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Central banking during the global financial crisis
The case of Mexico

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Preface

I am thankful to all people who have supported me in this project with their advice, comment and suggestions. My supervisor Yuliya Rychalovska and my tutor Stéphanie Weynants have supported me with guidance, expertise and encouragement. All the mistakes and limitations in this project, are entirely of my responsibility.

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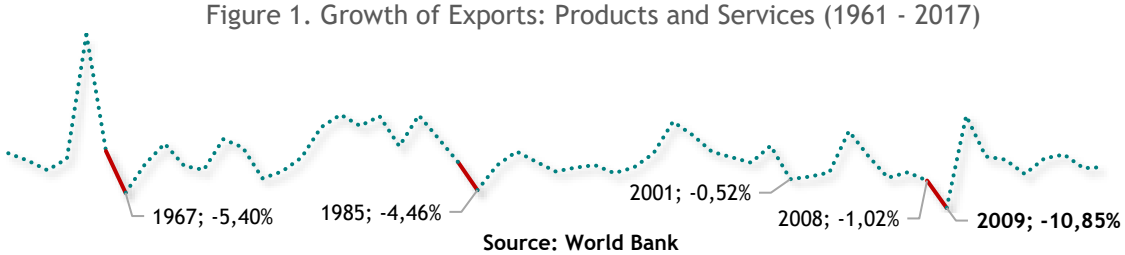
Contents

1. Introduction

The financial crisis of 2008, also called the global financial crisis, began on February 2007. At that time, it was unconceivable the idea that some financial institutions facing liquidity shortages in the US, would be able to damage other economies with such intensity. In the advanced economies, the financial links enabled this disruption to occur.

The global financial crisis imposed the largest shock in the post-war era. In the case of developing economies, they were channelled mainly through international trade. For Mexico, these shocks resulted in the worse contraction in exports since 1967 (Figure 1). For an economy defined by significant trade openness, having the US as the main commercial partner, directly connected Mexico with the turmoil in the US economy.

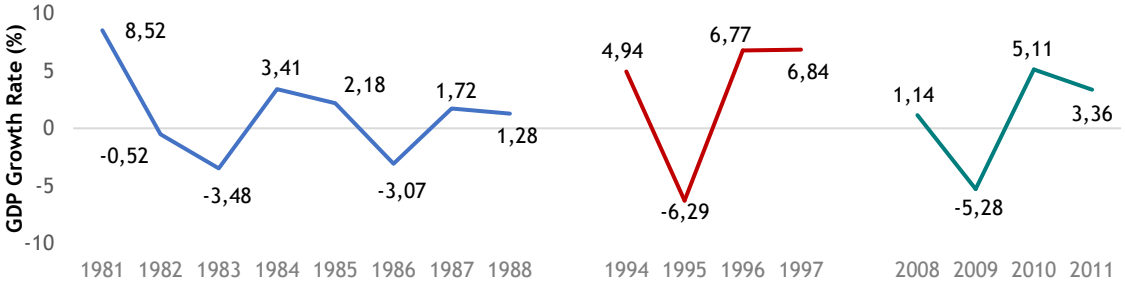
Figure 1. Growth of Exports: Products and Services (1961 - 2017)



Source: World Bank

When compared with previous crises in the recent Mexican history, the crisis of 2008 was the lighter in terms of GDP growth (Figure 2). Analysing the crises during the 1980s, the crisis of 1995 and the financial crisis of 2008, it is possible to realize that the country has been learning from those experiences, and those learnings has been materialized in improvements on governance, political stability and economic performance.

Figure 2. Mexican Financial Crises



Source: World Bank

Looking back to the other crises to understand the main limitations of these episodes. The crises at beginning of 1980s, were sufficient to entitle the whole decade of 80,

as the lost decade crisis. The build-up phase started already in the middle-end of the previous decade. During the presidential term of 1970-76, the erosion of the fiscal position, combined with the 1973 oil shock, boosted capital flight.

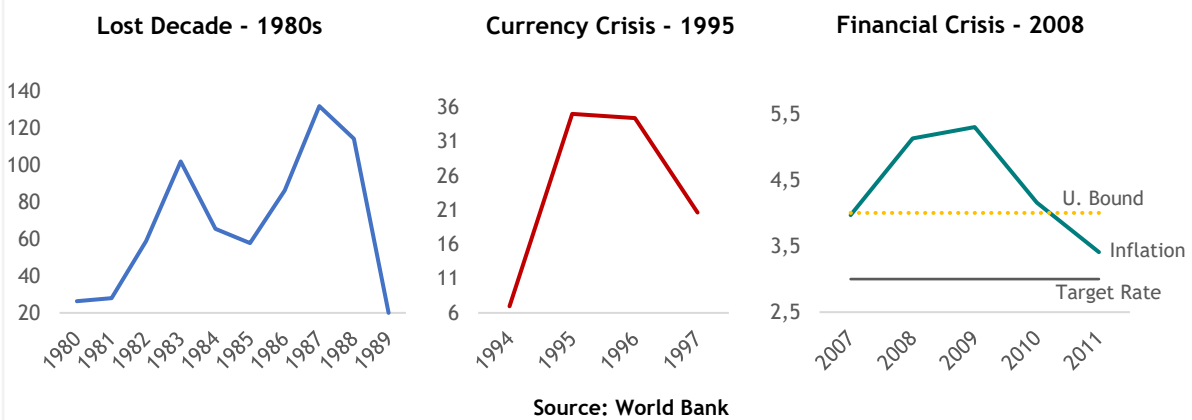
The macroeconomic instability was prolonged until 1980, when the government decide to nationalize the private banking system and promote drastic cuts on public expenditure, potentializing the effects of the crisis. After several attempts to devaluate the exchange rate and with inflation above 100% (Figure 3), the administration decided to denationalize the banking sector in 1989, privatize some state-owned companies, resulting in more investments, economic growth and improvement on macroeconomic stability.

In the episode of 1995, similar elements to the crises during 1980s are verified. The excessive intervention on exchange rates associated to a non-intervention rhetoric undermined the political credibility. In addition, the escalation of the political instability due to the murderer of one candidate for presidency, enhanced the risk-premium of bonds.

