the length of the legal term of office of central bank governor, which is available on the central bank websites. Second, I capture whether or not each central bank governor's replacement was directly employed by any ministry or top government agency that relates to the economy, commerce, trade, or industry in the executive branch within the previous one-year frame, as also done in Vuletin and Zhu (2011).[27] Arguably, hiring someone as a central bank governor who is, at the time of the hiring, the highest official in any of these ministries or government agencies represents the clearest case of central bank "capture." Excluding these changes from the aggregate turnover series represents those governors who represent executive branch capture of the central bank (or "premature" and "ally" type governors). The data on the type of chairman are, obviously, a subset of the total changes in the governor of the central bank of each country.

I re-estimate the model for the 42 countries including a fourth series that contains information pertaining to the "type of chairman dummy" which summarizes the "independence effect." Further categorizing the changes in chairman into regular changes versus those that signal the executive branch capture of the central bank reveals the frequency of changes in

[27] The use of a one-year time frame restriction allows the most obvious cases of dependency to come to light. If, for example, the central bank governor's replacement happened to have been the minister of finance 10 years before becoming a central banker, it would not necessarily have been clear that this replacement would have involved the capture of the central bank in hands of the executive branch.

the policy parameter when the government appoints a subservient central bank governor to exploit the inflation-output trade-off. The theoretical model, in particular the results from table 8, can then be used to draw inferences about the magnitude of macroeconomic volatility generated by this shock.

Table 10 summarizes three results. The first and second columns in front of the "country" variable present the estimated TOR rate based on the quarterly data set, and the chairman effect, respectively. The third column presents the key mechanism; it outlines estimates of the chairman effect once non-premature and non-ally changes are excluded from the data on governor changes. The results confirm evidence of the independence channel: once regular and non-ally changes are excluded, there is still reasonable evidence of shifts in the policy parameters.

Table 10: Cross-Country Estimates of Chairman Effect

	Advanced Countries				Developing Countries		
Country	Estimated turnover ratio of central bank governor	Estimated Chairman Effect σ_p^d	Excluding Non-Premature and Non-Ally Changes	Country	Estimated turnover ratio of central bank governor	Estimated Chairman Effect σ_p^d	Excluding Non-Premature and Non-Ally Changes
Australia	0.148	0.1887	**0.0000**	Albania	0.181	0.2075	**0.0000**
Austria	0.164	0.1998	0.1828	Argentina	0.421	0.298	0.298
Belgium	0.117	0.167	0.1295	Bulgaria	0.203	0.2195	0.1098
Canada	0.094	0.0886	0.0068	Chile	0.181	0.2068	**0.0000**
Czech Republic	0.181	0.2099	0.2099	China	0.181	0.1771	0.1157
Denmark	0.174	0.1845	0.1121	Hungary	0.216	0.229	0.1974
Finland	0.149	0.1511	0.0266	India	0.14	0.1845	0.1845
France	0.155	0.0731	**0.0000**	Indonesia	0.258	0.246	0.1762
Germany	0.242	0.2336	0.2079	**Jamaica**	**0.000**	**0.000**	**0.0000**
Greece	0.151	0.187	0.187	**Lithuania**	**0.000**	**0.000**	**0.0000**
Italy	0.073	0.0758	0.0311	Malaysia	0.174	0.2032	0.1425
Japan	0.211	0.182	0.0218	Mexico	0.064	0.1222	0.1222
Malta	0.286	0.2638	0.0141	Pakistan	0.248	0.2428	0.2158
Netherlands	0.044	0.0969	**0.0000**	Philippines	0.137	0.1731	0.1276
New Zealand	0.128	0.1754	**0.0000**	Poland	0.151	0.1863	0.1863
Norway	0.136	0.1791	0.0878	Romania	0.145	0.2353	0.184
Slovak Republic	0.186	0.2107	**0.0000**	Russia	0.162	0.1968	0.2284
Spain	0.151	0.195	**0.0000**	South Africa	0.103	0.0634	**0.0000**
Sweden	0.14	0.183	0.1265	Thailand	0.372	0.2973	0.2564
United Kingdom	0.092	0.0866	0.0000	Turkey	0.289	0.2657	**0.0000**
United States	0.14	0.0842	0.0000	Uruguay	0.388	0.2887	0.2324
Average	0.151	0.1608	0.063	Average	0.191	0.1948	0.1322

Note: The table summarizes the baseline central bank TOR described in section 2, the estimated TOR computed for the country-specific sample used in the quarterly estimation of the model, and the estimated chairman effect computed from the model. The countries in bold did not experience any "Excluding Non Premature and Non Ally" type changes in chairmanship for the period considered.

Reasonable heterogeneity exists across countries. The average frequency of changes in policy parameters once a governor exits prematurely or is appointed by an ally of the government is higher in developing countries (68 percent) as compared to advanced economies (39 percent). As expected, in certain advanced economies, such as the United Kingdom, the United States, Austria and the Netherlands, there is no evidence of this effect. Moving to developing countries, there is sufficient evidence of premature exists and replacement of governors from the executive branch of the government, resulting in more frequent changes in the policy parameter. The results from table 10 also suggest that this mechanism is more prevalent in Argentina, as each change in leadership is estimated to have resulted in a change in the policy parameter. For other developing countries, such as Bulgaria or Malaysia, only half of changes in leadership corresponded to an exploitation of the inflation-output trade-off.

These results provide evidence of a channel through which the independence of a central bank is compromised due to a change in the policy parameter to exploit the inflation-output trade-off. Connecting the results of table 10 with the theoretical framework in particular, the counterfactual volatility generated in table 8, this mechanism is a significant source of inflation volatility. In fact, 25 percent of the inflation volatility in developing countries is due to this mechanism, which is estimated based on the average change in the policy parameter (setting $\sigma_p^d = 0.1322$) versus only about 15 percent of the volatility in inflation in developed economies (setting $\sigma_p^d = 0.063$). For individual countries, such as Argentina, Uruguay and Thailand, the additional volatility from this mechanism may be as high as 40 percent of the total inflation volatility. For other countries, such as the United States, and the United Kingdom, even though there is strong evidence of a "chairman effect," the "independence effect" goes not play any role in generating macroeconomic volatility.[28] The results suggest that the channel through which the government appoints a subservient central bank governor to exploit the inflation-output trade-off results in a shift in the policy parameters, generating macroeconomic volatility.

