Universidade do Minho
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Monetary Policy in Emerging Countries: An Empirical Analysis

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Doctoral Thesis
Ph.D. in Economics

Work developed under the supervision of:
Professor Doctor Fernando Alexandre

and
Professor Doctor Pedro Bação

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DIREITOS DE AUTOR E CONDIÇÕES DE UTILIZAÇÃO DO TRABALHO POR TERCEIROS

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“If you work on something a little bit every day,

you end up with something that is massive”

Kenneth Goldsmith

Resumo

Numerosos estudos empíricos têm-se dedicado a analisar os regimes de política monetária, tendo encontrado resultados consistentes para economias avançadas. No entanto, alguns desses resultados parecem não se aplicar às economias emergentes.

O principal objetivo desta tese é analisar empiricamente os regimes de política monetária nas economias emergentes. Abrange principalmente três capítulos empíricos sobre a concepção da política monetária, além da introdução, da revisão de literatura e da conclusão.

O primeiro trabalho empírico desenvolve um índice alargado de independência do banco central (CBI). O índice proposto complementa as medidas tradicionais de CBI considerando novas características da concepção institucional do banco central, como a independência externa. O novo índice (ECBI) inclui ainda dimensões específicas que contribuem para as decisões de política monetária nos países emergentes, e que não consideradas na maior dos estudos para as economias avançadas. O índice ECBI é posteriormente utilizado como variável explicativa da dinâmica da inflação nos países emergentes recorrendo a modelos econométricos estáticos e dinâmicos com dados em painel. Os resultados das estimações apontam para uma relação negativa entre o ECBI e a inflação numa amostra de dezoito economias emergentes.

O segundo trabalho empírico investiga o efeito de choques da política monetária no produto e nos preços, utilizando dados trimestrais para um painel de dezoito países emergentes, no período 2000-2017. Este estudo usa um modelo PVAR para examinar a relação causal da dinâmica entre as variáveis macroeconómicas. Os resultados indicam que o choque da taxa de juro reduz ligeiramente o produto como previsto pelos modelos principais, que também parece reagir mais rapidamente ao choque da política monetária. Um efeito negativo foi observado na reacção da oferta monetária ao choque da taxa de juro, mas o seu efeito desaparece rapidamente.

A última investigação empírica examina se o comportamento de fixação das taxas de juro dos bancos centrais reage às condições externas, acrescentando-as às variáveis padrão comummente utilizadas na literatura. Os resultados revelaram que os bancos centrais, para além de reagirem às variáveis tradicionais da política monetária (inflação e hiato do produto), reagem também a variáveis externas.

Statement of Integrity

I hereby declare having conducted my thesis with integrity. I confirm that I have not used plagiarism or any form of falsification of the results in the process of thesis elaboration.

I further declare that I have fully acknowledged the Code of Ethical Conduct of the University of Minho.

Abstract

Numerous empirical studies have been devoted to analysing monetary policy regimes and have demonstrated consistent propositions and patterns for advanced economies. However, some of those results seem not to hold for the majority of emerging economies.

The main objective of this thesis is to empirically analyse monetary policy regimes in emerging economies. It primarily covers three empirical works on monetary policy design, besides introduction, a literature review, and a conclusion.

The first empirical work develops an extended central bank independence (CBI) index. The proposed index complements traditional CBI measurements by considering new characteristics of central bank institutional design, such as external independence. The novel index (ECBI) also comprises specific dimensions that contribute to monetary policy decisions in emerging countries, which are not included in most studies for advanced economies. The ECBI index is then used as an explanatory variable for inflation dynamics in emerging countries in both static and dynamic panel econometric models. Our findings point to a negative relationship between ECBI and inflation in a sample of eighteen emerging economies.

The second empirical work investigates the effect of the monetary policy shock on output and price using quarterly panel data of eighteen emerging countries over the period 2000–2017. This study employed a PVAR model to examine the dynamic causal relationship between macroeconomic variables. The findings indicate that the interest rate shock reduces gross domestic product as expected, and output also appears to react relatively fast. A negative effect was observed in the response of the money supply to the interest rate shock, but its effect fades away quickly.

The last empirical research paper examines whether central banks' interest rate setting behavior responds to external conditions by adding them to the standard variables commonly used in literature. The findings revealed that the central banks do not just react solely to traditional monetary policy variables (inflation and output gap) but also to external variables.

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1 Introduction

A key goal of monetary policy is to achieve price stability (low and stable inflation) and to stabilize economic fluctuations. Monetary policy influences the growth of the money supply in an economy, which affects interest rates and the inflation rate. The monetary policy frameworks within which central banks operate have also been subject to major changes over recent decades. The low level of inflation achieved in advanced countries is often seen as the result of the implementation of credible monetary policies, effective monetary transmission mechanisms, and the adoption of policy rules (Obstfeld; Tiwari and Viñals, 2015). However, the mechanisms through which monetary policy impacts real economy are less understood in emerging markets than advanced economies.

The literature points to the macroeconomic developments and institutional factors, such as greater monetary autonomy, as significant contributors to price stability (Ha, Kose and Ohnsorge, 2019, Aizenman, Chinn and Ito, 2008). Other empirical studies confirm that developments in globalization and technology increase the weight of emerging market economies in global economic activity, which has had an impact on inflation (Chang, 2015, Manopimoke,2015, Bianchi, 2015, Sanchez, 2018, Charbonneau, 2017). Globalization and technology created productivity improvements through the substitution of labor by, for example, automation that suppressed a rise in total demand due to the artificial replacement, which may have led to deflationary effects.

The central bank can control inflation over time by tightening and easing monetary policy, but the transmission process is uncertain and evolving with the structure of the economy (Orphanides, 2015). The structural characteristics of the economy differentiate developed and developing countries in terms of macroeconomic and institutional development. In particular, developing countries tend to have less developed institutions and to have lower central bank credibility than developed countries (Fraga, Goldafjn and Minella, 2003).

A second feature of less developed countries is an uncompetitive banking system, imperfections in financial markets, and a greater incidence of default risk (Blanchard, 2005), which is in part attributable to a public finance problem, such as a traditional reliance on the banks as a source of finance and a combination of financial repression and controls on capital outflows (Frankel, 2009, Reinhart, Rogoff and Savastano, 2003). The third structural difference is that the goods markets are often more exposed to international influences, which tends to cause higher macroeconomic volatility in developing than developed countries (Hausmann, Panizza, and Rigobon, 2006).

The conduct of monetary policy in developing countries confronts various challenges of extreme episodes of monetary instability, swinging from very high inflation, massive capital flight, and collapses in their financial systems (Mishkin,2002). Over the recent past, the financial sector of most developing countries, known as "emerging markets", have gradually become more liberalized, and most of them moved to an inflation-targeting regime as a framework for the conduct of monetary policy (Ha, Kose and Ohnsorge,2019; Jonas and Mishkin, 2004). Emerging countries have succeeded in reducing inflation to single digits during the period of the 1990s (IMF, 2015), aided by success in further strengthening macroeconomic fundamentals and better macroeconomic management (Alesina and Summers, 1993, Cobham, 2012, Mladenovic et al., 2022).

Since the early 2000s, following the steps of advanced economies, several central banks in emerging markets have achieved independence from the central government and have increased their credibility by subduing their historically high inflation. Monetary policy in these countries now largely consists of setting nominal interest rates to target inflation and the toolkit for central banks is the monetary policy formulation strategy. Despite the monetary policy normalization, empirical studies have given little attention to monetary policy in emerging countries. Most studies on monetary policy either rely upon individual emerging countries time series analysis or advanced economies. There is a limited number of studies across emerging countries.

This thesis contributes to the literature on monetary policy, central bank independence and inflation by presenting an empirical analysis of a group of 18 emerging countries for the period 2000-2017.

Chapter one introduces the overall purpose and significance of the thesis, the aims of each chapter, and the research methodology. It covers three interrelated monetary policy dimensions, corresponding to three main different empirical chapters: central bank independence, monetary policy shocks, and monetary policy reaction function. This scope allows us to present the most relevant features of monetary policy in emerging countries. A common theme that runs through the thesis is how those three aspects interact and how they could be designed to achieve adequate macroeconomic outcomes in terms of inflation and macroeconomic stability. It provides a vehicle for understanding the process of setting monetary policy and the constraints under which it is formulated in emerging countries.

In chapter two, we provide the main theoretical underpinnings for central bank independence based on the social welfare function of the central bank, its legal mandate, and the public preferences. We discuss the monetary transmission mechanism and how monetary policy shocks are transmitted within the system, and the normative ways of interest rate setting, i.e., the central bank's reaction function.

In chapter three, we develop a time-varying extended index integrating two components (external and domestic factors) of central bank independence to capture different aspects of previous indices, and we investigate its effect on inflation dynamics. Besides these variables, our static and dynamic specifications includes a set of control variables.

In chapter four, we follow the process through which monetary policy decisions affect the economy in general and the price level in particular, to examine empirically the effect of domestic and external shocks on output and prices. We use the panel vector autoregression (PVAR) approach proposed by Abrigo and Love(2015), using the generalized method of moment estimator. Our results seem to be robust, according to a variety of additional empirical exercises.

In chapter five, we estimate monetary policy reaction functions to evaluate to which variables central banks in emerging countries respond. This analysis provides insights into the factors influencing monetary policy decisions in emerging countries. In this chapter, we will use a dynamic panel data analysis (Arellano and Bond, 1991, Blundell and Bond, 1998) to obtain cross-country coefficients, using the generalized method of moments estimator, which has the advantage of taking into account the possible correlation between the regressors and the error term that could give rise to endogeneity. Several tests were implemented to check the robustness of the regressions.

Finally, in the last chapter, we present the overall conclusions derived from the analysis, general lessons, and policy implications for the design of effective monetary policy frameworks in emerging market economies.

2 Theoretical foundations underpinnings of central banks

This chapter discusses monetary policy, highlighting the relevance of the institutional design of central banks, in particular the importance of central banks' autonomy. It describes how central bank independence is categorized, the choices a monetary policymaker has, and the incentives to deviate from objectives, which carries the cost of lost credibility. This chapter also introduces the monetary transmission mechanism, i.e., how monetary policy shocks are transmitted within the system. Finally, it introduces the normative ways of interest rate setting, i.e., the central bank's reaction function. This chapter serves as a theoretical framework for the rest of the thesis, which will adopt an empirical approach to the issue of the relation between central bank independence and macroeconomic outcomes.

2.1 Introduction

The influence of monetary policy over current macroeconomic policies is profound and widespread, which results in the emergence of monetary policy as one of the most critical government responsibilities. Conventionally, the implementation of monetary policy is the responsibility of a central bank that uses its independence and policy instruments, namely the interest rate, to achieve and maintain low inflation and sustainable economic growth. This chapter discusses the main theoretical underpinnings for central bank independence in section 2.2, the monetary policy transmission mechanism in section 2.3, and the central bank's reaction function in section 2.4.

2.2 The theory of central bank independence

Central bank independence refers to the freedom of monetary policymakers from direct governmental and external influence in conducting monetary policy. In its operation, central banks face various kinds of uncertainty, coming from various economic and financial shocks, among others. Given those shocks, the activity of central banks is intended to contribute to macroeconomic stability and to the efficiency and stability of the financial system, which are conducive to better overall economic performance.

The degree of independence of the central bank depends primarily on its legal mandate, which should take into account the social welfare function, i.e., should reflect the public preferences (or the so-called median-voter preferences). Therefore, central banks may have price stability as its primary goal (e.g., European Central Bank) or a dual mandate, for price stability and full employment (e.g., Federal Reserve in the United States), where the central bank may place more stress on price stability or economic growth as its major target.

2.2.1 Central bank's objective functions and social welfare

The literature on monetary policy games views the objective function of monetary policymakers as a social welfare function, with the implied assumption that the central bank behaves as a benevolent social planner (Kydland and Prescott, 1977; Barro and Gordon, 1983; Backus and Driffill,1985).

A simple description of the policymaker's problem, as Cecchetti (1997) explained, starts with an inter-temporal general equilibrium model based on the social welfare function, production functions and market imperfections that cause nominal shocks. Following Wickens (2008), our presentation assumes that the central bank seeks to minimize the expected value (E_t) of the objective function:

$$E_t \sum_{i=1}^{\infty} \beta^i [(\pi_{t+i} - \pi^*)^2 + \alpha(y_{t+i-1} - y^*_{t+i-1})^2] \tag{2.1}$$

This objective function depends on the inflation target (π^*), future values of inflation (π_{t+i}), current and future values of output (y_{t+i-1}) and of its target level (y^*_{t+i-1}). Furthermore, β is the discount factor and α is the weight attached to the output objective relative to that of the inflation objective. The aim of the policymaker is to minimize the present value of deviations of inflation and output from their target levels. Assume that the utility function (the expected value of which is assumed to correspond to the intertemporal social welfare function) for the typical household (producer of good z) in period t is

$$U_t = \ln c_t - \gamma \ln y_t(z) \tag{2.2}$$

where c_t is the index of total household consumption, $y_t(z)$ is production (the associated term reflects disutility from the work required to produce $y_t(z)$), and ln indicates the natural logarithms of these variables. The index of total household consumption is given by the constant elasticity of substitution (CES) function

$$c_t = \left[\int_0^1 c_t(z)^{\frac{(\sigma-1)}{\sigma}} \right]^{\frac{\sigma}{(\sigma-1)}} \tag{2.3}$$

where the parameter $\sigma > 1$ denotes the elasticity of substitution. Consumption and work, or simply goods and services, are imperfect substitutes if σ is finite. A higher value of σ implies greater substitutability. The general price index, P_t, is an aggregate of the prices of the individual goods, $p_t(z)$, given by

$$P_t = \left[\int_0^1 p_t(z)^{(1-\sigma)} \right]^{\frac{1}{1-\sigma}} \tag{2.4}$$

The typical household's budget constraint is given by

$$p_t c_t = p_t(z) y_t(z) \tag{2.5}$$

Given the constant CES consumption index and the utility function, the household's demand for good z is defined by

$$c_t(z) = \left[\frac{p_t(z)}{p_t} \right]^{-\sigma} c_t \tag{2.6}$$

The market clearing condition in the goods market requires that consumption equals production. Thus $c_t(z)$ = $y_t(z)$ and c_t = y_t, which implies that we can rewrite equation 2.6 as

$$y_t(z) = \left[\frac{p_t(z)}{pt} \right]^{-\sigma} y_t \tag{2.7}$$

Using these assumptions, it is possible to represent the central bank's objective function, given in equation 2.1, as an approximation to an inter-temporal utility function based on equation 2.2. Thus, the central bank's generally accepted quadratic objective function may be interpreted as an approximation to an intertemporal social utility function under certain assumptions.

A fundamental feature of the price adjustment mechanism is the assumption that the general price level is made up of the prices of many individual items and that the prices of these components adjust at different speeds (Wickens,2008). Calvo(1983) assumes that firms adjust their prices infrequently and that opportunities to adjust appear randomly. Additionally, in each period, there is a constant probability ρ that the firm can adjust its price and $(1-\rho)$ is the probability that the price remains the same; because these adjustment possibilities occur randomly, the interval between price changes for an individual firm is a random variable. When allowed to change the price, the firms choose a price to minimize a discounted sum of the squared deviations of the actual price and the flexible price.

With a large number of firms, a fraction ρ will actually adjust their price each period, setting it equal to the desired price, p_t^*. Thus the aggregate price level can be expressed as

$$p_t = \rho p_t^* + (1-\rho)p_{t-1} \tag{2.8}$$

Given the above equation, inflation may be written as

$$\pi_t = (1-\gamma)(p_t^* - p_{t-1}) + \gamma E_t \pi_{t+1} \tag{2.9}$$

where γ is a function of parameters of the model.

These equations show that at time t the actual change in the price is related to the desired change in the price and to the expected future change in the price (Wickens,2008).

Walsh(2003) argues that one attractive aspect of the Calvo model is that it indicates how the output movements have a smaller impact on current inflation, holding the expected future inflation constant. The current demand conditions become less important when the opportunities to adjust prices occur less often.

2.2.2 Reputation and credibility in monetary policy

The political economy approach to monetary policy making highlights alternative objectives of central banks (Cukierman, 1992). Following the arguments of Kydland and Prescott(1977) and Barro and Gordon(1983) on the problems of central bank credibility, incentives, and ability to pre-commit to chosen policies, commonly known as time (in)consistency, the central bank has incentives to announce low inflation policies, and then deviate from that promise in order to achieve short-term gains in real economic outcomes. Sooner or later, agents will understand the policy maker's behaviour and will adjust inflation expectations, leading to higher inflation.

This inflationary bias creates the need for a credible commitment mechanism, leading many countries to choose independent central banks. Time inconsistency is said to arise when, though nothing has changed, the central bank's choices are not equal for different time horizons. This is an interesting phenomenon, for the central bank is maximizing the welfare of those who are misled (Drazen, 2000). However, the presence of pre-commitments eliminates this bias. This fact constitutes a basic argument in favour of fixed rules rather than discretion (Cukierman, 1992).

Barro and Gordon(1983) stressed the importance of reputation for a monetary policy with an explicit inter-temporal objective, i.e., attempting to minimize the present discounted value of a one-period loss function over the entire horizon. The inter-temporal nature of the objective creates a trade-off for the policymaker: to get a current benefit by setting the current inflation rate above the expected value, which is balanced against the cost of higher inflation in the future.

Again following Wickens (2008), let the monetary policy instrument be denoted by z. An intuitive assumption is that the effect of a monetary instrument on the inflation rate is stochastic and can be captured with the stylized transmission mechanism

$$\pi = z + \nu \tag{2.10}$$

where ν is a shock unobserved by the central bank that has a zero mean, $E(\nu) = 0$. Note that another simplifying assumption is that the transmission mechanism above is instantaneous and involves no lags. Thus, the rational expectation of inflation is

$$E\pi = \pi^e = z \tag{2.11}$$

At present, an additional assumption is of a discretionary type monetary policy rather than a rule.

Barro and Gordon(1983) discussed and specified the central bank's objective function as

$$U = \lambda(y - y_n) - \frac{1}{2}(\pi - \pi^*)^2 \tag{2.12}$$

where π^* is the target rate of inflation. The implication of equation 2.12 is that the central bank prefers output (y) to be above its natural level (y_n) but dislikes inflation (π) deviating from the target. The central bank's problem is to choose z to maximize U subject to the constraints provided by the state of the economy. One of the constraints is a supply function, which takes the form of a stylized version of the Phillips equation

$$y = y_n + \alpha(\pi - \pi^e) + \varepsilon \tag{2.13}$$

where ε is an output shock.

The second constraint for a central bank's objective function is the stylized transmission mechanism, represented by equation 2.10. Substituting these two constraints, the objective function 2.12 takes the following form:

$$\begin{aligned} U &= \lambda[\alpha(\pi - \pi^e) + \varepsilon] - \frac{1}{2}(\pi - \pi^*)^2 \\ &= \lambda[\alpha(z + \nu - \pi^e) + \varepsilon] - \frac{1}{2}(z + \nu - \pi^*)^2 \end{aligned} \tag{2.14}$$

The first order condition is

$$\frac{\partial U}{\partial z} = \alpha\lambda - (z + \nu - \pi^*) = 0 \tag{2.15}$$

and the solution for the policy instrument z is

$$z = \alpha\lambda + \pi^* - \nu \tag{2.16}$$

The central bank does not know ν, and by using its best guess, namely that $E(\nu) = 0$, the optimal setting of z is

$$z = \alpha\lambda + \pi^* \tag{2.17}$$

and this implies the actual inflation rate is

$$\pi = \alpha\lambda + \pi^* + \nu \tag{2.18}$$

and so the public's rational expectation of inflation is

$$\pi^e = E\pi = \alpha\lambda + \pi^* > \pi^* \tag{2.19}$$

Equation 2.19 shows that the expected inflation is greater than its target level. This phenomenon is known as inflation bias.

The existence of inflation bias is dependent on the policymaker's preferences between output and inflation levels. Thus, if $\lambda = 0$, the central banker acts like a strict inflation targeter, inflation will be lower, and the inflation bias will be zero. Using a quadratic loss function would lead to a similar solution, with an inflation bias appearing whenever $1 > \lambda > 0$. In addition, welfare costs are minimized by setting $\lambda = 0$. Thus, a central bank following a policy of discretion may be as well be a strict inflation targeter, as there is no advantage to having $\lambda > 0$ (Wickens,2008).

Hence, credibility problems in monetary policy arise from two-period games between a policy-maker and the public, from the timing of occurrence of the first and second best solutions for the policy-maker, and from policy-makers incentives and constraints, which are a public knowledge. The absence of perfect information creates a divergence between what the public believes the rate of monetary expansion will be and the one planned by the monetary authorities. The absolute value of this divergence becomes the measure of policy-maker credibility (Masłowska,2012).

2.2.3 Independence and preferences of central bank

The central bank might choose to give more weight to achieving the inflation objective than does the public. This is known as conservatism and is accompanied by giving the central bank a greater degree of independence in the conduct of a monetary policy (Rogoff, 1985). If the central bank is free to choose the inflation rate according to its own objective function, some argue that, in this framework, it has both goal and instrument independence (Drazen, 2000). The empirical work in this area has found, at least for the industrialized economies, that countries' average inflation rates are negatively correlated with measures of the degree to which a central bank is independent of the political authorities.

Let us consider the problem of varying the preferences of the central bank, assuming it has the following objective function (Wickens, 2008)

$$U^{CB} = \lambda(y - y_n) - \frac{1}{2}(1+\delta)(\pi - \pi^*)^2 \tag{2.20}$$

where δ is the parameter that represents preferences, with a larger δ corresponding to a greater preference for price stability. The intuition here is that the central bank's preferences correspond to $\delta > 0$, while the public's preferences about the inflation rate correspond to $\delta = 0$. In other words, the assumption is that the central bank gives more weight to the inflation objective than the public. The objective function 2.20 can be rewritten in the following way

$$U^{CB} = (1+\delta)\left\{\frac{\lambda}{1+\delta}(y - y_n) - \frac{1}{2}(\pi - \pi^*)^2\right\} \tag{2.21}$$

from which we find the optimal setting for policy

$$z^* = \frac{\alpha\lambda}{1+\delta} + \pi^* = \pi^e \tag{2.22}$$

This shows that the effect of a greater central bank preference for price stability is to reduce both z and the inflation bias. The measure of welfare will depend on whose welfare function is being used. The central bank's level of welfare is

$$U^{CB} = \lambda(\alpha\nu + \varepsilon) - \frac{1}{2}(1+\delta)\left(\frac{\alpha\lambda}{1+\delta} + \nu\right)^2, \tag{2.23}$$

$$E(U^{CB}) = -\frac{1}{2}\left[\frac{(\alpha\lambda)^2}{1+\delta} + (1+\delta)\sigma_\nu^2\right], \tag{2.24}$$

and the public's welfare function is

$$U^{P} = \lambda(\alpha\nu + \varepsilon) - \frac{1}{2}\left(\frac{\alpha\lambda}{1+\delta} + \nu\right)^2, \tag{2.25}$$

$$E(U^{P}) = -\frac{1}{2}\left(\frac{\alpha\lambda}{1+\delta}\right)^2 - \frac{1}{2}\sigma_\nu^2, \tag{2.26}$$

This welfare function implies that the public's welfare is affected by the value of preferences δ, because it obtains a benefit (an inflation rate closer to the target) from having a central bank more averse to inflation than itself. In this framework, appointing a conservative central bank increases social welfare.

2.2.4 Central bank independence and free lunch hypothesis

The central bank independence in developed countries has been considered as a "free lunch", and the result derived above illustrates why. Its major idea lies in the belief that the central bank independence has no costs, only benefits. It is difficult to give credit for the use of this term in this context, but (Grilli, Masciandaro and Tabellini, 1991, p.375) wrote: 'Thus having an independent central bank is almost like having a free lunch; there are benefits but no apparent costs in terms of macroeconomic performance'. There can be, however, some cost in the form of increased output variability (Rogoff, 1985).

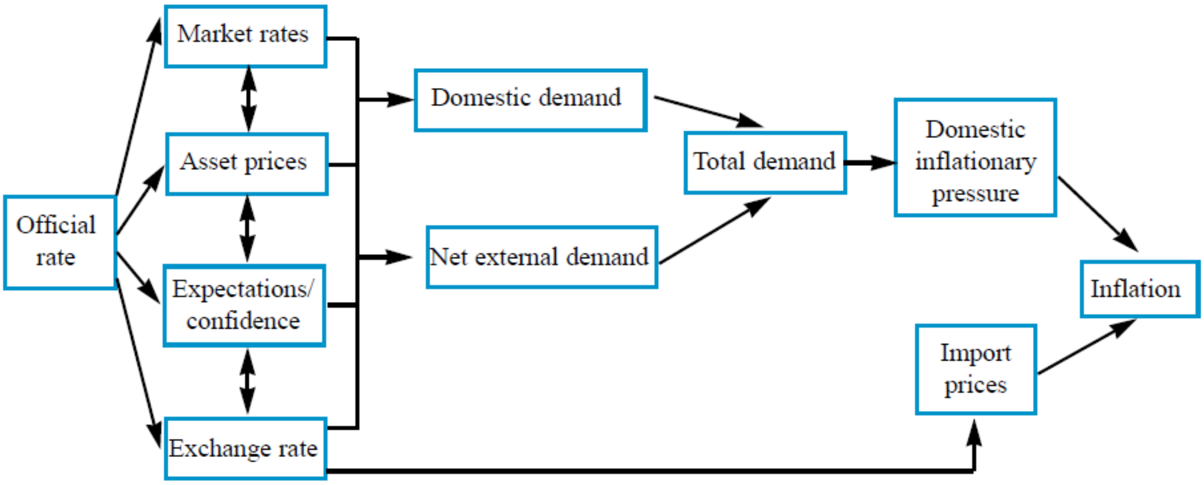
The exogeneity of central bank independence and the "free lunch" hypothesis is challenged by Debelle(1996), who states that the degree of inflation aversion of the central bank, without consideration of the existing institutional structure and the preferences of society, may not necessarily result in a free lunch. The central bank's preferences are no longer the main determining factor of the state of the economy. They are accompanied by the preferences of the fiscal authority, the nature of the policy game (the Stackelberg equilibria are seen as more adequate by the author than the commonly examined Nash equilibrium), and the obligation to repay debts.

Debelle (1996) concludes that the optimal degree of central bank inflation aversion is: (i) increasing with society's weight on inflation; (ii) decreasing with society's weight on output; (iii) decreasing with society's weight on government spending. The conclusions drawn from Debelle's analysis may give an answer to a fundamental question concerning differences in optimal monetary policy in various countries. The higher the weight that society places on inflation, the more inflation-averse a central bank will be chosen. Hence, the central bank institutional framework depends on decisions made by societies with different objective functions. The empirical relationship between independent monetary authority and inflation may simply reflect differences in inflation aversion across countries (Debelle, 1996).

2.3 Transmission mechanism of monetary policy

The transmission mechanism intuitively involves the propagation of changes in monetary policy through the financial system. This stage of the transmission mechanism explains how changes in the central banks' decisions are transmitted through the money market to markets that directly affect the spending decisions of individuals and firms, i.e., the bond market and the bank loan market. This involves the term structure, through which short-term money market rates affect long-term bond rates, and the marginal cost of loan funding, through which bank loan rates are affected.

Figure 2.1 The monetary policy transmission mechanism



Source:Author's design

Let us focus on traditional the interest rate channel, one of the most important channels of the transmission mechanism. From Figure 2.1, we can disentangle two main stages.

The first stage involves how the official rate influences interest rates in the economy. The official rate influences the cash rate, i.e., the money market interest rates such as those on overnight loans between financial institutions. It also influences market rates like the deposit and lending rates. The second stage of transmission indicates how markets rates influence the real sector (economic activity) and inflation. The interest rates for households and firms affect aggregate demand and inflation. For example, lower interest rates lead to higher aggregate demand by stimulating spending; businesses increase their prices more rapidly in response to higher demand, leading to higher inflation. But there is a lag between changes in official rates and its effect on economic activity and inflation because economic agents take time to adjust their behaviour.

2.3.1 Monetary Policy Shocks

The most frequently discussed source of monetary policy shocks is shifts in central bank preferences, caused by changing weights on inflation versus output in the loss function. Some studies explicitly link the empirically identified shocks to shifts in estimated central bank preferences (Owyang and Ramey, 2004; Lakdawala, 2015), but most treat them as innovations to a Taylor rule.

The effect of monetary policy on the economy is one of the most studied empirical questions in macroeconomics. The handbook of Macroeconomics chapter "Monetary policy shocks: What have we learned and to what end?" summarized and explored the implications of many of the 1990s innovations in studying monetary policy shocks (Christiano et al., 1999). Their benchmark model used a Cholesky decomposition in which the first block of variables (consisting of output, prices, and commodity prices) was assumed not to respond to monetary policy shocks within the quarter (or month). They called this identification assumption the recursiveness assumption. On the other hand, they allowed contemporaneous values of the first-block variables to affect monetary policy decisions. Perhaps the most important message of the chapter was the robustness of the finding that a contractionary monetary policy shock, whether measured with the federal funds rate or non-borrowed reserves, had significant negative effects on output. On the other hand, the price puzzle continued to pop up in some specifications.

Not all research on monetary policy shocks has been conducted in the canonical time-invariant linear SVAR model. Some papers have estimated regime-switching models, where monetary policy is driven not just by shocks but also by changes in the policy parameters. In an early contribution to this literature, Owyang and Ramey (2004) estimated a regime-switching model in which the Fed's preference parameters could switch between "hawk" and "dove" regimes. They found that the onset of a dove regime leads to a steady increase in prices, followed by a decline in output after approximately a year.

Primiceri(2005) investigated the roles of changes in systematic monetary policy versus shocks to policy in a period of 40 years. While he found evidence of changes in systematic monetary policy, he concluded that they are not an important part of the explanation of fluctuations in inflation and output. Sims and Zha (2006a) also considered regimes witching models and found evidence of regime switches that correspond closely to changes in the Fed chairmanship. Nevertheless, they also concluded that changes in monetary policy regimes do not explain much of economic fluctuations.