At that time, Mexico had joined NAFTA which turn into massive capital inflows. The expansionary fiscal policy sustained by short-term bonds with guaranteed repayment in US dollars was undermined, by the investors perception of the artificial value of pesos compared with US dollars. At that time, the exchange rate was fixed and pegged with the US dollar. Mexico defaulted in 1995 and at that time, inflation was above 30% (Figure 3).

Prior to the period involving the financial crisis of 2008, Mexico matured several institutional and policy reforms. For instance, the fiscal responsibility law was consolidated, as well the central bank independence. The exchange rate regime was not anymore fixed and since 2001, inflation targeting was the monetary policy regime in place. In the Figure 3, it is possible to visualize how inflation scale differs for the three episodes.

Figure 3. Inflation, consumer prices, annual (%)



Source: World Bank

The official adoption of inflation targeting in the end of 2001, contributed to significantly reduce inflation. It rendered the monetary authority more predictable, due to the emphasis on communicating in a forward-looking manner. By announcing decisions that were going to be taken in advance, the central bank promoted transparency and has the possibility to demonstrate commitment in tackling inflation through credible actions.

These institutional improvements, associated with the accumulation of reserves during the years before to the crisis, enabled Mexico, for the first time, to adopt countercyclical policies by itself. However, these improvements were not enough, to keep inflation within the interval boundaries, especially during the years of 2007 and 2010 (Figure 3). The financial stress generated by the crisis, demanded actions of the monetary authority.

In some cases, as in the US and the UK, the financial stress generated during the crisis obligated the monetary authority to shift the monetary policy, loosening it (Martin and Milas 2013), (Taylor 2019). However, in the case of developing economies, how the main effects were channelled through international trade, the monetary policy is designed to respond to different objectives. For instance, while in advanced economies the priority was to contain financial stress, in Mexico the objective could be to stimulate employment.

In this project, the interest is on evaluating the response of the Bank of Mexico, in terms of setting the interest rate during the financial crisis. To conduct this evaluation, two alternative responses are designed based on the Taylor rule. Each one of the three options; the selected response and the two alternatives, are designed to impact unemployment and inflation. After measuring their impacts, it will be possible to discriminate which response is the most beneficial in terms of inflation and unemployment given the demands of the Mexican economy.

Briefly, as result of the exercise, among the options considered in this study, the current response put in place by the Bank of Mexico is the most appropriated. This option represents the best stimulus for unemployment in the short-term during the financial crisis.

The structure of the personal project is the following: Section 2 will briefly review the literature. Section 3 will explore the data and the methodology. Section 4 presents and discusses results and Section 5 concludes.

2. Literature Review

In this section, three aspects related to the Taylor rule are going to be reviewed: First, the elements of the rule. Second, how the Taylor rule can be adapted to reflect specific characteristics of the economy. Finally, the relationship between the monetary policy rule and the financial stress is explored.

The discussion involving monetary policy-rules gained notoriety after Taylor (1992). The mixture involving clear objectives, represented by the targets of the monetary policy, in association with the need of greater transparency, founds correspondence with the development of the central banking activity. It placed the Taylor rule as a simpler but good descriptor of the central bank behaviour, in terms of setting the interest rate.

From a pure version, three elements are identified. First, the targets. Second, the temporal notions and third, the parameters. Within this framework, the targets represent the main indicators responsible for guiding the monetary policy actions. In addition, their specification shapes the interpretation of the Taylor rule. Some examples are unemployment and inflation targets. In some cases, they can be replaced by potential values, as in the case of potential output.

In terms of temporal notions, the Taylor rule can include two types: backward and forward-looking. The first one, occurs when a central bank react on what happened, and the second one, when a central bank reacts considering what is going to happen in the economy, demanding them to forecast the state of the economy in order to decide today. Previously, the central bank was designed as an institution that included past information in its decisions, denoting a kind of persistency (Stock and Watson 2001).

Finally, the parameters are estimated, and are responsible for amplifying or minimizing the effects generated by the gaps. The gaps are measured by the difference between observed values and their respective target, or potential value. They are also called deviations. Within this framework, parameters are policymaker preferences or trade-offs that they are willing to accept, for having a certain interest rate. (Bernanke 2015).

In the literature, several versions of the Taylor rule are present. The starting version is the pure version, and the developments verified in the non-linear and modified

versions are departures from this initial version (Castro 2011). Although this variety, the Taylor rule can be adapted by adding pertinent elements into the specific rule, reflecting particularities of a certain economy. For example: intervention on exchange rates could be included, if the government is interventionist.

This dynamism embodied in the Taylor rule is an advantage, once it allows adjustments to occur more easily. For an economy as the Mexican one, international shocks significantly affect the exchange rate (Jayasuriya and Leu 2017). These effects are captured by the volatility of the exchange rate and can be reproduced in terms of growth rate.

During the crisis of 2008, the central bank of Mexico intervened on the exchange rate in several occasions. After the establishment of the currency swap lines with the US, the Mexican authorities intervened with the objective to stabilize or reduce the cost of the US dollar. Also, it was expected that to reduce banking spread, but, the quality of the collateral limited these achievements. (Fleming and Klagge 2010).

The establishment of current swap lines by the Federal Reserve, were part of a program to protect the US dollar. According the financial stress was increasing, the cost of US dollars was increasing, and the pressure on US banks as well. Initially, only advanced economies were targeted but afterwards some developing economies were also included, cases of Brazil and Mexico. As result, the central banks of these economies were responsible for implementing this policy, enabling to act simultaneously in different economies.

Lately, it would be verified that part of the spillovers absorbed by the emerging market economies were also results of inaccurate actions of central banks in advanced economies. These decisions to stimulate the economy by monetary policy, distanced from fundamentals, generated excesses of liquidity, enlarging financial imbalances verified later in the housing market booms occurred in Spain and in the US. (Taylor, 2019).

To precise, by fundamentals, is referred to a Taylor rule in its pure form, where is included the potential output and the inflation target. In this specific rule, the analysis consists on verifying the distance between the interest rate defined by this specific rule and the current interest rate practiced by the central Bank. Lastly, Taylor (2019) realizes that institutions in advanced economies acted inaccurately in different phases of the crisis.

