

# Monetary policy in the context of Inflation Targeting Regime: An empirical analysis based on a VEC model

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**Abstract:** This article assesses the performance of the Inflation Targeting Regime (ITR) for six countries during the period 1990-2020. Empirically, this article was based on the vector error correction model (VEC). The results indicate that the ITR was not able to generate the expected outcomes in most of the analyzed countries. In this regard, the diversity of the observed results was due to the structural and institutional specificities of each country, but also because of the limits of the theoretical framework on which the ITR is based.

**Key-words:** Inflation Target Regime; Monetary Policy; VEC Model.

**Código JEL:** E42; E52; E58

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## 1. Introduction

As is well known, the Inflation Targeting Regime (ITR) has been adopted as a monetary policy framework by a significant number of countries in recent decades. It also has been an important instrument for policymakers and central banks. This Regime has been incorporated into the theoretical framework of mainstream economic models, more specifically those related to the New Consensus Macroeconomics (NCM), which is based on three main equations: IS Curve, Phillips Curve and Taylor rule.<sup>5</sup>

In Brazil, several economists (ARESTIS, FERRARI-FILHO and PAULA, 2011; MODENESI and ARAUJO, 2013; ROCHA and OREIRO, 2008) have criticized the *modus operandi* of the ITR, that is, whether there is a causal relationship between the basic interest rate, Selic, and inflation, such that positive changes in the interest rate tend to stabilize the price level.

This article aims at assessing the performance of the ITR for six countries – Brazil, Canada, Chile, United Kingdom, Mexico, and New Zealand, whose selection criteria will be explained in Section 2 –, during the period 1990-2020. In line with this main objective, empirical analysis is based on the estimation of a Vector Error Correction (VEC) model. The idea is to show that the ITR was unable to obtain the results expected by policymakers in most of the analyzed countries. According to the main results, the argument is that the diversity of developments related to monetary policy based on the ITR involves the institutional specificities of each country and the limits of the theoretical framework on which such regimes are based.

In addition to this introduction, this article is composed of three additional sections. Section 2 presents the institutional aspects of ITR for each of the six selected countries. Section 3 estimates a VEC model to analyze the effects of monetary policy in the six countries that adopt ITR and discusses the main results. Section 4 concludes.

## 2. Institutional aspects of the ITR for all selected countries

Based on the methodology developed by Farhi (2007) and Hammond (2012), this section presents the main institutional aspects of the ITR for the following countries: Brazil, Canada, Chile, United Kingdom, Mexico, and New Zealand. The sample was based on three main criteria: (i) the inclusion of advanced (Canada, United Kingdom, and New Zealand) and emerging (Brazil, Chile, and Mexico) economies with the aim of analyzing different economic and institutional features; (ii) the time of longevity of ITR adoption (Canada, Chile, United Kingdom, and New Zealand, in the beginning of the 1990s, and Brazil and Mexico in 1999 and 2001, respectively); and (iii) the inclusion of Latin American countries with similar inflation histories (Brazil, Chile, and Mexico).

Farhi (2007), for example, compares Brazil with six other countries (South Africa, Chile, South Korea, Mexico, Thailand, and Turkey) to show that given the main characteristics of the ITRs adopted in each of the selected countries, the most important aspect of the ITR for all analyzed countries is the pass-through exchange rate volatility to prices. According to her arguments, the greater the pass-through mechanism the greater the impact of the exchange rate on prices and interest rates. Based on this finding, the author concludes that the different institutional arrangements of the ITR have a direct influence on the performance of the monetary policy.

Hammond (2012) analyzes the institutional aspects of 27 countries that adopted the ITR. He emphasizes, among others, the horizon for target convergence, the target level, and the forecasting model adopted by each central bank. The author's main conclusion is that ITR has been successful in most countries that have adopted it in the last 20 years.

Table 1 presents the main ITR aspects and inflation rate for each selected country at the end of 2020.

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<sup>5</sup>For additional details, see Carlin and Soskice (2006).

**Table 1. The key aspects of ITR in all selected countries**

Country and date of adoption of the ITR	Monetary authority	Institutionality	Index of inflation core	Target horizon	Monetary Policy instrument	Target and band/2020	Annual inflation/ 2020
Brazil/June 1999	Central Bank of Brazil (CBB)	Target set by Government and CBB	CPIA	Yearly target	Selic (overnight)	4.0%, tolerance interval +/- 1.5 p.p.	4.52%
Canada/February 1991	Bank of Canada (BC)	Target set by Government and BC	CPI	Every 5 years	Interest rate (overnight)	2.0% tolerance Interval +/- 1.0% p.p.	2.35%
Chile/September 1990	Central Bank of Chile (CBC)	CBC	CPI	Every 2 years	Interbank rate (overnight)	3.0%, tolerance Interval +/- 1.0% p.p.	2.97%
United Kingdom/January 1992	Bank of England	Government	CPI	Every Moment	Interbank rate	2.0%	0.83%
Mexico/January 2001	Bank of Mexico (BMEX)	Members' board (5 members)	CPI	3 years	Interbank rate (overnight)	3.0% tolerance Interval +/- 1.0% p.p.	3.15%
New Zealand/January 1990	Reserve Bank of New Zealand (RBNZ)	RBNZ and Minister of Finance	CPI	3 years	Official cash rate	Betewwen 1.0% and 3.0%	2.0%

Source: Farhi (2007), Hammond (2012), CBB (2022), BC (2022), CBC (2022), Bank of England (2022), BMEX (2022) and RBNZ (2022).

Based on Table 1, the relevant characteristics for defining the ITR are as follows: (i) central bank independence and monetary policy autonomy; (ii) official inflation index; (iii) time horizon for convergence to the inflation target and inflation target with its tolerance intervals; and (iv) monetary policy instrument used by the Monetary Authority.

The first consideration to be highlighted is the independence of the central bank. All the selected countries have independent central banks. This means that all central banks have complete autonomy in defining their inflation targets. Moreover, all countries analyzed in our sample guarantee the central bank's operational autonomy, which indicates that the implementation of monetary policy avoids the well-known inflationary bias.

The second consideration concerns the inflation index. All countries use the full Consumer Price Index (CPI).

The third consideration relates to the definition of inflation target. This aspect is known as ITR accountability. All selected countries, as shown in Table 1, define an inflation point target and have a tolerance band.

Finally, considering that the central banks of countries that adopt ITR have operational independence, they are free to choose the instruments necessary to reach a previously established inflation target. In our sample, the monetary policy used by central banks is generally overnight and the interbank rate.

To conclude this section, one additional observation, when comparing inflation in each country at the end of 2020, is that with the exception of Brazil and United Kingdom, whose annual inflation rates were 4.52% and 0.83%, respectively, all other countries in the sample had inflation rates between 2.0% and 3.0%. Moreover, at the end of 2020, due to the COVID-19 crisis, the nominal interest rates dropped substantially, and the real interest rates in these countries were very low or even negative.

### 3. An empirical analysis of the efficiency of the ITR

The purpose of this section is to assess the efficiency of the ITR. To this end, a VEC was estimated for each selected country, inspired by Modenesi and Araujo (2013) and Fonseca, Peres, and Araujo (2016).