Boivin et al. (2010) focus on time variation in the estimated effects of monetary policy in the context of a factor augmented vector autoregression (FAVAR), using the standard Cholesky identification method. They confirm some earlier findings that the responses of real GDP were greater in the pre-1979Q3 period than in the post-1984Q1 period. Barakchian and Crowe(2013) estimate many of the standard models, such as those by Bernanke and Mihov (1998); Romer and Romer (2004) and Sims and Zha (2006a), splitting the estimation sample in the 1980s and showing that the impulse response functions change dramatically. In particular, most of the specifications estimated from 1988 to 2008 show that a positive shock to the federal funds rate raises output and prices in most cases. Recent work by (Angrist et al., 2013) finds related evidence that monetary policy is more effective in slowing economic activity than it is in stimulating economic activity.

A part of the variation in central banks' policy instruments reflects policy makers' systematic responses to variations in the state of the economy. The systematic component is typically formalized with the concept of a reaction function (feedback rule). As a practical matter, it is recognized that not all variations in central bank policy can be accounted for as a reaction to the state of the economy. The unaccounted variation is formalized with the notion of a monetary policy shock. Given the large role that the concepts of a feedback rule and a policy shock play in the literature, we begin by discussing several sources of exogenous variation in monetary policy.

Christiano et al. (1999) identify a monetary policy shock with the disturbance term in an equation of the form:

$$S_t = f(\Omega_t) + \sigma_s \varepsilon_t^s \tag{2.27}$$

where S_t is the instrument of the monetary authority, and f is a linear function (the feedback rule) that relates S_t

to the information set Ω_t. The random variable, $\sigma_s \varepsilon_t^s$, is a monetary policy shock. Here, ε_t^s is normalized to have unit variance, and we refer to σ_s as the standard deviation of the monetary policy shock.

Christiano et al. (1999) offer three interpretations of these policy shocks. The first is that ε_t^s reflects exogenous shocks to the preferences of the monetary authority, perhaps due to stochastic shifts in the relative weight given to output and inflation. These shifts could reflect shocks to the preferences of the members of the Federal Open Market Committee (FOMC), or to the weights by which their views are aggregated. A change in weights may reflect shifts in the political power of individual committee members or in the factions that they represent. The second source of exogenous variation in policy can arise from strategic considerations (Ball, 1995 and Chari, Christiano and Eichenbaum, 1998). The Fed's desire to avoid the social costs of disappointing private agents' expectations can give rise to an exogenous source of variation in policy. Specifically, shocks to private agents' expectations about Fed policy can be self-fulfilling and lead to exogenous variations in monetary policy. The third source of exogenous variation could reflect various technical factors. Bernanke and Mihov (1995) focus on the measurement error in the preliminary data available to the FOMC at the time it makes its decision.

2.4 Central banks' reaction function

The framework for our empirical analysis of central banks' reaction function follows the one presented in Divino (2009), According to the standard Taylor (1999) rule, the central bank sets the interest rate in response to the values taken by inflation and the output gap. The policy instrument is the nominal interest rate, and the policy goals are to stabilize inflation and output around their target values. In our empirical analysis of monetary policy in emerging countries we use panel data. We will assume that the monetary policy reaction function is common across the countries of our sample. For country i in period t, the target level of the nominal interest rate is given by:

$$i_{it}^* = i^* + \alpha(\pi_{it} - \pi^*) + \beta \hat{y}_{it} \tag{2.28}$$

where π_{it} is a measure of inflation; π^* is the target inflation rate; $\hat{y}_{it}$ is the output gap, and i^* is the desired interest rate when both inflation and output are at their target levels. Equation 2.28 is a cross-country version of the Taylor rule. However, as noticed by several authors (Woodford, 2003, Clarida et al., 1998, 2000; Judd and Rudebusch, 1998), a static model is too restrictive to describe actual central banks' behaviour. Basically, it assumes immediate adjustment of the monetary policy instrument and ignores the tendency of central banks to smooth interest rate changes. A more general approach can be taken by assuming a partial adjustment of the actual interest rate to its target level, as given by the following model:

$$i_{it} = (1 - \rho) i_{it}^* + \rho i_{it-1} \tag{2.29}$$

According to equation 2.29, the central bank adjusts the actual interest rate to the desired level by a fraction $(1 - \rho)$ each period. The degree of interest rate smoothing is represented by ρ.

This simple formulation has been criticized for not taking into account the effects of the exchange rate on monetary policy, which have been considered by later studies (Ball, 1999; Svensson, 2000; Taylor, 1999 and Ghosh et al., 2016).

3 Central Bank Independence and Inflation: a novel index and empirical application

This chapter describes in detail the information, features, and coding rules employed to create a new index of central bank independence. It also compares this new index with the existing indices and presents several descriptive statistics regarding the evolution of central bank independence over time. We also examine the central bank independence-inflation nexus in a new empirical investigation, taking into account the endogenous evolution of the level of independence over time.

3.1 Introduction

The prime role of the central banks is to conduct monetary policy to achieve price stability (low and stable inflation) and to stabilize economic fluctuations; it is also commonly believed that inflationary pressure creates macroeconomic instability (Bick, 2010; Bittencourt, 2012; Burdekin et al., 2004; Li and Zou, 2002; Ibarra and Trupkin, 2016; Kremer et al., 2013), which poses a major challenge to policymaking.

As discussed in the previous chapter, the idea of an independent monetary authority has been widely accepted over the last several decades, and its benefits for inflation stabilization are accepted by the majority of researchers and decision-makers (Forder, 2005). It provided an argument in favour of an independent monetary authority. Kydland and Prescott (1977) conveyed their argument regarding the use of rule-based policymaking to maximize social welfare. Barro and Gordon (1983) addressed the issue of dynamic inconsistency by means of the independence of the central bank to formulate a credible, consistent, and efficient monetary policy. Rogoff (1985) put forward the idea of an independent and conservative central banker to reduce inflationary bias (see details in chapter 2).

Following these theoretical propositions, many empirical studies report the existence of an inverse relationship between central bank independence (CBI) and inflation (Cukierman, 1992; Alesina, 1988; Grilli et al., 1991; Cargill, 2013). Alesina and Summers (1993) further showed that this negative relationship did not come at the cost of lower real economic activity, i.e. independent central banks provide social benefits in the form of reduced inflation rates while incurring no costs in the form of higher output volatility or slower economic growth. This empirical finding then led to a broad consensus that the optimal monetary policy must be based on the principle of independence and a clear mandate for price stability or low inflation.

The stabilizing effects of central bank independence are not only accepted by scholars (Kern et al., 2019; Plender,2008; Cukierman, Miller and Neyapti, 2002), but also by international agencies and policy makers (Bernhard, Broz and Clark, 2002; IMF, 1999; Siklos, 2008; World Bank, 1992). These works have led economists and policymakers to believe that central bank independence is one of the key elements for successful inflation control and macroeconomic stability.

Although economic reasons may justify the establishment of an independent monetary authority (Debelle and

Fischer, 1995), the recent developments in the literature also recognize that the institutional and financial structures may matter for the conduct of monetary policy and for price stability outcomes (Krause and Rioja, 2006; Hielscher and Markwardt, 2012; Posen, 1993; Acemoglu et al., 2008). The literature discusses two channels through which the development of the financial sector influences the achievement of the inflation target: (i) the role of the financial sector in reducing government dependence on seigniorage (Neyapti, 2003, Cukierman, Edwards and Tabellini, 1991); and (ii) the mechanism of the credit channel (Bernanke and Blinder, 1988; Bernanke and Gertler, 1995). In a fragile financial system, fiscal dominance not only flourishes to finance budget deficits but also leads to the ineffectiveness of interest rate channels to influence output, prices, and ultimately inflation.

Institutional development is equally important to ensure that the central bank remains independent of government interference regarding the objective of maintaining low inflation (Aisen and Veiga,2008; Crowe and Meade,2008; Garriga and Rodriguez, 2019; Salahodjaev and Chepel, 2014; Khan and Hanif, 2018).

Most empirical evidence concerning legal central bank independence from political influences in the conduct of monetary policy has focused mainly on developed countries (Cukierman, 1992; Eijffinger and de Haan, 1996; Crowe and Meade, 2007; Alesina and Summers, 1993; Arnone and Romelli, 2013; Klomp and De Haan, 2010). The relationship between central bank independence and inflation in emerging countries has not been subject to multivariate cross-sectional analyses (McNamara,2003; McNamara and Castro,2003) and few studies rely upon individual country time series analysis or small subsets of developing countries (Acemoglu et al.,2008; Bodea and Hicks,2015; Landström, 2011; Alpanda and Honig, 2014; Neyapti, 2012).

We argue that neither purely domestic nor purely external factors can account for the observed levels of the central bank independence. Domestic factors can explain much of the variance in central bank independence in developed countries, while the external factors play a crucial role in developing countries facing (a relative) need for capital (Forder, 2005).

This chapter has four major contributions to the literature on central banking and the institutions. First, we construct a new index to integrate two components (external and domestic factors) of central bank independence, to capture in a unified framework different aspects of previous indices, such as the ones proposed by Garriga (2016) and Aizenman, Chinn, and Ito (2010). This new central bank independence index captures the specific dimensions that contribute to monetary policy decisions in emerging countries that were not included in most previous studies.

Second, we provide an empirical analysis based on the novel central bank independence index, regarding the relation between independence and inflation outcomes (Cevik and Zhu, 2019; Crowe and Meade, 2008;Klomp and De Haan, 2010, Vuletin and Zhu,2011; Polillo and Guillen, 2005; Acemoglu et al., 2008). Our study, using a large database for 18 countries in the period 2000-2017, also discusses whether the central bank behaviour in emerging countries is consistent with the predictions of extant theories.

Third, the study takes into account the distinctive behaviour of emerging countries to examine the effect of financial systems and of the institutional quality on price stability. This contributes to the growing literature studying the role of institutions on macroeconomic stability (Jácome and Vázquez, 2008; Klomp and de Haan,2010; Bodea et al., 2019; Boix and Svolik, 2013; Gehlbach and Keefer, 2012; Magaloni, 2008). Additionally, our analysis will also include global financial integration, which was unconsidered in previous empirical studies for emerging markets.

Finally, from an econometric perspective, we improve on the static analysis provided by Balls et al. (2016); Chrigui et al. (2011). We apply a system-GMM panel estimator, which controls for simultaneity and omitted variable biases. We prefer the system-GMM over the difference-GMM (Nurbayev et al., 2018; Aguir, 2018; Deniz et al., 2016) because the former estimator is better instrumented to capture the effects of highly persistent variables than the latter, as demonstrated in Arellano and Bover (1995) and Blundell and Bond (1998). We also extend the main results and explore their robustness to different specifications with a set of additional regressors.

The remainder of this chapter is organized as follows. Section 3.2 discusses the issue of measurement of central bank independence. Section 3.3 presents the empirical literature on central bank independence. Section 3.4 defines and develops the extended central bank independence index. Section 3.5 describes the empirical application of the novel index and inflation nexus. Section 3.6 discusses the empirical results. Finally, we conclude in Section 3.7.

3.2 Measuring central bank independence

This section covers and gives a critical assessment of previous studies on the measurement of central bank independence. We examine the measures of the most influential and largely cited central bank independence indices to have insight on how to successfully create a new index. Research on the concept of central bank independence and on the institutional relationship between central banks and governments has gained pace in recent years Crowe and Meade(2008). Historically, the argument for central bank independence was part of a strategy to prevent governments from debauching the value of the currency in order to finance public spending. This argument for central bank independence was encapsulated, in various theoretical and empirical studies, in the maxim that it was crucial to separate the power to print money from the power to spend it (Freedman,2003). This rationale for central bank independence still holds true in developing economies that rely on seigniorage for a significant portion of their revenues.

Giving independence to the central bank is considered as a canonical reform in governance, fundamental to improve monetary policy decision-making. It is a particularly interesting type of institutional reform to study empirically. The implementation of a monetary policy framework based on an independent central bank is associated with an inflation objective. Evaluation of the deviations from that objective is the basis for the assessment of the success of an independent central bank (King, 1997).

Central bank independence can be defined as institutional independence, implying a set of legal provisions that guarantee that the central bank carries out its tasks and duties without political (or, more generally, external) interference (Issing, 2006). We follow this definition to establish the contours of monetary independence in our measurement variables and to propose a novel index that comprises consistent and complete information on central bank independence in emerging economies.

The literature on central bank independence provides the starting point to the definition of a set of indicators that are relevant for the design of a central bank independence index. The indicators concern monetary policy instruments and objectives, but also central bank governance and its interaction with the government (Grilli et al., 1991; Cukierman et al., 1992; Lybek, 1999, among others). Grilli, Masciandaro and Tabellini (1991) (hereafter abbreviated as GMT) develop their central bank independence index considering two additive legal measures of central bank autonomy. The first one focuses on political features, i.e., the capacity to choose the final goals of monetary policy, such as the inflation target or the level of economic activity. The second focuses on economic and financial features, i.e., the capacity to choose the instruments with which to pursue these goals. Each of those two dimensions of central bank independence is measured using a number of indicators so that the central bank is given two scores: one for political independence and the other for economic independence.

Moreover, GMT (1991) elaborate on three features of a monetary regime that influence political independence, namely (i) the "procedure for appointing" the members of the monetary authority's governing bodies; (ii) the relation between "these bodies and the government" and (iii) the central bank's "formal responsibilities" (Grilli, Masciandaro & Tabellini, 1991). The economic dimension of independence was assessed by taking into consideration (i) the government's intervention in deciding "how much to borrow from the central bank" and (ii) the "nature of monetary instruments" controlled by the monetary authority (Grilli, Masciandaro & Tabellini, 1991).

GMT(1991) employed the indices of economic and political independence to rank a sample of 18 industrialized countries. The results show the ranking changing substantially on the two scales. Thus, the authors argued that using either political or economic independence on its own for international comparisons would be misleading. Using the computed indices to assess the relation between inflation and central bank independence, GMT(1991) reports a negative and significant relationship between the index of economic independence and inflation rates, especially during periods of high inflation, while political independence was only significant during the 1970s. Debelle and Fischer (1995) also found similar empirical results, concluding that inflation performance is better when the central bank has a mandate for monetary stability.

Cukierman (1992) constructed a de jure index of political and economic autonomy (LVAU: Legal Variables-Unweighted and LVAW: Legal Variables-Weighted). This very comprehensive index of central bank autonomy was one of the earliest and most widely used indices for measuring central bank independence and also for relating it to macroeconomic performance, namely to rank central banks according to their degree of independence and to test the relationship between central bank independence and inflation. The index includes dimensions of legal independence in four categories: (i) statutory objectives of the central bank; (ii) the appointment and dismissal of the governor; (iii) the role of the central bank in policy formulation; and (iv) the provisions for budget deficit finance and limitations on lending to the government.

The central bank independence index proposed by Aizenman, Chinn and Ito (2010) gauges monetary independence through the deviation of the domestic interest rate from the base (or foreign) interest rate. The authors consider the reciprocal of the annual correlation between the monthly interest rates of the home country and the reference country to assess whether a country's monetary policy is independent for its own domestic purposes rather than dependent on external monetary influences. The index developed by Aizenman, Chinn and Ito (2010) has the following expression:

$$MI = 1 - \frac{Corr(i_c, i_j) - (-1)}{1 - (-1)} \tag{3.1}$$

where i denotes interest rates in the home country (c) and in the base country (j) in a given year, $Corr$ is the correlation coefficient between the two variables inside the brackets. The base country is defined as the country with which a home country's monetary policy is most closely linked, as suggested by Shambaugh (2004). By construction, the minimum and maximum values are 0 and 1, respectively. The index is smoothed out using three-year moving averages. However, the index has some weaknesses given that the home country may use other tools to implement monetary policy rather than the interest rate. In fact, some countries have used reserve management and financial repression to gain monetary independence, while others have used both while strictly following the base country's monetary policy. This shows the complexity of incorporating all those issues in the calculation of a monetary independence index. Thus, the authors assign an arbitrary monetary independence value of 0.5 (midscale of index) for such a case appears to be a reasonable compromise.

The central bank independence index proposed by Garriga (2016) is coded as the Cukierman et al.(1992) index, ranging from 0 (lowest) to 1 (highest) levels of central bank independence. It comprises four main components: (i) financial independence; (ii) policy independence; (iii) the central bank objective; and (iv) personal independence. It combines 16 legal attributes that affect central bank independence, following the Cukierman(1992) criteria. The Cukierman, Webb, and Neyapti (1992) (hereafter abbreviated as CWN) criteria permitted Garriga to analyse different dimensions of central bank independence. The index considers criteria such as the governor's appointment and term, the central bank's objectives, participation in monetary policy, and lending restrictions to the government.

Despite their contributions, the preceding indices do not consider both domestic and external effects in a cohesive framework when determining the degree of central bank independence. Also, to the best of my knowledge, there is no study in the literature covering both domestic and external measures of central bank independence in a unified framework. This chapter aims at contributing to present a novel central bank independence index that attempts to overcome some of the drawbacks of the existing measures.

The following section presents a literature review on central bank independence and inflation.

3.3 A review of the empirical literature on central bank independence in emerging countries

The current section provides an empirical survey of both central bank independence indices and inflation, setting the ground for our proposal of a new index of CBI and for the analysis of its relationship to inflation dynamics.

According to the theory on central banks presented in Chapter 2, an independent and autonomous monetary authority leads to a more stable economic environment (Maxfield, 1997). Thus, the main motive behind the granting of such autonomy is the belief that an independent and sovereign monetary authority would have more power to diminish inflation and price volatility and, thus, to promote economic growth (Cukierman, 1994). This belief stems not only from theory but also from empirical studies, both for developed and developing countries.

In the late 1980s, numerous studies in developed countries have shown a clear negative relationship between inflation and central bank independence – see, for example, Debelle (2017), Grilli et al. (1991); Cukierman (1992); Alesina and Summers (1993); Eijffinger and Schaling (1992). These empirical studies then led to a broad consensus that the central banks institutional setting should be based on the principle of independence, with a clear mandate for price stability.

However, more recent studies on the relation between CBI and inflation are ambiguous (Crowe and Meade, 2008; Jácome and Vázquez, 2008; Klomp and De Haan, 2010; Arnone and Romelli,2013). Siklos (2002) shows that countries where central banks were made independent in the 1990s had already achieved lower inflation performance in the 1980s. Hielscher and Markwardt (2012) even identified a non-linear relationship between central bank independence and inflation, providing support to calls for limitations on the independence of central banks.

Hillman (1999) finds that, in transition economies, greater independence is connected with higher inflation. This runs counter to the notion that a central bank's independence will allow for prudent policymaking and restrict political opportunism. That is, empirical data suggests that central bank independence may be insufficient to guarantee policy discipline in transition economies. Others found no relationship between central bank independence and inflation (Cargill, 1995; Campillo and Miron, 1997; Logue and Sweeney, 1981).

Many studies focusing on transition economies Iwasaki and Uegaki (2017) and Petrevski et al. (2012) have found no relationship between measures of central bank independence (the Cukierman, Webb and Neyapti—CWN—index and the Grilli, Masciadaro and Tabellini—GMT—index) and inflation. Another study by de Mendonça and Veiga(2017) on Latin America, concluded that central bank independence has no statistically significant effect on inflation and argues that this may be due to high macroeconomic instability and low policy credibility throughout the region.

In emerging countries, reforms favouring central bank independence have been fostered by the experience of inflation targeting regimes in advanced countries since the end of the 1980s. Bernanke et al. (1999), Mishkin (1999) and Svensson (1997) claim that since the initial credibility of emerging markets' central banks was low, officially adopting inflation targeting has contributed to make their monetary policy more credible and, thus, has led to better macroeconomic outcomes.

On the empirical front, works like Gonçalves and Salles (2008), Lin and Ye (2009), Batini and Laxton (2007) and IMF (2006) have provided positive evidence about the performance of inflation targeting regimes in developing countries, with lower inflation rates and less volatile inflation and output growth. When compared to the ambiguous results of Ball and Sheridan (2005), Gonçalves and Carvalho (2009) and Levin et al. (2004) for developed economies, which better meet the preconditions for efficient inflation targeting policy, the aforementioned findings suggest that worries about lack of institutional maturity may be unfounded. It seems that, as IMF (2006) claims, inflation targeting has contributed to strengthening the institutions of developing economies, a necessary condition for macroeconomic stability, through a more efficient monetary policy.

A vast body of literature (Campillo and Miron, 1997;Coenen and Straub, 2005; Aisen and Veiga,2008; Hielscher and Markwardt, 2012) on the relationship between institutional quality and inflation supports the view that the development of the financial system and the quality of the political environment may be necessary conditions for the effectiveness of central bank independence (Posen, 1995). Evidence of a clear impact of financial development on stabilization policies is given in Cecchetti and Krause(2001), who find evidence suggesting that an improvement in the depth of the financial sector and the intermediation process, measured by a less centrally controlled banking system, has contributed to the reduction in inflation and output variability. Bittencourt et al. (2014) also emphasise the role of deeper financial markets in allowing private agents to smooth expenditure, thereby reducing fluctuations in economic activity. In poorly developed financial sectors, the central bank cannot target as low inflation levels as it would like, because of the unemployment it stands to create (Mehrotra and Yetman, 2015).

Ma and Lin (2016) also argues that monetary policy and the financial system are interdependent. The financial system is important in assessing the relation between an independent monetary authority and inflation for various reasons. Posen (1993) argues that the causal relationship between central bank independence and inflation is explained by a third factor which he terms financial opposition to inflation. This author also argues that central banks are more able to enforce an anti-inflationary policy when there is a coalition of interests, politically capable of protecting the central bank's anti-inflationary policy. Central bank independence is also a possible result of the quality of political institutions. For instance, in countries with good checks and balances, monetary institutions may have greater autonomy (Moser,1999; Keefer and Stasavage,2000 and Farvaque, 2002). On the other hand, Campillo and Miron (1997);Crowe and Meade (2008) show that politically unstable countries have higher inflation rates. Rogoff(1985) argues that central bank independence is beneficial to the society by allowing lower inflation levels. The governments who respect the independence of central banks will allow them to operate freely to achieve their objectives of low inflation.

The bulk of the literature, however, has focused on legal central bank independence from political influences in the conduct of monetary policy, with little attention to effective monetary autonomy. The later is at the core of the macroeconomic policy trilemma, stating that an independent monetary policy, a fixed exchange rate and free movement of capital cannot exist at the same time (Obstfeld and Taylor, 2004; Obstfeld, Shambaugh and Taylor, 2005). In this perspective, the large spillovers from the monetary policies of developed countries to the smaller economies is not new. During the mid-1980s, when central banks in advanced economies raised policy rates, after several years of negative real interest rates, similar complaints were lodged, and some may partly trace the financial crises in Latin America and subsequently in East Asia to the movements in interest rates in advanced economies. Since Mundell (1963) outlined the hypothesis of the monetary trilemma, policy management in the open economy has been viewed as a policy trade-off among the choices of monetary autonomy, exchange rate stability, and financial openness (Aizenman et al., 2011, 2013; Obstfeld, 2014; Obstfeld et al., 2005 and Shambaugh,2004).

The aftermath of the global financial crisis (Rey, 2013) led to the conclusion that the monetary policy of developed countries influences other countries' national monetary policy mostly through capital-flows, credit growth, and bank leverages, making the type of exchange rate regime of the developing countries irrelevant. In other words, developing countries are all sensitive to a global financial cycle irrespective of exchange rate regimes. Many studies (such as Zlate and Ahmed, 2013; Forbes and Warnock, 2012;Fratzscher, 2011 and Ghosh et al., 2012) have documented the importance of global factors, particularly interest rates in advanced economies and global risk appetite, in affecting capital flows to small open economies.

Nonetheless, these studies have also highlighted that domestic, country-specific factors also retain importance. In particular, the institutional and macroeconomic policy frameworks of the emerging market economies also determine the variations in flows. Recently, the global financial crisis transformed the main goal of central bank independence from price stability to the steadiness of the financial system and made central banks implement remedial policies in order to prevent its consequences. For instance, Cukierman (2016) states that the global financial crisis moved the financial stability goal to the forefront of central banks' concerns and it reminded of the lender of last resort function of central banks. Moreover, the global financial crisis has made it obvious that central banking is more than keeping inflation low; it is responsible for financial stability as well. In addition, as stated in Haan and Eijffinger (2016) in the aftermath of the global financial crisis central banks had to intervene on a grand scale to maintain financial stability.

Most of the studies, both on the developed and on the developing world, conclude that the desired rate of inflation is determined by the degree of inflation aversion (including policy preferences, Rogoff, 1985), macroeconomic developments (including income level, trade openness and fiscal deficits, Végh, 1989; Romer, 1993; Campillo and Miron, 1997; Lane, 1997; Galí and Gertler, 1999; Catao and Terrones, 2005; Clark and McCracken, 2006; Badinger, 2009), the flexibility of labor-market institutions (Cukierman and Lippi, 1999), the type of exchange rate regimes (Levy-Yeyati and Sturzenegger, 2001; Husain, Mody, and Rogoff, 2005).

The empirical evidence has shown the need for larger sets of panel data, enabling the investigation of the effects of changes in central bank independence and its components over longer periods of time, and their possible impact on inflation dynamics (Arnone and Romelli, 2013; Dincer and Eichengreen, 2014). Both developments suggest quite convincingly that any empirical research should use a dynamic panel approach with model specification allowing explicitly for possible differences between countries with stronger and weaker institutions, supporting monetary independence to a different extent, and for the important role of other economic and fiscal variables (Polillo and Guillen, 2005; Bodea and Higashijima, 2017; Papadamou, Spyromitros and Tsintzos,2017).

The study of Nurbayev et al. (2018), who studied 124 countries over the period 1970-2013, using the two-step system-GMM and the legal CBI dataset by Garriga (2016), found no statistically significant effect on price stability. On the other hand, the study by Aguir(2018) on 17 countries over the period 1990-2016, applying the system-GMM, concluded that central bank independence is a prerequisite for a decline in inflation. Chrigui et al. (2011) examined the relation between legal independence and inflation for 40 countries over the period 1971-2004, using the static panel. These authors found that central bank independence improves price stability. Abel et al.(2017) studied 48 countries over the period 1970-2012, using the legal CBI index from Garriga (2016) and two-stage least square instrumental variables, concluded that central bank independence is more effective in lowering inflation. Balls et al. (2016) examined legal independence in 26 countries, in the period 2000-2007, using ordinary least squares, and found that CBI is important to monetary policy and financial stability. Deniz et al. (2016) investigated the relation between central bank independence and inflation in 40 countries, for the period 2002-2012, using fixed effects and panel GMM, and concluded that money growth, the real effective exchange rate, budget balance, GDP growth and output gap are the main determinants of inflation.

The measures presented are not easily comparable as each measure focuses on a different aspect of central bank independence. In fact, sometimes these measurements are not as informative as claimed and are subject to large classification problems (Cargill, 2013; Banaian, 2008). The majority of empirical studies incorporated variables that capture a set of restrictions on the government's influence on the management of monetary policy (Debelle and Fischer, 1994; Henning, 1994; Blanchard, 2004; Fabris, 2006, Ahmed et al., 2019). These insights from the literature heavily influenced our research strategy, which we present in Section 3.5. From the above review, we conclude that the relationship between central bank independence and inflation is still open to further investigation. Particularly in emerging countries and in the developing world, where financial systems and institutional quality differ significantly from the developed world.

3.4 Extended central bank independence index

This section attempts to expand the existing literature on central bank independence by proposing a new index of central bank independence. It contributes along two dimensions: one tackles more comprehensively the possible institutional arrangements, and another incorporates several aspects related to the external elements of CBI that were not previously grouped together in a unified index.

In the construction of the extended central bank independence (ECBI) index, we follow the dimensions highlighted in CWN index (1992), such as the central bank's legal arrangements, the central bank's objectives and policy formulation, as well as its limits on lending to the government. We have also considered the four main components of central bank independence proposed by Garriga (2016): personal independence, policy independence, objective independence, financial independence and the degree of central bank accountability. We extended it further by adding an external dimension proposed by Aizenman, Chinn and Ito (2010). Compared to traditional indices, the present index has the advantage of including most of the institutional arrangements proposed by the different studies. It captures the recent central bank reforms and expands existing measures by including criteria that were scattered across various studies without being aggregated in a unified index.

In coding each criterion, only information written in the legal documents governing the central bank is considered, specifically the one from the Central Bank Legislation Database (CBLD). The domestic component is divided into five main variables and each variable has equal weight as suggested in the studies done by Sharpe, and Andrews (2012); Gisselquist (2014). This methodology makes it possible to estimate the degree of CBI with a minimal subjective judgment (Cukierman, 1992).

The following variables capture the attributes necessary to build the novel index of central bank independence:

(i) Central Bank's Objective: the variable favours setting price stability as the sole or main objective of the central bank. The institutional commitment to price stability provides a framework to counter time-inconsistency, resist the inflationary bias of governments, and ensure the credible commitment of monetary policy (Mishkin, 1998; Issing, 2006; Arnone et al., 2007; Romelli, 2015).

(ii) Policy Independence: this variable is related to the extent to which policy decisions are carried out by the central bank with the lowest degree of government involvement. It comprises criteria for monetary policy formulation. In this regard, central banks with wider authority to formulate monetary policy and without government interference are categorized as most independent.

(iii) Financial Independence: this variable assesses the right of the central bank to utilize its financial resources without external involvement (Ivanović,2014). In coding this variable, the highest degree of independence is coded to central banks that own their capital, determine their budget internally and self-finance their losses without resorting to a third party, i.e., the government.

(iv) Personal Independence: this variable assesses the autonomy of the central bank governor from any potential political pressure.

(v) Accountability: this measure is related to the external monitoring of decisions about the ultimate objectives of monetary policy.

Each of the five criteria is coded using a uniform scale ranging between 0 and 1, with 0 implying the lowest degree of independence and 1 representing the highest degree of independence. The number of independence levels within each criterion varies based on the alternative legal characteristics related to this criterion. The underlying index follows an aggregation process, i.e, an average of those variables, to yield a single component measuring so called

”domestic independence”. In addition, the proposed index encompasses an additional aspect (vi) related to the ”external independence”, to take into account the importance of global factors such as interest rates in advanced economies and global risk appetite, to assess whether a country sets its own monetary policy for domestic purposes independently from external monetary influences.

Thus, construction of the ECBI-index involves coding the legal aspects of central banks into five groups, consisting of twenty-four different variables, constituting domestic aspects of central bank independence, and three variables capturing the external component of central bank independence, i.e. twenty-seven variables in total. Table 3.1 summarizes the variables and the respective score used in the computation of the extended central bank independence (ECBI) index.