This misbehaviour also contributed to magnify the effects verified in the aftermath of the Lehman Brothers bankruptcy. By easing monetary policy, the institutions

potentialized the financial imbalance. In fact, part of the criticism related to the imbalances generated, lies on the role assumed by monetary policy in some advanced economies. This is consistent with the idea of monetary policy becoming a tool to fulfil other objectives, as for stimulating economic growth instead to focus only on price stability (Taylor 2019).

In addition, the shift verified in the monetary policy rule was related with the financial stress generated during the during the crisis (Kahn 2010). In most of the advanced economies (Drakos and Kouretas 2015), monetary policy rule changed with the increase of financial stress, while in the case of the developing economies, this relationship is harder to be verified (Çamlıca 2016), (Floro and van Roye (2017).

In the absence of a directly relationship involving the monetary policy rules and the financial stress in Mexico, during the financial crisis, alternative evidences are verified. Initially, two evidences support the idea that the financial stress was significant. First, is how inflation distanced of the target, surpassing the upper boundary. Second, was the necessity to accept the currency swap lines.

In addition to these elements, there are other evidences that reinforce the hypothesis of Mexico suffering with great financial stress during the financial crisis. First, is the call for further cooperation by the governor of the Bank of Mexico, between developing and advanced economies in order to avoid further spillovers from advanced economies (Carstens 2015). Second, is the necessity by the central bank of Mexico to adopt some unconventional measures in order to be more incisive in controlling inflation.

Three examples can be mentioned: First, the Banking and Securities commission decision to allow greater flexibility to restructure the portfolios of financial institutions, by permitting them to purchase and sale government securities with mutual funds of the same financial group for a six-month period (Sidaoui, Ramos-Francia, Cuadra, 2010).

Second, the Federal Mortgage Corporation, guaranteed 65% of the debt issued by non-bank mortgages companies, contributing to reduce the funding costs and enabling, these institutions to issue short-term debt without guarantees, restoring the orderly functioning of the commercial paper market.

As conclusion, is possible to confirm that Mexico also suffered with the financial stress generated by the crisis, motivating or not a change on the monetary policy rule.

3. Methodology

3.1. The counterfactuals

The main objective is to assess the decision of the central bank concerning the set-up of interest rate. In order to perform this task, a counterfactual is elaborated, based on Taylor (1992) and described in equation (1). The interpretation of this counterfactual is equivalent to an alternative decision, in other words, if the central bank has decided to set up the interest rates follow this policy rule, what would look like.

In this policy-rule, the interest rate reflects the values of inflation and unemployment, as on Stock and Watson (2001). However, a dummy variable and the growth rate of exchange rate also, reflecting the role of exchange rate for a developing economy[1].

$$R_{(t)} = r^* + 1.5(\bar{\pi}_{(t)} - \pi^*) - 1.25(\bar{\mu}_{(t)} - \mu^*) + \text{values of } R, \pi, \mu + \gamma\Delta_{st} + \epsilon_{(t)} \quad (\mathbf{1})$$

The error $\epsilon_{(t)}$ can be interpreted as a monetary policy shock, and is represented by:

$$\epsilon_{(t)} = R_{(t)} - 1.5\,\bar{\pi}_{(t)} + 1.25\,\bar{\mu}_{(t)} - \gamma\Delta_{st} = \text{constant} + \text{values of } R, \pi, \mu \quad (\mathbf{2})$$

Respectively, the meaning of the variables, and in the dataset are represented by:

$R_{(t)}$ = Federal Funds Rate (Interest Rate).
r^* = Desired Real Rate of Interest (Policy Rate − IR).
$\bar{\pi}_{(t)}\ \bar{\mu}_{(t)}$ = Inflation and Unemployment means (Inflation Index and Unemployment Rate).
π^*, μ^* = Inflation and Unemployment Targets (Inflation Target and NAIRU).
γ, Δ_{st} = Intervention, growth rate of exchange rate (Exchange Rate variation)[2]

The difference between the backward and forward-looking rules lie on the means. The specification is similar as well the parameters and variables, but when it comes to the means, in the backward-looking (BL) specification, it is included respectively, past values of inflation index and unemployment rates. While, in the case of the forward-looking (FL) component, the values included in the means are values of periods ahead of the current period in evaluation. In both cases, the time-horizon include 12 periods, equivalent to a year.

1. The values 1,5 and 1,25 are estimations and standard values from the literature, for instance check Stock and Watson (2001) for more details. The dummy variable before the exchange rate growth rate, refers to when the central bank intervenes on it, consequently assuming value 1.

2. The interventions are listed on the Bank of Mexico website, and the score 1 is assigned if at least 1 intervention in that specific month occurred.

Conceptually, these components refer to which type of information the central bank reacts. In other words, having into consideration a certain perspective of the economy, where the central bank assumes to base its own decisions. In the literature, there are several evidences reinforcing the forward-looking component. A justification is related to the monetary policy, the decisions take time to reach the economy. Consequently, the decisions of today has to be placed for an economy of tomorrow.

About the Taylor rule (Taylor 1992), is the main instrument for assessing the monetary policy rules, remaining as basis for other versions, denominated augmented, modern, non-linear among others. Initially, it raised concerns due to the incorporation of the output gap and the natural rate of unemployment.

Both of them are theoretical variables, and their measurement present substantial errors due to the need of forecasting. The presence of noise could lead policymakers to deviate from their intended outcomes (Estrella and Mishkin 1998), once an activist policy could lead to greater destabilization (Modigliani 1977). The lack of clear rules on how forecasts should be done, configures a window for discretion. (Orphanides 2003).[3]

On the other hand, concerning the economic meaning, the inflation and unemployment gaps included in the Taylor rule, are measures able to capture the credibility of the central bank and how heated the economy is[4]. The parameters before the variables, amplify their effects, and the signs, their respective cyclicality.

In the literature, the common method adopted to estimate the Taylor rule is the General Method of Moments (GMM), especially in the optimal monetary policy rule literature. The GMM allows to capture non-linearities present in the dataset, and represents a common standard, while the OLS represents a specific case of GMM. Both are verified.

As result, the OLS method is preferred when compared with the GMM. The main motivation is due to the presence of negative values as estimated values. For an economy like the Mexican one, the adoption of negative interest rates would seem implausible even when the context of the crisis is considered.