I perform a robustness check to verify these results. I estimate the relationship between the model-implied chairman effect and the estimation consistent turnover rate compared to the baseline TOR used in the panel estimation. This relationship illustrates the frequency of change in the policy parameter due to changes in the chairmanship; a one-to-one relationship between the estimated turnover rate and the model-implied chairman would imply that each change in the chairman corresponded to a shift in the policy parameter.

Table 11 compares the relationship between the model-implied chairman effect with TOR from the actual data. The results reveal a positive relationship between the frequency of

[28] As pointed out in the NYT quote in the beginning of this paper, the situation may change given the current Trump-Yellen dynamic. Conditional on President Trump appointing a Chairman more inclined to growth in the future, the model will permit me to identify whether a shift in policy parameters did indeed take place.

change in policy objectives and chairman turnover rate. However, this relationship is stronger when the model-consistent chairman turnover rate is used. This is expected since the estimated TOR is captured from the data used in the model's estimation procedure. Consistent with the estimates presented in tables 9 and 10, the results suggest that of the total changes in chairmanships, more than half the changes in the central bank leadership generated a shift in the policy parameter

Table 11: Model-implied vs. data-implied TOR

σ_p^d	All countries	All countries
TOR	0.275***	–
(baseline)	[0.064]	–
TOR	–	0.6346***
(estimated)	–	[0.601]
R-squared	0.32	0.73

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

Note: The dependent variable is the model-implied chairman turnover rate. Constant coefficients are not reported. Standard errors are computed using robust standard errors.

The hypothesis, that the government can create surprise variability in inflation by changing the weight on policy objectives through the appointment of a new chairman, is found to be robust when examined across countries. Furthermore, empirical analysis of a large set of countries suggests that the type of chairman change is positively related to the frequency of shifts in the policy parameter. Indeed, by using information regarding premature exits and whether the replacement is an ally of the government, I am able to explicitly identify "executive capture" of the central bank. Estimating this model using quarterly data on 42 advanced and developing economies explains approximately 25 percent of the total volatility in inflation in developing economies, and 15 percent of the total volatility in inflation in advanced economies. In this sense, the findings extend the policy literature (Eijffinger and Hoeberichts (2008), Bernanke (2010), Adolph (2013), Taylor (2013), Levieuge and Lucotte (2014)) by suggesting that the nature of appointment of central bank chairmen may need to be further investigated. Klomp and de Haan (2010) reach similar conclusions.

6. Analytical Investigation

Explicitly modelling policy as varying over time enables me to explore questions related to the role of the stochastic process governing the policy parameter. This added sophistication outlines a deeper mechanism at work, highlighting important features of the model. I focus on investigating the propagation mechanism of a shocks to the policy parameter, I derive analytical expressions for the impact on inflation, output and interest rates.[29] The results of the analytical analysis below are presented in figure 3. Similar to Galí (2009), I use the method of undetermined coefficients to calculate the response of interest rates, inflation and output to a change in the policy parameter:

$$i_t = \Lambda_3 \Phi_\pi \bar{\pi}^{ss} \phi_{\pi,t} \tag{8}$$

$$\pi_t = -\frac{\Lambda_2}{\Lambda_2(\Phi_\pi - \rho_p) - \Lambda_1 \sigma(\rho_p - 1)} \Phi_\pi \bar{\pi}^{ss} \phi_{\pi,t} \tag{9}$$

$$y_t = -\frac{\Lambda_1}{\Lambda_2(\Phi_\pi - \rho_p) - \Lambda_1 \sigma(\rho_p - 1)} \Phi_\pi \bar{\pi}^{ss} \phi_{\pi,t} \tag{10}$$

Here $\Lambda_1 = (1 - \theta\beta\bar{\pi}^{(1-\chi)(\epsilon-1)}\rho_p)((\rho_p - \theta\bar{\pi}^{(1-\chi)(\epsilon)})(1 - (\beta\bar{\pi}^{1-\chi} + \eta(\epsilon - 1))\rho_p) - \lambda\varphi\rho_p\xi) - \eta\rho_p^2\theta\beta\bar{\pi}^{(1-\chi)(\epsilon-1)}(\epsilon - 1)(\rho_p - \theta\bar{\pi}^{(1-\chi)(\epsilon)})$, $\Lambda_2 = (\rho_p - \theta\bar{\pi}^{(1-\chi)(\epsilon)})(\kappa(1 - \theta\beta\bar{\pi}^{(1-\chi)(\epsilon-1)}\rho_p) + \eta\rho_p(1 - \sigma)(1 - \theta\beta\bar{\pi}^{(1-\chi)(\epsilon-1)}))$ and $\Lambda_3 = 1 + \frac{\Lambda_2\Phi_\pi}{\Lambda_2(\Phi_\pi - \rho_p) - \Lambda_1\sigma(\rho_p - 1)}$.

Based on the solutions outlined in equations (8) – (10), I can infer important results pertaining to the propagation mechanism of the policy shock. The following analysis is also highlighted in figure 3 and 4.

Larger Shock to Policy parameters A larger change in policy generates a larger movement in interest rates and, therefore, larger changes in inflation and output. Notice that in the baseline case, interest rates move by 7-basis points to a 14-basis-point shock to the inflation bias, compared to the10-basis-point movement to a 20-basis point-shock, and 25-basis-point movement to a 50-basis-point shock.