Table 3.1 Components of the extended central bank independence index

Variable	Criteria	Characteristics	Score
Domestic aspects of proposed index			
Central Bank Objective	Price stability objective	Price stability is mentioned as the only or major objective in the charter	1
		Price stability is mentioned as one goal with other compatible objectives without priority given (i.e. financial stability)	0.75
		Price stability is mentioned along with other conflicting objectives (i.e. full employment) without priority given	0.5
		Central bank charter does not include any provision concerning objectives	0.25
		The stated objectives do not include price stability	0
Policy Independence	Formulation of monetary policy	Central bank alone	1
		Both central bank and government	0.75
		Central bank participates with the government, but has little influence	0.5
		Central bank only advises the government	0.25
		Government alone	0
Financial Independence	Determination of the central bank's internal budget	Central bank board alone determines the internal budget or with the approval of the legislature or the president	1
		Only the legislature or the president determines the internal budget of the central bank	0.67
		Only the executive branch determines the internal budget of the central bank	0.33
		Only the executive branch determines the internal budget of the central bank	0
Personal Independence	Appointment of the governor	Double veto arrangement, whereby the central bank board nominates and the president or the legislature appoints	1
		Appointment is carried out exclusively by the central bank board	0.83
		Appointment is carried out by a council composed of members from the central bank board, executives and legislatures	0.67
		Appointment is done exclusively by the legislature	0.5
		Appointment is done exclusively by the president	0.33
		Appointment is done exclusively by the executive branch collectively (i.e. the cabinet)	0.17
		Appointment is done exclusively by some members of the executive branch	0
Accountability	External Monitoring	Central bank shall appear before the legislature	1
		Central bank shall appear before the president	0.5
		Central bank shall appear before the government	0
External aspects of proposed index			
External Independence	Extent of deviation of the domestic interest rate from the base rate	No external monetary influences	1
		Medium external monetary influences	0.5
		High external monetary influences	0

Another factor to examine are the weights assigned to each criterion. In theory, the weights assigned to each criterion reflect the relative importance and influence of the underlying criterion in terms of its contribution to the ECBI (Jácome, 2001; Pisha, 2011). Due to the lack of a theory to guide the selection of weights, the proposed index uses equal weighting to eliminate any degree of subjectivity (Sharpe and Andrews, 2012; Gisselquist, 2014). The proposed index analyses the behaviour of the central bank; since the information gathered is based on legal provisions related to CBI, a simple coding technique is employed to simplify the data collection process and reduce the degree of subjectivity inherent in more sophisticated coding.

3.4.1 Computation of central bank independence index

The idea for constructing an extended central bank independence index (ECBI) is then to aggregate the identified components into a single index that best represents the set of information. In this exercise the two subcomponents were reduced to a single index of novel central bank independence using a Principal Components Analysis (PCA).

PCA allows us to identify the principal directions in which the data vary by transforming a set of correlated variables into a set of uncorrelated "components". The first principal component is selected as the linear index of all the variables that capture the largest amount of information common to all of the variables, which may then be used as the index (Filmer and Pritchett, 2001).

This approach allows the determination of the most appropriate weightings for each variable to derive an index that captures maximum variation. The PCA provides more accurate weights than simple summation. Technically, the PCA procedure is concerned with elucidating the covariance structure of a set of variables. It projects a dataset to a new coordinate system by determining the eigenvectors and eigenvalues of a matrix. It involves the calculation of a covariance matrix of a dataset to minimize the redundancy and maximize the variance.

The first principal component is calculated such that it accounts for the greatest possible variance in the data set. The second principal component is calculated with the condition that it is uncorrelated with the first principal component and that it accounts for the next highest variance. This continues until a number of principal components equal to the original number of variables have been calculated.

After the computation exercise, a central bank will be the more independent the higher the value of those indices. The average values of the index for the 18 emerging economies in our sample are presented in Table 3.2. The values reported in Table 3.2 indicate that larger emerging economies show a higher level of central bank independence. For example, the central bank of Russia shows the highest independence index (0.63), followed by Brazil. On the other hand, the central bank of Qatar displays the lowest value of independence at 0.30. It is also equally important to note that, following the global financial crisis, central bank independence indices show a significant increase, reflecting the implementation of central bank reforms.

Table 3.2 Extended central bank independence index (2000-2017)

Country name	**Russia**	**Brazil**	**South Africa**	**Chile**	**Korea**	**Colombia**	**Czech Republic**	**China**	**Malaysia**
ECBI value	0.63	0.61	0.54	0.51	0.51	0.49	0.49	0.48	0.48
Country name	**Pakistan**	**India**	**Hungary**	**Peru**	**Mexico**	**Thailand**	**Philippenes**	**Egypt**	**Qatar**
ECBI value	0.45	0.44	0.43	0.42	0.41	0.40	0.38	0.35	0.30

Source: Author's computation

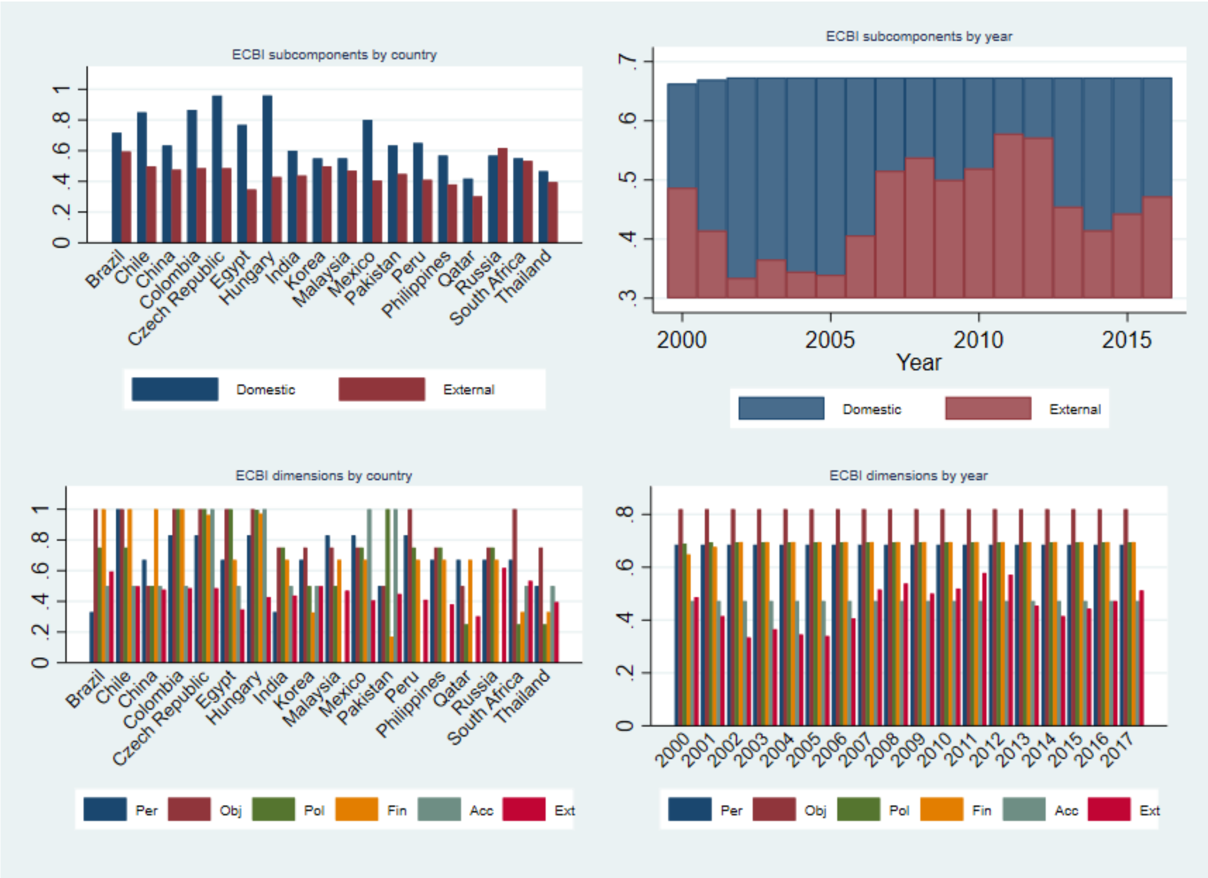
3.4.2 Characteristics of the proposed CBI index

This subsection presents some characteristics and descriptive statistics of the ECBI index. It includes a breakdown of the ECBI score and discusses the relationship between the novel index of central bank independence and other measures of central bank independence.

The database covers a set of 18 emerging countries over the period 2000-2017. It focuses on the central bank legislation and on the assessment of whether a country sets its own monetary policy for domestic purposes. Looking at the differences between these dimensions of the index is particularly useful for policy makers to assess which aspects of central bank institutional design can be improved. Figure 3.1 shows the average degree of ECBI by dimensions and by subcomponents for the whole sample of countries. It is important to note that the first five elements constitute the domestic component of central bank independence while last one captures the external independence of central bank.

Figure 3.1 indicates that there is very little variation in the average value of independence across dimensions. Interestingly, the characteristics related to objective independence are associated with the highest average value of independence, showing a significant improvement in central bank decision making in emerging market economies. Looking at the dimensions with the lowest degree of independence, we can find one related to external independence.

Figure 3.1 Evolution of the subcomponents and dimensions of the ECBI index



Each bar indicates the average value of independence of the different dimensions of the ECBI index.

Per: personal independence, Obj: objective independence, Pol: personal independence,

Fin: financial independence, Acc: accountability, Ext: external independence.

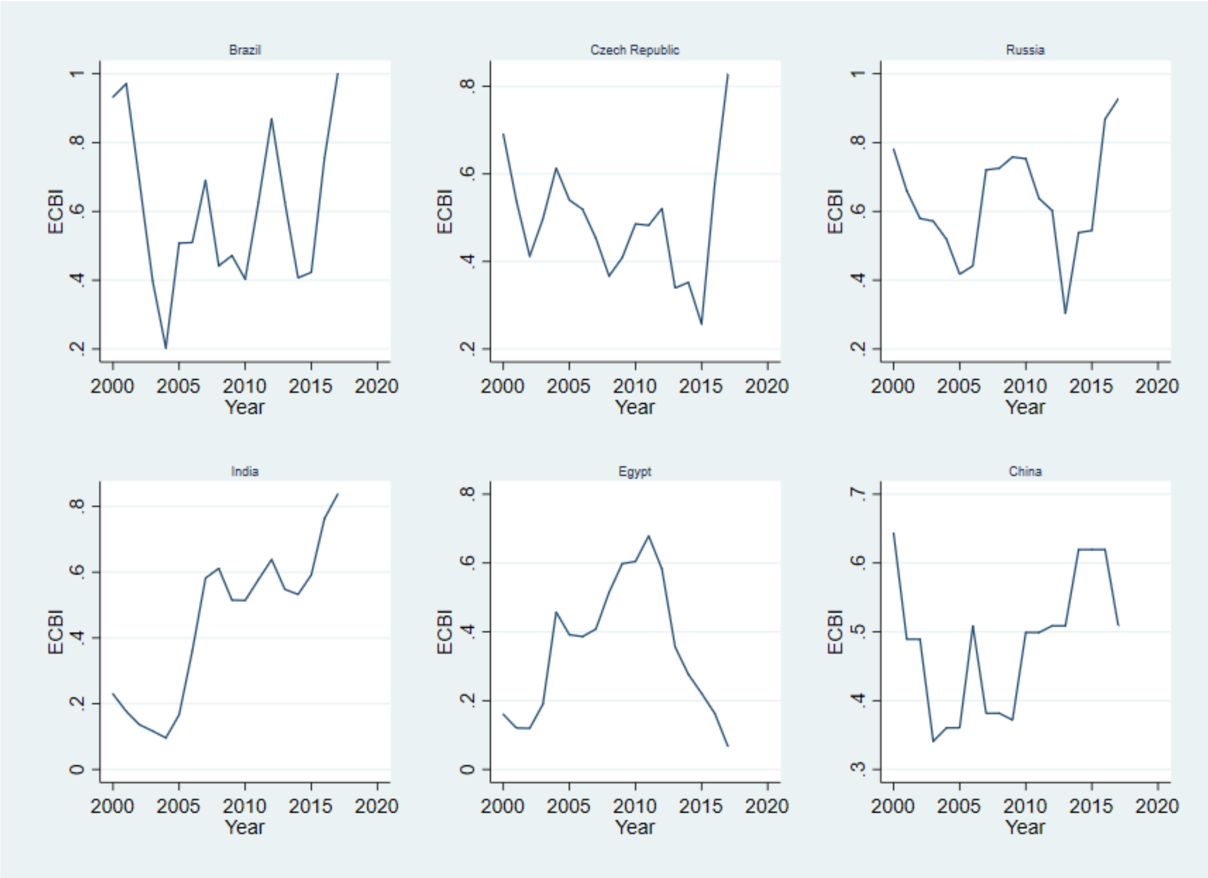
Source:Author's computation

The lack of significant variation in the average value of domestic independence across dimensions is mainly due to the common international regulatory frameworks such as: (i) Central bank objectives have come to include financial stability and financial supervision. Financial supervision is sometimes merged with the central bank, and sometimes the mandate of one or more stand-alone agencies. (ii) Decision-making is better sheltered by arrangements relating to central bank board member selection criteria, appointment procedures, and changes in size of the Board. (iii) Accountability mechanisms are strengthened. (iv) Central banks are mandated to collect more, and more specific, data and information. Interestingly, the domestic dimension appears to be the dominant contributor to the ECBI index.

Another important innovation of the ECBI index is its computation techniques and its dynamic nature, that allows us to track the evolution of central bank independence over time. This also improves on previous approaches of assessing the changes in the degree of central bank independence that recompute the level of ECBI at two different, usually distant moments in time (Arnone et al., 2009).

By recomputing the level of independence after each central bank's legislative and external reforms, we can draw a complete picture of how central bank institutional design has evolved over time. The evolution of the proposed index, for a group of selected countries, is represented on Figure 3.2, while Appendix A.1 presents the data for each country during the period 2000-2017.

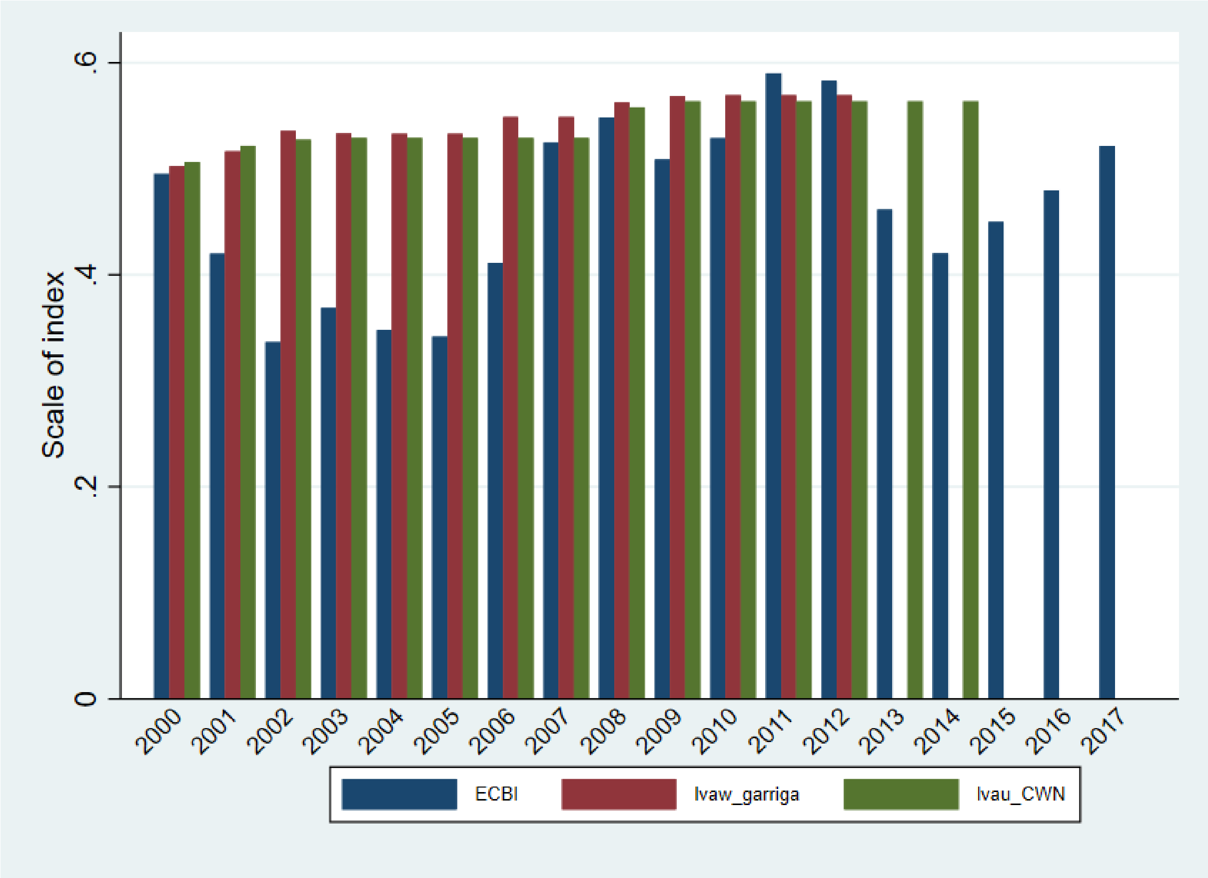
Figure 3.2 Evolution of the ECBI index for a group of countries from 2000 to 2017



Source:Author's computation

Figure 3.3 we show the evolution of the ECBI index against the Garriga Index, developed by Garriga(2016), and the Cukierman Webb and Neyapti(CWN)(1992) index, as updated by Bodea and Hicks (2015) to cover an extended set of countries over a long horizon. These extra indices will be utilized as a robustness check for identifying the drivers of central bank reforms. The ECBI index will thus identify the entire range of central bank legislative revisions that changed the degree of central bank independence in the countries studied between 2000 and 2017. Since, we recompute the amount of CBI every time the central bank statute is updated, the ECBI index captures a far higher number of reforms.

Figure 3.3 ECBI against the Garriga and CWN Indices

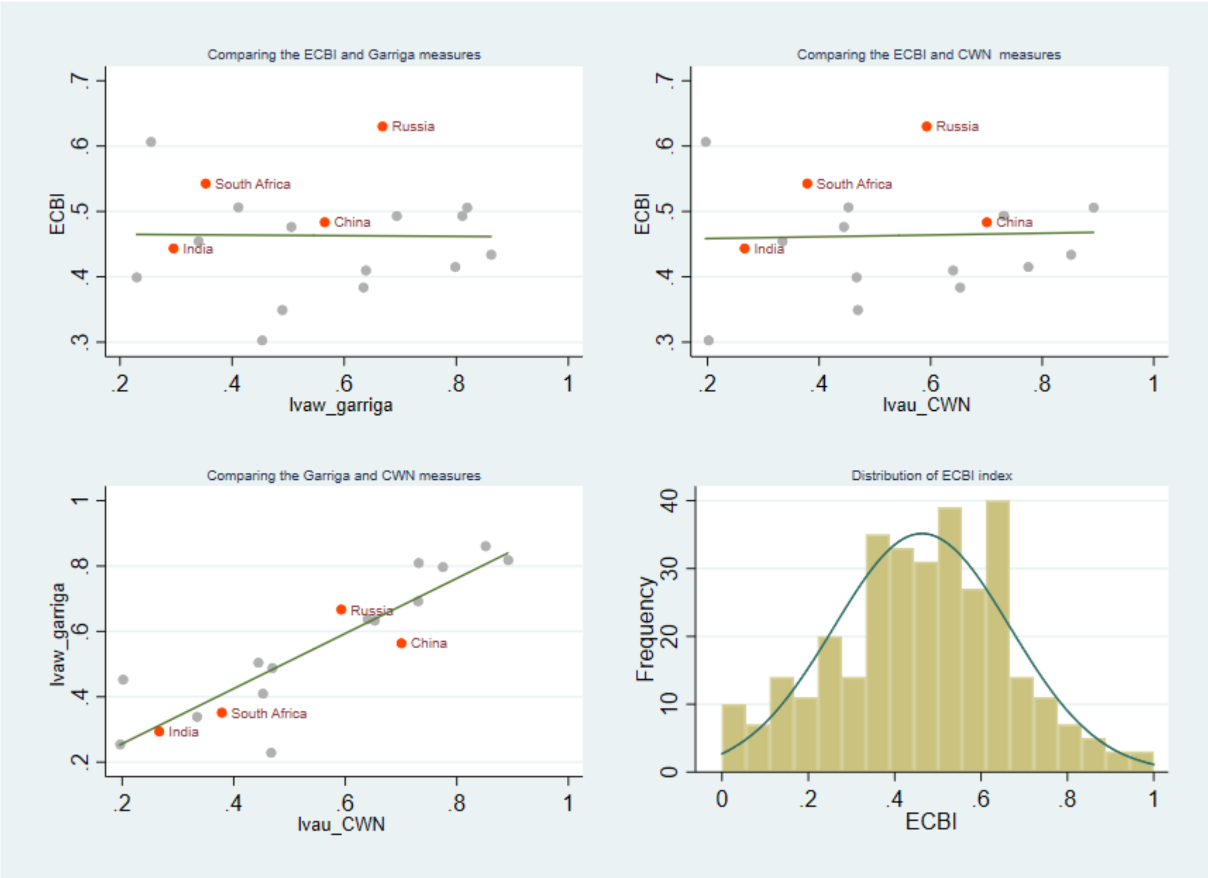


Source:Author's configuration

Comparison of the ECBI with other indices of central bank independence reveals some divergence. This is unsurprising, considering the additional external dimensions included in the ECBI as elements affecting central bank autonomy. However, in the period after 2007, the ECBI and the alternative indices have followed a similar pattern.

Other perspectives on the relationship between the ECBI and the alternative indexes are provided by the partial regression plots in Figure 3.4. These show the relation between the ECBI and the alternative indices. The correlation between the ECBI and the alternative indices is not significant, while the alternative indices are clearly correlated between them, which is expected given their similarities in terms of measurement and dimensions.

Figure 3.4 Comparison of central bank independence measures



Source:Author's computation

The actual values of the pair-wise correlations between the new index and the alternative measures are in Table 3.3. Overall there is positive correlation between all measures, but it is very small when the ECBI index is involved.

Table 3.3 Correlation between measures of CBI

	ECBI	Garriga	CWN
ECBI	1.00		
lvaw_garriga	0.13	1.00	
lvau_CWN	0.11	0.89	1.00

Source: Author's computation

Given similar levels of independence along the different measures, the rest of the analysis focuses on the aggregated index of independence computed using the PCA. This also allows for a comparison with previous studies, most of which investigate the link between CBI and macroeconomic outcomes. In line with Arnone et al. (2009), we find that the average degree of ECBI has sharply increased, especially after 2005. The detailed nature of the new dataset on central bank design helps us to recompute the degree of central bank independence. According to the rationale for $ECBI$, we would expect an increase in $ECBI$ to result in a decrease in inflation, which would correspond to a negative sign of the $ECBI$ coefficient in a regression with inflation as the dependent variable.

It is normally argued that a high level of central bank independence is associated with some explicit mandate for the bank. However, the literature explains existing variations in central bank independence across countries (Cukierman,1994 and Posen,1993a). This variation takes into account the view that delegation of authority by politicians is used as a (partial) commitment device. The more independent the central bank, the stronger the commitment of policymakers. There is also the view that political interests in society drive monetary policy, and the central banks will take strong anti-inflationary action only when there is a coalition of interests politically capable of protecting it.

As mentioned above, giving independence to the central bank is considered a canonical reform in governance. However, the impact of reform is conditional on the initial political equilibrium that generated the need for reform. For instance, only policy reforms that the groups with political power cannot easily avoid are likely to achieve their objectives. Consequently, in emerging countries where there are strong institutions (perhaps more likely to happen in large emerging countries) policy reform is likely to be very effective with high scores compared to other emerging countries.

The independence of the central bank is normally ensured through legislation and the institutional framework that governs the bank's relationship with elected authorities, particularly the finance minister. Specific procedures for selecting and appointing the head of the central bank will be enshrined in central bank legislation. Central bankers in emerging countries may have an edge in defending independence over their counterparts in industrialized nations. They should simply publicise that in developing countries, real or perceived central bank independence has far greater benefits than in mature economies.

The study by Wachtel and Blejer (2020) on central bank independence identified three factors that contribute to these results: (i) Building an institution in emerging markets. The need to construct, strengthen, and safeguard institutions is at the heart of almost every development strategy. (ii) Accumulation of Human Capital. One facet of independence has gained widespread acceptance: practically all central banks have sufficient independence to run their own budgets within defined boundaries. (iii)The Impact of International Clubs. Central banks have a stronger bond with their international counterparts than other institutions. They have their own international gathering place, are involved in multilateral institutions, and are members of numerous regional groups. They act as a conduit for the dissemination of good practices and the implementation of more effective transmission methods.

3.5 Empirical Application: ECBI index and Inflation

In this section, we first describe the data and sample. Then we go through the various models and estimation techniques that will be used to evaluate the role of central bank independence in the inflation dynamics of emerging economies.

3.5.1 Data and sample

To investigate the effect of the extended central bank independence index on inflation dynamics, we use annual panel data spanning 2000-2017 on eighteen emerging countries: Brazil, Chile, China, Colombia, Czech Republic, Egypt, Hungary, India, Korea, Malaysia, Mexico, Pakistan, Peru, Philippines, Qatar, Russia, South Africa and Thailand. These countries mostly joined developed countries in the modernization of the monetary framework (Schaechter, Stone and Zelme, 2000; Jonas and Mishkin, 2004;Carré,2011). We have not considered five countries – Greece, Indonesia, Poland, Taiwan, Turkey and United Arab Emirates – due to data unavailability.[1] The variables' names, definitions and data sources are given in Table 3.4.

Our dependent variable is the annual inflation rate (Inf). The vector of control variables is grounded on the theoretical foundations on inflation (Fisher, 1911, Friedman, 1968; Klomp and De Haan, 2010; Laurens et al., 2015; Masciandaro and Romelli, 2015; Agur et al., 2015; Goodhart and Lastra,2018; Aizenman et al., 2013; Ghosh et al., 2016; Nanovsky and Kim, 2018; Cevik and Zhu, 2019).

FO is a measure of financial openness or integration developed by Chinn and Ito (2006). The Chinn-Ito index is normalized between zero and one, with higher values indicating that a country is more open to cross-border capital transactions, this indicator is important because emerging countries have a wide variance in capital controls (Aizenman, 2018; Aizenman et al., 2010; Obstfeld et al., 2005; Rey, 2015).

In line with Cukierman et al. (2002); De Haan and Kooi (2000), Klomp and De Haan (2010) and Jácome and Vázquez (2008), we take into account domestic factors in the link between central bank independence and inflation, focusing on economic, financial and institutions indicators. $BgtBal$ is the government's budget balance as a percentage of GDP (see, Kabuga,2018), a comprehensive proxy for fiscal dominance, capturing direct governmental influence in the conducting of monetary policy. A large budget deficit can be an exogenous source of inflation (Neyapti,2003; de Haan and Van't Hag,1995; Beetsma and Bovenberg, 1997). A balancing or surplus budget safeguards the monetary authority against government pressure to finance its budget, hence, strengthens central bank independence (Grilli et al., 1991; Wijnholds and Hoogduin, 1994; Lybek, 1999; Issing, 2006; Arnone et al., 2007). We expect that when there is a budget surplus, the government is reducing its financing needs and the central bank is working properly and more independently, and thus we expect a negative relation with inflation.

$FinDev$ is a financial development indicator. It is measured by the log of the ratio of private bank credit to GDP (see, Detragiache et al., 2006) to capture banking sector development. The bigger the ratio, the larger the size of the banking sector's opposition to inflation, and the higher the increase in the credibility of monetary policy institutions to focus on price stability.

$InstQual$ is an institutional quality variable, which is proxied by the rule of law index that captures perceptions of the extent to which agents have confidence in and abide by the rules of society (Acemoglu et al., 2008; Bodea and

[1]We prefer homogenous countries(income group) and balanced data in the panel since unbalanced data create some problems in testing and estimation and updated data on all variables are available up to 2017.

Hicks, 2015; Fazio et al., 2018). Hayo and Voigt (2008); Garriga (2016) also find evidence that a significant relation between central bank independence and inflation only exists if checks and balances are sufficiently strong. Under the assumption that central bank independence is socially beneficial (Rogoff, 1985) greater democratic accountability makes it more costly for politicians to deviate from the socially preferred central bank design and thus increases the credibility of the central bank.

Following Daniels, et al. (2005) and Wickens (2008), we use the change in the log of real GDP per capita ($\Delta LGDPC$) as a proxy for a country's level of economic development, a higher per capita GDP is likely to be associated with a reduction in the costs of inflation, so inflation aversion might be lower. The nominal lending interest rate (Int); when the interest rate is high, the supply of money is smaller, and hence inflation decreases (Asgharpur, Kohnehshahri and Karami,2007). However, there is a transmission lag between the interest rate and its subsequent effect on goal variables. Since an optimizing central bank should take into account the lag in the effect of a change in the interest rate on output (the so-called policy lag) and any lag in the Phillips curve from a change in output to inflation (Alexandre, Bação and Driffill (2011), we introduce the interest rate in the model with a time lag.

The annual percent change in the broad money supply (MSG) should also be an important variable, under the common assumption that prices increase with the money supply (McCandless and Weber, 1995; Walsh, 2003; Nassar, 2005; Oomes and Ohnsorge, 2005; Pelipas, 2006; Hossain, 2010; Umaru and Zubairu, 2012; Islam et al.,2017). This is in line with the Friedman (1956) views on the monetarist hypothesis, which claims that the money supply is the most important determinant of inflation and deflation episodes in an economy.

We also consider open economy factors in the explaination of inflation dynamics (Bernhard, 2002; Clark and Hallerberg, 2000; Hallerberg, 2002; Lohmann, 1998; Cevik and Zhu, 2019). Thus we include as an explanatory the log of trade openness(LTO) (Keho, 2017), defined as the sum of exports and imports in relation to GDP. Trade openness is thought to be linked to lower prices, implying a negative relationship between inflation and trade openness. For instance, Romer (1993) argues that inflation is lower in small and open economies.