It was decided to estimate a VEC model for each country, rather than estimating a panel model or even a joint regression, as this had not been previously done in the empirical literature and the results would be more transparent for each country. Although other models may have advantages over the VEC model, they do not allow for separate analysis for each selected country, particularly in terms of building a cross-country comparison, which is the focus of this section

### ***3.1. Methodology***

Considering that in our sample, some countries implemented the ITR in the 1990s and others in the 2000s, for comparative purposes, the number of observations (months) for the model estimation took into account the beginning of the ITR adoption period in each of the selected countries. For example, in 1990, New Zealand was the first country to adopt the ITR and, as a result, the number of observations reached 360 months; in our sample, the last country to adopt the ITR was Mexico in 2001, and therefore, the number of observations in the estimated model is 240 months. Even with the data discrepancy, countries present appropriate observations for estimating the VEC model, as argued by Wooldridge (2002).

Due to the difference in the data collected for each central bank, we sought to maintain a minimum standard in the data, with the objective of obtaining results that are compatible with the traditional theory. In all analyzed cases, the included variables are: interest rate (the effective interest rate of each country), CPI (monthly rate of change of price indices for each country), GPD (industrial index of physical production, as a proxy for economic activity), and exchange rate (nominal exchange rate, monthly average). The interest rate was chosen as the exogenous variable because it is the main instrument for managing the ITR. It is important to mention that the exchange rate was selected as the most endogenous variable because through the expectations channel, all other variables can affect it simultaneously.

Finally, on the one hand, based on economic literature and reinforced by Granger causality tests (GRANGER, 1980), the price index precedes the activity proxy. On the other hand, the choice of variables was partly based on the previously mentioned empirical literature (MODENESI and ARAUJO, 2013; FONSECA, PERES and ARAUJO, 2016; FONSECA, OREIRO and ARAUJO, 2018).

Once the series were properly treated, we sought to assess whether the variables in question followed a stationary stochastic pattern, thus carrying out three unit root tests for each series of data extracted from each country to show the order of statistically significant integration of each variable. The unit root tests performed were those of Phillips-Perron – PP (1988), Augmented Dickey-Fuller (ADF) (1979, 1981), and Kwiatkowski-Phillips-Schmidt-Shin – KPSS (1992). The null hypothesis of the tests is that the analyzed series are non-stationary, with the exception of the KPSS test, whose null hypothesis is that the variable is stationary. The presence of constant, constant and trend or no constant and no trend were included in the tests for each variable to perform the tests as completely as possible. Considering all the tests performed, the variables of each country were integrated of order one (non-stationary).

### ***3.2. VEC Model: Estimation and results***

After analyzing each variable, Johansen's cointegration tests (JOHANSEN, 1988) were carried out in a summarized form to verify whether the linear combination of variables for each country is stationary, thus indicating that there is a long-term relationship between them. Table 2 shows the results of the cointegration tests for all analyzed countries.

**Table2. Johansen's cointegration test for all selected countries**

Country	Cointegration numbers	Trace Statistics			Maximum Value Statistics		
		Observed	Critical Value 5%	P-Value	Observed	Critical Value 5%	P-Value
Brazil	R = 0	<b>79.72953</b>	<b>63.87610</b>	<b>0.00130</b>	<b>37.28362</b>	<b>32.11832</b>	<b>0.01070</b>
	R ≤ 1	42.44591	42.91525	0.05570	22.34217	25.82321	0.13500
Canada	R = 0	<b>68.84509</b>	<b>63.87610</b>	<b>0.01800</b>	<b>34.79019</b>	<b>32.11832</b>	<b>0.02300</b>
	R ≤ 1	34.05490	42.91525	0.28600	21.69159	25.82321	0.16010
Chile	R = 0	<b>82.64894</b>	<b>63.87610</b>	<b>0.00060</b>	<b>39.83874</b>	<b>32.11832</b>	<b>0.00470</b>
	R ≤ 1	42.81020	42.91525	0.05120	23.44005	25.82321	0.10000
United Kingdom	R = 0	<b>59.61414</b>	<b>54.07904</b>	<b>0.01480</b>	<b>31.03873</b>	<b>28.58808</b>	<b>0.02380</b>
	R ≤ 1	28.57541	35.19275	0.21650	16.18293	22.29962	0.28540
Mexico	R = 0	<b>73.06819</b>	<b>63.87610</b>	<b>0.00690</b>	<b>46.13881</b>	<b>32.11832</b>	<b>0.00050</b>
	R ≤ 1	26.92938	42.91525	0.68520	12.60333	25.82321	0.83280
New Zealand	R = 0	<b>80.57023</b>	<b>63.87610</b>	<b>0.00110</b>	<b>43.58381</b>	<b>32.11832</b>	<b>0.00130</b>
	R ≤ 1	36.98642	42.91525	0.17260	18.99970	25.82321	0.30530

Source: Software Eviews 9. Elaborated by the authors.

The null hypothesis of the test is that there is no cointegration relationship between variables. Thus, the tests show that all countries reject the null hypothesis at a significance level of five percent, both for the trace statistics and the maximum value statistics, thus indicating the existence of at least one cointegration vector for each country. Therefore, comparative estimates are made with the adoption of the VEC model, starting with the number of lags to be included in the model for each country, using selection tests of the system of Autoregressive Vector equations (VAR).

However, the results obtained were heterogeneous. Most tests point to the ideal of a maximum of one, two, or three lags for each country, but there are results that point to a greater number of lags, as are the cases of four lags for Canada and United Kingdom, five for Brazil, Canada, and New Zealand, seven for Mexico and eight for Chile and United Kingdom.

In addition to Johansen's cointegration test, a test of the inverse roots of the characteristic polynomial of each country was performed. The results were significant, indicating that the estimated VEC models were stable and empirically robust. Therefore, we estimate the following models for each country, as shown in Table 3.

**Table 3. The number of lags used in the model**

Country	Lag
Brasil	19
Canada	17
Chile	26
United Kingdom	8
Mexico	14
New Zealand	21

Source: Software Eviews 9. Elaborated by the authors.

Table 3 presents the following considerations. The first is the high number of lags in developed countries, such as Canada and New Zealand. This option for high numbers of lags did not occur randomly, but rather, respecting the model's estimation, so that the residuals remained well behaved. The second point concerns the problem of overparameterization, that is, a situation in which the number of estimated parameters exceeds the number of observations. Except for Canada, Chile, and United Kingdom, the other countries had overparameterization problems. However, this is not especially serious since the purpose of the analysis is to compare the behavior and effectiveness of monetary policy under the ITR.

The next step is to present the results of the Granger causality tests for the block variables, which are often used to assess whether a given variable causes another variable in the Granger sense. The lag selection for this test was based on the Akaike (1974) or Schwarz (1978) information criterion, which always adopts the smallest possible lag between the two criteria. The results are presented in Table 4, which shows only the relationships that reject the null hypothesis of absence of Granger causality at five percent.