3. Staiger, D. Stock, J.H., Watson, M.W. (1997) – The NAIRU, Unemployment and Monetary Policy. Journal of Economic Perspective. Volume 11, Number 1 - Pages 33-49. Available at: < https://bit.ly/2VQw5vS >

4. Bernanke, B. S. (2015) – The Taylor Rule: A benchmark for monetary policy? Available at: < https://brook.gs/2vZBMxL > Accessed on: 18th April 2019

3.2. Testing the counterfactuals

After having decided which method is able to generate the most appropriated counterfactuals, is time to discuss the second part of the methodology, which is responsible for assessing the implications of these counterfactuals (BL & FL) and of the factual (IR) on the economy.

To quantify the effects of the counterfactuals, a different method is required. At this stage, the interest lies on how they affect unemployment rate and inflation index. To support this objective, the SVAR is adopted. The benefit by adopting the SVAR model is the requirement of identification. VAR models do not require this step, however without it, the basis for analysis would be inexistent[5].

In order to estimate a SVAR (4), differently to the recursive version, an additional matrix is required to characterize the contemporaneous relationships among the variables in the VAR (5), as shown in the following representation.

$$A_{y_t} = C_1 y_{t-1} + \cdots + C_k y_{t-k} + \varepsilon_t \; ; \; e_t = B u_t \quad (4)$$

$$Y_t = A_1 y_{t-1} + \cdots + A_k y_{t-k} + e_t \quad (5)$$

$A_{\cdot}$ is the matrix of contemporaneous restrictions, ε_t is the vector of the structural shocks and the shocks are identified by placing direct restrictions on the matrix A. By identifying, it is established a connection between the recursive form and the structural form of the model[6]. In addition, it guarantees the orthogonality of the shocks.

By imposing the condition of orthogonality, each shock occurs separately. In order to implement that, two matrixes are defined, A and B. The form of the matrix A defines the recursive structure and the main diagonal in B orthogonalize the effects. The (.) represents a floating value, allowing variability to occur, representing the short-term restriction.

$$A = \begin{bmatrix} 1 & . & . \\ 0 & 1 & . \\ 0 & 0 & 1 \end{bmatrix}, B = \begin{bmatrix} . & 0 & 0 \\ 0 & . & 0 \\ 0 & 0 & . \end{bmatrix}$$

5. Sims, C. (1982) - Policy analysis with econometric models. Brooking Papers on Economic Activity.
Available at: <https://www.brookings.edu/wp-content/uploads/1982/01/1982a_bpea_sims_goldfeld_sachs.pdf>

   Sims, C. (1986) - Are forecasting models usable for Policy Analysis? Quarterly Review.
Available at: < https://www.minneapolisfed.org/research/QR/QR1011.pdf >

6. Stock and Watson (2001) - Vector Autoregressions. Journal of Economic Perspectives.
Available at: < https://www.aeaweb.org/articles?id=10.1257/jep.15.4.101>

An important step of SVAR is related to the ordering of the variables. This step is conducted with support of the granger test, once it enables to establish the direction of the causality and consequently contributes for individuating the best ordering.

The samples are divided initially, by specification of interest rate: factual (IR), forward-looking (FL) and backward-looking (BL). Afterwards, a second specification is established in terms of time-horizon dimension. The initial three samples are subdivided based on periods without relation with the financial crisis, and with relation to the financial crisis, generating two types of samples: Normal period & Financial Crisis.

Table 1 report all the orderings by sample and specification of interest rate. In the appendix, the tests and orderings are further explained.

Table 1. Ordering of the Variables

1) Sample: Normal Period	First	Second	Third
1) Interest Rate (IR)	Inflation Index	Unemployment Rate	Interest Rate
2) Backward-Looking (BL)	BL	Inflation Index	Unemployment Rate
3) Forward-Looking (FL)	Unemployment Rate	Inflation Index	FL
2) Sample: Financial Crisis			
1) Interest Rate (IR)	Inflation Index	Unemployment Rate	Interest Rate
2) Backward-Looking (BL)	Inflation Index	BL	Unemployment Rate
3) Forward-Looking (FL)	FL	Inflation Index	Unemployment Rate

In addition, before to estimate the Impulse Response Function (IRF), all the orderings mentioned above were tested to verify their conditions related to stationarity and the stability. As result, all the orderings were retained stable, enabling the estimation of IRF with consistency.

Finally, the orderings mentioned previously and described in the Table 1, are estimated by adopting the IRF. The objective in estimating them with this function, consists on the need to quantify the impact on variables as unemployment rate and inflation index. With the results of this last step, it will be possible to assess the implications of each response and evaluate which alternative would suit better for an economy as the Mexican one.

3.3. Data

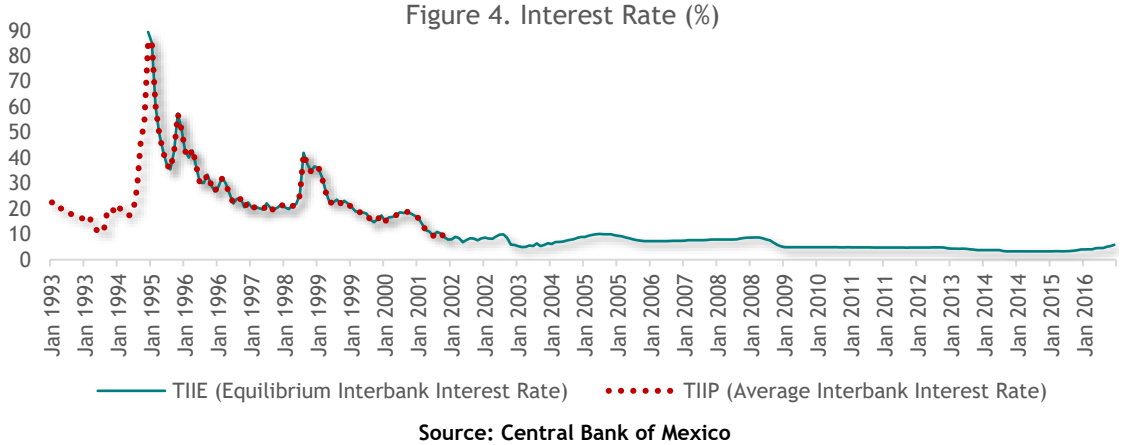
The dataset contains six variables: interest rate, policy rates, inflation, unemployment, NAIRU and inflation target. Starting on November 1998 and concluding on December 2016, totalizing 218 observations and configuring a monthly time-series. On Table 2, there is a description of the data and the basic statistics are described in the Table 3.