The change in the log of the real effective exchange rate (ΔLER) accounts for other policy choices that may affect the anti-inflationary effects of central bank independence (Fleming, 1962; Mundell, 1961). If a country's currency appreciates, imports become cheaper, which reduces inflation.

As robustness checks for our main estimations, first we perform a sensitivity analysis, controlling for additional effects. We include a measure of monetary freedom ($MonFr$), under the assumption that price controls can lead to high inflation in addition to market distortions (Beach and Miles,2004). We also include the change in log ratio of stock market total value traded to GDP ($LStMkrt$) (Kabuga, 2018) as a proxy for stock market sector development (Dincer and Eichengreen,2014). We also follow Aisen and Veiga (2006) and Desai et al.(2003) and control for political stability ($PolSt$), a measure of perceptions of the likelihood that the government will be destabilized or overthrown by unconstitutional or violent means, which might increase inflation (Campillo and Miron, 1997).

As a second way to increase robustness, we use a procedure for selecting regressors. Finally, we examine the medium-term relation between central bank independence and inflation using 3-year non-overlapping intervals. This is to give enough time for the sluggish responses of macro variables and separate the central bank independence treatment effects from the effects of other events occurring in close proximity in the 2000-2017 period.

Table 3.4 Data sources and definitions

Variable name	**Definition**	**Source**
Inf	Annual inflation rate	IMF's International Financial Statistics(IFS)
ECBI	Extended central bank independence	Author's computation
MSG	Annual percent change in the broad money	IMF's International Financial Statistics(IFS)
Int	Lending nominal rate of interest	World Development Indicator(WDI)
GDPC	Real GDP per capita	World Development Indicator(WDI)
ER	Real effective exchange rate	IMF's International Financial Statistics(IFS)
TO	Trade openness	TheGlobalEconomy database
BgtBal	Government's budget balance as a% of GDP	World Development Indicator(WDI)
FinDev	Financial development indicator	TheGlobalEconomy database
InstQual	Institutional quality variable	TheGlobalEconomy database
FO	Financial openness or integration	Chinn and Ito(2006)
MonFr	Monetary freedom	TheGlobalEconomy database
StMkrt	Stock market sector development indicator	TheGlobalEconomy database
PolSt	Political stability	TheGlobalEconomy database
Garriga	Central bank independence index	Ana Carolina Garriga(2016)
CWN	Central bank independence index	Cukierman Webb & Neyapti(1992)

Source: Author's literature survey

Descriptive statistics are provided in Table 3.5. A correlation matrix is presented in Appendix A.2.

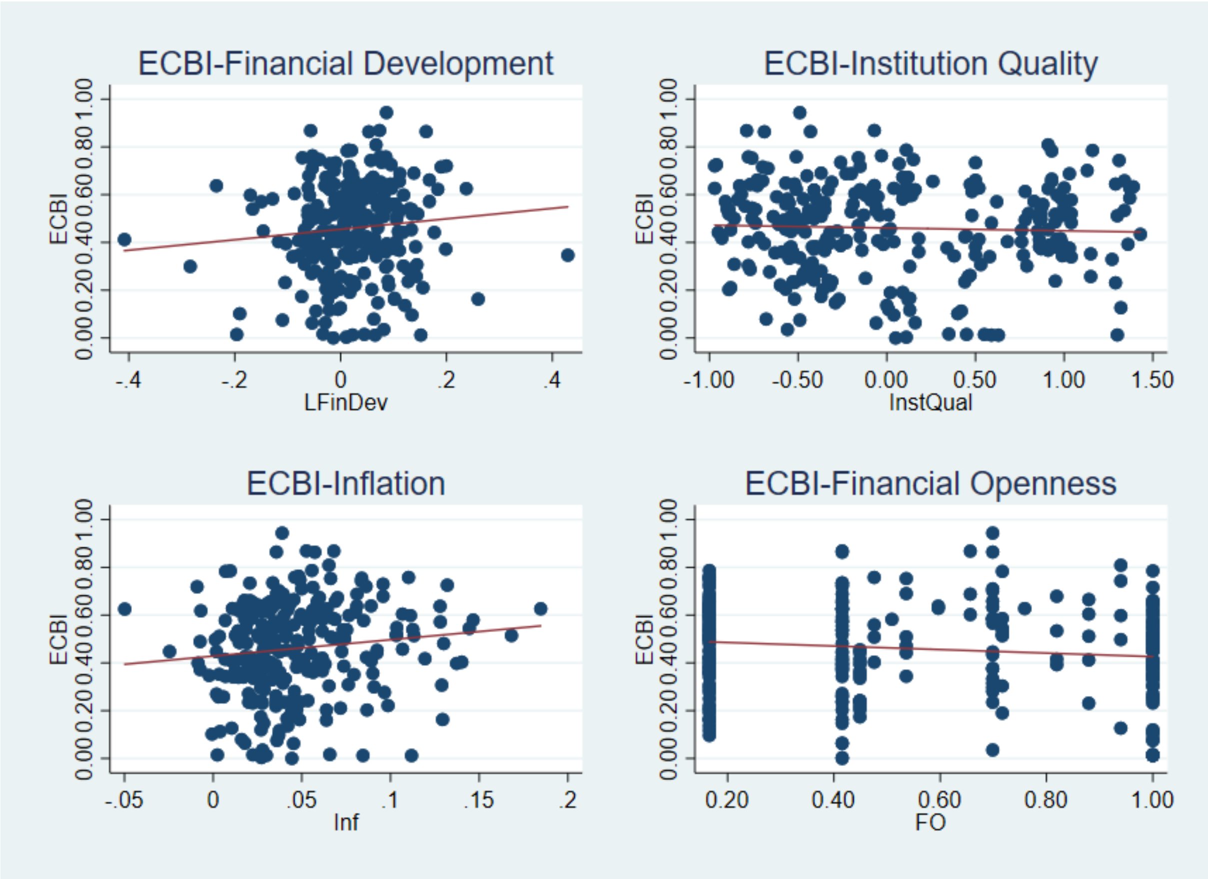
Table 3.5 Descriptive statistics

VARIABLES	**N**	**mean**	**sd**	**min**	**max**	**skewness**	**kurtosis**
ECBI	259	0.471	0.187	0	0.944	-0.296	2.779
Int	259	11.28	10.12	2.089	67.08	3.154	13.85
FO	259	0.528	0.323	0.166	1	0.310	1.611
MSG	259	12.52	8.089	-11.09	42.91	1.104	5.714
BgtDef	259	-1.948	4.411	-12.93	21.56	1.092	7.189
InstQual	259	0.0247	0.669	-0.970	1.430	0.481	1.972
Inf	259	0.0464	0.0347	-0.0499	0.185	1.046	4.514
DLGDPC	259	0.0304	0.0304	-0.0815	0.128	-0.349	4.217
DLER	259	0.00938	0.0673	-0.247	0.262	-0.286	4.859
LTO	259	4.174	0.545	3.096	5.349	0.213	2.202
LFinDev	259	3.885	0.621	2.549	5.060	0.0460	2.109

Source: Author's computation

The scatter plots and the best-fitting linear lines of the ECBI versus other variables of interest for the emerging countries are presented in Figure 3.5.

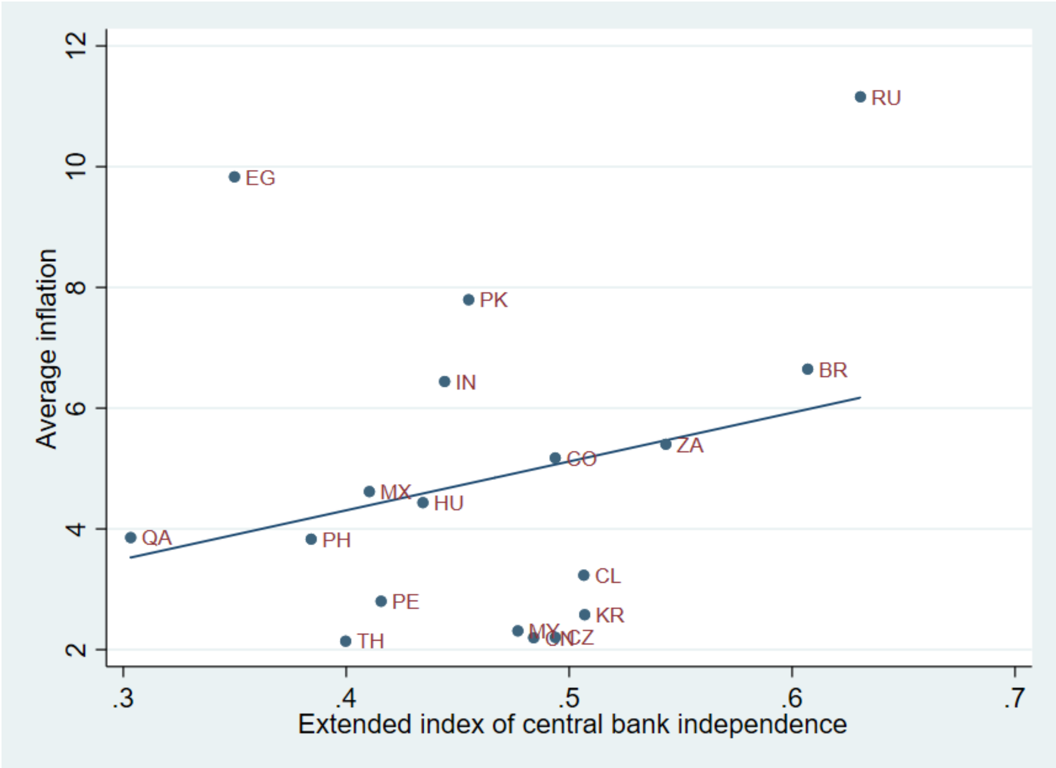
Figure 3.5 Scatter plots of ECBI



Source:Author's computation

Figure 3.6 shows the scatter plot of ECBI and inflation. In that figure, each dot corresponds to the average over the whole period for each country. Somewhat surprisingly, it suggests that there may be a positive association between ECBI and inflation.

Figure 3.6 Extended Central Bank Independence (ECBI) Index and Inflation



Source:Author's computation

3.5.2 Models and estimation techniques

The starting point of the empirical exploration to evaluate the effect of central bank independence on inflation performance, is the existing stock of knowledge (Katseli et al., 2012; Deniz et al., 2016; Aguir, 2018; Balls et al., 2016; Chrigui et al., 2011, among others), which suggests a static model of inflation as our baseline specification:

$$Inf_{it} = \lambda ECBI_{it-1} + \omega FO_{it} + \gamma BgtBal_{it} + \delta LFinDev_{it} + \theta InstQual_{it} + \beta X_{it} + \alpha_i + \varepsilon_{it} \quad (3.2)$$

where $i = 1, ..., N$ denotes the country, $t = 1, ..., T$ denotes time, Inf is our dependent variable (annual rate of inflation), $ECBI$ is the measure of central bank independence, $LFinDev_{it}$ is a measure of financial development, $InstQual_{it}$ is a measure of institutional quality, and X_{it} represents other control variables already defined in previous subsection and ommitted here to keep the equation at a compact length. ε is the error term, assumed to be independently and identically distributed. α_i denotes the unobserved individual-specific time-invariant effects.

The estimation method is usually suggested on the basis of the nature of α_i: (i) The random effects model assumes that α_i are uncorrelated with the regressors. In this case, we can obtain unbiased, consistent and efficient estimates of the parameters using Generalized Least Squares (GLS). Note that under the hypothesis of no correlation between regressors and individual effects, Ordinary Least Squares(OLS) estimators are unbiased and consistent but not efficient. (ii) The fixed effects model allows the α_i to be correlated with the regressors. In this case, the within estimator (WG) may be used to consistently estimate the parameters.

All these methods (GLS, OLS, and WG) have alternative versions that are robust under heteroskedastic disturbances (Davidson and MacKinnon, 2004). However, the static model employed by Balls et al. (2016) and Chrigui et al. (2011), among others, ignores past inflation, which appears unrealistic and may lead to misleading conclusions.

All of the above-mentioned "static" panel techniques do not incorporate any temporal dependency (lags) of the dependent variable. To account for the persistence in inflation, we introduce the lag of inflation into the model. This also helps to address further issues of endogeneity, reverse causality and omitted variable bias. We then have the following alternative specification:

$$\begin{aligned} Inf_{it} = \psi Inf_{it-1} + \lambda ECBI_{it-1} + \omega FO_{it} + \gamma BgtBal_{it} + \delta LFinDev_{it} + \\ \theta InstQual_{it} + \beta X_{it} + \alpha_i + \varepsilon_{it} \end{aligned} \tag{3.3}$$

By construction, Inf_{it-1} is correlated with α_i. Since Inf_{it-1} is correlated with α_i, GLS, OLS and WG estimators are biased and inconsistent. An alternative transformation to remove individual effects α_i is the so-called "first difference" transformation. However, in this case again the WG and GLS estimators are inappropriate. The model suffers from an endogeneity problem because, given its dynamic structure, ΔInf_{it-1} is correlated with $\Delta\varepsilon_{it}$. To solve this problem, Anderson and Hsiao(1982) proposed to control endogeneity using ΔInf_{it-2} or Inf_{it-2} as instruments for ΔInf_{it-1}. In fact, lagged levels of the endogenous variable, three or more time periods before, can also be used as instruments (Holtz-Eakin et al., 1988), and if the panel includes three or more time periods, we will have more available instruments than unknown parameters.

Arellano and Bond (1991) proposed a method that exploits all possible instruments. Using the Generalized Method of Moments (GMM,Hansen, 1982), they obtained estimators using the moment conditions generated by lagged levels of the dependent variable. These estimators are called difference GMM estimators.

Arellano and Bover (1995) and Blundell and Bond (1998) proposed an alternative method. In addition to differencing the model in equation 3.3 and using lagged levels of Inf_{it-1} as instruments for ΔInf_{it-1}, they worked with the "original" model and used the lags of the first difference of Inf as instruments for lagged Inf. The estimators obtained in this way are called system GMM estimators.

This method was developed to improve upon the behaviour of difference GMM estimators when the autoregressive parameter ψ approaches unity. In this case, lagged levels of the dependent variable are weak instruments. There is preference for the system-GMM over the difference-GMM (Nurbayev et al., 2018; Aguir, 2018;Deniz et al., 2016) because the former estimator is better instrumented to capture the effects of highly persistent variables than the latter, as demonstrated in Arellano and Bover (1995) and Blundell and Bond (1998).

Once difference or system GMM estimates are obtained, the validity of the model must be checked: (i) Arellano and Bond (1991) proposed a test to detect serial correlation in the disturbances. Note that the presence of serial correlation in the disturbances affects the validity of some instruments. If ε_{it} is serially correlated to order 1, then Inf_{it-2} is correlated with $\Delta\varepsilon_{it-1}$, and therefore Inf_{it-2} would be an invalid instrument. Serial correlation of order 1 in ε_{it} implies serial correlation of order 2 in $\Delta\varepsilon_{it}$. When the null hypothesis of this test (no serial correlation of order 2 in the first difference) is not rejected, the validity of that instrumental variable is also not rejected. (ii) The Sargan test (Sargan, 1958) tests the the null hypothesis of the validity of instrument subsets.

3.6 Empirical results and discussion

This section provides empirical evidence on the relationship between central bank independence and inflation in emerging countries. The evidence is provided by the estimation of models based on equations 3.2 and 3.3. We also provided robustness checks.

3.6.1 Baseline estimations

Table 3.6 shows the estimates of our baseline models. The results concern two sets of models: static models estimated by pooled-OLS and fixed effects estimators, and dynamic models estimated by difference-GMM and system-GMM. Within each set of models, the models vary according to the CBI index that is included (ECBI or Garriga or CWN), and according to the presence of additional variables in the specification.

The estimates of the dynamic models by SGMM suggest that there is some inflation persistence, which may cast some doubt on the relevance of the static models. However, the DGMM estimates of the coefficient of lagged inflation are not statistically significant.

In the dynamic models, the $ECBI$ is the only CBI index that is statistically significant, which may mean that it provides an interesting addition to the information provided by the traditional CBI indices. Furthermore, as expected, its coefficient has a negative sign, i.e., countries where the central bank is more independent appear to achieve a lower inflation rate, confirming other empirical findings (Baumann et al., 2021, Jácome and Vázquez, 2005).

For the control variables we obtain coefficients that are in line with expectations and broadly comparable to earlier findings. Possibly the most significant results are that (1) money growth appears to be positively associated with inflation, confirming the predictions of extant theories and empirical literature (McCandless and Weber, 1995; Walsh, 2003; Nassar, 2005; Oomes and Ohnsorge, 2005; Pelipas, 2006; Hossain, 2010; Umaru and Zubairu, 2012; Islam et al., 2017), and (2) that development of the financial sector appears to lower inflation. This points to the fact that more developed financial sectors contribute to a more effective monetary policy, i.e., improvement of the monetary policy transmission mechanism (Didier and Schmukler, 2014; Eichengreen, 2015). The institutional quality ($InstQual$) has a negative and significant relationship with inflation in some of the static and dynamic specifications. The results support the findings from previous studies (Busse and Hefeker, 2007; Hielscher and

Markwardt, 2012; Rochon and Olawoye, 2013).

The government's budget balance ($BgtBal$) turned out with the expected negative sign in the model estimated by SGMM (in this case and in the case of the OLS estimator, there is statistical significance). This implies a negative relationship between inflation and the budget balance: budget deficits tend to be bad for inflation.

Table 3.6 ECBI and Inflation-Baseline Estimations

	Static Models							**Dynamic Models**								
	OLS	OLS	OLS	OLS	FE	FE	FE	FE	DGMM	DGMM	DGMM	DGMM	SGMM	SGMM	SGMM	SGMM
Inf(-1)									-0.079 (0.246)	-0.212 (0.289)	-0.138 (0.262)	-0.630 (0.424)	0.550*** (0.044)	0.540*** (0.044)	0.538*** (0.057)	0.514*** (0.049)
Garriga(-2)	-0.014 (0.011)				-0.088** (0.035)				-0.205 (0.245)				-0.015 (0.012)			
CWN(-2)		-0.006 (0.008)				0.012 (0.022)				-0.317 (0.389)				-0.006 (0.007)		
ECBI(-2)			-0.006 (0.009)	-0.013 (0.008)			-0.010 (0.009)	-0.010 (0.009)			-0.095** (0.043)	-0.178* (0.097)			-0.016* (0.008)	-0.019** (0.009)
MSG	0.001*** (0.000)	0.001*** (0.000)	0.001*** (0.000)	0.001*** (0.000)	0.000 (0.000)	0.001** (0.000)	0.001** (0.000)	0.000* (0.000)	-0.000 (0.001)	-0.000 (0.001)	0.000 (0.001)	-0.002 (0.002)	0.001*** (0.000)	0.001*** (0.000)	0.001*** (0.000)	0.001*** (0.000)
L.Int	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000** (0.000)	-0.001 (0.001)	-0.001* (0.001)	-0.001* (0.001)	-0.001 (0.001)	0.006 (0.004)	0.008 (0.007)	0.006 (0.007)	0.014 (0.014)	-0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	-0.000 (0.000)
DLER	0.028 (0.039)	-0.034 (0.031)	-0.033 (0.031)	-0.030 (0.026)	0.047 (0.038)	-0.032 (0.030)	-0.031 (0.030)	-0.014 (0.026)	-0.167 (0.194)	-0.252 (0.195)	-0.261 (0.173)	-0.155 (0.286)	0.072 (0.053)	0.020 (0.036)	0.005 (0.035)	-0.023 (0.038)
DBgtDef	-0.001 (0.001)	-0.001 (0.001)	-0.001 (0.001)		-0.000 (0.001)	-0.000 (0.001)	-0.000 (0.001)		0.000 (0.001)	0.001 (0.002)	-0.001 (0.002)		-0.000 (0.000)	-0.001 (0.000)	-0.001** (0.000)	
BgtDef				-0.001*** (0.000)				-0.001 (0.001)				0.001 (0.004)				-0.001*** (0.000)
DLGDPC	-0.123* (0.067)	-0.152** (0.062)	-0.162*** (0.060)	-0.191*** (0.061)	-0.128 (0.080)	-0.213*** (0.073)	-0.208*** (0.073)	-0.182** (0.075)	-0.312 (0.318)	-0.312 (0.414)	-0.179 (0.381)	-0.518 (0.485)	-0.100 (0.059)	-0.118* (0.065)	-0.124 (0.075)	-0.039 (0.049)
DLTO	0.041 (0.031)	0.009 (0.028)	0.010 (0.028)		0.028 (0.033)	-0.009 (0.029)	-0.011 (0.029)		0.275*** (0.100)	0.231 (0.143)	0.171 (0.124)		0.105*** (0.024)	0.097*** (0.023)	0.097*** (0.025)	
LTO				-0.009** (0.004)				0.024* (0.013)				0.277 (0.239)				-0.002 (0.005)
FO	0.004 (0.007)	-0.001 (0.005)	-0.003 (0.005)	0.007 (0.006)	-0.010 (0.015)	-0.008 (0.013)	-0.010 (0.013)	-0.013 (0.014)	0.104 (0.181)	0.154 (0.252)	0.159 (0.202)	-0.231 (0.377)	0.003 (0.008)	-0.004 (0.006)	-0.004 (0.005)	0.006 (0.011)
DLFinDev	-0.066*** (0.023)	-0.055*** (0.020)	-0.057*** (0.020)		-0.044* (0.024)	-0.039* (0.021)	-0.039* (0.020)		-0.013 (0.127)	0.050 (0.187)	-0.147 (0.169)		-0.060*** (0.020)	-0.047*** (0.016)	-0.052*** (0.017)	
LFinDev				0.004 (0.004)				0.007 (0.010)				0.068 (0.199)				-0.000 (0.007)
InstQual	-0.007** (0.003)	-0.005** (0.003)	-0.005* (0.003)	-0.004 (0.003)	-0.010 (0.015)	-0.006 (0.013)	-0.005 (0.013)	-0.012 (0.014)	-0.008 (0.178)	0.020 (0.180)	0.039 (0.151)	-0.161 (0.129)	-0.009* (0.004)	-0.007* (0.004)	-0.009** (0.004)	-0.004 (0.007)
N	198	234	234	234	198	234	234	234	180	216	216	216	198	234	234	234
Groups					18.000	18.000	18.000	18.000	18.000	18.000	18.000	18.000	18.000	18.000	18.000	18.000
hansenp													0.750	0.850	0.591	0.717
j									16.000	16.000	16.000	16.000	16.000	16.000	17.000	17.000
ar1p									0.036	0.197	0.241	0.577	0.001	0.001	0.001	0.001
ar2p									0.290	0.296	0.204	0.217	0.066	0.198	0.260	0.397

*Note:(i) respectively, the sign *,**, and *** describe the significance level of10%,5% and 1%;*
(ii) standard errors are reported in brackets

Source: Author's computation

Given that baseline estimation included policy variables that may be related to the CBI indices and thus affect the estimation results, we decided to drop these variables and examine the kind of direct link between CBI and inflation that is supported by the results. The estimates for this case are presented in Table 3.7. The conclusion of this exercise is that dropping the policy variables do not change the results significantly.

Table 3.7 Dropping Policy Variables

	Static Models								Dynamic Models							
	OLS	OLS	OLS	OLS	FE	FE	FE	FE	DGMM	DGMM	DGMM	DGMM	SGMM	SGMM	SGMM	SGMM
Inf(-1)									0.171	0.557	-0.158	-0.388***	0.640***	0.621***	0.634***	0.557***
									(0.559)	(1.554)	(0.151)	(0.095)	(0.070)	(0.051)	(0.056)	(0.046)
Garriga(-2)	-0.014				-0.099***				-0.683				-0.020			
	(0.010)				(0.034)				(0.814)				(0.012)			
CWN(-2)		-0.010				0.009				2.045				-0.018**		
		(0.007)				(0.023)				(5.829)				(0.007)		
ECBI(-2)			-0.009	-0.012			-0.013	-0.012			-0.081**	-0.092***			-0.018*	-0.021**
			(0.009)	(0.009)			(0.009)	(0.009)			(0.031)	(0.032)			(0.009)	(0.008)
DLGDPC	-0.082	-0.123**	-0.143**	-0.156***	-0.096	-0.202***	-0.198***	-0.191***	-0.527	-0.370	-0.434**	-0.521***	0.026	-0.018	-0.055	0.001
	(0.063)	(0.060)	(0.058)	(0.060)	(0.075)	(0.070)	(0.069)	(0.069)	(0.611)	(1.215)	(0.170)	(0.132)	(0.063)	(0.059)	(0.066)	(0.054)
DLTO	0.032	0.029	0.029		0.007	0.016	0.012		0.371	0.377	0.169*		0.093***	0.094***	0.096***	
	(0.026)	(0.024)	(0.024)		(0.027)	(0.025)	(0.025)		(0.236)	(0.467)	(0.090)		(0.023)	(0.020)	(0.022)	
LTO				-0.007*				0.024*				0.084				-0.004
				(0.004)				(0.013)				(0.071)				(0.003)
FO	0.004	-0.001	-0.004	-0.003	-0.013	-0.017	-0.020	-0.028**	0.004	0.453	0.276**	0.109	0.010	0.003	-0.005	-0.006
	(0.007)	(0.005)	(0.005)	(0.006)	(0.015)	(0.013)	(0.013)	(0.014)	(0.363)	(1.043)	(0.118)	(0.090)	(0.009)	(0.007)	(0.007)	(0.009)
DLFinDev	-0.048**	-0.031*	-0.031*		-0.032	-0.031	-0.031		-0.457	0.041	-0.141*		-0.048*	-0.035	-0.038*	
	(0.021)	(0.018)	(0.019)		(0.023)	(0.020)	(0.020)		(0.430)	(0.351)	(0.073)		(0.023)	(0.021)	(0.021)	
LFinDev				0.000				0.013				-0.078*				-0.005
				(0.004)				(0.009)				(0.041)				(0.004)
InstQual	-0.008***	-0.007***	-0.007***	-0.004	-0.004	-0.005	-0.004	-0.012	-0.026	-0.059	0.036	-0.104*	-0.009	-0.009*	-0.007	-0.003
	(0.003)	(0.003)	(0.003)	(0.003)	(0.014)	(0.013)	(0.013)	(0.014)	(0.269)	(0.722)	(0.110)	(0.053)	(0.005)	(0.005)	(0.004)	(0.005)
N	198	234	234	234	198	234	234	234	180	216	216	216	198	234	234	234
Groups					18.000	18.000	18.000	18.000	18.000	18.000	18.000	18.000	18.000	18.000	18.000	18.000
hansenp													0.435	0.634	0.683	0.886
j									8.000	8.000	16.000	16.000	12.000	12.000	12.000	12.000
ar1p									0.353	0.653	0.657	0.870	0.002	0.002	0.001	0.002
ar2p									0.248	0.893	0.340	0.467	0.316	0.554	0.662	0.733

*Note:(i) respectively, the sign *,**, and *** describe the significance level of10%,5% and 1%;*
(ii) standard errors are reported in brackets

Source: Author's computation

We also extend our baseline specification to examine the role of possible interactions between the independence of the central bank and variables related to the institutional environment, namely openness, financial development and institutional quality. The corresponding estimates are presented in Table 3.8. We report results concerning these interactions for all the alternative measures of central bank independence (Garriga, CWN, and the ECBI) for comparison purposes. However, the introduction of the interactions seems to increase the noise in the estimation, for the results now show little statistical significance. The marginal effects of the $ECBI$ (with a 90% confidence interval) for various levels of the interacted variables is in Appendix A.3.