Steady State Inflation The analytical expressions suggest that the effect of changes in the policy parameter on the interest rate, inflation and output is positively related to steady state inflation. Since steady state inflation is multiplied with the policy shock, higher gross steady state inflation leads to a larger change in the interest rate, resulting in a more volatile path for inflation.[30] Therefore, if the monetary authority switches its preferences on inflation from a region where trend inflation is high, it will generate a larger impact on inflation volatility, as compared to the effects of this shock when steady state inflation is

[29] To illustrate the effect of changes in policy, I set Φ_y and Φ_i to zero in order to obtain these expressions. The main results are robust to including these parameters. For the rest of this section, I calibrate the model based on the estimation of the full model.

[30] This relationship is also verified by taking the first derivatives of the expression with respect to steady state inflation, $\frac{d\pi_t}{d\bar{\pi}^{ss}}$.

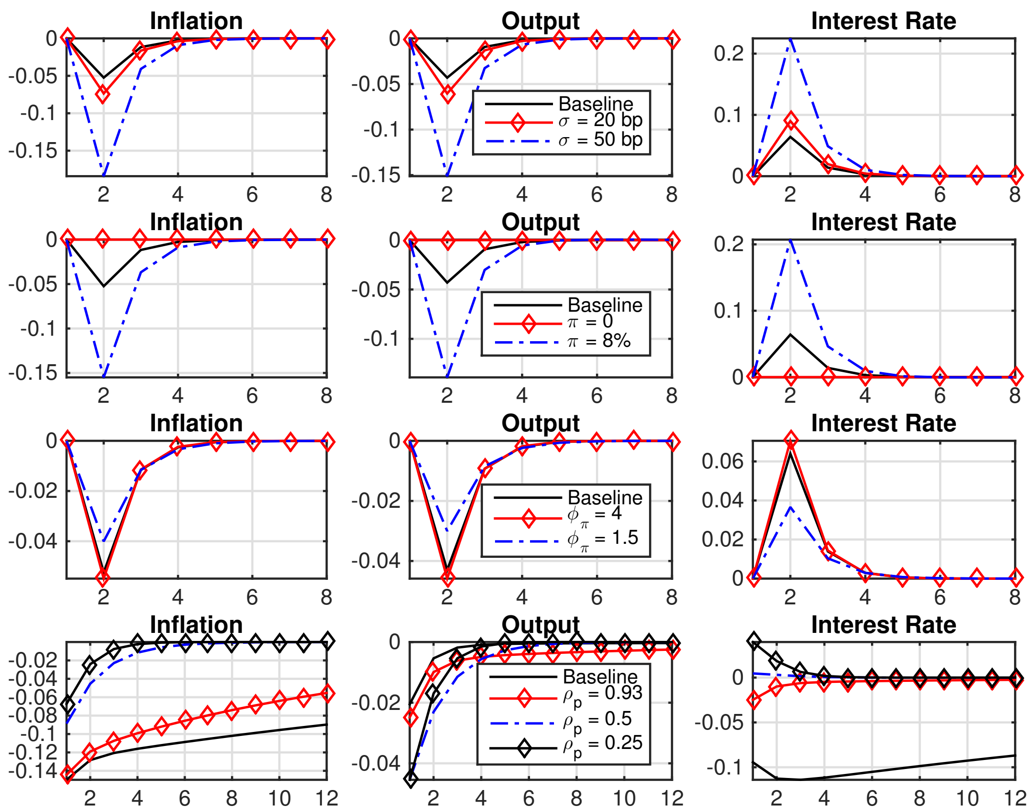
relatively lower. Moreover, setting steady state (gross) inflation to one implies that $\bar{\pi}^{ss}$ is zero. Under this parameterization, the impact of a shock in the policy parameter will tend to zero, and a change in this parameter would have no effect on the macro dynamics of the economy. This result implies that nonzero trend inflation serves as a crucial propagating mechanism in this model.

Weight on Inflation Analogous to the case with high trend inflation, Φ_π is multiplied with this shock, and is therefore increasing in the magnitude of the change in interest rates. This implies that when the mean response to inflation is large, a change in policy has a greater impact on the volatility of output, inflation and interest rates, as compared to a case when the mean response is lower.[31] This mechanism can be extended to study a central bank that adjusts interest rates gradually. In that case, the aggregate response to inflation will be multiplied with the coefficient on the lagged interest rate, and will therefore decrease the effect of the shock to the policy parameter.

Role of Persistence Varying the degree of persistence in the shock to the policy parameter reveal several interesting and novel insights. First, notice that as the persistence of the shock rises, interest rates rise by less, output falls by less, and inflation falls by significantly more. If the persistence of the policy parameter is sufficiently high, the nominal rate will decline in response to a rise in $\phi_{\pi,t}$. This is a result of the downward adjustment in the nominal rate induced by the decline in inflation. In that case, and despite the lower nominal rate, the policy shock still has a contractionary effect, though this shock is absorbed in this model by the extremely forward-looking Phillips curve. Numerical analysis suggest that the response to interest rates switches when ρ_p is between 0.60 - 0.70. In the baseline case, interest rates fall by 9 basis points, when ρ_p is set to 0.93. In comparison, interest rates fall by 8 basis points when ρ_p is set to 0.5, and rise by 0.4 basis points when ρ_p is set to 0.25.

[31] This relationship is also verified by taking the first derivatives of the expression with respect to the average response of the central bank to inflation, $\frac{d\pi_t}{d\Phi_\pi}$.

Figure 3: Analytical Investigation: Policy Parameter



Note: This figure presents impulse responses of inflation and output to the policy parameters when the volatility of the shock is varied (panel 1), trend inflation is varied (panel 2), the average response to inflation is varied (panel 3), and when the persistence is varied (panel 4). The x-axis presents the quarterly time period and the y-axis presents percentage deviations from the steady state.