Table 2. Data Description

Variable	Obs.	Begin	End	Source	Empirical variable
1) Interest Rate (IR) (%)	218	11-1998	12-2016	Banxico	28-day TIIE and TIIP
2) Policy Rate (%)	218	11-1998	12-2016	BIS	Policy Rates (IR)
3) Inflation Index	218	11-1994	12-2016	INEGI	Consumer Price Index
4) Unemployment Rate (%)	218	11-1998	12-2016	INEGI	Unemployment Rate Women and Men
5) NAIRU	218	11-1998	12-2016	OCDE	NAIRU, adjusted, SA
6) Inflation Target (%)	218	11-1998	12-2016	Banxico	Inflation Target
7) Exchange Rate Var (%)	218	11-1998	12-2016	FRED	Mexico/ US Foreign Exchange Rate

From the Table 2, there are is an observation concerning interest rate, and inflation target. Interest rate is composed by two series: 28-day TIIE 1 and 28-day TIIP (historic series). The latter started previously in January 1993 and ceased in December 2001, while the former starts in January 2002 until the last point of data December 2016. Figure 4 shows this convergence contained inside of the variable interest rate.

Figure 4. Interest Rate (%)



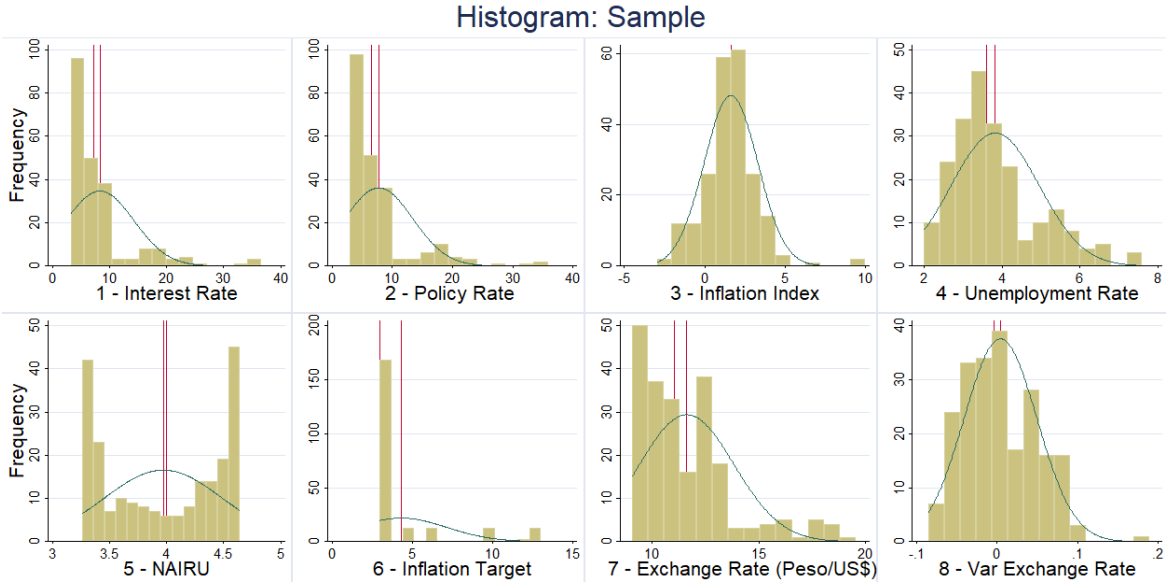
Source: Central Bank of Mexico

The inflation index is calculated following Stock and Watson (2001), the formula applied to compose the value is: $\pi_t = 400\ln(P_{(t)}/P_{(t-1)})$, where $P_{(t)}$ is the consumer price index at time (t) and $P_{(t-1)}$ is the consumer price index at time (t-1).

Table 3. Descriptive Statistics: Dataset

Variable	Mean	Median	Std. Dev.	Min	Max
1) Interest Rate (%)	8.318303	7.205	5.966043	3.29	36.6
2) Policy Rate (%)	7.771055	6.585	5.644065	3	35.85
3) Inflation Index	1.629831	1.65113	1.669195	-2.95966	9.975616
4) Unemployment Rate (%)	3.818427	3.595	1.130389	2	7.6
5) NAIRU (%)	3.970836	3.994565	0.518835	3.262295	4.644063
6) Inflation Target (%)	4.293578	3	2.847273	3	13
7) Exchange Rate Var (%)	.0042379	-0.00377	.0454461	-.0848716	.189642

The inflation target has its observations interpolated, as result the annual value was disaggregated equally to all the months of that respective year. The NAIRU was also interpolated, with the same purpose, but in that case, it was adopted the linear interpolation.



With regards to the exchange rate and its variation. The variation is calculated as the growth between the compared with the previous year. In the Taylor rule described in the previous section, this variation is considered by the dependent variable when is captured by the dummy variable, indicating an intervention of the Central Bank on exchange rate. Finally, the data frequency was daily, by averaging was built the monthly series.

3.4. The financial crisis sub-sample

A central point of the current study is the definition of the sub-sample related to the financial crisis. This section will discuss two alternatives to define the time-horizon of this sub-sample. First, the Federal Reserve timeline is considered and second the GDP growth rate of Mexico (Appendix Figure 1 = A. Figure 1).

Concerning the Federal Reserve timeline, the first event occurred in February 2007 with the Freddie Mac announcement about subprime mortgages and mortgage-related securities. Finishing in March 2011, with a stress test confirming sufficient capital adequacy to start buying back shares, repaying the government capital and paying dividends. This timeline is considered once is a very accurate representation of the financial crisis events.

However, as mentioned previously, there are differences in terms of effects and roles assumed by advanced economies and developing economies. In absence of an official timeline, the GDP growth rate can represent this proxy variable for transmission effects. As mentioned previously, developing economies faced two phases during the crisis, divided by the Lehman Brothers bankruptcy.