Table 3.8 ECBI and Inflation-Interactions

	Static Models							Dynamic Models								
	OLS	OLS	OLS	OLS	FE	FE	FE	FE	DGMM	DGMM	DGMM	DGMM	SGMM	SGMM	SGMM	SGMM
Inf(-1)									-0.231	0.168	-0.068	-0.565***	0.569***	0.542***	0.662***	0.350**
									(0.210)	(0.616)	(0.180)	(0.184)	(0.101)	(0.060)	(0.053)	(0.164)
Garriga(-2)	-0.007				-0.102*				-0.135				-0.007			
	(0.024)				(0.054)				(0.483)				(0.032)			
CWN(-2)		-0.001				0.017				1.410				-0.012		
		(0.018)				(0.029)				(1.984)				(0.020)		
ECBI(-2)			-0.017*	-0.023**			-0.019**	-0.026***			-0.036	-0.040			0.035	-0.085
			(0.009)	(0.010)			(0.010)	(0.010)			(0.072)	(0.075)			(0.039)	(0.084)
DLGDPC	0.013	-0.009	-0.048	-0.011	-0.062	-0.080	-0.097	-0.055	-0.518	-0.262	-0.712**	-0.595**	0.022	0.004	0.015	0.044
	(0.070)	(0.059)	(0.056)	(0.058)	(0.084)	(0.070)	(0.065)	(0.068)	(0.419)	(0.934)	(0.322)	(0.286)	(0.084)	(0.049)	(0.071)	(0.107)
DLTO	0.098***	0.095***	0.099***		0.067**	0.080***	0.085***		0.153	0.159	0.286**		0.094***	0.093***	0.110***	
	(0.025)	(0.022)	(0.021)		(0.027)	(0.023)	(0.021)		(0.135)	(0.240)	(0.132)		(0.021)	(0.017)	(0.020)	
LTO				-0.006				0.045***				0.096				-0.023
				(0.004)				(0.014)				(0.106)				(0.035)
FO	0.040	0.048***	-0.009	-0.006	0.014	0.049	-0.006	-0.028*	0.822*	0.534	0.169	0.198	0.037	0.041*	0.011	-0.090**
	(0.024)	(0.017)	(0.009)	(0.010)	(0.049)	(0.044)	(0.016)	(0.017)	(0.416)	(1.047)	(0.176)	(0.200)	(0.026)	(0.021)	(0.023)	(0.037)
DLFinDev	-0.095	-0.123**	0.058		-0.168*	-0.119**	0.029		-0.251	-0.193	-0.126		-0.129	-0.145**	0.077	
	(0.082)	(0.054)	(0.051)		(0.100)	(0.060)	(0.051)		(0.614)	(0.842)	(0.246)		(0.080)	(0.051)	(0.069)	
LFinDev				-0.003				0.008				-0.109				-0.062**
				(0.004)				(0.009)				(0.077)				(0.026)
InstQual	-0.039***	-0.052***	-0.006	-0.003	-0.026	-0.129***	-0.030*	-0.023	-0.344	-0.009	0.038	0.094	-0.033*	-0.049***	-0.004	0.046*
	(0.013)	(0.011)	(0.007)	(0.008)	(0.053)	(0.033)	(0.016)	(0.017)	(0.319)	(0.803)	(0.172)	(0.170)	(0.016)	(0.012)	(0.012)	(0.023)
GRR × FO	-0.045				0.019				-0.805				-0.045			
	(0.040)				(0.077)				(0.567)				(0.043)			
GRR × FD	0.106				0.251				0.466				0.146			
	(0.142)				(0.167)				(0.922)				(0.124)			
GRR × ID	0.044**				-0.043				0.711				0.041*			
	(0.019)				(0.090)				(0.581)				(0.023)			
CWN × FO		-0.069**				-0.040				0.292				-0.055		
		(0.028)				(0.078)				(1.944)				(0.032)		
CWN × FD		0.186*				0.199*				0.322				0.214**		
		(0.097)				(0.105)				(1.243)				(0.088)		
CWN × ID		0.065***				0.166***				0.033				0.061***		
		(0.016)				(0.059)				(1.226)				(0.017)		
ECBI × FD			-0.187*	-0.077*			-0.103	-0.032			0.489	0.201			-0.218	-0.167
			(0.107)	(0.044)			(0.107)	(0.045)			(0.609)	(0.269)			(0.163)	(0.144)
ECBI × ID			-0.005	-0.002			0.000	0.003			-0.025	0.190			-0.008	-0.019
			(0.014)	(0.014)			(0.014)	(0.014)			(0.257)	(0.284)			(0.021)	(0.025)
ECBI × FO			0.018	0.011			0.016	0.013			-0.036	0.046			-0.018	0.081*
			(0.016)	(0.016)			(0.016)	(0.015)			(0.072)	(0.068)			(0.033)	(0.045)
N	162	198	234	234	162	198	234	234	144	180	216	216	162	198	234	234
Groups					18.000	18.000	18.000	18.000	18.000	18.000	18.000	18.000	18.000	18.000	18.000	18.000
hansenp													0.490	0.902	0.766	0.354
j									18.000	16.000	16.000	16.000	13.000	13.000	13.000	13.000
ar1p									0.400	0.529	0.063	0.870	0.003	0.001	0.002	0.014
ar2p									0.727	0.618	0.796	0.847	0.284	0.406	0.219	0.796

*Note:(i) respectively, the sign *,**, and *** describe the significance level of10%,5% and 1%;*
(ii) standard errors are reported in brackets
Source: Author's computation

It may be argued that CBI is caused by inflation rather than causes inflation. Countries where inflation is high may want to give more independence to the central bank as a way to give it more power to fight inflation. In this case, CBI is an endogenous variable that evolves in response to changing political, social or economic factors. Posen(1995) discusses these issues of causality between central bank independence and inflation. He shows that the various levels of independence reflect differences in countries' financial opposition to inflation. He suggests that central bank independence contributed to the fall of inflation in OECD countries, a result that was made possible by the fact that in these countries a big part of the population actually prefers low and stable inflation.

de Jong(2002) shows that the distribution of power in the society and the degree of uncertainty avoidance might also explain differences in central bank independence. Political systems can be an equally important factor influencing a country's degree of central bank independence. Our findings highlight the importance of central bank independence as a useful tool for lowering inflation, but it is not the only one.

3.6.2 Robustness checks

To further assess whether the results in Table 3.6 are robust, in Table 3.9 we estimate specifications with additional regressors. The additional regressors concern monetary freedom, stock market development and political stability. The results are qualitatively similar to those observed in Tables 3.6 and 3.7, i.e., the estimates change very little when we introduce the new variables.

Table 3.9 Robustness Checks: Additional regressors

	Static Models								**Dynamic Models**							
	OLS	OLS	OLS	OLS	FE	FE	FE	FE	DGMM	DGMM	DGMM	DGMM	SGMM	SGMM	SGMM	SGMM
Inf(-1)									-0.265	-0.006	-0.054	-0.304***	0.498***	0.557***	0.481***	0.458***
									(0.224)	(0.193)	(0.149)	(0.115)	(0.137)	(0.113)	(0.104)	(0.074)
Garriga(-2)	-0.013				-0.053				-0.481				-0.028			
	(0.011)				(0.046)				(0.562)				(0.080)			
CWN(-2)		-0.009				-0.005				0.960				0.005		
		(0.008)				(0.025)				(0.624)				(0.054)		
ECBI(-2)			-0.014	-0.020**			-0.018*	-0.022**			-0.026	-0.040			-0.029	-0.022**
			(0.009)	(0.009)			(0.010)	(0.009)			(0.031)	(0.028)			(0.017)	(0.008)
DLGDPC	0.021	-0.015	-0.037	-0.013	-0.041	-0.112	-0.115*	-0.084	-0.488	-0.026	-0.501*	-0.224	-0.098	-0.156	-0.139	-0.086
	(0.062)	(0.057)	(0.056)	(0.059)	(0.075)	(0.068)	(0.068)	(0.066)	(0.412)	(0.359)	(0.293)	(0.185)	(0.327)	(0.281)	(0.185)	(0.123)
DLTO	0.090***	0.089***	0.089***		0.079***	0.093***	0.086***		0.177	0.045	0.259**		0.122**	0.128***	0.061	
	(0.023)	(0.021)	(0.021)		(0.025)	(0.022)	(0.022)		(0.155)	(0.169)	(0.110)		(0.048)	(0.041)	(0.046)	
LTO				-0.006				0.054***				0.217***				0.006
				(0.004)				(0.013)				(0.056)				(0.011)
InstQual	-0.003	-0.002	-0.003	-0.001	-0.021	-0.017	-0.013	0.003	0.043	-0.083	0.021	0.136*	-0.108	-0.116	-0.132	-0.065
	(0.005)	(0.004)	(0.004)	(0.005)	(0.018)	(0.016)	(0.016)	(0.016)	(0.189)	(0.210)	(0.102)	(0.074)	(0.080)	(0.123)	(0.085)	(0.043)
FO	0.011	0.005	0.001	0.013	0.024	0.011	0.007	-0.024	0.357*	0.475***	0.222**	0.119	0.017	-0.011	-0.020	0.003
	(0.009)	(0.007)	(0.006)	(0.008)	(0.017)	(0.014)	(0.014)	(0.015)	(0.199)	(0.160)	(0.111)	(0.107)	(0.062)	(0.049)	(0.022)	(0.010)
MonFr	-0.001**	-0.001**	-0.001***	-0.001***	0.000	0.000	-0.000	-0.000	0.002	0.002	0.002	0.002**	0.001	0.000	0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.003)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
DLStMrkt	-0.005	-0.006*	-0.006**		-0.003	-0.005*	-0.006*		-0.011	-0.009	-0.004		-0.021	-0.016	-0.015	
	(0.004)	(0.003)	(0.003)		(0.004)	(0.003)	(0.003)		(0.017)	(0.019)	(0.013)		(0.019)	(0.018)	(0.009)	
LStMrkt				0.002				0.004*				-0.016				0.006*
				(0.002)				(0.002)				(0.016)				(0.003)
PolSt	-0.005	-0.005	-0.004	-0.005	-0.006	-0.002	-0.002	-0.008	-0.046	-0.053	-0.047	-0.066	0.052	0.059	0.071	0.025
	(0.004)	(0.003)	(0.003)	(0.004)	(0.009)	(0.008)	(0.008)	(0.008)	(0.083)	(0.092)	(0.053)	(0.043)	(0.056)	(0.075)	(0.050)	(0.022)
N	192	226	226	228	192	226	226	228	174	208	208	210	156	192	226	228
Groups					18.000	18.000	18.000	18.000	18.000	18.000	18.000	18.000	18.000	18.000	18.000	18.000
hansenp													0.631	0.471	0.554	0.454
j									14.000	18.000	16.000	16.000	13.000	13.000	13.000	13.000
ar1p									0.235	0.322	0.016	0.551	0.011	0.010	0.002	0.001
ar2p									0.568	0.633	0.848	0.706	0.837	0.602	0.487	0.648

*Note:(i) respectively, the sign *,**, and *** describe the significance level of10%,5% and 1%;*
(ii) standard errors are reported in brackets

Source: Author's computation

In another robustness check we investigate the relation between central bank independence and inflation using 3-year non-overlapping intervals instead of annual observations. The results are in Table 3.10. The significance and sign of the coefficients on ECBI are somewhat affected by this change.

Table 3.10 Robustness Checks: 3-year non-overlapping intervals

	Static Models								Dynamic Models							
	OLS	OLS	OLS	OLS	FE	FE	FE	FE	DGMM	DGMM	DGMM	DGMM	SGMM	SGMM	SGMM	SGMM
Inf(-1)									0.728	0.291	-0.037	-0.759	0.347	0.248	0.127	0.621***
									(0.518)	(0.873)	(0.854)	(0.459)	(0.289)	(0.154)	(0.412)	(0.160)
Garriga(-2)	0.014				0.145**				0.534*				0.005			
	(0.020)				(0.057)				(0.278)				(0.048)			
CWN(-2)		-0.013				-0.008				0.601				-0.018		
		(0.015)				(0.038)				(0.726)				(0.023)		
ECBI(-2)			0.026	0.025			-0.004	-0.012			-0.018	-0.090			0.042*	0.013
			(0.016)	(0.018)			(0.016)	(0.016)			(0.141)	(0.130)			(0.023)	(0.019)
DLGDPC	-0.068	-0.055	-0.039	-0.004	-0.255**	-0.278**	-0.284**	-0.272**	-0.220	-0.665	-0.396	-0.738**	-0.122	-0.109	-0.063	-0.005
	(0.099)	(0.099)	(0.098)	(0.110)	(0.109)	(0.117)	(0.117)	(0.115)	(0.320)	(0.777)	(0.498)	(0.318)	(0.206)	(0.196)	(0.145)	(0.116)
DLTO	0.112***	0.104***	0.104***		0.098***	0.087***	0.088***		0.269**	0.436	0.207		0.086	0.070	-0.243	
	(0.035)	(0.035)	(0.034)		(0.029)	(0.031)	(0.031)		(0.131)	(0.384)	(0.129)		(0.055)	(0.043)	(0.250)	
LTO				-0.012				0.101***				0.194				-0.012**
				(0.008)				(0.029)				(0.153)				(0.006)
FO	-0.016	-0.006	-0.008	-0.008	-0.026	-0.025	-0.025	-0.043*	0.054	0.218	0.150	-0.014	-0.018	-0.014	-0.000	-0.003
	(0.014)	(0.011)	(0.010)	(0.013)	(0.024)	(0.025)	(0.025)	(0.024)	(0.220)	(0.465)	(0.203)	(0.225)	(0.015)	(0.013)	(0.020)	(0.016)
DLFinDev	-0.087**	-0.095***	-0.090***		-0.070**	-0.087**	-0.084**		-0.169	-0.422	-0.189		-0.105**	-0.124***	-0.184	
	(0.034)	(0.034)	(0.033)		(0.034)	(0.035)	(0.037)		(0.170)	(0.431)	(0.326)		(0.044)	(0.028)	(0.253)	
LFinDev				-0.003				0.041*				0.082				0.002
				(0.008)				(0.022)				(0.075)				(0.011)
InstQual	-0.013**	-0.015***	-0.013**	-0.008	0.037	0.049	0.049	0.001	-0.115	-0.303	0.018	0.191	-0.013	-0.017	-0.022**	-0.005
	(0.005)	(0.005)	(0.005)	(0.007)	(0.032)	(0.034)	(0.034)	(0.036)	(0.181)	(0.511)	(0.298)	(0.222)	(0.009)	(0.010)	(0.010)	(0.011)
N	72	72	72	72	72	72	72	72	54	54	54	54	72	72	72	72
Groups					18.000	18.000	18.000	18.000	18.000	18.000	18.000	18.000	18.000	18.000	18.000	18.000
hansenp													0.046	0.091	0.368	0.370
j									10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000
ar1p									0.296	0.798	0.906	0.430	0.542	0.595	0.107	0.008
ar2p									0.474	0.324	0.497	0.751	0.417	0.539	0.347	0.447

*Note:(i) respectively, the sign *,**, and *** describe the significance level of10%,5% and 1%;*
(ii) standard errors are reported in brackets
Source: Author's computation

Finally, we provide additional evidence on the relation between CBI and inflation by means of cross-sectional regressions of inflation on each of the CBI indices. The central bank indices and inflation have evolved over time. Thus we estimate the simple cross-section regressions at different points in time, namely for 2000, 2005 and 2010. The results are in Table 3.11. The slope of the central bank independence indices is positive, but appear to have declined in more recent years. The strength of the relation, as measured by R-squared or the adjusted R-squared, also appears to have declined. This is particularly true for the ECBI index.

Table 3.11 Cross-sectional regressions of inflation on CBI indices

Garriga and Inflation				
Period	**Garriga**	**Nbs**	**R2**	**adjR2**
2000	0.068	18	0.589	0.565
2005	0.084	18	0.658	0.638
2010	0.061	18	0.532	0.504
CWN and Inflation				
Period	**CWN**	**Nbs**	**R2**	**adjR2**
2000	0.066	18	0.549	0.522
2005	0.080	18	0.593	0.569
2010	0.060	18	0.516	0.487
ECBI and Inflation				
Period	**ECBI**	**Nbs**	**R2**	**adjR2**
2000	0.110	18	0.706	0.689
2005	0.111	18	0.781	0.768
2010	0.084	18	0.752	0.737
2015	0.067	18	0.453	0.421

Source: Author's computation

3.6.3 Policy variables and CBI

Before concluding this chapter, we present a brief note on the relation between policy variables and CBI that was mentioned above, when the policy variables were dropped from the specifications of the model. Table 3.12 reports the results obtained when the CBI indices (Garriga, CWN, and ECBI) are each regressed on the policy variables (money growth, interest rate, first difference of the log of the exchange rate, first differene of the government's budget balance, and the government's budget balance). The results indicate that there is in fact a statistically significant relation between the indices and some of the policy variables. This may raise some problems for the estimation and the interpretation of models that include these variables. Interestingly, the signs of the coefficients seem to vary with the CBI index, highlighting the fact they appear to convey different information. Obviously, this is a very basic analysis, which aims at giving nothing more than a first impression of the relations that may exist between CBI and these policy variables.

Table 3.12 Influence of policy variables on ECBI

	Garriga	Garriga	CWN	CWN	ECBI	ECBI
MSG	-0.001	-0.005***	-0.002	-0.001	-0.012***	-0.008**
	(0.001)	(0.001)	(0.002)	(0.002)	(0.004)	(0.003)
Int	-0.040***	-0.035***	-0.010	-0.020	0.015*	0.016*
	(0.011)	(0.011)	(0.018)	(0.014)	(0.008)	(0.008)
DLER	-0.068	-0.332**	-0.041	-0.139*	0.972***	0.816***
	(0.045)	(0.134)	(0.059)	(0.074)	(0.154)	(0.281)
DBgtDef	-0.005*	-0.010*	0.001	-0.001	0.000	0.005
	(0.003)	(0.006)	(0.005)	(0.005)	(0.012)	(0.012)
BgtDef		0.027***		0.001		-0.022*
		(0.003)		(0.008)		(0.013)
N	198	198	234	234	270	270
Groups	18.000	18.000	18.000	18.000	18.000	18.000

Standard errors in parentheses
Source: Author's computation.
$^{*}\ p < 0.1$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$

3.7 Conclusions and policy implications

The negative relationship between central bank independence and inflation is widely studied. However, most empirical evidence concerns mainly the restricted case of developed countries, or small subsets of developing countries, with mixed results (Acemoglu et al., 2008; Bodea and Hicks,2015; Landström, 2011; Alpanda and Honig, 2014; Neyapti, 2012).

Our study builds on this empirical literature to construct an extended central bank independence ($ECBI$) index. After examining the properties of the ECBI index, this chapter presents an empirical exploration of the relationship between the ECBI index and inflation dynamics in a broad panel data setting that involves eighteen emerging countries in the period 2000-2017.

The empirical results show that there is a negative relationship between central bank independence and inflation, suggesting that central bank independence has stabilizing effect on inflation and confirming other empirical findings (Baumann et al., 2021, Jácome and Vázquez, 2005) for the emerging and developing countries. The findings also indicate that there is persistence in inflation dynamics over time in emerging countries.

We also examined if there are any interactive or indirect effects of central bank independence operating through financial and institutional development. We found that some interactions have statistical significance, but overall the results are unclear.

As robustness checks, we estimated specifications with additional regressors, namely stock market development, political stability and monetary freedom. The results are qualitatively similar to those observed in our baseline findings, as the estimates change very little when we introduce the new variables. We also examined the medium-term relation between central bank independence and inflation using 3-years non-overlapping intervals instead of annual observations. The conclusions regarding the impact of the ECBI index on inflation are affected by this change; statistical significance changed in some cases, as well as the sign of the coefficient.

The main results and implications from this study contribute to the discussion on the policy consensus arguing that central bank independence is an effective tool to curb inflation. Our finding is that the extended central bank independence index has a negative effect on inflation. This suggests that the central bank independence is helpful in managing inflation in emerging countries. Furthermore, our findings indicate the possibility that central bank independence is more effective in lowering inflation in the presence of high levels of financial sector development and institutional quality.

4 Dynamic Effects of Monetary Policy Shocks on Output and Price

This chapter focuses on the analysis of the simultaneous effects of monetary policy shocks on goal variables, i.e. output and prices, in eighteen emerging markets economies, using a recently developed methodology for PVAR models. The analysis sheds light on the most persistent shocks and on the extent to which the shock is significant to output and price fluctuations.

4.1 Introduction

Monetary policy plays a crucial role in determining the level of macroeconomic activity in most countries. Over the past decades, monetary policy in developed, emerging and developing countries has predominantly used interest rates and money supply as the main indicators of monetary policy (Guo et al.,2013). Monetary policy affects all kinds of economic and financial decisions that are made by economic agents. Particularly, it influences the performance of the economy's fundamental variables, such as inflation, output and employment, as well as asset prices, exchange rates, and consumption and investment decisions.

In emerging markets, as in other areas, maintaining prices and supporting sustainable economic growth are their main mandates assigned to the central bank. However, central banks do not directly manage inflation or influence output and employment; they do so indirectly through their monetary policy tools. Achieving these objectives clearly requires an understanding of the process through which monetary policy affects economic activity, particularly regarding the relationship between the central bank's instruments and economic variables such as output and inflation.

Monetary policy actions are endogenous to the state of the economy, but it is hard to estimate the true effects of monetary policy actions on an economy. A proper analysis of this issue necessitates that the exogenous parts of the monetary policy actions (monetary policy shocks) be identified properly. However, identifying and computing the responses, detailing the magnitude and speed with which macroeconomic aggregates adjust to the monetary policy shock is also not an easy task, as (Giuseppe and Giorgio,1999) asserted. The empirical results are also ambivalent, leading to different views across analysts, academics and policy makers. Empirical papers mostly argue that the issue is highly dependent on the structure of the economy under study, on the empirical methodology being employed, on the sample selected, on the choice of economic variables and on the identifying restrictions imposed on the models.

Modern time series methods for investigating the effects of monetary policy are essentially based on the framework developed by Sims(1980). During the 1970s and much of the 1980s, shocks to monetary policy were measured as shocks to the stock of money (Barro,1978). This early work offered evidence that (a) money was (Granger-)causal for income; and (b) that fluctuations in the stock of money could explain an important fraction of output fluctuations. However, other studies discovered that the inclusion of interest rates in the vector autoregressive (VAR) model significantly reduced the importance of shocks to the money stock for explaining output. Consequently, some researchers concluded that monetary policy is not important for understanding economic fluctuations (Sims,1980;Litterman and Weiss,1985).

Nevertheless, the ability of monetary policy to influence output and prices in the short-run is broadly accepted in economic theory and well documented by a number of time series analyses of monetary policy transmission. For advanced countries, a large body of empirical literature investigating the effects of monetary policy on macroeconomic variables is based on multivariate models such as the vector autoregressive models (Christiano et al. 1999, Bernanke and Mihov,1998, Kim and Roubini,2000). Their findings provide a plausible description of the monetary policy decision process.

Despite worthwhile empirical works in this area, there is a quite limited number of studies on emerging countries. Some notable empirical works on monetary policy shocks include(Garcia-Cicco, Pancrazi,and Uribe,2010), but they are generally based on an individual country's experience, or on testing whether production, the stock market, employment, consumption and price levels respond to monetary shocks (Andries and Billon 2016; Bahmani-Oskooee and Mohammadian 2018; Freitas Val et al. 2018; Kim and Kim 2017; Ong and Sato 2018; Yıldırım-Karaman 2017; Zhang and Huang 2017).

This chapter attempts to address the question of what are the dynamic effects of monetary policy on macroeconomic variables, adopting a cross-country perspective. This study examines empirically the effect of shocks on output and price, including in the analysis oil prices, the federal funds rate and a measure of central bank independence. The empirical analysis uses a recently developed panel vector autoregression (PVAR) methodology proposed by (Abrigo and Love 2015). This methodology uses the generalized method of moments (GMM) estimator and allows testing the Granger causality between the variables.

In principle, this methodology may help overcome the issue of endogeneity. Although the variance decomposition and the impulse response functions may be sensitive to the ordering of the variables (suggesting a sensitiveness analysis), they may provide insights as to how a shock to monetary policy affects output and prices in both the short-run and the long-run. This helps us to analyse with some detail the persistence of shocks transmitted to output and prices, and the extent to which the shocks are significant.

A variety of additional empirical exercises indicates that our results are robust. The additional exercises include alternative orderings of the variables and splitting our sample into two groups — oil exporting and oil importing countries — to take into account the different nature of the respective economies.

Our contribution to the literature on the effect of a monetary policy shock on output and prices derives from the use of a recent empirical technique for panel data. To the best of our knowledge, this is the first study that brings these separate streams of shocks together, particularly in the case of emerging markets.

4.2 Literature Review

The present section provides a comprehensive literature survey on the impact of monetary policy shocks on macroeconomic variables, highlighting several case studies and estimates they report, which will be used as benchmarks in our analysis.

Though a gigantic body of literature is available on monetary policy analysis, most of it is concerns individual and/or developed economies. A few researchers have made attempts to evaluate monetary policy in emerging market economies. At the end of this section, we present a brief review of a few prominent studies carried out for emerging countries, as well as the methodologies they employed.

Empirical research explicitly or implicitly draws from the theory of monetary policy transmission mechanisms, which is neatly summarized by (Mishkin,1996). Gambacorta et al.,2014 studied the impact of monetary policy in eight countries using a panel VAR. They deal with the wake of the financial crisis, when monetary policy reached its limits to stimulate the economy as interest rates in many countries neared the zero lower bound. They use monthly data starting from the financial crisis (2008-2011) and focus specifically on developed countries as many developing countries still had room to maneuver policy rates. The use of a panel VAR helps to uncover common factors among systemic shocks. These systemic shocks include the financial crisis and the monetary policy response to it. The setup uses Pesaran and Smith's (1995) mean group estimator to uncover country heterogeneity. An expansion of the central bank's balance sheet temporarily increases inflation and output. These impacts are similar to the case of conventional monetary policy, albeit with a weaker inflation response.

Interestingly and despite country heterogeneity, the countries' responses to unconventional monetary policy are similar and not that much different from an average response over all the countries. This corresponds to the findings of (Bekaert et al.,2013), who study the effects of a variety of monetary policy shocks on risk and uncertainty using a structural VAR. Regardless of their measure of monetary policy (Fed funds rate or M1 money supply), they show that looser monetary policy lowers risk and uncertainty in the short to medium run.

Jannsen et al.(2015) use a panel VAR to test the monetary transmission channel. They interact each of the endogenous variables with a dummy for financial crises based on a narrative approach. They emphasise the importance of uncertainty and confidence indicators in obtaining their results. They use GDP, inflation and stock market volatility as the main variables with the short term interest rate as the monetary policy tool. They show that GDP and inflation are more responsive to a monetary policy shock during a financial crisis, compared to the recovery phase of a crisis.

More importantly, they show that the response of GDP and inflation is higher when uncertainty is present. During the crisis, monetary policy reduces uncertainty by a much larger extent compared to the recovery phase. This reduction in uncertainty leads to a stronger expansion in prices and output. Other researchers employ structural vector autoregressive (SVAR) models to estimate dynamic responses of macroeconomic variables due to monetary policy shocks. Canova and de Nicolo(2002) find that monetary shocks significantly drive output and inflation cycles in all G-7 countries. In addition, they conclude that monetary shocks are the dominant source of macroeconomic fluctuations in three of the seven countries. However, Mountford(2005) finds contradictory evidence indicating that monetary policy shocks play only a small role in the total variation of macroeconomic variables. Only supply shocks impose a permanent effect on output, which is consistent with the previous finding by(Blanchard and Quah,1989). Using the US data, (Uhlig,2005) finds that contractionary policy shocks have no clear effect on output. Furthermore, prices fall gradually in response to a contractionary monetary shock.

Morsink and Bayoumi,2003) provided an analysis of Japan's economy. They used VAR analysis with Choleski decomposition to examine the monetary transmission mechanism in Japan and trace the influence of a monetary policy shock on economic activity, the interest rate and prices. The estimations are based on quarterly data covering the period from the first quarter of 1980 to the third quarter of 1998. In the basic model, real private demand (representing real activity) significantly declines with monetary tightening and bottoms out after 8-10 quarters. The price level responds positively to contractionary monetary shock, an effect which is known as the price puzzle. They also find that tightening monetary policy leads to a rise in interest rates in the economy.

Moving now to studies about developing economies, (Bhuiyan,2012) finds that monetary policy shocks are not the dominant source of fluctuations in industrial production in Bangladesh. Furthermore, industrial production responds to monetary shocks with a lag of over half a year while inflation responds with a lag of more than one year. The lagged responses of output and price level are consistent with the view of (Obstfeld and Rogoff,1995).

Cheng(2006) applied both recursive and non-recursive SVAR models to monthly data of the Kenyan economy for the period between 1997 and 2005. He found that an increase in the short-term interest rate leads to an initial increase in the price level (price puzzle) followed by its falling, which is statistically significant for about two years following the shock. In response to a contractionary monetary policy, output also rises initially (output puzzle) but falls eventually, though the decline is not statistically significant. A shock to the interest rate explains a larger fraction of inflation (30 percent) than output (10 percent).

Chuku(2009) used an SVAR model to trace the effects of a monetary policy shock on output and prices for the Nigerian economy. He made the assumption that the central bank cannot observe unexpected changes in output and price within the same period. He conducted the analysis using three alternative policy instruments: broad money, minimum re-discount rate and real effective exchange rate (REER). He found evidence that a monetary policy shock carried through the quantity-based nominal anchor has modest effects on output and prices, with a very fast speed of adjustment. Differently, innovations to the price-based nominal anchors have neutral and fleeting effects on output.

We now present short notes on some of the main results from the literature on the impact of a monetary shock on output, on the contribution of monetary shocks to output fluctuations, and on whether the price puzzle is present. (Ramey,2016) provides additional notes on the literature, focusing on the work by (Christiano et al.,1999), (Uhlig's,2005), (Amir Ahmadi and Uhlig's,2015), (Smets and Wouters',2007), (Bernanke et al.'s,2005), (Romer and

Romer,2004), (Coibion,2012), (Barakchian-Crowe,2013), (Gertler-Karadi,2015), and (Boivin et al.'s,2010).

This set of literature helps us to redefine the monetary policy transmission mechanism as the process by which changes in monetary policy instruments lead to the desired outcome of price stability and real output growth. However some empirical research supports the conventional Keynesian theory that interest rates mediate the transmission process (Boivin etal.(2010). However, studies like Borio and Zhu(2012) showed that asset prices and lending rates are the conduits via which monetary policy has an effect on the rest of the economy. In light of these contrasting viewpoints, it is evident that the nature of the monetary transmission mechanism in emerging markets can only be determined empirically. As a result, this study adds to the literature by attempting to understand how output and prices in emerging countries respond to monetary policy shocks and how the transmission mechanism works. Most studies suggest that both domestic and external shocks (especially those originating from the developed world, particularly the United States) have a considerable impact on emerging market economies. Thus the empirical study should allow for this possibility.

4.3 Methodology and Data

In this section, we describe in detail a PVAR model. This is the technique this study will be relaying on in the empirical models. We also discuss in this section our data and sample selection.

4.3.1 The PVAR Approach

The panel VAR model can be represented in the following form:

$$Y_{it} = \Phi(L)Y_{it} + \Theta(L)X_{it} + \mu_i + \theta_t + \varepsilon_{it} \tag{4.1}$$

where $i = 1, 2, l \ldots, N$ (N is the number of "individuals", which will be countries in our empirical analysis) and $t = 1, 2, 3, l \ldots, T$ (T is the number of observations for each individual), Y_{it} is the vector of endogenous variables, X_{it} is the vector exogenous variables, $\Phi(L)$ and $\Theta(L)$ are matrix polynomials in the lag operator with $\Phi(L) = \Phi_1 L^1 + \Phi_2 L^2 + \ldots + \Phi_p L^p$ and $\Theta(L) = \Theta_1 L^1 + \Theta_2 L^2 + \ldots + \Theta_p L^p$. In this case, p is order of the PVAR, i.e., we may say it is a PVAR(p). μ_i is a vector of country-specific effects, θ_t denotes the influence of time effects, and ε_{it} is a vector of idiosyncratic errors. The PVAR method works by combining the classic VAR framework with a panel data configuration that allows for unobserved individual heterogeneity. Because of the presence of correlation between the regressors and the fixed effects, the typical fixed-effect estimator is known to be biased in dynamic panel specifications.

In a dynamic panel, we may use the forward orthogonal deviations to address this issue (Love and Zicchino, 2006); see also (Arellano and Bover, 1995). This method also allows for the use of lagged regressor values as instruments, and the coefficients are estimated using the generalized method of moment (GMM).

After estimating all of the panel VAR's coefficients, the impulse response functions (IRFs) are generated using the Cholesky decomposition to identify the shocks. We can then also compute the corresponding forecast error variance decomposition (FEVD).