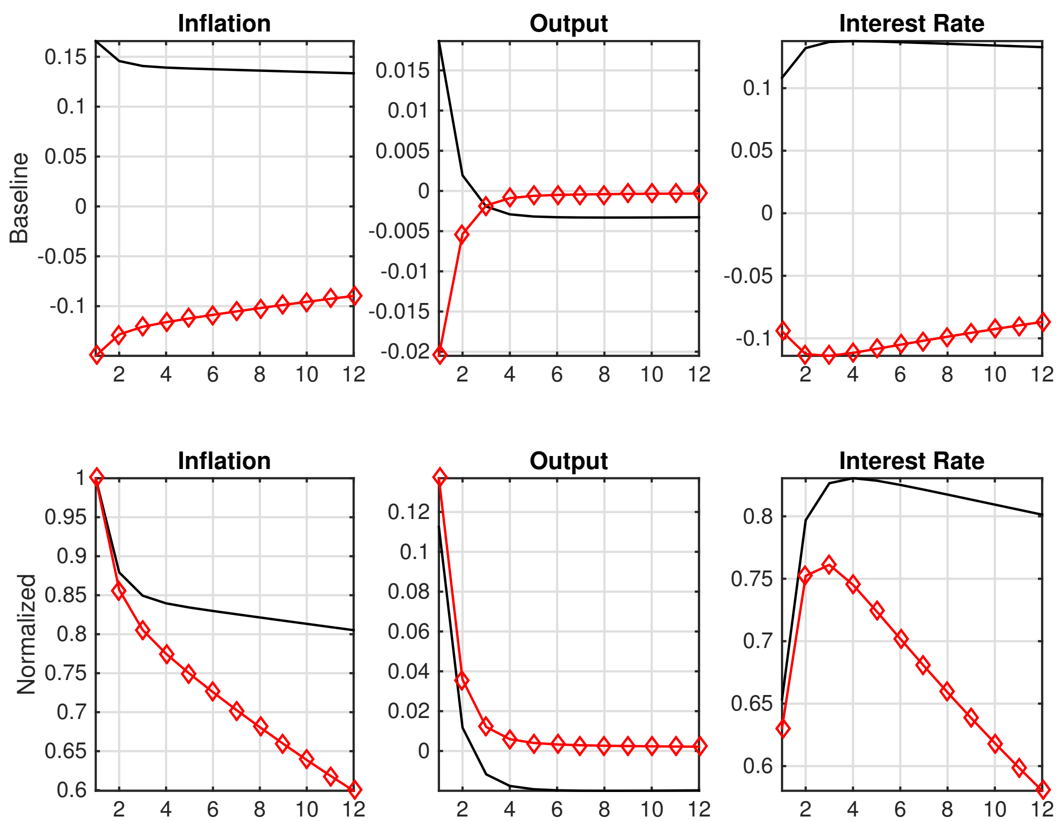
Comparison with a Time Varying Inflation Target Last, I compare the effect of a shock to the policy parameter with a time-varying inflation target. I compare the baseline policy rule with the following:

$$i_t = \Phi_i i_{t-1} + (1 - \Phi_i)[\Phi_\pi(\pi_t - \pi_t^T) + \Phi_y y_t] + v_t \tag{11}$$

The inflation target is allowed to follow an AR(1) process centred around steady state inflation, $\bar{\pi}$, and is calibrated with the values presented in Ireland (2005). Figure 4 plots the impact of these two shocks on output, interest rates and inflation.

First, looking at the baseline effects, a positive shock to the inflation target acts similarly to an expansionary monetary policy shock, raising inflation and output. This causes interest rates to gradually rise. On the other hand, a positive shock to the policy parameter behaves similar to a contractionary monetary policy shock, and causes output and inflation to fall. Looking at the second panel, which normalizes each shock, further highlights the characteristics these two policies. Primarily the effect of the shock to the inflation target is more persistent compared to the shock to the policy parameter as inflation, output and interest rates fall quickly compared to the gradual movements in inflation, output and interest rates generated by the shock to the inflation target.

Figure 4: Analytical Investigation: Policy Parameter vs. Inflation Target



Note: This figure presents impulse responses of inflation and output to the policy parameters and the inflation target. The x-axis presents the quarterly time period and the y-axis presents percentage deviations from the steady state. The solid black line outlines the effect of the shock to the inflation target and the red line (with diamonds) outlines the effect of the shock to the policy parameter.

While a shock to policy, and a shock to the inflation target generate different interest rate dynamics as highlighted in the first panel of figure 4, they can be categorized as observationally equivalent, as seen in the second panel of the same figure. In this sense, the shock to policy generates economically significant welfare effects.

Broadly, the modeling exercise extends the literature on two fronts. First, it contributes to the literature that has thus far focused solely on the effect of changes in these parameters on determinacy and on policy activeness (Taylor (1999), Clarida et al. (1998a), Orphanides (2002), Boivin (2005), Lubik and Schorfheide (2004a), Coibion and Gorodnichenko (2011), and Foerster (2016)), and has yet to connect shocks to the policy parameter and macroeconomic volatility along the lines of Roberts (2006), and Canova et al. (2010).

Second, the analytical results, such as the crucial role of positive trend inflation and the average weight on the policy parameter as propagation mechanisms to the policy shock present several interesting insights and areas for future work. For example, combining these theoretical results with the historical evolution of the policy shock contributes to the extensive research on the changes in the conduct of monetary policy, the transmission mechanism, and the structural and policy shocks in the U.S. (Clarida et al. (1998a), Cogley and Sbordone (2008), Sims and Zha (2006), Coibion and Gorodnichenko (2011), Cogley and Sargent (2005), Primiceri (2005b), Justiniano and Primiceri (2008), Bhattarai et al. (2016)). The quantitative similarities between shifts in policy parameters and exogenous shocks to interest rates connect with the findings of Lakdawala (2016), offering an alternative perspective on explaining the source of monetary policy shocks.

7. Conclusions

This paper identifies a formal mechanism that may explain the reduction in macroeconomic instability due to greater central bank independence.

I propose that the government can create surprise variability in inflation by frequently changing the weight on policy objectives through the appointment of a new chairman. In a New Keynesian framework, frequency of policy shifts is connected with a "chairman effect." To identify departures from full independence, I classify chairmen based on tenure (premature exits), and the type of successor (whether the replacement is a government ally). Bayesian estimation using cross-country data confirms the relationship between policy shifts and central bank independence. The results show that executive capture explains approximately 25 percent of the total volatility in inflation in developing economies, and 15 percent of the total volatility in inflation in advanced economies. The policy implications from the paper urge revisiting of the appointment procedures to mitigate this channel, and ensure price stability.