**Table 4. Granger causality test for all selected countries**

Country	Lags	Variable	Cause
Brazil	19	CPI	Interest Rate
		Interest Rate	CPI
		Exchange Rate	Interest Rate, CPI
Canada	17	Interest Rate	CPI
		GDP	Interest Rate, CPI
		CPI	Interest Rate
Chile	26	CPI	Interest Rate, GDP
		GDP	Interest Rate
		Interest Rate	CPI
		Exchange Rate	CPI
United Kingdom	8	CPI	Interest Rate
		Interest Rate	CPI
		GDP	Exchange Rate
Mexico	14	Exchange Rate	CPI
		CPI	Exchange Rate
New Zealand	21	Interest Rate	GDP
		GDP	CPI
		CPI	GDP
		Exchange Rate	CPI, GDP

Source: Software Eviews 9. Elaborated by the authors.

Table 4 shows the following: (i) in general, the interest rate helps to predict the CPI – that is, the test specifically shows that there is a causal relationship between interest rates and price levels; and (ii) there is a relationship between exchange rate and CPI as the exchange rate can influence the price level via pass-through.

After presenting the Granger test for all countries, we sought to highlight the cointegration vectors for each country analyzed, as shown in Table 5.

**Table 5. Cointegration Vector for all selected countries\***

Country	Normalized Conitegration Vector				
	Interest Rate (-1)	C	CPI (-1)	GDP (-1)	Exchange Rate (-1)
Brazil	1	281,5987	23,2512	-3,76927	-49,5106
	-		(-5.20223)	(-2.28423)	(-32.2158)
	-		[ 4.46946]	[-1.65013]	[-1.53684]
Canada	1	25,19396	-0,545385	0,41673	-5,260013
	-		(-0,6794)	(-0,22973)	(-2,15763)
	-		[-0.80275]	[ 1.81397]	[-2.43786]
Chile	1	-70,30597	-0,598174	0,909348	0,053018
	-		(-0,13163)	(-0,16672)	(-0,0098)
	-		[-4.54435]	[ 5.45444]	[ 5.40874]
United Kingdom	1	-6,915729	0,195852	-0,035269	-1,746418
	-		(-0,05517)	(-0,09025)	(-3,98381)
	-		[ 3.54997]	[-0.39080]	[-0.43838]
Mexico	1	53,47355	-0,357214	-0,39711	-0,955887
	-		(-0,17164)	(-0,09158)	(-0,19452)
	-		[-2.08122]	[-4.33629]	[-4.91404]
New Zealand	1	-121,3388	1,910818	0,40812	-44,20857
	-		(-0,38771)	(-0,14245)	(-6,46279)
	-		[ 4,92845]	[ 2,86497]	[-6,84048]

Source: Software Eviews 9. Elaborated by the authors.

(\*)Standard deviation in parentheses and t-statistic in brackets.

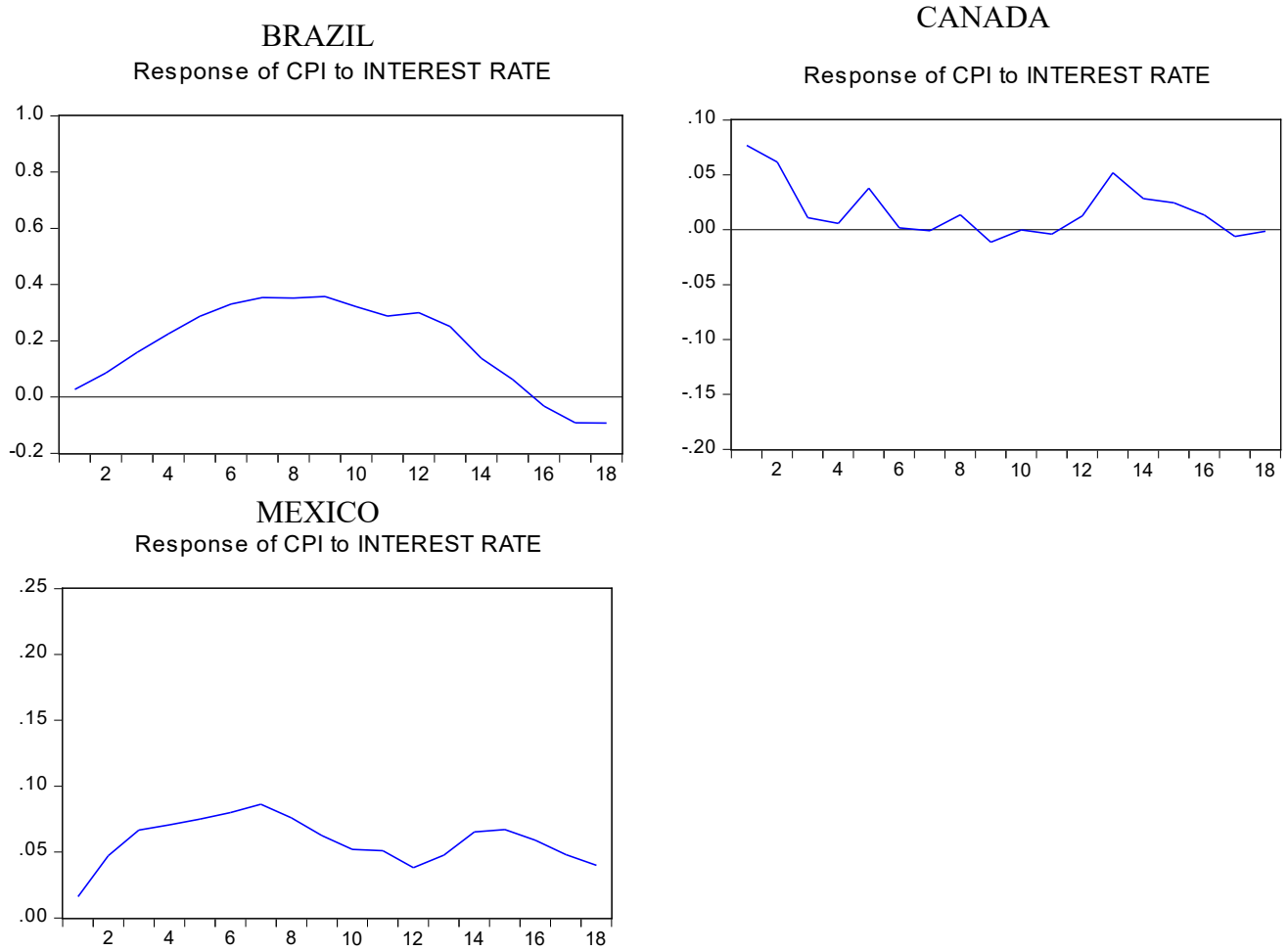
Based on Table 5, it is possible to interpret the cointegration equations as a reaction function of each central bank in each country in the long run. The equations were normalized for the variable of interest, which could compromise the interpretation of the magnitude of the estimated coefficients for each country. However, what matters for our analysis is that the interest rate is an endogenous variable and depends directly and positively on three other variables: CPI, GDP, and exchange rate. In summary, the signs of the parameters of the equations are consistent with the obtained results.

### **3.3. The ITR performance: A comparative analysis of the selected countries**

This subsection aims to verify the effectiveness of the monetary policy in countries that adopt the ITR, in the sense of how the management of the interest rate affects the price level. To this end, we analyze the responses of the CPI variable to a positive shock (Generalized One Standard Deviation Innovations) on the interest rate, using impulse response function (IRF).