Assuming that all other shocks are maintained constant, the impulse response function describes one variable's reaction to changes in a certain shock. A defining characteristic of shocks is that they are orthogonal. The shocks enter the model via the idiosyncratic errors, which are functions of the shocks. However, because the actual variance-covariance matrix of the errors is unlikely to be diagonal, it is necessary to decompose the residuals using a method that produces orthogonal shocks. The standard procedure is to employ the Choleski decomposition, which requires assuming a specific ordering of the shocks, which corresponds to a ordering of the variables in the model.

The identifying assumption is that the shocks associated with variables that come earlier in the ordering impact the variables that come later, both simultaneously and with a lag, whereas the shocks associated with variables that come later only affect the earlier variables with a lag. Monte Carlo simulations are used to calculate the standard errors of impulse response functions as well as confidence intervals (Garita 2011).

4.3.2 Empirical model

In our empirical model, Y_{it} is a vector of the major emerging countries' endogenous variables (RGDP — real GDP growth, CPI — inflation in the consumer price index, MSG — growth of money supply, IR — interest rate, and ER — exchange rate; see Table 4.1). In turn, X_{it} represents the vector of the exogenous variables that control for external shocks that may affect economic outcomes in emerging countries (OIL — oil price index, FFR — Federal Funds rate, and ECBI — the extended central bank independence index).

We regressed the PVAR with the following ordering of the endogenous variables: ER, IR, MSG, RGDP and CPI. The ordering of the variables was based on the assumption that a shock to monetary policy would be transmitted to price level and output later than to financial and monetary variables, and later to prices than to output, given the evidence provided by the related literature (see, Christiano, Eichenbaum and Evans 2005).

As we mentioned, we assume that the variables in X_{it} are exogenous to the rest of the PVAR. In other words, these variables influence the other variables of the model, Y_{it}, but there is no feedback from Y_{it} to X_{it}.

4.3.3 Data and sample selection

This study uses quarterly panel data for the period 2000-2017, covering eighteen emerging countries during the period 2000-2017. The countries are Brazil, Chile, China, Colombia, Czech Republic, Egypt, Hungary, India, Korea, Malaysia, Mexico, Pakistan, Peru, Philippines, Qatar, Russia, South Africa, and Thailand. The main data sources (both economic and financial statistics) were the World Economic Outlook (WEO), the World Bank's World Development Indicators (WDI), and the Federal Reserve Bank of St Louis website (FRED). The PVAR model includes a wide range of variables that capture various aspects of the economy, from the monetary sector to macroeconomic aggregates, together with a broad measure of external measures.

The variables' names, definition and data sources are given in Table 4.1. Annual data was interpolated to obtain quarterly time series. In Table 4.2 we report descriptive statistics (number of observations, mean, standard deviation, minimum, maximum, skewness and kurtosis) of the variables in our dataset.

Table 4.1 Data sources and definitions

Variable name	Definition	Source
RGDP	The percentage change of real gross domestic product	World Bank's World Development Indicators (WDI)
CPI	The annualized percentage change in consumer price index	IMF's International Financial Statistics(IFS)
MSG	The growth money supply/ broad money	IMF's International Financial Statistics(IFS)
IR	The nominal interest rate	IMF's International Financial Statistics(IFS)
ER	The real effective exchange rate (an increase is an appreciation of the domestic currency)	IMF's International Financial Statistics(IFS)
OIL	The oil price index	IMF's Primary Commodity Prices
FFR	The federal funds rate	Federal Reserve Bank of St Louis website
ECBI	The Extended Central Bank Independence Index	Author's computation

Table 4.2 Descriptive statistics

VARIABLES	N	mean	sd	min	max	skewness	kurtosis
ER	1,296	100.3	23.74	53.07	172.3	0.689	2.997
IR	1,296	11.58	10.27	1.293	72.40	3.081	13.48
MSG	1,296	12.51	8.786	-12.63	60.98	1.299	6.102
RGDP	1,296	4.613	3.576	-8.634	27.70	1.106	9.401
CPI	1,296	4.819	3.863	-7.478	24.37	1.573	7.004
OIL	1,296	136.2	58.18	49.30	241.4	0.305	1.796
FFR	1,296	1.761	2.009	0.0733	6.520	1.035	2.651
ECBI	1,296	0.463	0.204	0	1	-0.0953	2.796

Source: Author's computation

4.4 Empirical results and discussions

This section reports the specification analysis, the estimates of the PVAR model, forecast error variance decomposition and the impulse response functions. The estimations are done primarily through the pvar command for STATA (Abrigo and Love,2016).

4.4.1 Specification of the PVAR

The specification of a PVAR model requires the selection of the lag order (number of lags, p, of the endogenous, Y_{it}, and exogenous explanatory variables, X_{it}, to be included on the right-hand side of equation 4.1). We choose the lag order of our PVAR model by applying the procedure described in Andrews and Lu(2001). The lag-length selection is critical for PVAR analysis since excessively few lags may fail to capture the dynamics within the system, lead to omitted variables, bias the remaining coefficients and originate error autocorrelation. On the other hand, too many lags lead to a quick loss of a degrees of freedom and over-parameterization. We would like to select a model that does not reject the null for Hansen's J test and also minimizes the moment selection criteria suggested by Andrews and Lu(2001). Besides the lag order, it is also up to the researcher to choose the instruments to be used in the estimation of the PVAR, particularly, the lag at which endogenous variables are to be used as instruments. Thus, we are interested in a combination of lag order and instruments that meets the conditions above. Table 4.3 shows the computed model and moment selection criteria for our PVAR.

Table 4.3 Lag-order selection statistics

Order - Inst.	CD	J	J pvalue	MBIC	MAIC*	MQIC*
1 - 2 lags	0.9999826	88.77006	0.00000	-25.22159	56.77006	25.93689
1 - 3 lags	0.9999959	148.4394	0.00000	-79.07678	84.f43936	22.90431
2 - 3 lags	0.9999981	31.1547	0.01285	-82.60337	-.8452953	-31.61282
1 - 4 lags	0.9999959	169.2476	0.00000	-171.3155	73.24761	-18.85473
2 - 4 lags	0.9999986	70.59624	0.00009	-156.4458	6.596236	-54.80532
3 - 4 lags	0.9999986	16.79372	0.39906	-96.72731	-15.20628	-45.90706

Source: Author's computation

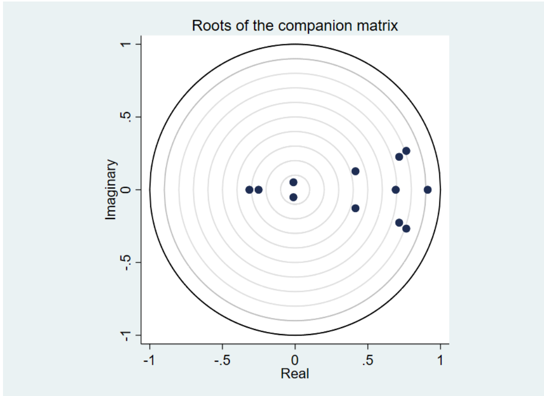
We begin the process by imposing the number of lags for the instruments to be equal to two, and testing the PVAR(1) model. In this case the Hansen J test rejects the null with p-values below 0.01. Next we impose that the number of lags for the instruments is equal to three, which allows us to compare a PVAR(1) against a PVAR(2). We obtain a p-value of 0.00000 for the PVAR(1) and 0.01285 for the PVAR(2); the Hansen J test rejects the null with p-values below 0.05. We then impose four as the number of lags for the instruments, and compare the PVAR(1), PVAR(2) and PVAR(3) models. When the number of lags for the instruments is four, the model rejects the null of the J test for the PVAR(1) and for the PVAR(2), both with p-values lower than 0.01. However, the PVAR(3) passes this test with a p-value clearly larger than 0.1. Thus we will use the PVAR(3) with four lags in the instruments in the remaining sections.

Further, we assess the stability of our PVAR model by checking whether all eigenvalues lie within the inner circle (Abrigo and Love, 2015; Hamilton, 1994; Lutkepohl, 2005). When they do, a fixed point (also known as an equilibrium point) is stable. The stable fixed point is such that a system is initially disturbed around its fixed point yet eventually returns to its original location and remains there. This implies that the impulse-response functions will converge to zero. Stability also implies that the panel VAR is invertible and has an infinite-order vector moving-average representation, providing an interpretation to estimated IRF and FEVD (Abrigo and Love, 2015).

Table 4.4 Eigenvalues

Eigenvalue		Modulus
Real	**Imaginary**	
0.9118383	0	0.9118383
0.7646127	-0.2671039	0.8099242
0.7646127	0.2671039	0.8099242
0.7156113	-0.2262303	0.7505196
0.7156113	0.2262303	0.7505196
0.6918055	0	0.69180552
0.4149906	-0.1271726	0.4340393
0.54149906	0.1271726	0.4340393
0.3148245	0	0.3148245
0.2514466	0	0.2514466
-0.0117648	0.0514057	0.0527347
-0.0117648	-0.0514057	0.0527347

Source: Author's computation



Source:Author's estimation

The results in Table 4.4 confirm that the estimated PVAR satisfies the stability conditions.

4.4.2 PVAR Estimates

The estimated coefficients of our PVAR model are reported in Table 4.5 — we leave out the exchange rate to reduce the amount of information conveyed (the reader is referred to Appendix B for further details.). The estimates indicate that, within our setup, we can not set aside the possibility that monetary policy shocks and exogenous shocks (particularly via the Federal Funds rate) play a role in the determination of macroeconomic outcomes in emerging countries.

Table 4.5 Estimates of the baseline PVAR model

VARIABLES	CPI	RGDP	MSG	IR
CPI(-1)	1.246***	0.00836	0.527***	0.0260
	(0.0385)	(0.0412)	(0.145)	(0.0350)
CPI(-2)	-0.237***	-0.0763	-0.629**	-0.0109
	(0.0441)	(0.0466)	(0.248)	(0.0495)
CPI(-3)	-0.155***	0.0491*	0.198	-0.0294
	(0.0235)	(0.0285)	(0.183)	(0.0311)
RGDP(-1)	0.00143	1.192***	0.418***	0.0455**
	(0.0232)	(0.0361)	(0.144)	(0.0206)
RGDP(-2)	0.00676	-0.244***	-0.622***	-0.0156
	(0.0303)	(0.0484)	(0.206)	(0.0272)
RGDP(-3)	0.00563	-0.127***	0.197	-0.00274
	(0.0211)	(0.0284)	(0.151)	(0.0194)
MSG(-1)	0.00848	0.0371***	0.974***	-0.00873
	(0.0119)	(0.0116)	(0.0445)	(0.00673)
MSG(-2)	-0.00982	-0.0297**	-0.114**	-0.00499
	(0.0116)	(0.0138)	(0.0517)	(0.00891)
MSG(-3)	-0.00268	0.0143	-0.0523	0.00761
	(0.00919)	(0.0106)	(0.0369)	(0.00781)
IR(-1)	0.0843	-0.127***	-0.244	1.391***
	(0.0526)	(0.0466)	(0.187)	(0.0916)
IR(-2)	-0.0750	0.0967*	0.557*	-0.490***
	(0.0611)	(0.0585)	(0.311)	(0.122)
IR(-3)	-0.00374	0.0297	-0.303*	0.0451
	(0.0309)	(0.0316)	(0.184)	(0.0591)
ECBI(-1)	0.433	-0.579	-1.736	0.242
	(0.269)	(0.417)	(1.271)	(0.249)
FFR(-1)	0.0432*	-0.0103	0.168**	0.0428*
	(0.0226)	(0.0205)	(0.0832)	(0.0226)
OIL(-1)	0.000255	-0.000554	0.00386	0.000399
	(0.000617)	(0.000743)	(0.00279)	(0.000679)
Observations	1,224	1,224	1,224	1,224

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source:Author's estimation

In fact, the estimates indicate that the dynamics of the interest rate affect GDP growth. However, it is not clear from these estimates whether the dynamics of the interest rate has any impact on inflation. Interestingly, the same pattern is visible in the case of money supply, i.e., it seems to carry additional information relative to the information in the interest rate.

Finally, the estimated model indicates the significant role of exogenous variables in the model. In particular, the Federal Funds rate appears to impact the interest rate, money supply growth and inflation.

To provide further insights into these issues, in Table 4.6 we report the results of Granger causality tests. These tests examine whether past values of each of the explanatory variables are useful in predicting the values of each of the endogenous variables, conditional on past values of the other variables (Granger, 1969).

Table 4.6 Granger causality tests

Equation	\Excluded	chi2	df	Prob >chi2
CPI	RGDP	0.950	3	0.813
	MSG	1.662	3	0.645
	IR	3.305	3	0.347
	ALL	5.66	9	0.773
RGDP	CPI	4.561	3	0.207
	MSG	10.955	3	0.012
	IR	14.820	3	0.002
	ALL	37.366	9	0.000
MSG	CPI	13.850	3	0.003
	RGDP	14.343	3	0.002
	IR	3.255	3	0.354
	ALL	28.742	9	0.001
IR	CPI	3.405	3	0.333
	RGDP	7.675	3	0.053
	MSG	3.811	3	0.283
	ALL	15.783	9	0.072
H0: Excluded variable does not Granger-cause Equation variable *H1: Excluded variable Granger-causes Equation variable*				

The Granger causality test evidenced the presence of a unidirectional relationship between CPI inflation and the money supply, with inflation Granger-causing money. The Granger causality test also indicates the existence of bidirectional relationships between the interest rate and output, and between money and output. Interestingly, CPI inflation does not appear to be predicted by any of the other three variables.

4.4.3 Forecast error variance decomposition

In this subsection we present an analysis of the forecast error variance decomposition of our PVAR model. The decomposition itself is reported in Table 4.7.

Table 4.7 Variance Decomposition for the baseline model

CPI	CPI	RGDP	MSG	IR
0	0	0	0	0
1	1	0	0	0
5	0.9868646	0.0009521	0.0004969	0.0116864
10	0.9748157	0.0067357	0.0040789	0.0143697
RGDP	CPI	RGDP	MSG	IR
0	0	0	0	0
1	0.0061388	0.9938612	0	0
5	0.0030936	0.9417948	0.0341398	0.0209719
10	0.0038682	0.8953822	0.077381	0.0233686
MSG	CPI	GDP	MSG	IR
0	0	0	0	0
1	0.0011456	0.0176874	0.9811671	0
5	0.0257672	0.0393419	0.9333193	0.0015716
10	0.0313204	0.0369569	0.927667	0.0040558
IR	CPI	GDP	MSG	IR
0	0	0	0	0
1	0.0196936	0.0024842	0.0000006	0.9778202
5	0.0278562	0.003892	0.0067257	0.9615262
10	0.0205861	0.0153469	0.0086788	0.9553881

Source: Author's Computation

The results from the FEVD show us the percentage of the forecast error variance of each endogenous variable that is accounted for by each of the shocks associated with each of the endogenous variables in the model. In addition, that information is provided for different time horizons.

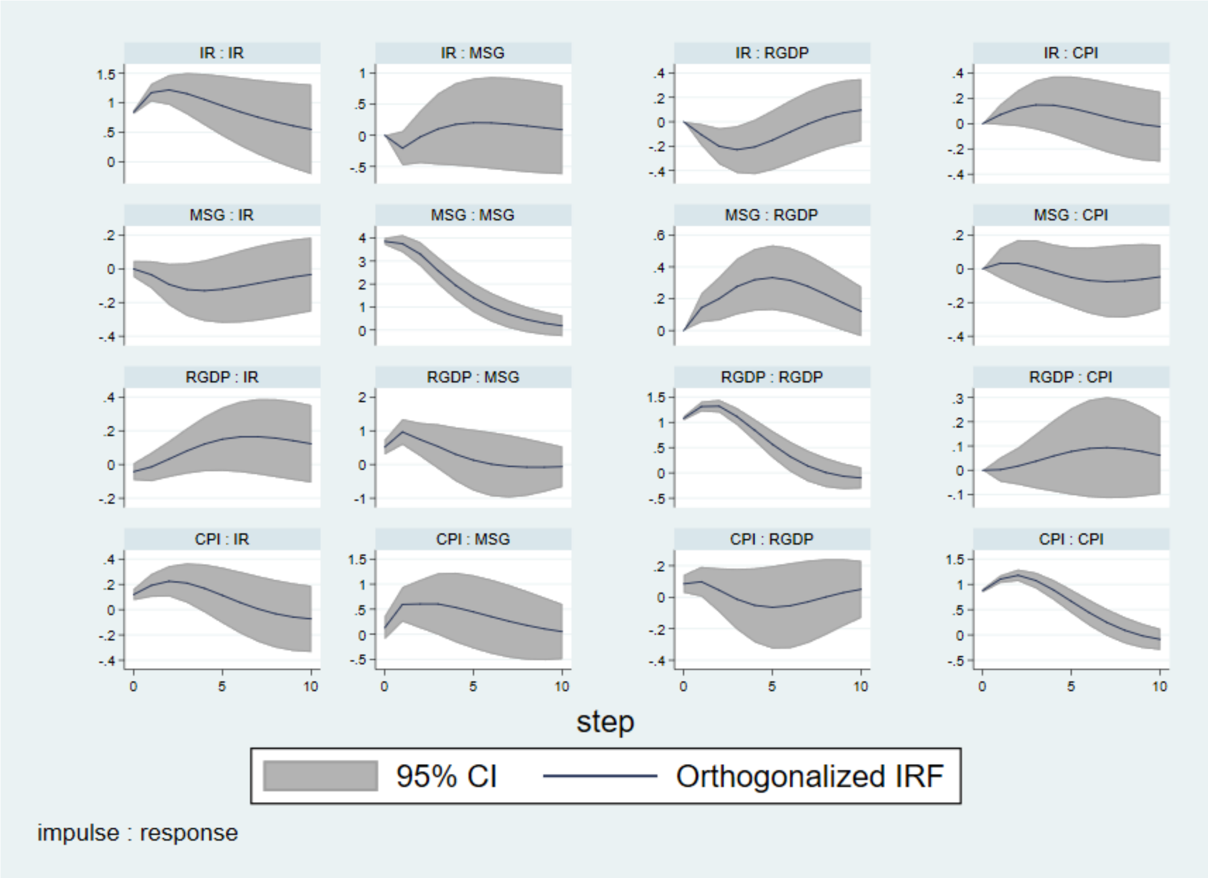
Thus, in Table 4.7, each value shows the share of the forecast error variance of the variable located on the top-left corner of each of the four panels of Table 4.7, that is due to the shock associated with the variable in each column.

The numbers therefore show that the shock to the nominal interest rate contributes very little to output and inflation uncertainty, ranging from 1 % to little more than 2%. The findings also showed that money supply appears to account for a bit more of the uncertainty in output, but not of inflation.

4.4.4 Impulse response analysis

This section presents the impulse response functions and the 95% confidence interval band that was generated based on 200 Monte Carlo simulations. The IRFs characterize the impact of adding a standard deviation to the error term in one equation in period 0, while holding the rest unchanged. Figure 4.1 shows the IRFs and the confidence bands for our PVAR model.

Figure 4.1 Impulse response functions for the baseline model



Source:Author's estimation

Similarly to the Granger causality tests, there appears to be a relation between the interest rate and output, but it i not clear whether interest rate shocks do move CPI inflation. Nevertheless, if they do, then it appears that in this model the "price puzzle" is also present, in the sense that a positive interest rate shock leads to an increase in the inflation rate. As for output, the impact of the interest rate shock is negative as expected. Money shocks also impact output in the expected way, i.e., a positive monetary shock leads to an increase in output.

4.4.5 Robustness checks

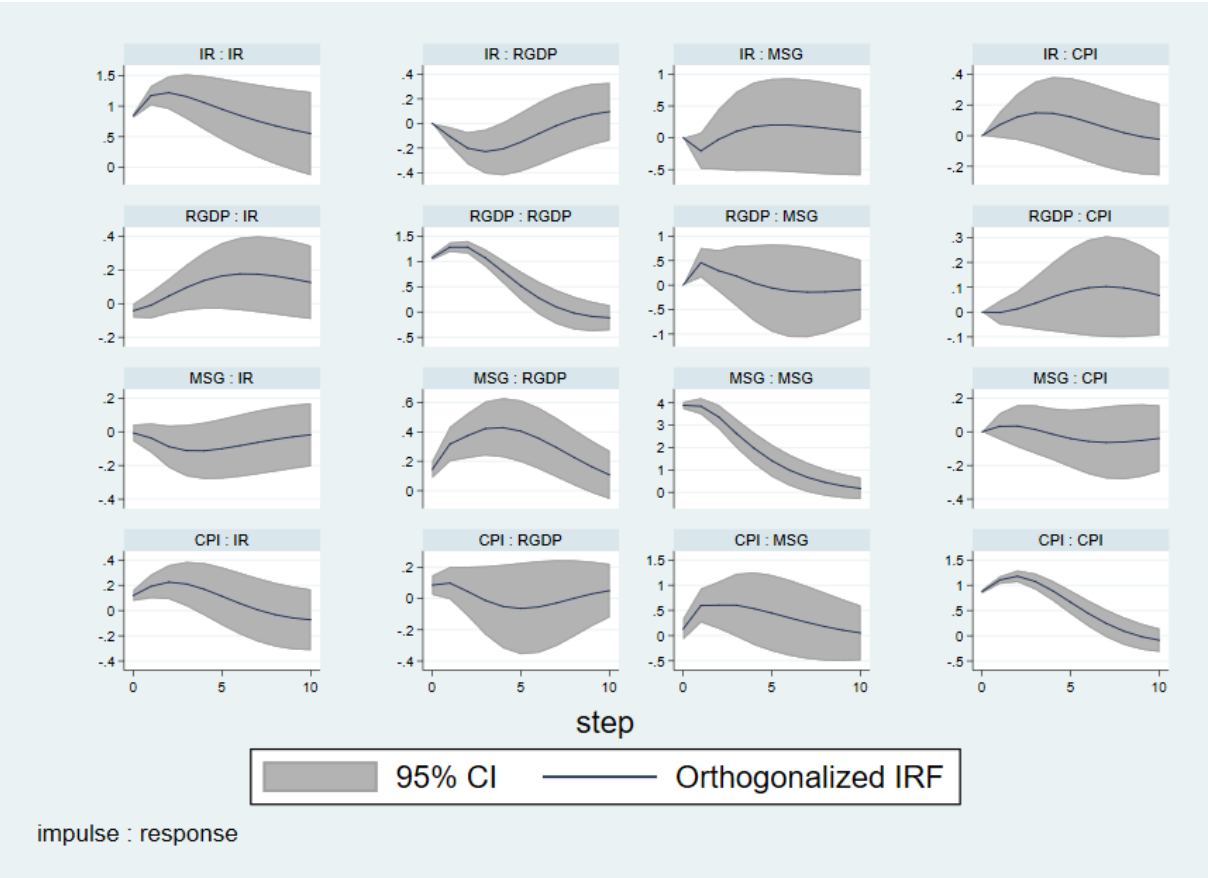
To assess the robustness of the results, we perform two additional empirical exercises. First, since the impulse-response functions are sensitive to the ordering of the variables, we recomputed the IRFs with a different ordering of the variables in the PVAR. Second, since some countries in our sample are oil importers while others are oil exporters, we split our sample into those two groups and estimate the IRFs separately for oil importers and for oil exporters.

a) Alternative ordering

We now analyze how different our results would be had we used a different ordering for our variables. In the alternative ordering, we reverse the order of the exchange rate and the nominal interest rate, as well as the order of money and output. As before, the identification assumption for the shocks is given by the Choleski decomposition.

When the use this alternative ordering of the variables, the behaviour of the impulse response functions changes only very slightly — see Figure 4.2. The general effect is that the reordering of variables in the model tends to smooth the impulse response functions as they converge to zero.

Figure 4.2 Impulse response functions with an alternative ordering



Source:Author's estimation

b) Sample decomposition

Our analysis also allows for a role of oil prices in macroeconomic policies in emerging markets. Since oil movements will have different effects on oil importers and on oil exporters, we split our sample into two subsamples, one of oil exporters and another of oil importers. The oil importing countries group is composed by Chile , Czech Republic, Egypt, Hungary, India, Korea, Pakistan, Peru, Philippines, South Africa and Thailand. The group of oil exporting countries includes Malaysia, Mexico, Qatar, Russia, Colombia, China, and Brazil. The estimated coefficients are reported in Table 4.8.

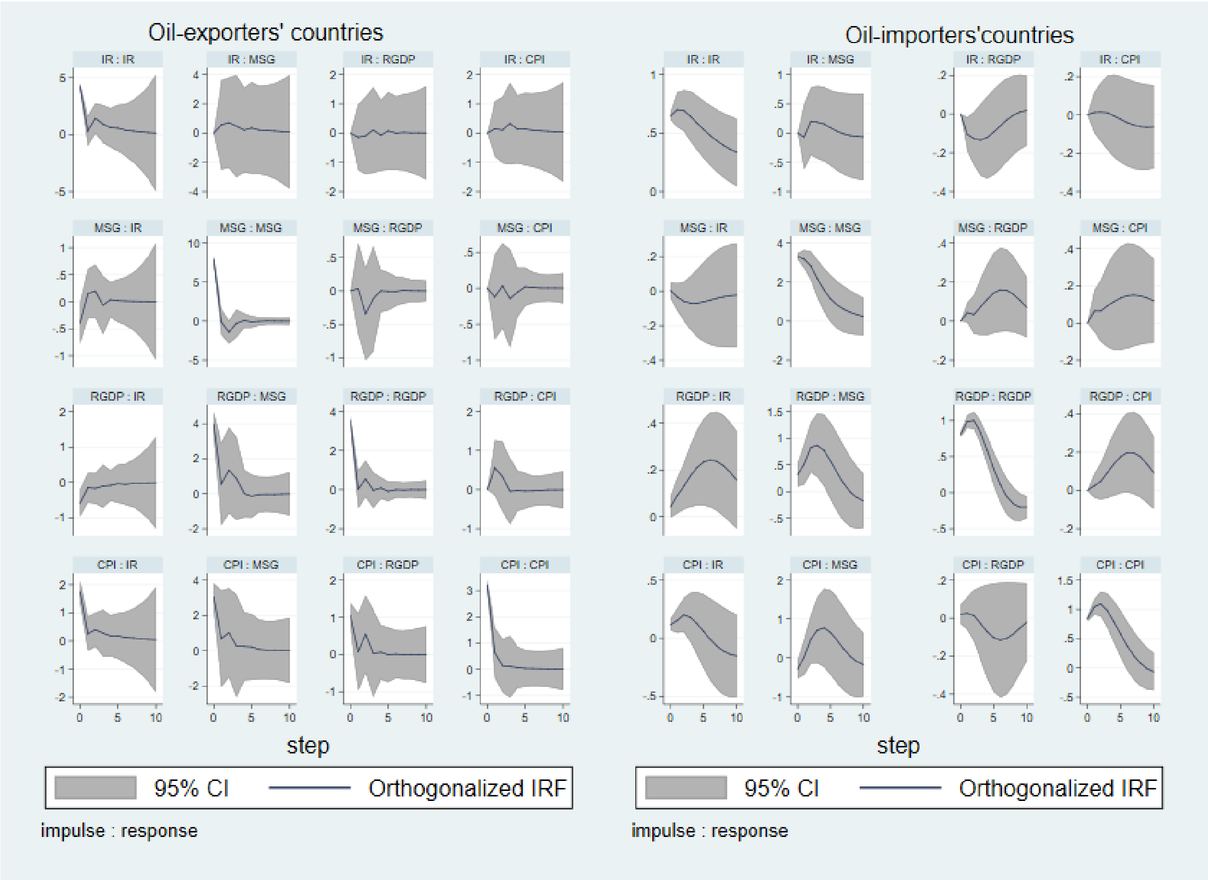
Table 4.8 Estimates of the PVAR for oil-exporters and for oil-importers

	Oil-exporters			**Oil-importers**		
VARIABLES	CPI	RGDP	IR	CPI	RGDP	IR
CPI(-1)	0.00974	-0.236	-0.112	1.244***	0.00797	0.0475
	(0.145)	(0.162)	(0.134)	(0.0631)	(0.0343)	(0.0446)
CPI(-2)	0.107	-0.122	-0.128	-0.262***	-0.0252	0.00502
	(0.131)	(0.146)	(0.124)	(0.0642)	(0.0368)	(0.0551)
CPI(-3)	0.0576	-0.184	-0.0361	-0.143***	-0.0186	-0.0801**
	(0.145)	(0.135)	(0.118)	(0.0261)	(0.0243)	(0.0400)
RGDP(-1)	0.168	-0.00774	0.0949	0.0298	1.226***	0.0560*
	(0.107)	(0.133)	(0.0847)	(0.0274)	(0.0437)	(0.0316)
RGDP(-2)	0.123	-0.166	0.135	-0.00990	-0.250***	-0.0264
	(0.102)	(0.117)	(0.0821)	(0.0299)	(0.0542)	(0.0421)
RGDP(-3)	0.0745	-0.0555	0.0199	0.0279	-0.170***	0.00573
	(0.112)	(0.105)	(0.0760)	(0.0180)	(0.0301)	(0.0287)
IR(-1)	0.0649	0.00214	-0.0267	-0.0254	-0.205***	1.019***
	(0.0919)	(0.114)	(0.163)	(0.0895)	(0.0752)	(0.126)
IR(-2)	0.0119	0.0575	0.127	0.00957	0.186**	-0.0171
	(0.0805)	(0.0832)	(0.134)	(0.102)	(0.0881)	(0.189)
IR(-3)	0.0507	0.119	0.106	0.00159	-0.00442	-0.0698
	(0.0811)	(0.0827)	(0.114)	(0.0429)	(0.0562)	(0.0942)
ECBI(-1)	2.487	-3.246	1.407	0.653**	0.00625	0.161
	(2.476)	(2.482)	(2.364)	(0.298)	(0.298)	(0.276)
FFR(-1)	-0.0595	-0.339**	-0.0656	0.0451*	0.0532*	0.0639***
	(0.153)	(0.144)	(0.200)	(0.0258)	(0.0280)	(0.0214)
OIL(-1)	0.00930	-0.0155*	0.00443	0.00196**	0.000127	0.00222***
	(0.00856)	(0.00901)	(0.00911)	(0.000809)	(0.000850)	(0.000652)
Observations	476	476	476	748	748	748

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

The first impression from comparing Tables 4.5 and 4.8 is that the dynamics are a bit different across the two groups, for there are some differences in the sign, magnitude, and significance of the coefficients. Nevertheless, to perform a more precise comparison, it is important to look at the corresponding IRFs. These are presented in Figure 4.3. The IRFs suggest that in oil-importing countries there is a clearer bidirectional relation between the interest rate and output.