Explicitly modelling policy using a time-varying parameter approach highlights several interesting and important features of the model. The crucial role of positive trend inflation and the average weight on the policy parameter as propagation mechanisms to the policy shock present several interesting insights and areas for future work. The quantitative similarities between the change in policy parameter and an exogenous shock to interest rates offer an alternative perspective on explaining the source of monetary policy shocks. Devoting more effort to explaining the role of time-varying parameters in medium-to-large scale DSGE models, and studying the implications of possibly time-varying shifts in the stochastic process on historical U.S. macroeconomic volatility may be of interest to future researchers.

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A. Appendix: for online publication

A.1. Data Sources and Transformations: Panel Regression

The baseline data on chairman dismissal is compiled by Vuletin and Zhu (2011), and consists of 42 countries for the period 1972 through to 2006, of which 21 are advanced economies and 21 are developing countries. The additional variables used to estimate the empirical specification presented in section 2.2 are described below.

Inflation Date on annual inflation is taken from the Global Financial Data.

Inflation volatility I calculate rolling window of 4 years to calculate standard deviation of inflation (Bowdler and Malik (2005)) to obtain a measure of inflation variability. My results are robust for window lengths of 3 and 5 years.

TOR rate Similar to Klomp and de Haan (2010), I calculate the turnover rate (TOR) using a rolling average over 4 years preceding a central bank governor change. According to Vuletin and Zhu (2011) using rolling windows to calculate average turnover rate of central bank governors allows for a more gradual and continuous institutional change. It is important to remark that because we calculate the rolling average over 4 years preceding a central bank governor change, we do not include current or future changes of central bank governor in our current calculation of TOR. This strategy purges reverse causality concerns, a crucial distinction because Dreher et al. (2008) find that past inflation increases the likelihood of a central banker to be replaced. My results are robust when calculating TOR over 2,3 and 5 years.

Government Regime Data on 'Regimes' is taken from Democracy Time-series Data used in Norris et al. (2008). The series contains data on the social, economic and political characteristics of 190 countries with over 700 variables from 1971 to 2007. It merges the indicators of democracy by Freedom House, Vanhanen (2000), Polity IV, and Cheibub et al. (2010), plus selected institutional classifications and also socio-economic indicators from the World Bank. This dataset is in a country-year case format and therefore suitable for time-series analysis.

Efficiency I use the data on financial efficiency, which is available in the Global Financial Data, as used in Cihak et al. (2012). This indicator represents the efficiency of financial intermediaries and markets in intermediating resources and facilitating financial transactions. Since a number of variables can further be categorized under efficiency, I take the mean of variety of indicators related to efficiency. My results remain robust to a variety of other indicators representing financial development, such as depth (size of financial institutions and markets), stability (stability of financial institutions and markets), access (degree to which individuals can and do use financial services) as well as other factors influencing financial development.

Output volatility I use real GDP to calculate output volatility, with the underlying data available in the Global Financial Data. I convert this data into growth rates and calculate standard deviation of output over rolling window of 4 years to coincide with the baseline measure of inflation volatility. My results are robust for window lengths of 3 and 5 years.

A.2. Log-linearization

$$I_t = V_t(I_{t-1})^{\Phi_i}[\Pi_t^{\Phi_{\pi,t}} Y_t^{\Phi_y}]^{1-\Phi_i} \tag{12}$$

Define $\ln(X_t) = x_t$. Therefore;

$$exp(i_t) = exp(v_t)exp(\Phi_i i_{t-1})exp((1-\Phi_i)exp(\phi_{\pi,t})(\pi_t))exp((1-\phi_i)exp(\phi_y)(y_t)) \tag{13}$$

Next, I take logs on both sides:

$$i_t = v_t + \Phi_i i_{t-1} + (1-\Phi_i)(exp(\phi_{\pi,t})\pi_t + \Phi_y y_t) \tag{14}$$

To be consistent with the quarterly model, this non-linear equation represents quarterly variables. I now linearize this equation to obtain the time-varying rule in the following form:

$$i_t = \Phi_i i_{t-1} + (1-\Phi_i)[\Phi_\pi(\bar{\pi}^{ss}\phi_{\pi,t} + \pi_t) + \Phi_y y_t] + v_t \tag{15}$$

In this equation, $\bar{\pi}^{ss}$ represents quarterly steady state inflation and $\phi_{\pi,t}$ is the time-varying policy parameter. Notice that when trend inflation is zero, $\bar{\pi}^{ss}$ is zero, and it returns the following policy rule which is commonly used in the literature:

$$i_t = \Phi_i i_{t-1} + (1-\Phi_i)[\Phi_\pi \pi_t + \Phi_y y_t] + v_t \tag{16}$$

A.3. Data Sources and Transformations: Bayesian Estimation

The following table summarizes the data used to estimate cross-country model. I outline the period covered in the estimation process as well as the data source. The complete data set may be obtained from the online appendix.