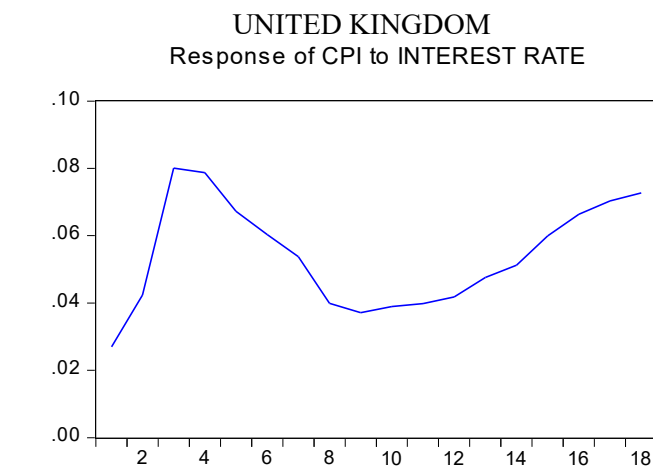
In each country, an increase of the interest rate receives a positive response of the price level. For comparative purposes, Figures 1-3 present the results of the countries in which the price level responds partially, moderately and explosively, respectively, when the interest rate increases.

**Figure 1. IRF for countries where the price level responds partially when the interest rate increases**



Source: Software Eviews 9. Elaborated by the authors.

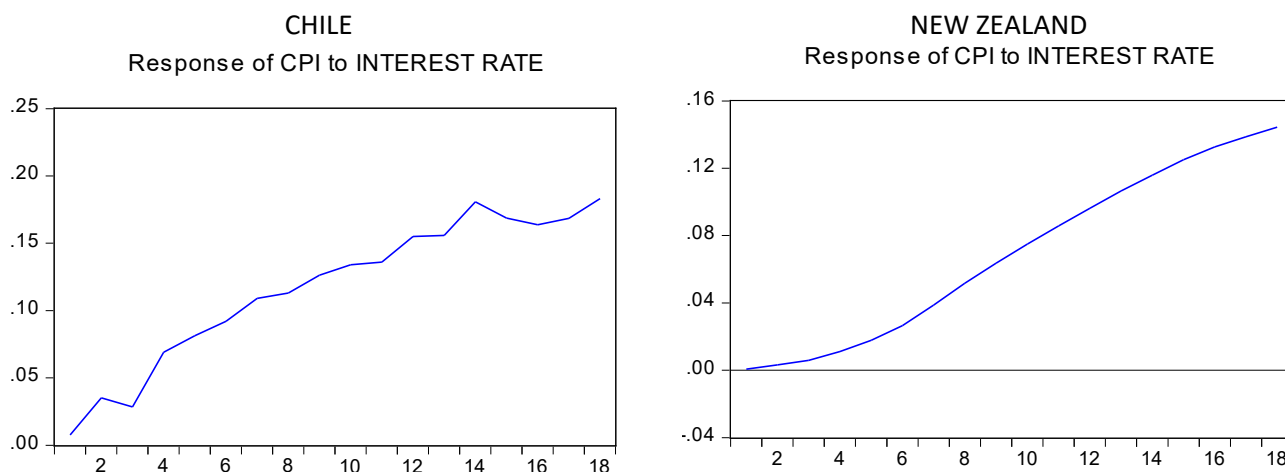
**Figure 2. IRF for countries where the price level responds with a moderate increase when the interest rate increases**



Source: Software Eviews 9. Elaborated by the authors.



**Figure 3. IRF for countries where the pricelevel responds explosively when the interest rate increases**



Source: Software Eviews 9. Elaborated by the authors.

The results for Brazil, Canada, and Chile show that the price response to a restrictive monetary policy (increase in interest rates) is neutral or very volatile in the first periods, entering a declining and negative trajectory only in period 11 in Chile and 16 in Canada. In Brazil, the response to a contractionary monetary policy is followed by an initial rise in inflation, with a decreasing trajectory; that is, inflation subsides only after nine periods for Brazil.

This phenomenon is known in the literature as price-puzzle, a term coined by Eichenbaum (1992). This positive correlation, at least initially, between inflation and the interest rate, has been the object of constant academic debate since the empirical reality does not match the theory proposed by the ITR.<sup>6</sup>

Moreover, there are cases in which the IRF gave results that are counterintuitive to what is expected from a restrictive monetary policy. These results were expected given the complexity of a comparative empirical exercise in which there are intrinsic differences in each country, which are beyond the analysis proposed here. In Chile, the effect of a restrictive monetary policy is a permanent increase in inflation, while in New Zealand the effect is a huge increase in inflation.

Chile, New Zealand and the United Kingdom registered very low inflation rates during almost the entire period and the increase in inflation in the last years of the sample was followed by increases in interest rates, which explains the positive relationship between inflation and interest rates.

In the case of Canada, although the relationship between interest and inflation is economically significant, due to the negative relationship between the two variables, the coefficient of interest was not significant in the long-term function and in the IRF, which cuts the zero axis at few moments. Perhaps the low variability of interest rates in Canada is an explanation for this, as for almost 10 years interest rates have not changed in the country.

In the case of Mexico and Brazil, interest rates and inflation are higher and more volatile and, therefore, despite the price puzzle (Walsh, 2003: Chapter 1), the expected negative relationship between interest and inflation is confirmed.

Although this subsection has explored only the price level responds to the interest rate, the other IRFs, such as interest rate to exchange rate, CPI to interest rate, CPI to exchange rate, GDP to interest rate, GDP to exchange rate and exchange rate to interest rate, to all countries, are shown in the Appendix.

The analysis of the empirical results presented indicates that the ITR, by itself, does not seem to be an efficient regime to guarantee price stability in the analyzed economies. This is because, in developed countries that adopt ITR and have low interest rates and inflation, the relationship between inflation and interest was not economically significant in the estimated models. In developing countries, Brazil and Mexico, despite the negative effects of interest rate shocks on inflation, the inflation rate was

<sup>6</sup>For additional details, see Sims (1992), Eichenbaum (1992), Hanson (2004), Giordani (2004), Modenesi and Araujo (2013) and Fonseca, Peres and Araujo (2016).

higher than most developed and developing economies. It should also be noted that the trajectory of the product, in these two countries, exhibited lower growth than that of the world economy, most of the time.

#### 4. Conclusions

This article presents a comparative analysis of six countries that adopted the ITR, evaluating the efficiency of such a regime for the period 1990-2020. From an empirical point of view, this contribution is based on the estimation of the VEC models. The results obtained in the sample of the analyzed countries indicated that in some countries, the ITR was not completely successful in reducing and stabilizing the inflationary process. Looking specifically to the Brazilian case, it is notable that over the period 1999–2020, the targets were missed in 2001, 2002, 2003, 2004, 2015 and 2020, while in 16 years, the inflation rate rates were greater than the inflation targets set by the CBB. From our point of view, this finding must be associated with both the structural and institutional specificities of each country and the limits of the theoretical framework on which ITRs are based.

Finally, the contributions of the article to the empirical literature related to the analysis of ITR are as follows: (i) the institutional aspects of the ITR for all selected countries of the sample are able to explain the main results; and (ii) it presented a diverse sample, both temporally and geographically that covered both periods of prosperity and economic recession.