Figure 4.3 Impulse response functions for oil-exporters and for oil-importers



Source:Author's estimation

4.5 Conclusions and policy implications

The aim of this chapter was to examine the dynamic effect of monetary policy shocks on output and prices using quarterly panel data of eighteen emerging countries over the period 2000-2017. This study employed PVAR to examine the dynamic causal relationship between macroeconomic variables.

Our empirical findings shed more light on the debate surrounding the effect of monetary policy shocks on output and price. We find that interest rate shocks contribute relatively little to output and inflation uncertainty.

The impulse response functions indicate that the interest rate shock leads to a short-run price puzzle, in which inflation rises. However, output reacts in the expected way, declining in response to a positive interest rate shock.

This result is robust in a variety of additional empirical exercises, particularly for the oil-importing countries in our sample. For oil-exporters, the confidence bands are very wide.

The fact that monetary policy shocks do not appear to clearly lower inflation may be a sign of problems in conducting monetary policy in emerging countries. Several explanations are possible. Perhaps monetary policy makers are not sufficiently credible, or they lack effective tools, or they lack information about the transmission mechanism, or they have not had price stability as their primary goal, or the model we used in this chapter is not suitable and leads to misleading conclusions. In any case, future research on this topic appears to be necessary.

5 The Monetary Policy Reaction Function: an empirical investigation

This chapter examines central banks' interest rate setting behaviour in emerging countries. The empirical analysis is based on panel data models. Besides the traditional variables in monetary policy reaction functions, our specifications will also include other variables, particularly the extended central bank independence index.

5.1 Introduction

According to the literature, most central banks in emerging markets are currently concentrating their efforts on maintaining price stability and have been working hard to figure out how they should react to fundamental economic developments Mehrotra and José (2011). Central banks use monetary policy instruments to impact the economy, primarily to stabilize the economy by keeping inflation and output at their target levels. The nominal interest rate has become the prime monetary policy instrument for several central banks. The low level of inflation achieved in recent decades in advanced countries is often seen as the result of the adoption of policy rules and the independence of central banks. Taylor (1993) argued that monetary policy in the United States during the 1980s and early 1990s might be regarded as following a certain rule. Interest rate rules have also been depicted as helpful in supporting inflation stabilization by preventing time inconsistency (Kydland and Prescott, 1977; Barro and Gordon, 1983) and promoting transparency for the public (Svensson, 2000 and 2008). Clarida, Gali and Gertler (1999) extended the basic ideas of Taylor for New Keynesian models.

There are various studies that look at how central banks actually react to changes in economic conditions. However, there is still a gap in the literature, for most of the research has explored typical central bank response functions, using conventional rules, with a particular emphasis on country time series analysis. Extended central bank reaction functions have received little attention, and a single country's experience may not provide enough evidence on the nature, the benefits and the costs of specific monetary policy behaviours.

In order to provide additional evidence regarding the nature and effectiveness of alternative interest rate settings, particularly in emerging countries, it is useful to examine panel data. The empirical findings could help to determine how central banks react to underlying economic trends and provide useful information for discussing monetary policy in attaining the long-term objective of macroeconomic stability (Billi,2009).

This chapter examines the central banks' interest rate setting behaviour in emerging countries in recent years. This study sheds light on the factors that influence monetary policy decisions, including whether monetary policy responds exclusively to traditional monetary policy variables such as inflation and output or whether it also considers a variety of additional factors such as the international environment and the level of central bank independence. We estimate our panel data models Arellano and Bond(1991) by the generalized method of moments (GMM), which has the advantage of taking into account the possible correlation between the regressors and the error term that could give rise to endogeneity problems. We also report estimation results for the pooled OLS and fixed-effects estimators, for comparison purposes. In addition, we estimate at first a basic version of an interest rate rule which contains as regressors the inflation rate and the output gap. Then, in extended versions, we add the exchange rate and also a range of other factors, particularly related to the international environment.

5.2 Literature Review

The current section provides a review of related works on central bank interest rate setting, group classification and country-specific estimates of the central bank reaction function that may be considered as benchmarks in our analysis.

The seminal paper on the central bank behaviour and reaction functions is Taylor(1993) as discussed in chapter two of this thesis. Several studies have looked at central bank reaction functions in industrialized economies, such as Cukierman and Muscatelli(2008), Qin and Enders(2008) and Neuenkirch and Tillmann(2014). These studies look at how central banks in advanced countries react to changes in factors including inflation, output, and the exchange rate. Time series and panel data approaches are used, as well as a variety of empirical methodologies. Next we present a set of country studies that concentrate on a few developed countries, such as the United States, the United Kingdom, the Eurozone, and Japan. Comparisons across countries have only been made in a few instances in the past. However, in the literature on monetary policy norms, more recent studies that pool country data have begun to emerge.

US: Taylor (1999) argues that the monetary policy of the US Federal Reserve may be represented by an equation of the form $i_t = \bar{i} + \varphi_\pi(\pi_t - \bar{\pi}) + \varphi_X X_t$, where subscript t denotes time, i_t is the policy rate, $\bar{i}$ is the equilibrium rate of interest, π is inflation, $\bar{\pi}$ is the inflation target, X_t is the output gap, φ_π is the responsiveness of the policy rate to inflation and φ_X is the responsiveness of the policy rate to the output gap. Empirical exercises show that φ_π was about 0.81 and φ_X was roughly 0.25 during the pre-Volcker era, which lasted from 1960 to 1979. During the period 1987-1997, also known as the post-Volcker period, φ_π was about 1.53 and φ_X was about 0.77. Defining the Taylor principle as $\varphi_\pi > 1$, the post-Volcker era is found to follow the Taylor principle (where monetary authorities boost nominal interest rates by more than one percentage point for every percentage point increase in inflation). The study by (Alexandre,Bação and Gabriel,2008) on Taylor-type rules versus optimal policy in a Markov-switching economy, suggests that to follow a specific simple rule is the best prescription for monetary policy of US and the findings suggest that a Taylor-type rule is very effective at stabilizing output and inflation, consistent with other scholars (see,Taylor1993 ; Rudebusch 2006 and Reis,2006). The study conducted by (Conraria, Martins, and Soares,2018) estimates the Taylor Rule in the time-frequency domain to detect lead-lag relationships between the policy rate and inflation and the output gap that differ along time and cyclical frequencies.

Judd and Rudebusch(1998) concentrates on a straightforward model of the Federal Reserve's reaction function, but argues that the reaction function appears to have changed over time, possibly due to changes in the Federal Open Market Committee's membership. The estimates of φ_π confirm that US monetary policy has been consistent with the Taylor principle in the post-1979 period, but not before.

Clarida, Gali and Gertler (2000) estimate a "forward-looking" monetary policy reaction function for the postwar United States economy. Again, the results point to substantial differences in the estimated rule across periods. Interest rate policy during the Volcker-Greenspan era appears to have been far more sensitive to fluctuations in inflation than before Volcker. A simple macroeconomic model is used to show that the Volcker-Greenspan rule stabilizes inflation and output. For that period, the estimates of φ_π and φ_X are consistent with the results of Taylor(1999).

Orphanides(2003) presents a different approach and reaches a different conclusion, namely that monetary policy followed the Taylor principle even during the pre-Volcker era. This is evidenced by the estimates larger than 1 obtained for φ_π during the period 1966-1979. According to Orphanides, the problem was that the real-time data available when monetary policy decisions were being made were misleading.

Coibion and Gorodnichenko (2011) present results more in line with the rest of the literature. Baseline regressions in Coibion and Gorodnichenko (2011) reveal that during 1969-1979, US policy rates responded to current inflation with a coefficient of about 0.79. During the late 1980s and early 1990s, the responsiveness increased to 1.58. In addition, the policy response to output growth increased from 0.04 in 1969-1979 to 2.21 in 1983-2002.

In additional work, Coibion and Gorodnichenko (2012) report regressions that indicate that the role of interest smoothing is considerable. Short-run responses of policy rates (for the period 1987:Q4-2006:Q4) to inflation are 0.35 using OLS and 0.60 using IV estimation, according to the paper's estimates of a Taylor rule involving both a smoothing parameter and serial correlation in the residuals.

European Union (EU): the results presented by Gerlach and Schnabel(2000) suggest that interest rates in the EMU countries behave in a way similar to the Taylor rule, responding to the output gap and inflation. Their empirical study concerns the period between 1990 and 1998, and thus allowance must be made for the period of exchange market turmoil between 1992 and 1993. Their estimates of φ_π range between 0.98 and 1.62, and thus appear to be consistent with the Taylor principle. Their estimates of φ_X are generally smaller, in a narrow range between 0.22 and 0.32.

Ullrich (2003) studies monetary policy in the euro area. Taylor-type reaction functions are utilized to model the interest rate behaviour, i.e., the inflation rate and the output gap feature as the major explanatory variables. Nevertheless, they add other explanatory variables, particularly the European Central Bank's reaction to the Federal Reserve's policy moves. Between 1995 and 1998, the estimated monetary policy rule's inflation coefficient (weight) was greater than 1. The output gap coefficient fluctuated between 0.24 and 0.44, which is quite significant. However, between 1999 and 2002, the coefficient of inflation fell below one. This leads to the conclusion that an important structural change occurred in the European monetary policy reaction function between the two time periods under consideration.

Germany: Bernanke and Mihov(1997) studied the behaviour of the Bundesbank given its price stability objective. They observe that variations in expected money growth have little impact on Germany's monetary policy. As a result, they conclude that the Bundesbank is a money-targeter rather than an inflation-targeter.

Clausen and Meier(2005) used a real-time data set for Germany's GDP for the period 1973 to 1998. They estimate Taylor-type reaction functions for the Bundesbank using different measures of the real-time output gap. The reaction coefficients resemble those provided by Taylor for several real-time measures of the output gap pretty closely. However, when ex-post output gap data is fed to the estimated reaction functions, the predicted interest rate behaviour deviates from the observed behaviour, i.e., the real-time conclusions disagree with those based on ex-post data. Additionally, they conclude that broad monetary aggregates, like M3, played a minor effect in the Bundesbank's interest rate choices.

UK: Chevapatrakul et al.(2003) study the usefulness of a Taylor rule in the prediction of the next change in UK monetary policy during the period 1992-2000. Despite the fact that the Taylor rule is a valuable summary for monetary planners, they conclude that the information from inflation and the output gap is insufficient to predict the next change's direction.

Nelson (2000) estimates simple interest rate reaction functions for different UK monetary policy regimes. The Taylor rule estimates suggest that the inflation coefficient was greater than one only after 1992, when inflation-targeting was adopted.

Other countries: Clarida, Gali and Gertler (1998) report reaction functions for two sets of countries: the G3 (Germany, Japan, and the US) and the E3 (UK, France, and Italy). They argue that G3 central banks have fully implemented inflation targeting since 1979. The evidence also points to these central banks being proactive: they respond to anticipated inflation as opposed to lagged inflation. The E3 central banks were heavily influenced by Germany's monetary policy, forcing them to give more weight to inflation. In Germany, the inflation coefficient is estimated to range between 1.10 and 1.37 while the output gap coefficient ranges between 0.25 to 0.35. The inflation rate coefficient for Japan is estimated to be between 1.89 and 2.04, while the output gap coefficient is between 0.03 and 0.10. The inflation coefficient for the US Fed is estimated to be between 1.05 and 2.20, while the output gap coefficient is estimated to be between 0.07 and 0.56. Inflation coefficients in Germany, Japan, and the United States are generally compatible with the Taylor principle. Clarida, Gali and Gertler (1998) further observe that in England, the inflation coefficient ranges from 0.48 and 0.98 while the output gap coefficient ranges between 0.17 to 0.28. In France, the inflation coefficient ranges from 0.59 to 1.33, while output gap coefficient ranges from -0.07 to 0.88. In Italy, the inflation coefficient ranges from 0.59 to 0.91, while output gap coefficient estimates range from -0.03 to 0.22.

Emerging economies: there is limited empirical research on monetary policy rules and central bank reaction functions in emerging countries. According to Taylor(2002), market dynamics in emerging market economies may necessitate changes to the standard policy guideline that has been advocated for economies with more developed financial markets. He argues that the changes should probable concern either the choice of the instrument (money supply instead of an interest rate), the role of the exchange rate (which may be more important in emerging countries), or the magnitude of the coefficients.

In fact, according to numerous studies, advanced economies have a lower range of inflation coefficients than developing countries. Specifically, the panel regressions in Ghosh, Ostry and Chamon (2016) show that policy rates (as a deviation from the inflation target) respond to expected inflation (as a deviation from the inflation target) by 0.699 percentage points.

Hofman and Bogdanova (2012) report policy rule parameters for both advanced economies and emerging market economies. The reaction of policy rates to inflation in industrialized economies ranges from 0.0 to a little above 2.2. In emerging economies, policy rates respond to inflation with a coefficient in the range of 0.9 to 2.75.

Minella et al.(2003) show that the Central Bank of Brazil has reacted strongly to inflation expectations, in a way consistent with the inflation-targeting framework. Bleich et al.(2012) find that the introduction of inflation targeting changes the central bank's reaction function toward inflation stabilization.

Note that, although price stability is the central bank's primary goal, it is not the sole one. Central banks in emerging markets also consider the state of the economy and respond to changes in the output gap. Several studies indicate that monetary policy reaction functions vary across countries – e.g. Corbo et al (2001). According to the estimates presented in Schmidt-Hebbel et al.(2002), the central bank in Brazil reacts to the inflation gap, while in Chile the central bank reacts to the output gap. De Mello and Moccero(2011) estimate a structural model and VAR model for a number of Latin American countries. The results reveal that, under the inflation targeting regime, the central banks of Brazil and Chile react aggressively to predicted inflation. Colombia's and Mexico's monetary policies, according to the author, have grown less counter-cyclical.

Changes in the currency's exchange rate, in addition to inflation and output, are an essential element to consider in monetary policy for developing market countries. According to Mohanty and Klau (2004), in some countries, the response to exchange rate shocks is even stronger than to the inflation and output gaps. Moura and Carvalho(2010) shows that central banks react to inflation in Brazil, Mexico, Chile and Peru. Exchange rate matters for only Mexico, and the output gap for Chile, Colombia and Venezuela.

Aizenman et al. (2011) conclude that inflation and real exchange rates are significant determinants of policy interest rates, while the output gap is not. Besides domestic economic variables, external economic and financial conditions are also important for emerging economy central banks. Guney (2016) studies the interest rate setting behaviour of the Central Bank of Turkey. He argues that the central bank responds to the ten-year bond yield, as well as the inflation gap, inflation, and growth uncertainty. Similarly,Caputo and Herrera (2017) find that central banks respond to federal funds rate, inflation and output gap.

5.3 Data and Empirical Approach

This section describes the data and the model used in the analysis.

5.3.1 Data

This study uses quarterly panel data covering eighteen emerging countries during the period 2000-2017: Brazil, Chile, China, Colombia, Czech Republic, Egypt, Hungary, India, Korea, Malaysia, Mexico, Pakistan, Peru, Philippines, Qatar, Russia, South Africa, and Thailand.

The variables employed in our study were selected on the basis of the discussion presented in the literature, such as Taylor (1993), Clarida et al. (1998, 2000), Dennis (2003), Alexandre, Bação and Gabriel (2008) and Conraria, Martins, and Soares (2018), among others.

As discussed above, central banks determine policy interest rates primarily in response to deviations of inflation and output from the target. Following Clarida et al. (1998, 2000) and Aizenman et al. (2011), we employ an expanded Taylor rule, which includes the real exchange rate, 10-year US government bond yields, and commodity prices, in addition to the inflation and output gap (the percentage deviation of output relative to its potential).

The role of the exchange rate in interest rate setting has been highlighted in, for example, Mohanty and Klau, 2004, and Aizenman et al., 2011). Other external economic and financial conditions are also important for monetary policy in emerging countries. To take this into account, we add the change in the 10-year U.S. government bond yield and total foreign reserves, as proxies of global financial liquidity. When there is an abundant amount of global liquidity, this is reflected in lower U.S. interest rates (Guney, 2016 and Caputo and Herrera, 2017).

A distinguishing element of our study is the inclusion of the measure of central bank independence in the interest rate model. This captures the influence of other important issues in monetary policy making, particularly in emerging countries (Aizenman, Chinn, and Ito, 2010).

The main data sources were the World Economic Outlook (WEO), the World Bank's World Development Indicators (WDI), and the Federal Reserve Bank of St Louis website (FRED). The variables' names, definitions and data sources are given in Table 5.1. Annual data was interpolated to obtain quarterly time series. Descriptive statistics are reported in Table 5.2.

Table 5.1 Variables sources and their definitions

Variable name	Definition	Source
Ninter	The money market interest rate	World Bank's World Development Indicators (WDI)
Infl	The annualized percentage change in consumer price index	IMF's International Financial Statistics(IFS)
GDPg	The output gap measured as % deviation of output relative to trend computed from GDP per capita at constant USD	IMF's International Financial Prices
REER	The real effective exchange rate	IMF's International Financial Statistics (IFS)
USB	10-year US government bond	Federal Reserve Bank of St Louis
Tres	The total reserves measures external assets by central bank	IMF's International Financial Prices
Energ	The energy price index	IMF's Primary Commodity website
Food	The food price index	IMF's Primary Commodity
Rinter	The real interest rate	IMF's International Financial Statistics(IFS)
ECBI	The Extended Central Bank Independence Index	Author's computation

Table 5.2 Summary statistics

VARIABLES	N	mean	sd	min	max	skewness	kurtosis
Ninter	1,296	11.58	10.27	1.293	72.40	3.081	13.48
USB	1,296	3.532	1.240	1.563	6.480	0.208	2.065
ECBI	1,296	0.463	0.204	0	1	-0.0953	2.796
Infl	1,296	4.819	3.863	-7.478	24.37	1.573	7.004
DLREER	1,278	0.000911	0.0298	-0.258	0.312	-0.285	21.97
DLFood	1,278	0.00763	0.0565	-0.248	0.111	-1.201	7.176
DLEner	1,278	0.0106	0.129	-0.568	0.224	-1.578	7.366
DLTres	1,278	0.0270	0.0848	-0.501	0.542	0.647	11.60
GDPg	1,296	-0.00786	1.483	-6.037	6.930	0.106	4.523

Source: Author's computation. (Prefix "DL" denotes the log-difference of the series.)

5.3.2 Empirical model

We estimate the simple version of the Taylor rule describing the monetary policy decision in line with Taylor (1993), and then estimate extended versions to account for other factors in the interest rate decision (Clarida et al. (1998, 2000) and Aizenman et al. (2011)). This extension is an important issue, for the literature gives the international environment a significant role in monetary policy making (Modenesi,2011; Svensson, 2000; IMF, 2015; Guney, 2016; Caputo and Herrera, 2017). The general specification of the models to be estimated is the following:

$$i_{it} = \phi i_{it-1} + \alpha \pi_{it} + \beta \hat{y}_{it} + \delta er_{it} + \theta us_{it} + \lambda tr_{it} + \gamma en_{it} + \psi fp_{it} + \omega ecbi_{it} + \mu_i + \varepsilon_{it} \tag{5.1}$$

where i and t denote country and time, respectively, i_{it} is the nominal interest rate, π_{it} represents the quarterly inflation rate, $\hat{y}_{it}$ is the output gap calculated as a percentage deviation from its potential level using the Hodrick Prescott (HP) filter[2], er_{it} is the log level of the effective exchange rate, us_{it} is the 10-year US government bond yield, tr_{it} is total reserves, en_{it} is the energy price index, fp_{it} is a food price index, $ecbi_{it}$ is the extended central bank independence index, and μ_i is the unobserved time-invariant country-specific effect. Finally, ε_{it} is the error term, assumed to be independently and identically distributed (IID).

The dynamic panel data approaches proposed by (Blundell and Bond, 1997) will be used to assess the significance of various factors in the reaction function of the central bank. The GMM estimator is appealing because it can accommodate a situation where the lagged dependent variable is in the vector of the explanatory variables, and this is useful in the context of estimating equation 5.1. We use both the difference-GMM (DGMM) and the system-GMM (SGMM) estimators.

Despite the fact that the GMM estimator does appear to be an appropriate choice, it can suffer from large finite-sample biases if the instruments are weak. An excess of instruments may also lead to estimation problems. This poses a challenge related to the choice of the set of instruments. We will use the Roodman (2006; 2009) collapse technique to reduce the number of instruments. Two tests will be used to assess the appropriateness of our modelling and estimation choices: a test of autocorrelation in residuals and a test of over-identifying restrictions. In addition to GMM estimates, we will also report results for a static version of the Taylor rule, estimated using the pooled OLS and fixed-effects (FE) estimators.

5.4 Empirical results

In this section we report estimates of simple and extended versions of equation 5.1. We also discuss the results of robustness checks.

5.4.1 Baseline estimations

The baseline models are static and dynamic Taylor rules of the general form given in equation 5.1. The estimates are presented in Table 5.3.

[2] In the HP filter, the smoothing parameter was set as 1600, the standard value for quarterly data.

Table 5.3 Baseline specifications of the reaction function

		Static Models							Dynamic Models			
	OLS	OLS	OLS	FE	FE	FE	DGMM	DGMM	DGMM	SGMM	SGMM	SGMM
Ninter(-1)							0.659*** (0.036)	0.712*** (0.016)	0.555*** (0.018)	0.987*** (0.005)	0.986*** (0.005)	0.987*** (0.005)
Infl	0.014* (0.007)	0.014* (0.007)	0.014* (0.007)	0.047*** (0.010)	0.047*** (0.010)	0.046*** (0.010)	0.459*** (0.119)	0.116*** (0.019)	0.145*** (0.019)	0.008 (0.010)	0.006 (0.015)	-0.001 (0.010)
GDPg	0.112*** (0.019)	0.112*** (0.019)	0.111*** (0.020)	0.087*** (0.019)	0.087*** (0.019)	0.080*** (0.020)	0.719*** (0.096)	0.150*** (0.027)	-0.000 (0.028)	0.079** (0.034)	0.080** (0.031)	0.096*** (0.026)
DLREER		-1.163 (0.925)	-0.847 (0.936)		-0.940 (0.917)	-0.925 (0.926)		-2.846*** (1.011)	-2.372** (1.003)		-0.057 (2.263)	1.277 (1.794)
ECBI			-0.238* (0.139)			-0.097 (0.147)			0.306 (0.349)			-0.274* (0.139)
USB			0.024 (0.032)			0.084*** (0.032)			0.937*** (0.057)			-0.032 (0.023)
DLTres			-0.403 (0.333)			-0.384 (0.329)			0.179 (0.308)			-0.766* (0.432)
DLEner			-0.330 (0.305)			-0.395 (0.300)			-1.676*** (0.225)			-0.252 (0.230)
DLFood			-1.139* (0.661)			-1.118* (0.649)			0.118 (0.475)			-0.671** (0.291)
N	1278	1278	1278	1278	1278	1278	1260	1260	1260	1278	1278	1278
Groups				18.000	18.000	18.000	18.000	18.000	18.000	18.000	18.000	18.000
sarganp							0.000	0.000	0.000	0.059	0.054	0.065
hansenp										0.232	0.249	0.423
j							13.000	13.000	18.000	8.000	9.000	14.000
ar1p							0.359	0.000	0.000	0.047	0.045	0.042
ar2p							0.735	0.006	0.036	0.325	0.324	0.367

Dependent variable: Nominal interest rate
*Note:(i) respectively, the sign *,**, and *** describe the significance level of 10%,5% and 1%;(ii) standard errors are reported in brackets*

Source: Author's computation

Estimation of the static models produces coefficients for inflation and the output gap that appear somewhat low in the light of the literature reviewed earlier. The estimates obtained for the dynamic models, using the generalized method of moments estimators and reported in Table 5.3, show that the coefficient of the lagged interest rate is relatively high and statistically significant, indicating a high degree of persistence in the interest rate. Thus, the findings indicate a considerable interest rate smoothing, as captured by a first-order autoregressive term above 0.9 in the case of the models estimated by the SGMM estimator. Consequently, only about 10% of the adjustment to deviations from the target interest rate occurs within the period of the change. Additionally, the policy rate is influenced by both inflation and the output gap, consistent with the findings from earlier studies. The fact that the coefficient on inflation is positive and statistically significant suggests that central banks in emerging countries have followed an anti-inflation monetary policy, raising the interest rate when inflation increases. Nevertheless, the estimated coefficients coefficients for inflation are not in accordance with the Taylor principle.

The results concerning the additional variables are not conclusive across the specifications and estimators. Broadly, the estimates suggest that there may be some countervailing reaction to movements in exchange rates, reserves, and energy and food prices. Central banks in emerging countries also appear to follow movements in US interest rates. Finally, a higher level of central bank independence appears to lower the interest rate in emerging countries. However, as noted above, the results do not support these conclusions in a clear way.

When the SGMM estimator is used, the Hansen and autocorrelation diagnostic tests suggest that the model is well specified, since there is no evidence of second order residual serial correlation in the residuals and the validity of the over-identifying restrictions can not be rejected by the Hansen's J test. The diagnostic tests for the models estimated by DGMM do not give clear conclusions.

5.4.2 Robustness checks: alternative specifications

Further robustness checks of the previous results were carried out by estimating other specifications based on equation 5.1. In Table 5.4 we report estimates of three models which, besides the lagged interest rate in the case of the dynamic models, include a restricted set of variables: one includes only inflation, the second includes only the output gap, and the third includes inflation, the output gap and, of the group of additional variables considered previously, only the exchange rate. Relative to the results presented in Table 5.3, in general the changes are very small.

Table 5.4 Restricted specifications of the reaction function

	Static Models						**Dynamic Models**					
	OLS	OLS	OLS	FE	FE	FE	DGMM	DGMM	DGMM	SGMM	SGMM	SGMM
Ninter(-1)							0.484***	0.756***	0.713***	0.985***	0.988***	0.986***
							(0.032)	(0.014)	(0.016)	(0.005)	(0.005)	(0.005)
Infl	0.019**		0.014*	0.055***		0.047***	1.040***		0.115***	0.011		0.006
	(0.007)		(0.007)	(0.010)		(0.010)	(0.104)		(0.019)	(0.010)		(0.015)
GDPg		0.116***	0.112***		0.104***	0.087***		0.198***	0.138***		0.084**	0.080**
		(0.019)	(0.019)		(0.019)	(0.019)		(0.027)	(0.027)		(0.035)	(0.031)
DLREER			-1.163			-0.940			-2.892***			-0.057
			(0.925)			(0.917)			(1.011)			(2.263)
N	1278	1278	1278	1278	1278	1278	1260	1260	1260	1278	1278	1278
Groups				18.000	18.000	18.000	18.000	18.000	18.000	18.000	18.000	18.000
sarganp							0.000	0.000	0.000	0.050	0.090	0.054
hansenp										0.177	0.276	0.249
j							13.000	13.000	18.000	7.000	7.000	9.000
ar1p							0.000	0.000	0.000	0.048	0.047	0.045
ar2p							0.157	0.007	0.006	0.327	0.327	0.324

Dependent variable: Nominal interest rate
*Note:(i) respectively, the sign *,**, and *** describe the significance level of 10%,5% and 1%;(ii) standard errors are reported in brackets*

Source: Author's computation

In second set of alternative specifications we added the interactions of the extended central bank independence index with inflation and the output gap to the models estimated in Table 5.3. The results are presented in Table 5.5.

Table 5.5 Reaction functions with interactions

	Static Models							**Dynamic Models**				
	OLS	OLS	OLS	FE	FE	FE	DGMM	DGMM	DGMM	SGMM	SGMM	SGMM
Ninter(-1)							0.920***	0.690***	0.534***	0.987***	0.986***	0.991***
							(0.141)	(0.016)	(0.019)	(0.010)	(0.011)	(0.015)
Infl	0.046***	0.045***	0.057***	0.066***	0.066***	0.073***	-4.668***	-0.046	-0.083**	0.039	0.035	0.079
	(0.013)	(0.013)	(0.018)	(0.014)	(0.014)	(0.018)	(0.985)	(0.031)	(0.038)	(0.149)	(0.184)	(0.319)
GDPg	0.085*	0.086*	0.079	0.065	0.066	0.060	2.226	0.114*	-0.025	0.537	0.499	-1.129
	(0.048)	(0.048)	(0.048)	(0.048)	(0.048)	(0.048)	(2.709)	(0.060)	(0.060)	(0.682)	(0.680)	(1.993)
DLREER		-1.026	-0.825		-0.864	-0.922		-2.536**	-1.873*		0.124	0.843
		(0.924)	(0.935)		(0.917)	(0.927)		(1.010)	(1.006)		(1.870)	(2.248)
ECBI			0.212			0.191			-2.069***			-0.083
			(0.219)			(0.222)			(0.481)			(2.668)
USB			0.026			0.085***			0.888***			-0.076
			(0.032)			(0.032)			(0.058)			(0.084)
DLTres			-0.473			-0.440			0.227			-1.110
			(0.333)			(0.330)			(0.307)			(1.113)
DLEner			-0.356			-0.412			-1.679***			-0.304
			(0.305)			(0.300)			(0.224)			(0.771)
DLFood			-1.107*			-1.097*			0.147			-0.545
			(0.660)			(0.649)			(0.474)			(0.944)
Infl × ECBI	-0.066***	-0.065***	-0.091***	-0.045*	-0.044*	-0.062*	5.807***	0.362***	0.492***	-0.075	-0.066	-0.136
	(0.021)	(0.021)	(0.034)	(0.023)	(0.023)	(0.035)	(1.144)	(0.054)	(0.073)	(0.305)	(0.379)	(0.654)
GDPg × ECBI	0.058	0.055	0.067	0.048	0.046	0.044	-2.848	0.031	0.004	-0.928	-0.851	2.398
	(0.089)	(0.089)	(0.089)	(0.089)	(0.089)	(0.089)	(4.735)	(0.115)	(0.114)	(1.354)	(1.367)	(4.154)
N	1278	1278	1278	1278	1278	1278	1260	1260	1260	1278	1278	1278
Groups				18.000	18.000	18.000	18.000	18.000	18.000	18.000	18.000	18.000
sarganp							0.153	0.000	0.000	0.014	0.013	0.329
hansenp										0.252	0.266	0.288
j							15.000	15.000	18.000	8.000	9.000	14.000
ar1p							0.001	0.000	0.000	0.056	0.054	0.133
ar2p							0.009	0.013	0.058	0.343	0.338	0.430

Dependent variable: Nominal interest rate
*Note:(i) respectively, the sign *,**, and *** describe the significance level of 10%,5% and 1%;(ii) standard errors are reported in brackets*

Source: Author's computation

Inclusion of the interactions appears to affect in a strange way the DGMM estimates, which now assign a negative coefficient to the inflation term. The estimated coefficients for the interaction with inflation are usually negative (except when DGMM is used) and usually statistically significant (except when SGMM is used). Overall, it appears difficult to draw clear conclusions from these results. Nevertheless, the fact that the interaction terms are often statistically significant suggests that future research on its role may be warranted.