	Advanced Countries			Developing Countries	
Country	Data Source	Time Period	Country	Data Source	Time Period
Australia	FRED/RBA	1968:I - 2008:II	Albania	INSTAT/BeS	2003:I - 2008:II
Austria	FRED/OeNB	1968:I - 2008:II	Argentina	IFS/CRA	1994:II - 2008:II
Belgium	FRED/NBB	1966:I - 2008:II	Bulgaria	IFS/BNB	1994:I - 2008:II
Canada	FRED/BoC	1966:I - 2008:II	Chile	FRED/CBC	1997:II - 2008:I
Czech Republic	FRED/CZB	1992:I - 2008:II	China	FRBA/PBC	1992:II - 2008:II
Denmark	FRED/DNB	1974:I - 2008:II	**Hungary**	FRED/MNB	1990:I - 2008:II
Finland	FRED/BoF	1975:I - 2008:II	**India**	FRED/ISI	1994:II - 2008:II
France	FRED/BdF	1970:I - 2008:II	Indonesia	BSRI	2001.I - 2008:II
Germany	FRED/DB	1991:I - 2008:II	*Jamaica*	IFS/BoJ	2002.I - 2008:II
Greece	FRED/BoG/MoF	1995:I - 2008:II	*Lithuania*	IFS/LB	2000.III - 2008:II
Italy	FRED/BdI	1981:I - 2008:II	Malaysia	BNM	1997:I - 2008:II
Japan	FRED/BoJ	1966:I - 2008:II	Mexico	BdM	1993:I - 2008:II
Malta	FRED/CBM	1997:I - 2003:IV	**Pakistan**	IFS/SBP	1972:II - 2008:II
Netherlands	FRED/DNB	1986:I - 2008:II	Philippines	BSP	1994:I - 2008:II
New Zealand	FRED/RBNZ	1977:II - 2008:II	Poland	FRED/NBP	1995:I - 2008:II
Norway	FRED/NB	1979:I - 2008:II	Romania	BNR	1995:I - 2008:II
Slovak Republic	FRED/NBS	1997:II - 2008:II	Russia	FRED/BoR	1990:I - 2008:II
Spain	FRED/BdE	1994:II - 2007:II	South Africa	FRED/SARB	1960:I - 2008:II
Sweden	FRED/RB	1994:I - 2008:II	**Thailand**	IFS/BoT	1995:I - 2005:IV
United Kingdom	FRED/BoE	1975:IV - 2008:II	Turkey	FRED/TCMB	1991:II - 2008:II
United States	FRED/Fed	1966:I - 2008:II	Uruguay	FRED/BCU	1981:II - 2007:II

Note: Data on gross real GDP and consumer price index are obtained from the Federal Reserve Bank of St. Louis database (FRED), IMF's International Financial Statistics (IFS) or from the ministry of finance/central bank of each country. Detailed information about the key central bank policy rate as well as historical changes in central bank chairman is obtained from the country-specific central bank website. Data used in the estimation is the longest historical data available for each country. The countries in bold are countries who do not tack GDP at a quarterly or monthly frequency. For these countries industrial production was used a proxy instead of GDP. Countries in italics did not experience any changes in chairmanship for the data period available.

A.4. Overall Period Turnover and Frequency of Change in Central Bank Chairman

The following table summarizes the data used to plot figure 1 in the main text. The baseline data on governor dismissal is compiled by Vuletin and Zhu (2011), and consists of 42 countries for the period 1972 through to 2006, of which 21 are advanced economies and 21 are developing countries.

	Advanced Countries			Developing Countries	
Country	Average turnover ratio of central bank governor	Average frequency of central bank governor replacement	Country	Average turnover ratio of central bank bank governor	Average frequency of central bank governor replacement
Australia	0.143	7 years	Albania	0.333	3 years
Austria	0.192	5 years and 2 months	Argentina	0.800	1 year and 3 months
Belgium	0.115	8 years and 8 months	Bulgaria	0.200	5 years
Canada	0.114	8 years and 9 months	Chile	0.429	2 years and 4 months
Czech Republic	0.200	5 years	China	0.214	4 years and 8 months
Denmark	0.143	7 years	Hungary	0.188	5 years and 4 months
Finland	0.115	8 years and 8 months	India	0.286	3 years and 5 months
France	0.192	5 years and 2 months	Indonesia	0.143	7 years
Germany	0.115	8 years and 8 months	Jamaica	0.286	3 years and 5 months
Greece	0.276	3 years and 7 months	Lithuania	0.273	3 years and 7 months
Italy	0.115	8 years and 8 months	Malaysia	0.143	7 years
Japan	0.200	5 years	Mexico	0.114	8 years and 9 months
Malta	0.250	4 years	Pakistan	0.229	4 years and 4 months
Netherlands	0.077	12 years and 11 months	Philippines	0.171	5 years and 9 months
New Zealand	0.143	7 years	Poland	0.313	3 years and 2 months
Norway	0.114	8 years and 9 months	Romania	0.063	16 years
Slovak Republic	0.182	5 years and 5 months	Russia	0.286	3 years and 5 months
Spain	0.172	5 years and 9 months	South Africa	0.086	11 years and 7 months
Sweden	0.171	5 years and 9 months	Thailand	0.257	3 years and 10 months
United Kingdom	0.114	8 years and 9 months	Turkey	0.286	3 years and 5 months
United States	0.114	8 years and 9 months	Uruguay	0.371	2 years and 8 months
Average	0.155	6 years and 5 months	Average	0.255	3 years and 11 months

A.5. Model Parameters and Priors

The following table describes the parameters of the log-linearized DSGE model used in the text. The priors correspond to those used in Ascari et al. (2011).

Table A.5: Bayesian Estimation

Parameters	Description	Prior (mean, std)
χ	Indexation	Beta (0.50, 0.285)
θ	Calvo	Beta (0.50, 0.15)
σ	Risk aversion	Normal (2.50, 0.25)
Φ_π	Taylor rule response to inflation	Normal (2.00, 0.50)
Φ_y	Taylor rule response to output	Gamma (0.125, 0.05)
Φ_i	Policy persistence	Beta (0.50, 0.285)
ρ_a	Technology persistence	Gamma (0.90, 0.05)
ρ_v	Policy persistence	Beta (0.50, 0.15)
ρ_g	IS persistence	Gamma (0.90, 0.05)
ρ_p	Policy (II) persistence	Gamma (0.90, 0.05)
σ_p	Policy (II) standard deviation	IGamma (0.005, 2.00)
σ_a	Technology standard deviation	IGamma (0.005, 2.00)
σ_v	Policy standard deviation	IGamma (0.005, 2.00)
σ_g	IS standard deviation	IGamma (0.005, 2.00)
σ_p^t	Total standard deviation (including Chairman effect)	IGamma (0.005, 2.00)