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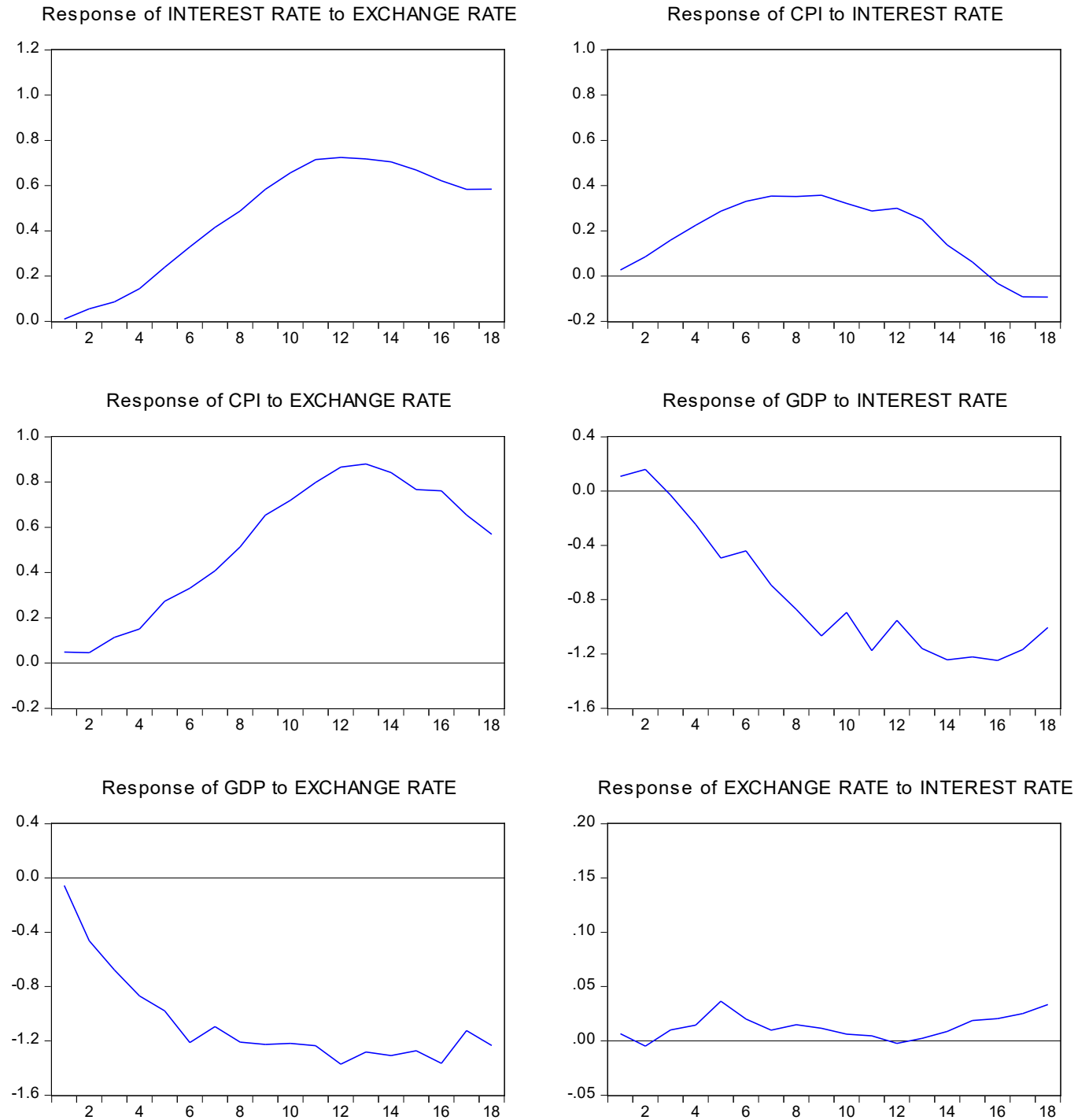
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# Appendix

## Figure 4. IRF to Brazil

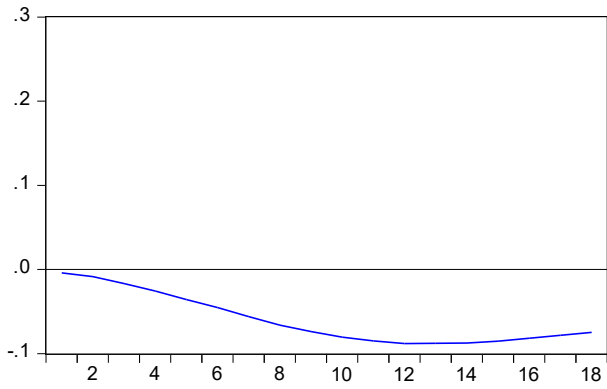
Response to Generalized One S.D. Innovations



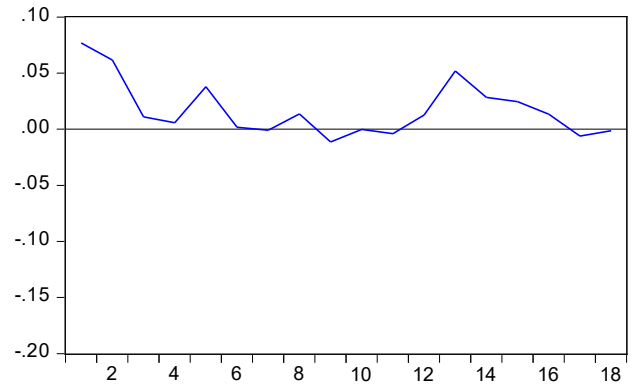
**Figure 5. IRF to Canada**

Response to Generalized One S.D. Innovations

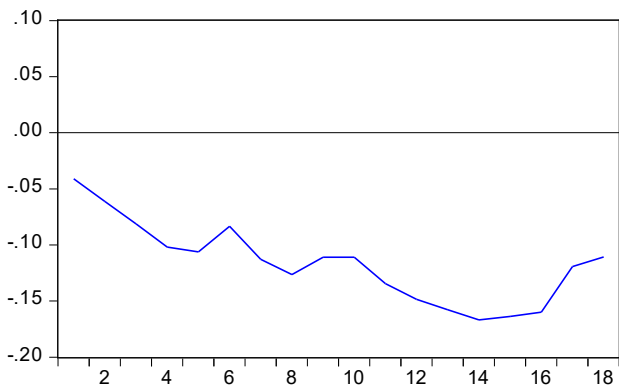
Response of INTEREST RATE to EXCHANGE RATE