5.4.3 Robustness checks: information lags

In this subsection, we estimate the models with the explanatory variables lagged one period. The rationale for this specification is that the policy maker's decisions may be responding to past information and not to current values, because of information lags. The results for the baseline specifications are in Table 5.6.

Table 5.6 Reaction functions with information lags

		Static Models						Dynamic Models				
	OLS	OLS	OLS	FE	FE	FE	DGMM	DGMM	DGMM	SGMM	SGMM	SGMM
Ninter(-1)							0.899***	0.651***	0.523***	0.987***	0.990***	0.991***
							(0.053)	(0.015)	(0.018)	(0.004)	(0.003)	(0.003)
Infl(-1)	-0.001	0.002	0.004	0.020**	0.020**	0.021**	0.237	0.044**	0.094***	-0.011	-0.008	-0.003
	(0.007)	(0.007)	(0.007)	(0.010)	(0.010)	(0.010)	(0.163)	(0.020)	(0.020)	(0.011)	(0.011)	(0.005)
GDPg(-1)	0.133***	0.134***	0.133***	0.119***	0.122***	0.117***	-0.425***	0.235***	0.094***	0.089***	0.102***	0.098***
	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)	(0.162)	(0.026)	(0.028)	(0.030)	(0.035)	(0.029)
DLREER(-1)		-1.387	-1.489		-1.205	-1.576*		-1.782*	-0.679		-0.032	0.356
		(0.940)	(0.952)		(0.942)	(0.954)		(1.006)	(1.034)		(1.562)	(1.075)
ECBI(-1)			-0.267*			-0.182			-0.182			-0.341
			(0.140)			(0.149)			(0.359)			(0.207)
USB(-1)			-0.004			0.051			0.990***			-0.038
			(0.031)			(0.032)			(0.055)			(0.028)
DLTres(-1)			-0.569*			-0.593*			-0.237			-0.993***
			(0.329)			(0.328)			(0.316)			(0.339)
DLEner(-1)			0.761**			0.695**			-0.595**			0.438
			(0.312)			(0.309)			(0.236)			(0.331)
DLFood(-1)			0.061			-0.022			0.780			0.125
			(0.663)			(0.657)			(0.485)			(0.525)
N	1278	1260	1260	1278	1260	1260	1260	1242	1242	1278	1260	1260
Groups				18.000	18.000	18.000	18.000	18.000	18.000	18.000	18.000	18.000
sarganp							0.000	0.000	0.000	0.027	0.011	0.009
hansenp										0.282	0.242	0.298
j							11.000	14.000	18.000	8.000	9.000	14.000
ar1p							0.007	0.000	0.004	0.049	0.040	0.036
ar2p							0.028	0.005	0.066	0.329	0.256	0.244

Dependent variable: Nominal interest rate
*Note:(i) respectively, the sign *,**, and *** describe the significance level of 10%,5% and 1%;(ii) standard errors are reported in brackets*

Source: Author's computation

Again, the differences relatively to the baseline estimations reported in Table 5.3 are not large. At most, the results in Table 5.6 seem to point more clearly toward a statistically significant negative coefficient for total reserves.

Table 5.7 reports the results corresponding to the restricted models presented in Table 5.4. As before, the changes in the results do no appear to be significant.

Table 5.7 Restricted reaction functions with information lags

	Static Models						Dynamic Models					
	OLS	OLS	OLS	FE	FE	FE	DGMM	DGMM	DGMM	SGMM	SGMM	SGMM
Ninter(-1)							0.682***	0.732***	0.649***	0.990***	0.991***	0.993***
							(0.029)	(0.014)	(0.015)	(0.004)	(0.006)	(0.004)
Infl(-1)	0.004		0.002	0.031***		0.020**	0.166*		0.047**	-0.002		-0.010
	(0.007)		(0.007)	(0.010)		(0.010)	(0.097)		(0.020)	(0.008)		(0.013)
GDPg(-1)		0.133***	0.134***		0.126***	0.122***		0.269***	0.239***		0.087**	0.103***
		(0.019)	(0.019)		(0.019)	(0.019)		(0.025)	(0.026)		(0.035)	(0.035)
DLREER(-1)			-1.387			-1.205			-1.869*			-0.038
			(0.940)			(0.942)			(1.008)			(1.660)
N	1278	1278	1260	1278	1278	1260	1260	1260	1242	1278	1278	1260
Groups				18.000	18.000	18.000	18.000	18.000	18.000	18.000	18.000	18.000
sarganp							0.000	0.000	0.000	0.062	0.017	0.009
hansenp										0.216	0.195	0.214
j							13.000	11.000	13.000	7.000	7.000	9.000
ar1p							0.000	0.000	0.000	0.049	0.047	0.040
ar2p							0.004	0.015	0.005	0.328	0.329	0.255

Dependent variable: Nominal interest rate
*Note:(i) respectively, the sign *,**, and *** describe the significance level of 10%,5% and 1%;(ii) standard errors are reported in brackets*

Source: Author's computation

For completeness, in Table 5.8 we report the results corresponding to introducing information lags in the models with interactions of Table 5.5. Once more, introducing information lags does not change the results much.

Table 5.8 Reaction functions with interactions and information lags

	Static Models						Dynamic Models					
	OLS	OLS	OLS	FE	FE	FE	DGMM	DGMM	DGMM	SGMM	SGMM	SGMM
Ninter(-1)							0.682***	0.625***	0.498***	0.990***	0.992***	0.989***
							(0.108)	(0.016)	(0.018)	(0.009)	(0.009)	(0.009)
Infl(-1)	0.035***	0.032**	0.037**	0.047***	0.044***	0.047**	-4.424***	-0.113***	-0.167***	0.032	0.047	-0.038
	(0.013)	(0.013)	(0.018)	(0.015)	(0.015)	(0.019)	(0.802)	(0.031)	(0.040)	(0.131)	(0.149)	(0.151)
GDPg(-1)	0.101**	0.088*	0.084*	0.083*	0.073	0.071	-0.914	0.167***	0.058	0.954**	0.952**	0.145
	(0.048)	(0.048)	(0.048)	(0.048)	(0.048)	(0.048)	(2.591)	(0.059)	(0.061)	(0.421)	(0.442)	(1.185)
DLREER(-1)		-1.214	-1.432		-1.071	-1.540		-1.495	0.028		-0.425	-0.436
		(0.939)	(0.952)		(0.942)	(0.954)		(1.013)	(1.039)		(1.523)	(1.344)
ECBI(-1)			0.066			0.083			-2.881***			-0.650
			(0.222)			(0.227)			(0.492)			(1.351)
USB(-1)			-0.004			0.049			0.944***			-0.025
			(0.031)			(0.032)			(0.057)			(0.048)
DLTres(-1)			-0.631*			-0.656**			-0.180			-0.357
			(0.330)			(0.330)			(0.315)			(1.309)
DLEner(-1)			0.756**			0.691**			-0.695***			0.700
			(0.311)			(0.309)			(0.236)			(1.715)
DLFood(-1)			0.068			-0.014			0.836*			-0.183
			(0.662)			(0.656)			(0.485)			(5.414)
Infl × ECBI(-1)	-0.073***	-0.061***	-0.069**	-0.062***	-0.054**	-0.059	6.687***	0.362***	0.567***	-0.066	-0.092	0.072
	(0.022)	(0.022)	(0.035)	(0.024)	(0.024)	(0.036)	(1.220)	(0.054)	(0.075)	(0.261)	(0.305)	(0.289)
GDPg × ECBI(-1)	0.068	0.096	0.101	0.078	0.104	0.097	1.520	0.116	0.027	-1.812*	-1.809*	-0.079
	(0.088)	(0.088)	(0.088)	(0.089)	(0.089)	(0.089)	(4.661)	(0.114)	(0.117)	(0.875)	(0.923)	(2.454)
N	1278	1260	1260	1278	1260	1260	1260	1242	1242	1278	1260	1260
Groups				18.000	18.000	18.000	18.000	18.000	18.000	18.000	18.000	18.000
sarganp							0.288	0.000	0.000	0.032	0.014	0.002
hansenp										0.407	0.360	0.147
j							15.000	15.000	18.000	8.000	9.000	14.000
ar1p							0.001	0.000	0.006	0.100	0.090	0.038
ar2p							0.057	0.013	0.088	0.415	0.334	0.253

Dependent variable: Nominal interest rate
*Note:(i) respectively, the sign *,**, and *** describe the significance level of 10%,5% and 1%;(ii) standard errors are reported in brackets*

Source: Author's computation

5.5 Conclusions and policy implications

This chapter presented empirical findings from a cross-country investigation of central banks' reaction functions. The estimation was based on a quarterly panel data set for eighteen emerging economies in the period 2000Q1 to 2017Q4.

The central question was characterizing the central banks' interest rate setting behaviour in emerging countries. Particularly, we wanted to see if central banks respond to external conditions, which we added to the variables commonly used in literature on the monetary policy reaction function.

The findings indicate that central banks in emerging markets follow an expanded Taylor rule. They respond to external financial conditions and commodity prices, in addition to inflation and the output gap. The inflation coefficient is significant, showing that central banks in emerging countries react to inflation with a view to keeping it on target.

We tested alternative specifications of the monetary policy reaction function. The results did not change much under the alternative specifications, which included interaction terms and lagged information.

The findings provide useful information to policymakers and pave the way for further research on central bank reaction functions. Future research in this area can be based on the reaction functions of the central banks in emerging countries in their extended form, namely including interactions with the extended central bank independence index, which had statistical significance in many of the specifications tested in this chapter.

6 Conclusions

In this thesis, we focused on the analysis of monetary policy in emerging market economies in the period from 2000 to 2017. We have added to the growing literature on monetary policy analysis in particular, and on macroeconomic stability in general. The thesis covers three interrelated monetary policy dimensions, corresponding to three main different empirical chapters: central bank independence, monetary policy shocks, and monetary policy reaction function. This scope allows us to contribute to the debate on monetary policy in emerging countries. A common theme that runs through the thesis is how those three aspects interact and how they could be designed to achieve adequate macroeconomic outcomes in terms of inflation and macroeconomic stability. We therefore expect that it may contribute for understanding the process of setting monetary policy and the constraints under which it is formulated in emerging countries.

Chapters three to five have served as cornerstones for this empirical research. In chapter three, we develop a time-varying extended index of central bank independence (ECBI) to investigate its relation with inflation dynamics. Besides these variables, our analysis includes control variables and uses both static and dynamic models. The ECBI index is enriched by incorporating two main aspects of central bank independence, notably domestic and external independence. Compared to traditional indices, the present index has the advantage of including the most of the institutional arrangements proposed by the different studies. It incorporates the recent central banks reforms, and expands existing measures by including criteria that are scattered across various studies without being aggregated in a unified index.

We further examine the central bank independence-inflation nexus. The findings showed that central bank independence contributes to achieving lower inflation in emerging market economies, partially with a time lag. Furthermore, our findings showed that central bank independence is more effective in lowering inflation in the presence of high levels of financial sector development.

In chapter four, we follow the process through which monetary policy decisions affect the economy in general and the price level in particular. We estimate the effect of monetary policy shocks on output and prices, utilizing a panel vector autoregression (PVAR). The empirical findings shed more light on the debate surrounding the effect of monetary policy shocks on output and price. We find that the shock to the nominal interest rate contributes to explain the dynamics of gross domestic product and inflation, though modestly. The findings also showed that money supply contributes to explain the dynamics of gross domestic product and inflation.

The impulse response functions indicate that the interest rate shock reduces gross domestic product. Furthermore, the gross domestic product initially exhibits an immediate negative reaction and this fall reverses its direction after the fourth quarter and remains insignificant thereafter. A negative effect appears to be also abruptly observed in the responses of the money supply to the interest rate shocks but its effect fades away after a quarter.

The results are robust in a variety of additional empirical exercises, particularly alternative ordering specifications, and controlling the effects of the oil prices by splitting our sample into two groups of oil exporting and importing countries. The general effect is that the reordering of variables in the model tends to smooth the impulse response functions as they converge to zero. The interest rate plays a role in influencing ultimate goals variables, but its impulse is relatively short-lived to impact the output and inflation, which would require rapid adjustment of other variables carrying out shocks to the rest of the economy.

In chapter five, we estimate extended monetary policy reaction functions to evaluate to which variables central banks in emerging countries respond. This analysis provides insights into the factors influencing monetary policy decisions in emerging countries. Additionally, we compare how monetary policy performance in emerging countries differs from more developed economies. In this task, we use a dynamic panel data analysis to obtain cross-country coefficients.

The main findings suggest that central banks follow an expanded Taylor rule and respond to deviations from the target in inflation, output gap, external financial conditions and commodity prices. The findings show that central banks of the emerging countries in our sample have followed an anti-inflation monetary policy, in which the coefficient on inflation is significantly greater than the output gap. The results remained robust in the case where the lag of the explanatory variables is used.

The policy implication that comes from the empirical findings is that central banks in emerging countries must strike the right balance between competing objectives. This will ensure that the benefits outnumber the costs in the policy design. In this case, it might be prudent for central banks to ensure that real rates of return are maintained even when policy rates are rising, and yet importantly, the monetary policymakers should pursue a macroeconomic agenda for emerging markets economies.

This thesis confirms the possibly conflicting impacts of a specific monetary policy stance and raises the ultimate question: how can we determine the best trade-off in terms of efficient monetary policy effects? This could lay the groundwork for future study and provide a better understanding of how to design and implement efficient monetary policy.

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Appendix A: Appendices to chapter 3

A.1 Evolution of ECBI Index by country 2000–17

Source:Author's configuration

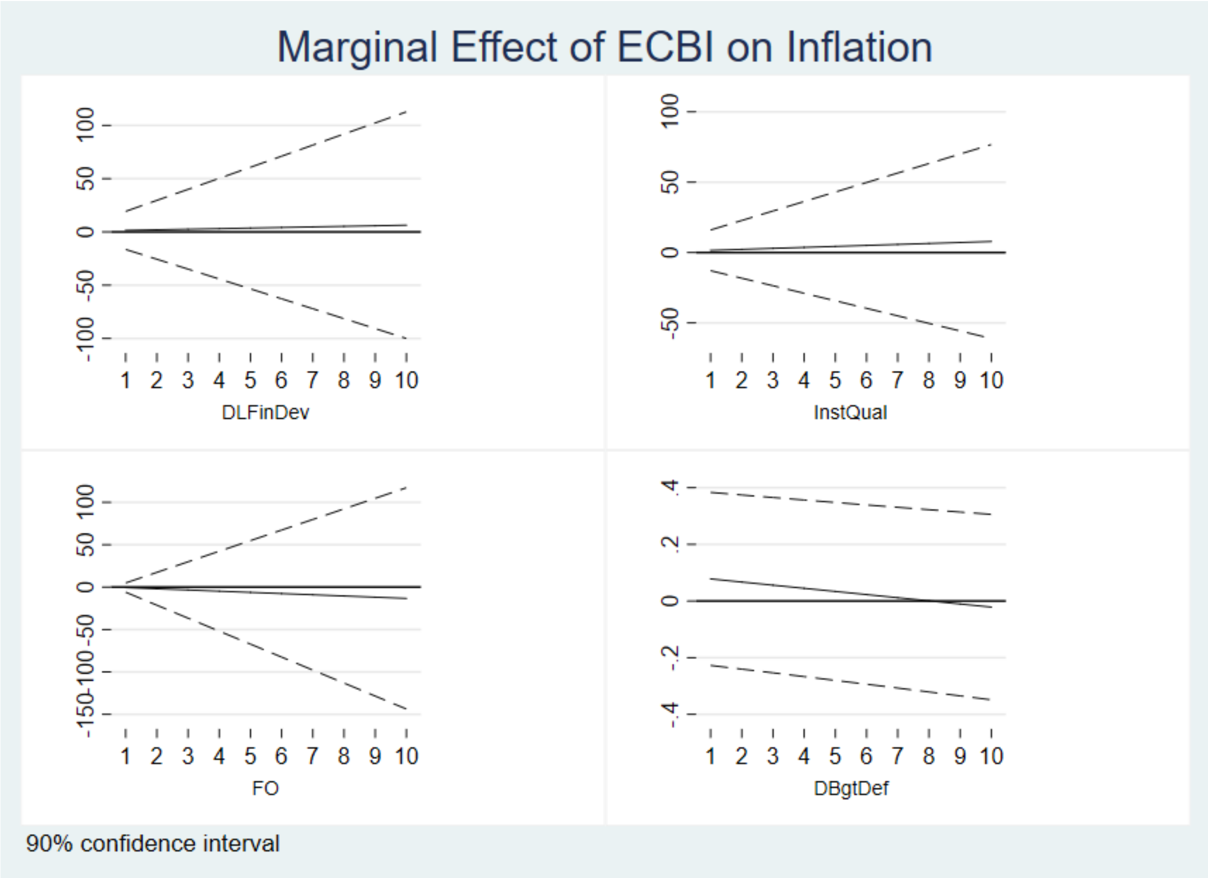
A.2 Correlation matrix of variables

	Inf	DLFinDev	InstQual	MSG	Int	DLTO	DLGDPC	DLER	ECBI	FO	DBgtDef
Inf	1.00										
DLFinDev	-0.05 (0.45)	1.00									
InstQual	-0.38*** (0.00)	-0.04 (0.52)	1.00								
MSG	0.40*** (0.00)	0.34*** (0.00)	-0.33*** (0.00)	1.00							
Int	0.30*** (0.00)	0.05 (0.42)	-0.27*** (0.00)	0.14* (0.02)	1.00						
DLTO	-0.00 (0.96)	0.04 (0.51)	0.06 (0.31)	0.08 (0.17)	0.00 (0.99)	1.00					
DLGDPC	-0.14* (0.03)	0.04 (0.46)	-0.14* (0.02)	0.28*** (0.00)	-0.11 (0.08)	0.21*** (0.00)	1.00				
DLER	0.07 (0.28)	0.08 (0.20)	-0.02 (0.72)	0.13* (0.03)	0.03 (0.63)	-0.25*** (0.00)	0.29*** (0.00)	1.00			
ECBI	0.12* (0.05)	0.10 (0.11)	-0.04 (0.51)	-0.05 (0.43)	0.11 (0.07)	-0.12* (0.05)	-0.04 (0.54)	0.09 (0.16)	1.00		
FO	-0.18** (0.00)	0.02 (0.79)	0.45*** (0.00)	-0.16* (0.01)	-0.05 (0.46)	0.09 (0.16)	-0.19** (0.00)	0.00 (0.97)	-0.13* (0.04)	1.00	
DBgtDef	-0.07 (0.25)	-0.12* (0.04)	0.01 (0.88)	0.11 (0.07)	-0.04 (0.53)	0.21*** (0.00)	0.32*** (0.00)	0.16** (0.01)	-0.04 (0.47)	-0.01 (0.89)	1.00

p-values in parentheses
$^{*}\ p < 0.05$, $^{**}\ p < 0.01$, $^{***}\ p < 0.001$

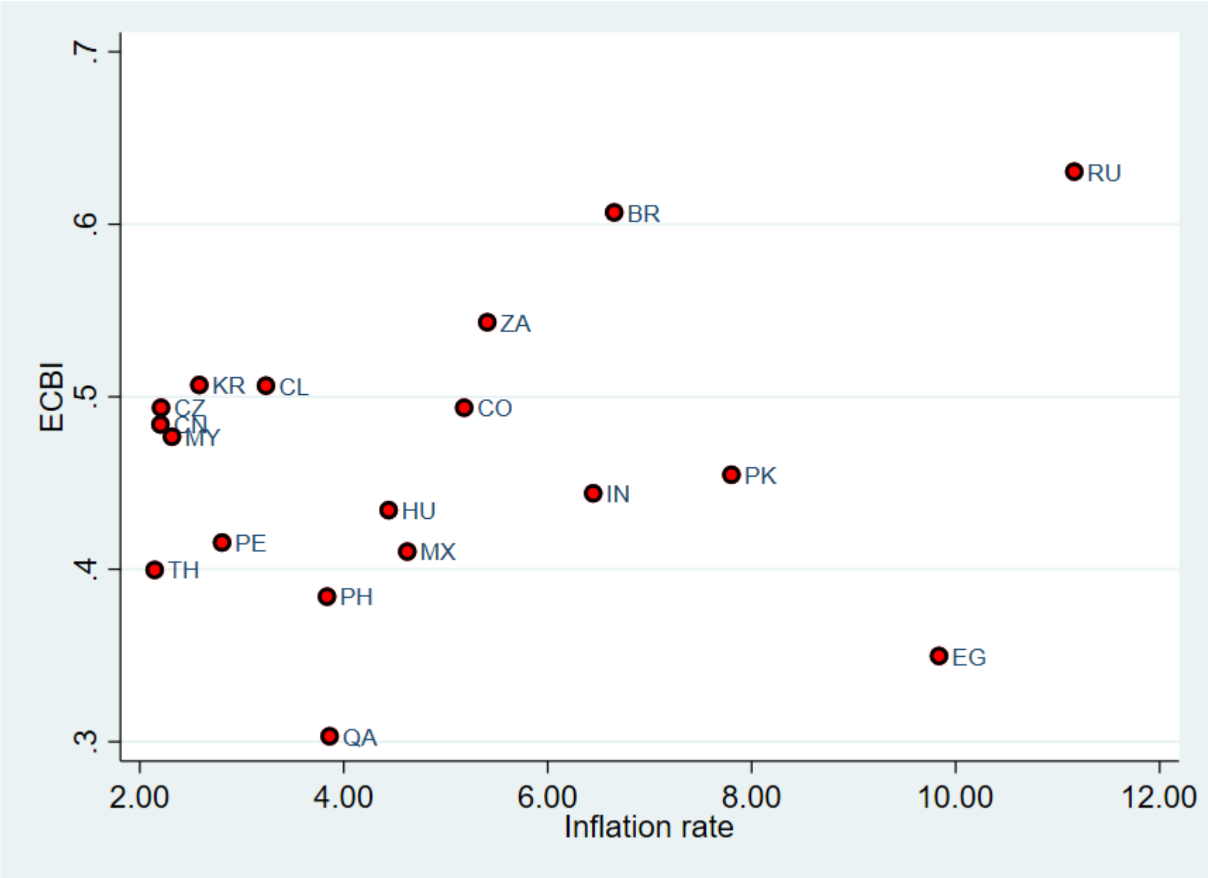
Source: Author's computation

A.3 Conditional joint effect of CBI on Inflation



Source:Author's configuration

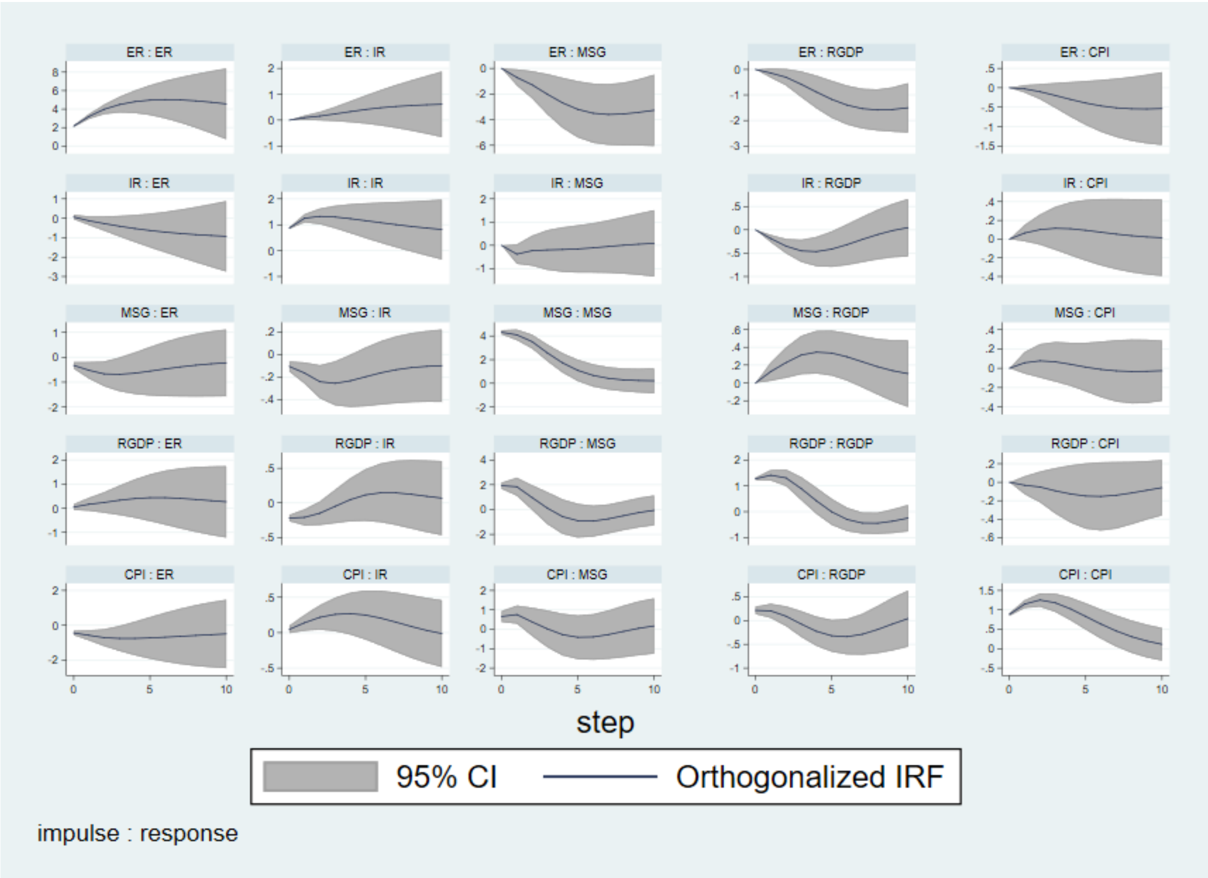
A.4 ECBI Index and Inflation 2000–17



Source:Author's configuration

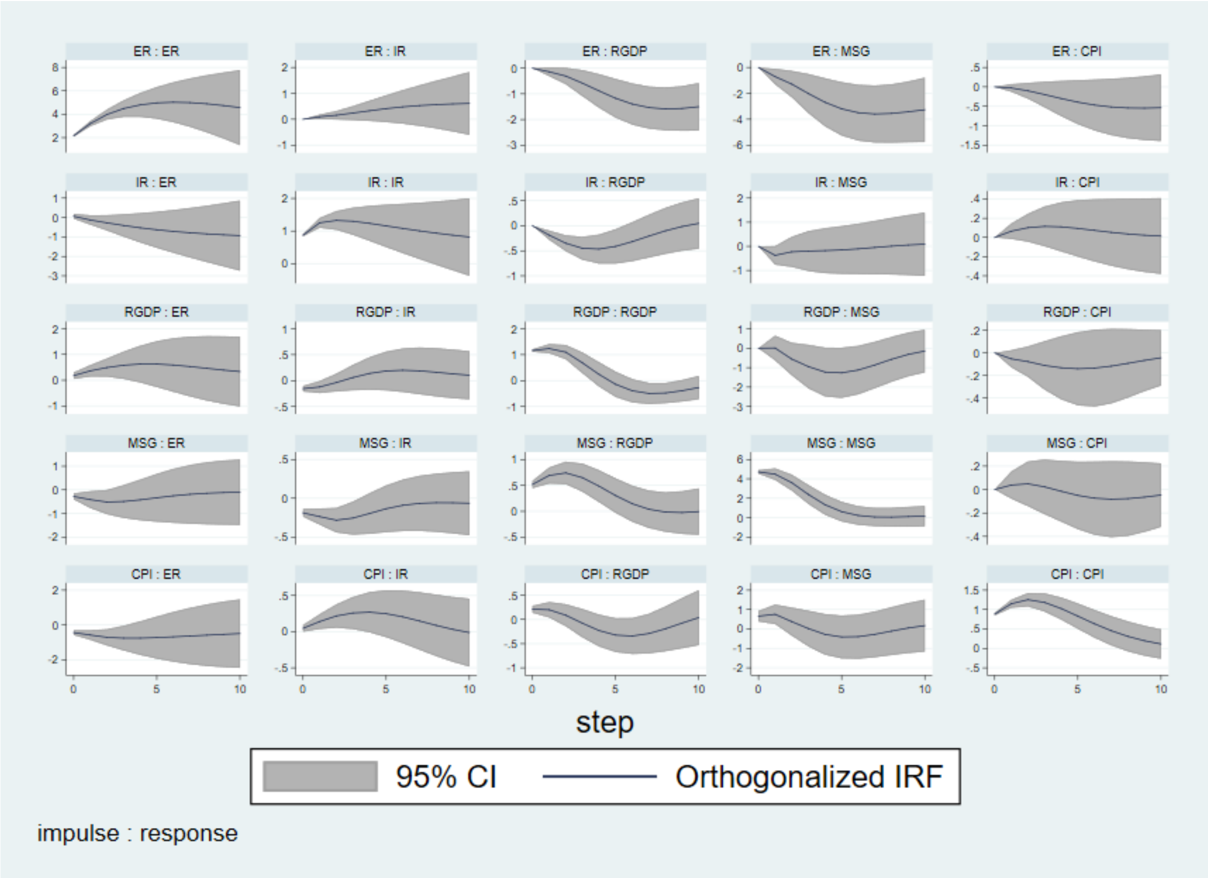
Appendix B: Appendices to chapter 4

B.1 Impulse response functions-baseline model



Source:Author's configuration

B.2 Impulse response functions-alternative model



Source:Author's configuration