A.6. Bayesian Estimation

A.6.1. Data and Algorithm

I use three key macro-economic quarterly US time series as observable variables for the model estimated in section 3: log of quarterly gross rate of the GDP deflator, the log deviation of real GDP with respect to its long run trend, and the federal funds rate All data are available from the FRED database. The data for the chairman turnover dates is available on the website of the Board of Governors of the Federal Reserve System. The model is estimated over the full sample period from 1966:I till 2008:II. To study how the measurement equations are altered to incorporate the chairman effect, the following equations define the time-varying parameter rule:

$$i_t = \Phi_i i_{t-1} + (1 - \Phi_i)[\Phi_\pi(\bar{\pi}^{ss}\phi_{\pi,t} + \pi_t) + \Phi_y y_t] + v_t \tag{17}$$

$$\phi_{\pi,t} = \rho_p \phi_{\pi,t-1} + \epsilon_t \tag{18}$$

The complete model when estimated using three series allows me to capture ρ_p and σ_p, where σ_p captures the standard deviation of changes in policy. To specifically identify the "chairman effect" I introduce a chairman dummy in the AR(1) process for the policy shock. The difference in volatility during periods when the chairman changes is identified using information from a fourth data series in the model estimation. Specifically, this series consists of values zero and one, with one specified against the quarters corresponding to changes in the chairman of the Federal Reserve. In the data sample there are five changes in the chairman therefore the dummy series has 5 observations equal to 1 at 1970:I (Martin), 1978:I (Burns), 1979:III (Miller), 1987:III (Volcker) and 2006:I (Greenspan). Observations at other points in this series are set to zero. The corresponding measurement equations of the quarterly model with the chairman dummy are (the bars denote steady state variables):

$$\begin{pmatrix} dlGDP_t \\ dlP_t \\ FEDFUNDS_t \\ FEDTOR_t \end{pmatrix} = \begin{pmatrix} \bar{\gamma} \\ \bar{\pi} - 1 \\ \bar{r} \\ 0 \end{pmatrix} + \begin{pmatrix} y_t - y_{t-1} \\ \pi_t \\ r_t \\ \sigma_p^t \end{pmatrix} \tag{19}$$

The complete model when estimated using these four series allows me to capture ρ_p and σ_p^t, where σ_p^t captures the aggregate standard deviation of changes in policy. Then σ_p^d, the "chairman effect" is extracted simply as $\sigma_p^d = \sigma_p^t - \sigma_p$.

Finally, the following algorithm is used to compute the MH procedure:

1. Choose a starting value or prior for our parameters stacked in Θ.

2. Draw Θ^* from $J_t(\Theta^*|\Theta^{t-1})$. The jumping distribution $J_t(\Theta^*|\Theta^{t-1})$ determines where we move to in the next iteration of the Markov chain and contains the support of the posterior.

3. Compute acceptance ratio r, according to:

$$r = \frac{p(\Theta^*|y)/J_t(\Theta^*|\Theta^{t-1})}{p(\Theta^{t-1}|y)/J_t(\Theta^{t-1}|\Theta^*)} \tag{20}$$

   If our candidate draw has higher probability than our current draw, then our candidate is better so we definitely accept it. Otherwise, our candidate is accepted according to the ratio of the probabilities of the candidate and current draws.

4. Accept Θ^* as Θ^t with probability $min(r, 1)$. If Θ^* is not accepted, then $\Theta^t = \Theta^{t-1}$. Candidate draws with higher density than the current draw are always accepted.

A sample of 200000 draws was created, with 2 MH chains, and the first 20% of the sample was rejected. The results remain robust when 200000 draws were created, with 5 MH chains and so forth.

A.6.2. Cross-Country Estimation

The following section describes the posterior estimates of the models parameters, which are estimated using Bayesian estimation techniques using three, quarterly country-specific series: log of quarterly gross rate of the GDP deflator/CPI, the log deviation of real GDP/production index with respect to its long run trend, and the central bank policy rate. I use the HP detrended output with the relative weight of the smoothing component set to 1600 as also done in Ascari et al. (2011). I include a fourth series that contains information pertaining to changes in the chairman of the country-specific central bank. Details on the data sources as well as the time period covered are summarized in appendix A.3. Table B.1 focuses on the results for advanced countries while table B.2 summarizes the results for developing countries.

Table B.1: Bayesian Estimation: Advanced Countries

	Aus.	Au.	Bel.	Can.	Cze.	Den.	Fin.	Fra.	Ger.	Gre.	Ita.	Jap.	Mal.	Net.	NZ.	Nor.	Slo.	Spa.	Swe.	UK.
χ	0.548	0.519	0.467	0.489	0.508	0.316	0.089	0.714	0.066	0.539	0.492	0.487	0.444	0.471	0.309	0.505	0.509	0.885	0.481	0.031
θ	0.467	0.578	0.581	0.486	0.576	0.797	0.356	0.56	0.537	0.246	0.592	0.586	0.819	0.769	0.824	0.566	0.468	0.26	0.587	0.384
σ	2.359	2.189	2.667	2.463	2.414	2.779	2.388	2.574	2.676	2.61	2.313	2.34	2.41	2.447	2.507	2.213	2.416	3.125	2.391	2.750
Φ_π	2.550	2.936	2.981	3.252	2.655	2.515	4.252	3.531	3.821	2.647	2.918	2.722	2.026	2.873	2.035	2.665	2.68	2.521	2.808	3.190
Φ_y	0.066	0.031	0.069	0.078	0.054	0.055	0.026	0.058	0.0381	0.099	0.097	0.024	0.106	0.065	0.086	0.058	0.078	0.093	0.098	0.062
Φ_i	0.591	0.927	0.727	0.776	0.933	0.948	0.843	0.711	0.926	0.814	0.764	0.923	0.991	0.924	0.897	0.804	0.85	0.363	0.926	0.737
ρ_a	0.984	0.996	0.989	0.985	0.988	0.994	0.996	0.99	0.915	0.965	0.974	0.997	0.851	0.987	0.941	0.987	0.977	0.978	0.967	0.982
ρ_v	0.319	0.374	0.445	0.248	0.299	0.3711	0.192	0.307	0.33	0.11	0.324	0.4	0.513	0.483	0.274	0.313	0.267	0.153	0.327	0.273
ρ_g	0.908	0.881	0.898	0.92	0.908	0.851	0.775	0.947	0.724	0.916	0.919	0.848	0.816	0.858	0.852	0.923	0.923	0.965	0.85	0.797
ρ_p	0.961	0.942	0.901	0.976	0.904	0.984	0.996	0.928	0.998	0.943	0.987	0.992	0.886	0.937	0.922	0.879	0.894	0.947	0.877	0.991
σ_p	0.004	0.003	0.0045	0.064	0.003	0.022	0.043	0.123	0.003	0.004	0.059	0.048	0.004	0.008	0.003	0.004	0.004	0.005	0.004	0.065
σ_a	0.017	0.027	0.012	0.013	0.045	0.074	0.018	0.008	0.013	0.015	0.009	0.028	0.126	0.032	0.064	0.021	0.029	0.005	0.01	0.015
σ_v	0.01	0.001	0.004	0.004	0.003	0.001	0.004	0.004	0.002	0.008	0.003	0.002	0.001	0.001	0.003	0.005	0.007	0.012	0.001	0.007
σ_g	0.001	0.001	0.001	0.001	0.002	0.004	0.001	0.001	0.002	0.001	0.001	0.001	0.01	0.002	0.005	0.001	0.002	0.001	0.001	0.001
σ_p^t	0.193	0.203	0.171	0.153	0.2135	0.206	0.194	0.196	0.2365	0.192	0.135	0.23	0.267	0.105	0.179	0.183	0.215	0.199	0.187	0.152
$\|LL\|$	514	384	292	327	301	539	320	244	181	216	113	485	157	139	536	340	214	138	79	340