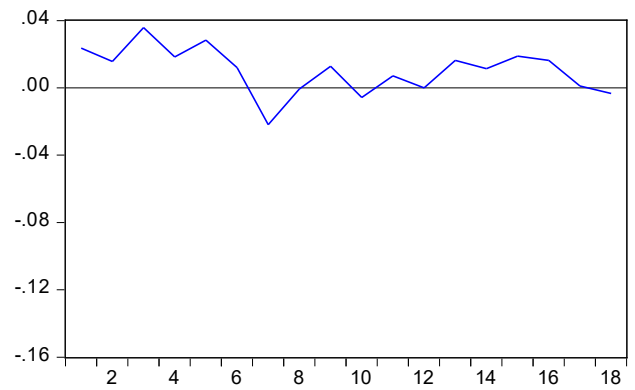
Response of CPI to INTEREST RATE



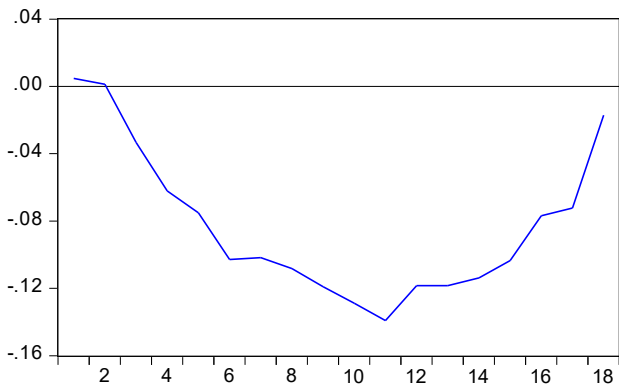
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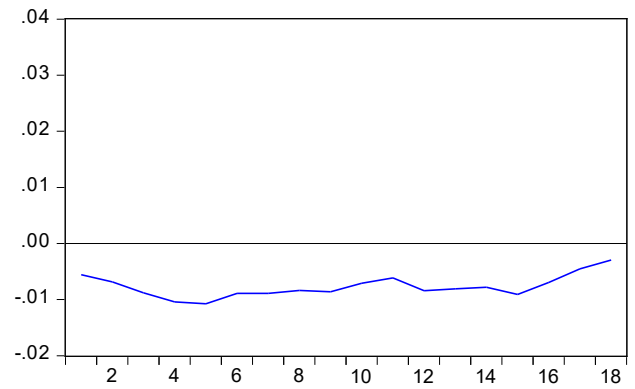
Response of GDP to INTEREST RATE



Response of GDP to EXCHANGE RATE



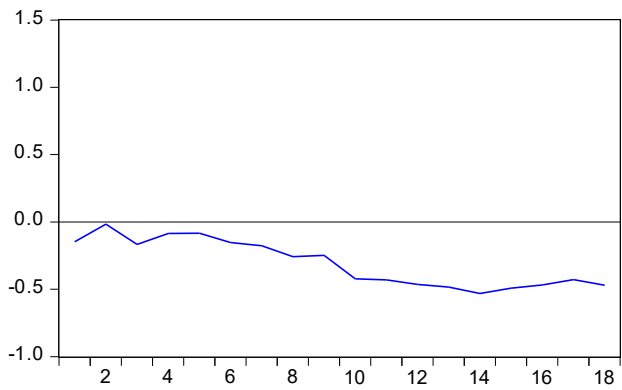
Response of EXCHANGE RATE to INTEREST RATE



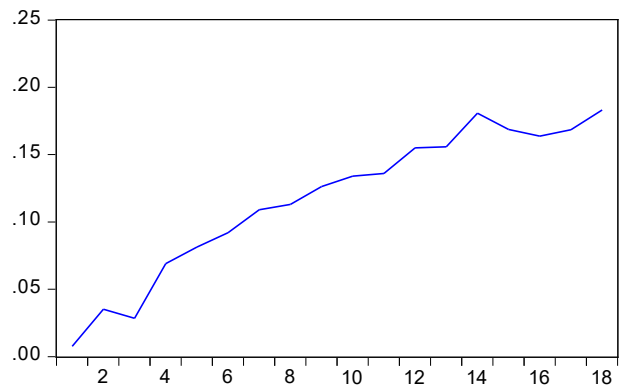
**Figure 6. IRF to Chile**

Response to Generalized One S.D. Innovations

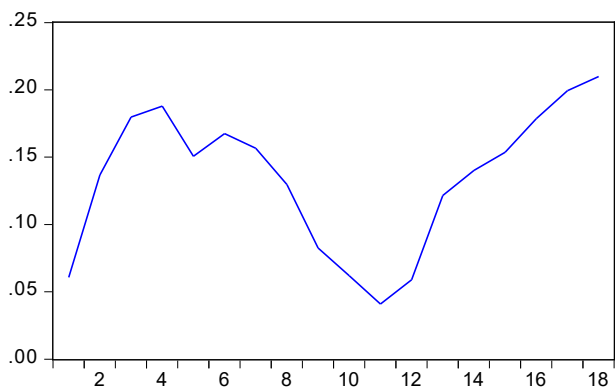
Response of INTEREST RATE to EXCHANGE RATE



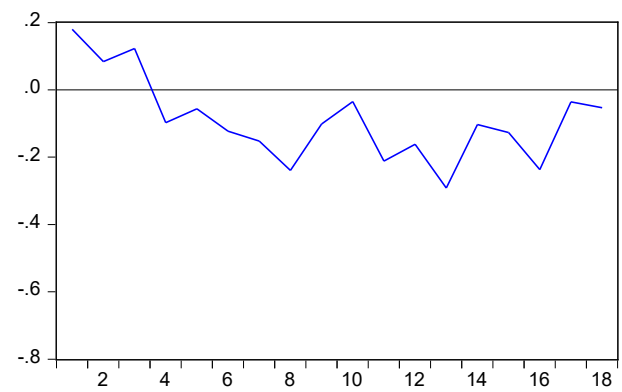
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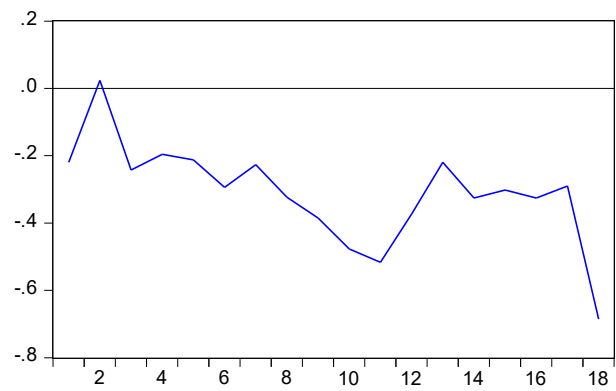
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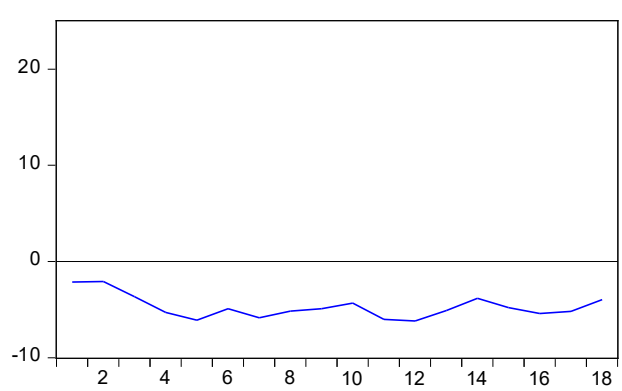
Response of GDP to INTEREST RATE