Therefore, considering the GDP growth rate of Mexico over the period (Figure 5), a difference in the end date emerge. For Mexico, the crisis ended in April 2009 and not in March 2011 with the GDP growth rate stabilizing in October 2009. Confirming the period from February 2007 until October 2009, containing 33/218 observations. Table 4 present the descriptive statistics of the sub-sample related to the Financial Crisis.

Table 4. Descriptive Statistics: Sub-Sample (Financial Crisis)

Variable	Mean	Median	Std. Dev.	Min	Max
1) Interest Rate (%)	7.428485	7.73	1.195568	4.89	8.74
2) Policy Rate (%)	6.997273	7.49	1.211302	4.5	8.25
3) Inflation Index	1.4642	1.55572	1.272408	-1.95614	4.521053
4) Unemployment Rate (%)	3.037617	2.99358	0.4425375	2.34346	4.19134
5) NAIRU (%)	4.117496	4.10586	0.1695171	3.860471	4.421051
6) Inflation Target (%)	3	3	0	3	3
7) Exchange Rate Var (%)	0.008612	-0.00546	0.057273	-0.08487	0.189642

4. Results

4.1. Selecting the counterfactuals

As first part of the methodology, the estimation of the counterfactuals was based on two methods; GMM and OLS. In the Figure 5 and Figure 6, they are presented and compared with the factual interest rate. Both of them are plotted for the period between February 2002 (2002m2) until February 2016 (2016m2).

Figure 5. GMM

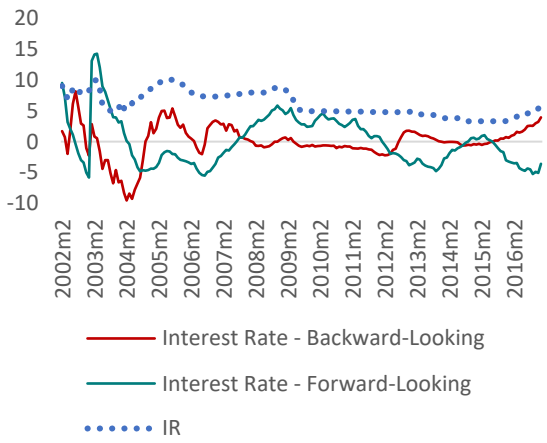
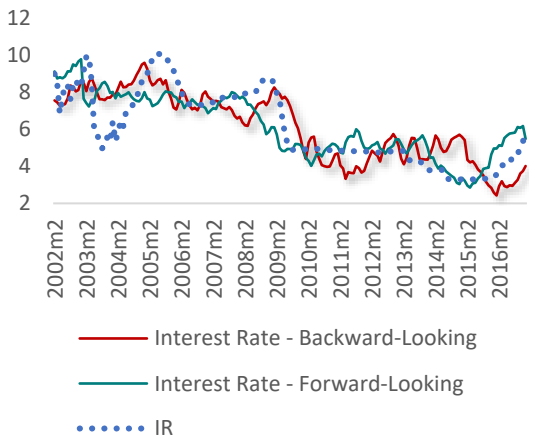


Figure 6. OLS



From the visual analysis, in the Figure 5, both estimations remained lower when compared to the real interest rate. It is possible to observe the non-linearity embodied in the method, by reflecting in the graphs of the estimated counterfactuals. Interest rate presents lower variability and in addition, in several periods the counterfactuals present negative values.

Figure 6 presents greater similarity between counterfactuals and interest rate. It is observable that their values are intersecting with the variable. Both of them present no negative values, and it is possible to observe relationships of leading-lag, reflecting the properties embodied in each counterfactual.

The counterfactuals estimated by the OLS (Figure 6), remain more reliable than the counterfactuals estimated with GMM (Figure 5). The main evidence is the presence of negative values, not finding correspondence in the economic context analysed.

4.2. Properties of the counterfactuals & the factual

After verifying which method estimated better outcomes, some comparisons with the factual are conducted. In figure 7 is compared the ratio between each counterfactual with the factual, while in the figure 8 is possible to observe that (BL) presents greater amplitude and number of observations above the interest rate. In addition, it presents greater average, median and standard deviation when compared with (FL).

Figure 7. Counterfactual/Factual

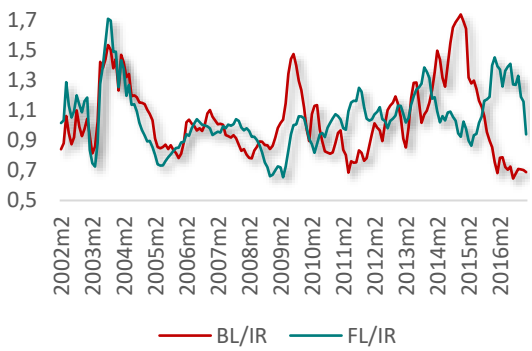
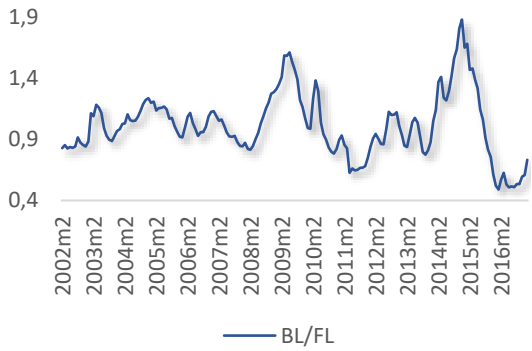
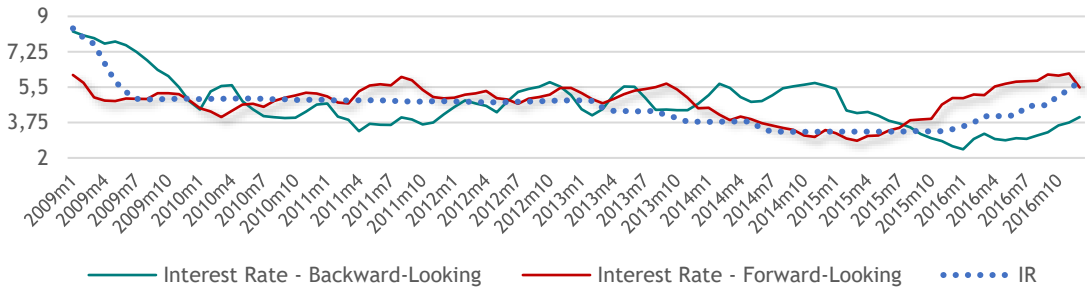


Figure 8. BL/FL



In 112/218 observations, the (FL) presents closer values to the factual (IR), while (BL) only 106/218. However, when the distance from the factual (IR) is measured, the counterfactual (BL) presents a lower average (1,12 vs 1,13), denoting greater approximation to (IR) than the counterfactual (FL). When this analysis, englobes all the observations, the result holds, confirming that counterfactual (BL) is the closest to (IR).