Note: I use 200,000 draws from the posterior to compute the model. Acceptance rates on average were between 20% to 35%. The log-marginal likelihoods are computed with the harmonic mean estimator presented in Geweke (1999). From left to right, the countries are Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Italy, Japan, Matla, Netherland, New Zealand, Norway, Slovak Republic, Spain, Sweden, and United Kingdom. The parameters of the model are described in appendix A.5.

Table B.2: Bayesian Estimation: Developing Countries

	Alb.	Arg.	Bul.	Chi.	Chn.	Hun.	Ind.	Ino.	Mal.	Mex.	Pak.	Phi.	Pol.	Rom.	Rus.	SA	Tha.	Tur.	Uru.
χ	0.381	0.809	0.718	0.481	0.008	0.491	0.507	0.654	0.369	0.643	0.014	0.254	0.048	0.155	0.65	0.252	0.391	0.535	0.363
θ	0.789	0.675	0.331	0.747	0.29	0.564	0.458	0.795	0.847	0.272	0.755	0.494	0.524	0.278	0.221	0.234	0.369	0.64	0.805
σ	2.237	2.433	2.365	2.403	3.013	2.532	2.361	2.479	2.453	3.073	3.037	3.021	2.924	2.784	2.589	2.347	2.558	2.781	2.588
Φ_π	2.926	2.027	2.383	2.598	3.364	2.59	2.696	2.147	3.228	3.416	3.611	3.453	3.438	2.869	2.258	3.262	2.521	1.375	3.246
Φ_y	0.034	0.121	0.089	0.121	0.077	0.064	0.072	0.13	0.12	0.123	0.033	0.066	0.044	0.106	0.094	0.04	0.093	0.071	0.121
Φ_i	0.977	0.672	0.178	0.819	0.996	0.926	0.951	0.858	0.655	0.034	0.966	0.579	0.916	0.146	0.298	0.834	0.806	0.796	0.47
ρ_a	0.994	0.915	0.966	0.947	0.976	0.985	0.974	0.903	0.946	0.892	0.999	0.96	0.979	0.914	0.927	0.99	0.979	0.939	0.896
ρ_v	0.473	0.524	0.447	0.242	0.229	0.358	0.171	0.322	0.503	0.426	0.505	0.383	0.306	0.632	0.198	0.158	0.286	0.358	0.447
ρ_g	0.857	0.791	0.817	0.844	0.803	0.931	0.889	0.835	0.857	0.833	0.839	0.79	0.924	0.814	0.964	0.979	0.895	0.947	0.943
ρ_p	0.92	0.964	0.91	0.94	0.945	0.912	0.901	0.917	0.666	0.918	0.96	0.995	0.777	0.896	0.759	0.997	0.891	0.926	0.999
σ_p	0.006	0.023	0.004	0.005	0.013	0.004	0.004	0.004	0.004	0.005	0.006	0.002	0.007	0.004	0.004	0.096	0.003	0.004	0.005
σ_a	0.194	0.119	0.352	0.032	0.013	0.044	0.025	0.017	0.066	0.035	0.333	0.01	0.04	0.029	0.029	0.017	0.049	0.07	0.159
σ_v	0.001	0.032	0.328	0.004	0.001	0.005	0.002	0.004	0.006	0.092	0.003	0.011	0.006	0.098	0.066	0.01	0.023	0.012	0.067
σ_g	0.006	0.019	0.0258	0.004	0.001	0.002	0.001	0.005	0.004	0.016	0.005	0.001	0.002	0.01	0.007	0.001	0.002	0.004	0.018
σ_p^t	0.213	0.322	0.223	0.211	0.19	0.233	0.188	0.25	0.208	0.127	0.249	0.175	0.193	0.188	0.201	0.16	0.301	0.269	0.294
|LL|	159	553	764	182	168	376	197	124	225	482	977	224	293	433	575	675	315	543	1036

Note: I use 200,000 draws from the posterior to compute the model. Acceptance rates on average were between 20% to 35%. The log-marginal likelihoods are computed with the harmonic mean estimator presented in Geweke (1999). From left to right, the countries are Albania, Argentina, Bulgaria, Chile, China, Hungary, India, Indonesia, Malaysia, Mexico, Pakistan, Philippines, Polan, Romania, Russia, South Africa, Thailand, Turkey, and Uruguay. The parameters of the model are described in appendix A.5.