Response of GDP to EXCHANGE RATE



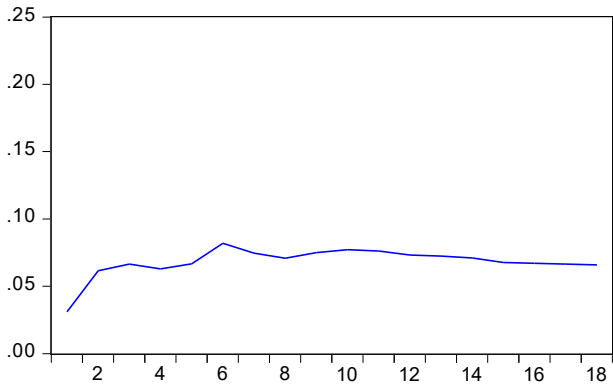
Response of EXCHANGE RATE to INTEREST RATE



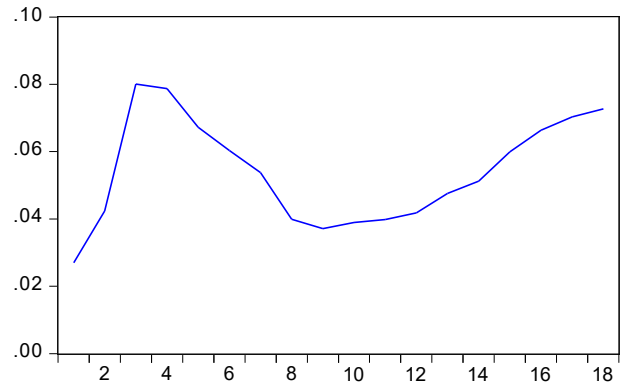
# Figure 7. IRF to United Kingdom

Response to Generalized One S.D. Innovations

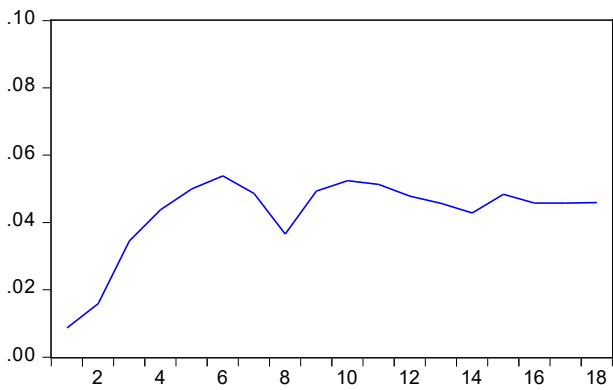
Response of INTEREST RATE to EXCHANGE RATE



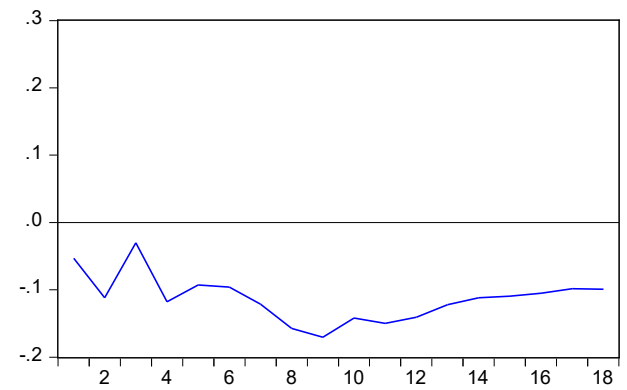
Response of CPI to INTEREST RATE



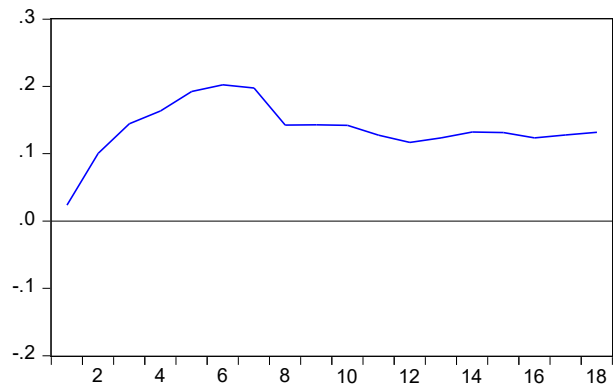
Response of CPI to EXCHANGE RATE



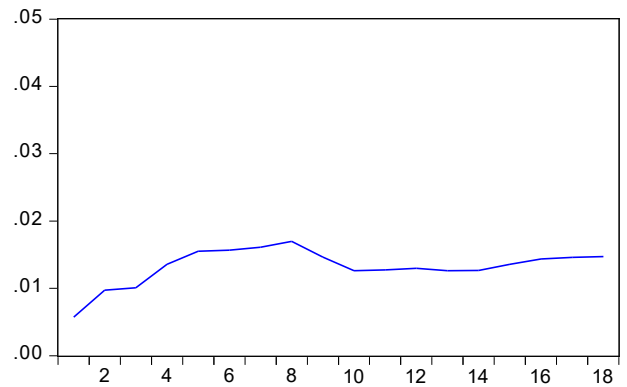
Response of GDP to INTEREST RATE



Response of GDP to EXCHANGE RATE



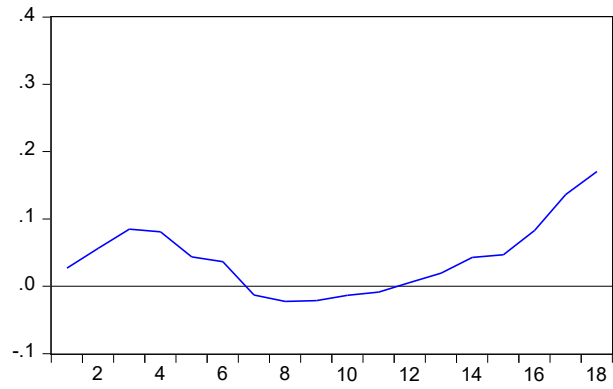
Response of EXCHANGE RATE to INTEREST RATE



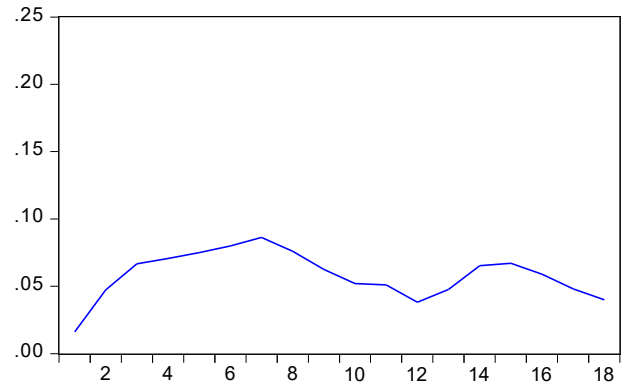
**Figure 8. IRF to Mexico**

Response to Generalized One S.D. Innovations

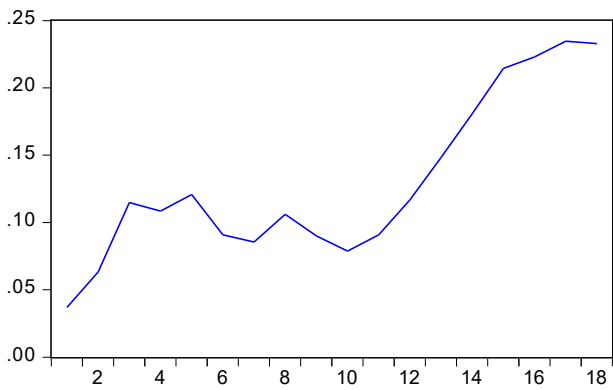
Response of INTEREST RATE to EXCHANGE RATE