Figure 9. Counterfactuals and Factual



In the financial crisis period, the counterfactual (BL) approximated more to the factual (IR) in 20/33 occasions. When the distance to the factual (IR) is considered, this approximation is intensified, becoming almost equal on aggregate (0.99 vs 0.89).[7,8]

7. In the Appendix, tables A7 and A8 reports the correlation between Interest Rate, Inflation Index, Unemployment Rate, Forward-Looking Interest Rate (FL – Interest Rate) and backward-Looking (BL – Interest Rate).

8. The distance between the counterfactual and the factual are calculated by dividing counterfactual by factual. The aggregate distance is calculated by averaging all these distances

4.3. Testing the Counterfactuals

The impulse response functions (IRF) of the counterfactuals are listed in the section 2 of the Appendix (Figures). There, they are split in two columns, where each one refers to one type of sample; Normal period and Financial Crisis, and in each graph shows the factual (interest rate - IR) and counterfactuals (BL and FL).

Analysing the relationship between the factual and counterfactuals as impulses and inflation index or unemployment rate as responses, it is possible to observe a considerable change in their effects according to the samples. The Table 5 report the results.

Table 5. Relationship of magnitudes among counterfactuals (n=10)

Samples:	Normal Period						Financial Crisis					
Variable	Inflation I.			Unemployment R.			Inflation I.			Unemployment R		
1) Mean	1	2	3	3	-1	-2	1	3	-2	-1	3	2
2) Median	3	1	2	3	-1	-2	1	3	-2	-1	-3	2
3) Std Dev	1	2	3	2	1	3	2	3	1	1	3	2
Fac/C.Fac	IR	FL	BL	IR	FL	BL	IR	FL	BL	IR	FL	BL

Score refers only to the magnitude (1 = Greatest), (3 = Lowest)[18]. The sign, to the direction of the effect

Analysing the results, in terms of intensity (Mean), the counterfactuals (FL & BL) are responsible for generating unemployment during the financial crisis. While, the factual (IR) reduces it. During normal period, is exactly the opposite, the factual (IR) generates unemployment while both counterfactuals reduce it.

When it comes to inflation index, the only option able to reduce it, is the counterfactual (BL) during the Financial Crisis. All the other options in both period of times generate inflation. In the financial crisis sample, this relationship is proportional by the magnitude. While, in normal period, the counterfactuals perform better than the factual (IR).

In terms of volatility, the less volatile during the financial crisis is the counterfactual (FL) and during normal period is the counterfactual (BL). The factual (IR) and the counterfactual (BL) alternates in the first and second options in the financial crisis, according to the variable. As conclusion, the only valid response is the factual (IR) once is able to reduce unemployment during the financial crisis, stimulating the economy.[9]

9. IR = Interest Rate, for values check the Appendix Table 17 (A.Table 17)
For the tables concerning the relative to the estimation, please check the Tables in the section Appendix.
For the figures concerning the impulse response functions, please check the Figures in the section Appendix

4.4. Discussion

In this section, the previous conclusions are further scrutinized. In order to do that, the economic context will be included with the objective to refine the quantitative findings, also establishing a connection with the economic context defined by the crisis.

Initially, the findings from the IRF analysis confirm the Bank of Mexico response as the best response among the options considered, during the financial crisis. This is motivated due to the implications generated in unemployment and inflation. In terms of unemployment, the factual (IR) is the only alternative that does not intensify unemployment. On the contrary it reduces and in terms of inflation, is highest between the periods 2 and 8.

This initial analysis highlights the trade-off accepted by policymakers during the crisis. This trade-off consists on accepting greater degree of inflation in order to reduce unemployment. In addition, based on the implications of monetary policy, it is possible to affirm that there was a shift in the objectives, emphasizing economic recovery, intended as promoting employment, in detriment to price stability.

Still in the financial crisis, the counterfactuals could be interpreted as weaker versions of recovery when compared to the factual (IR). If it is assumed that policymakers present greater aversion to inflation, the counterfactuals could be considered valid responses, once these responses are responsible for generating lower inflation compared with the factual (IR).

As consequence, in terms of recovery and here is intended, the alternative that is more stimulating to reduce unemployment, it is possible to refer to the factual (IR) as the best alternative in this sense, as stated at the beginning. The other two alternatives, the counterfactuals (FL, BL) represent weaker stimulus to reduce unemployment, however in the case of (BL), this stimulus is still more evident than in the case of (FL).

The counterfactual (FL) represents a hybrid option, once it does not reduce unemployment as the alternatives, and is the first option to stabilize around zero. Configuring an option that could contribute to prolong the effects of the crisis, lacking countercyclical properties, and consequently, discarding this alternative.

When it comes to the normal period sample, each option present well defined trade-offs. For instance, the factual (IR) is the best alternative to contain inflation, however on the other hand, face costs in terms of unemployment rate. While, the counterfactuals (FL, BL) present similar patterns in terms of inflation index, the counterfactual (FL) is more effective in reducing unemployment.

To further scrutinize these initial interpretations of the possible alternatives, related to the financial crisis and to the normal period, the targets for inflation (Inflation Target) and unemployment (NAIRU) valued as 4,5% are included in this analysis. They are useful to evaluate how distant, the responses generated by each alternative distant form them.

In the case of the financial crisis, although the factual (IR) present the higher value in terms of inflation when compared to the alternatives, this elevated value is still the closest to the target, when compared with the other two alternatives (FL, BL). Reconfirming the previous finding.

In the case of the normal period, the inflation target would support the selection of the factual (IR), assuring a behaviour from the policymaker centred in controlling the price level. The alternatives (FL, BL) would demand greater tolerance of policymakers with the level of inflation, because in order to reduce the level of unemployment, policymakers would have to accept higher inflation.