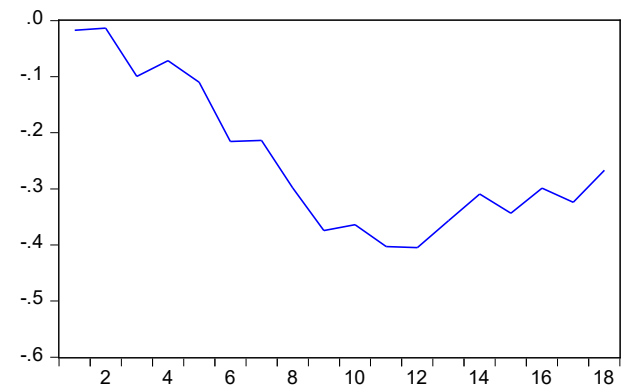
Response of CPI to INTEREST RATE



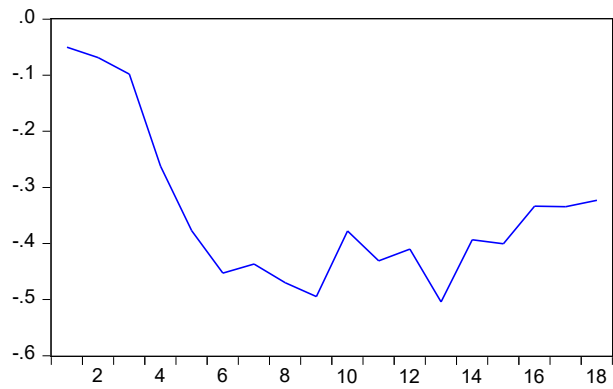
Response of CPI to EXCHANGE RATE



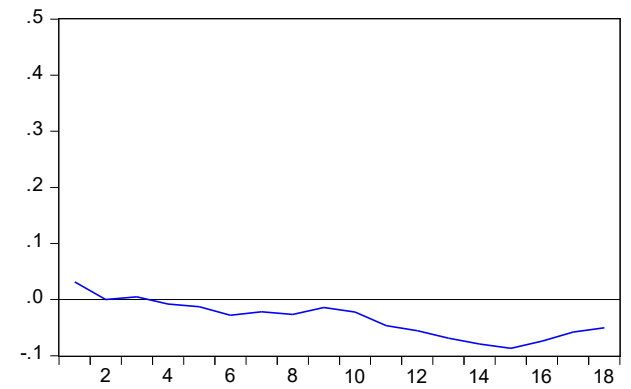
Response of GDP to INTEREST RATE



Response of GDP to EXCHANGE RATE



Response of EXCHANGE RATE to INTEREST RATE

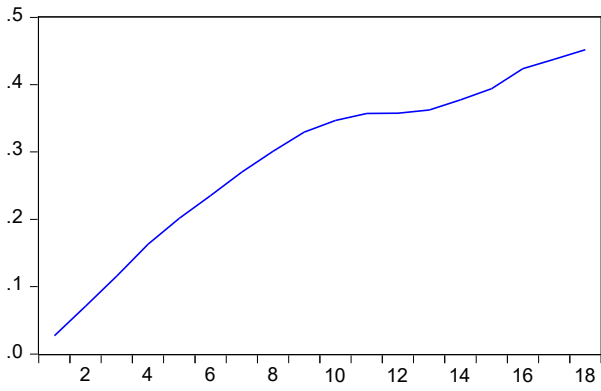




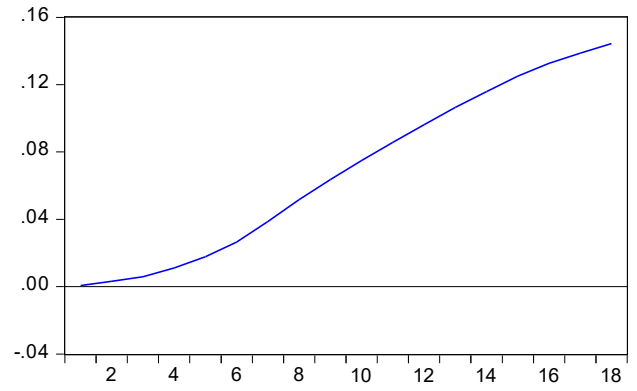
# Figure 9. IRF to New Zealand

Response to Generalized One S.D. Innovations

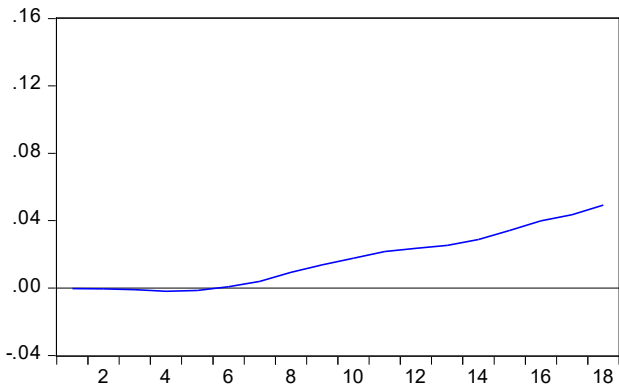
Response of INTEREST RATE to EXCHANGE RATE



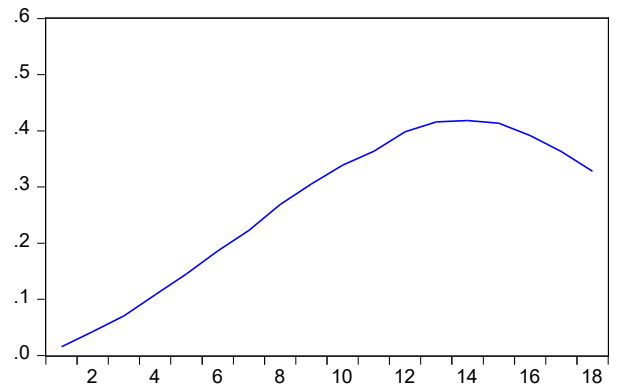
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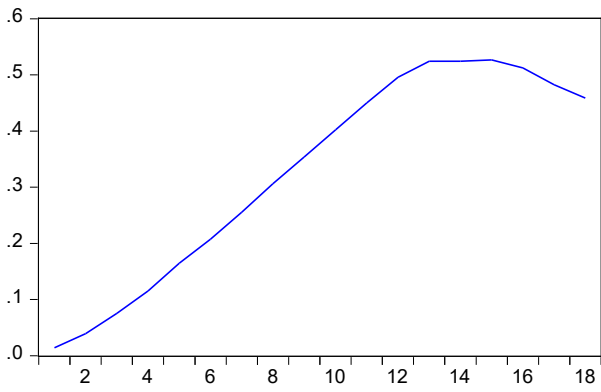
Response of CPI to EXCHANGE RATE



Response of GDP to INTEREST RATE



Response of GDP to EXCHANGE RATE



Response of EXCHANGE RATE to INTEREST RATE