Considering also the hyperinflationary past of Mexico, explored here through the crises during the 80s and the crisis of 1995, the willingness in returning to a similar pattern to boost employment sounds implausible. In addition, if at the end, policymakers decided to foster employment at the costs of inflation, it could be perceived as a time-inconsistency problem, once the central bank, discretionarily would pursue employment.

As result, it is possible to confirm that the Central Bank of Mexico was assertive during the financial crisis and during the normal period, with the conduction of the monetary policy.

Lastly, regarding the methodology, the initial finding, explored in the section properties of the counterfactual, diverged during the IRF analysis. In that section, it was found that the counterfactual (BL) in aggregate, during the financial crisis, deviates from the factual (IR) of 1%. Justifying the need of additional methods to further scrutinize an initial evidence, and consequently, the methodology applied.

5. Conclusion

This analysis explored the role of the monetary policy rules within the Mexican context during the financial crisis of 2008. Several methods were applied. Initially, the counterfactuals were estimated with OLS. After to quantify their effects on unemployment and inflation a SVAR was applied. Finally, an IRF analysis supported the interpretation of the results. The dataset is monthly based, starting on 01/1998 and ending on 12/2016.

The overall finding supports Martin and Milas (2013), Taylor (2019) in terms of confirming that the central bank deviated from the Taylor Rule during the financial crisis. However, this finding should be further contextualized.

First, central banks do not mechanically adopt versions of the Taylor Rule, consequently the deviation is expected and normal. The policy rule adopted by the Bank of Mexico present similarities with the forward-looking counterfactual estimated.

Second, the implications for deviating from the Taylor-Rule does not generate excessive unbalances, as in the case of the UK and US. This is confirmed by the decision of the Bank of Mexico in lowering interest rate in the aftermath the Lehman Brothers bankruptcy, and not previously.

In addition, following the analysis conducted, the factual (IR) represents the best stimulus that the Mexican authorities could decide for, at least when compared with the counterfactuals (FL, BL). During the crisis, the bank intervened on exchange rates several times. These interventions were included in the design of these counterfactuals, by including the dummy related to the occurrence of the intervention (1) or not (0), and the variation of the exchange rate to the initial specification (Stock and Watson, 2001).

A limitation of the exercise done are grounded in the methods applied and in the specification of the Taylor Rule. Changing the specification, would automatically lead to different results and by introducing different variables into the structural vector autoregressive models. Remaining future possibilities for future research.

Other window for future research concerns the relationship between inflation and interest rate decision, inflation and GDP growth. By assessing this relationship, would be possible to corroborate or not, if the decision was sufficient to readdress economic growth.

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Appendix

1. Tables

A. Table 1. Pair-wise correlation matrix (Dataset)

Variable	(1)	(2)	(3)	(4)	(5)	(6)	
1) Interest Rate (%)	1						
2) Policy Rate (%)	0.9942	1					
3) Inflation Index	0.5569	0.5698	1				
4) Unemployment Rate (%)	-0.1088	-0.1374	-0.0691	1			
5) NAIRU (%)	-0.6286	-0.6199	-0.2471	-0.0897	1		
6) Inflation Target (%)	0.8946	0.8859	0.474	0.0697	-0.5484	1	
7) Exchange Rate Var (%)	-0.039	-0.0312	-0.0168	-0.0189	0.0367	-0.0508	1

A. Table 2. Shock Estimation (ε)

	GMM BL b/se	GMM FL b/se	OLS BL b/se	OLS FL b/se
main				
BL - Inflation Index			1.399*	
			(0.63)	
BL - Unemployment ~e			-0.712**	
			(0.26)	
FL - Inflation Index				-3.949**
				(1.33)
FL - Unemployment ~e				0.826
				(0.59)
constant	1.399*	-3.949**	5.619***	29.030***
	(0.62)	(1.31)	(1.62)	(3.37)
b2				
constant	-0.712**	0.826		
	(0.26)	(0.59)		
b3				
constant	5.619***	29.030***		
	(1.61)	(3.34)		
R-sqr			0.091	0.056
dfres			176	176
BIC	.	.	885.9	1179.9

* p<0.05, ** p<0.01, *** p<0.001

A. Table 3. The counterfactual (Interest Rate estimation)

	IR-GMM-BL b/se	IR-GMM-FL b/se	IR-OLS-BL b/se	IR-OLS-FL b/se
main				
Taylor Rule - Infl~L			-0.218*	
			(0.11)	
Taylor Rule - Unem~L			-2.665***	
			(0.24)	
BL - Inflation Index			-4.600***	
			(1.13)	
BL - Unemployment ~e			1.695***	
			(0.24)	
Intervention on Ex~e			0.468	1.811
			(2.69)	(3.21)
Fitted values			3.229***	
			(0.32)	
Taylor Rule - Infl~L				-0.986***
				(0.08)
Taylor Rule - Unem~L				-1.534***
				(0.31)
FL - Inflation Index				1.391*
				(0.68)
FL - Unemployment ~e				0.197
				(0.19)
Fitted values				0.367***
				(0.07)
constant	-3.131***	-8.193***		
	(0.65)	(0.60)		
b2				
constant	0.652*	4.423***		
	(0.33)	(0.55)		
b3				
constant	0.245	-6.449***		
	(0.82)	(1.00)		
b4				
constant	2.966***	10.220***		
	(0.77)	(0.98)		
R-sqr			0.965	0.953
dfres			212	212
BIC	.	.	932.8	996.1

* p<0.05, ** p<0.01, *** p<0.001

A. Table 4. Counterfactual properties

Measure / Counterfactual	(BL) - Interest Rate	(FL) - Interest Rate
1) Median	7.0946755	7.031476

2) Mean	7.074883132	6.780547621
3) Standard Deviation	1.661113489	1.0178738
4) Variance	2.759298022	1.036067072

A. Table 5. Pair-wise correlation matrix (Sub-sample: Normal Period)

Variable	(1)	(2)	(3)	(4)	(5)
1) Interest Rate (%)	1				
2) Inflation Index	0.5748	1			
3) Unemployment Rate	-0.1272	-0.0942	1		
4) (BL) - Interest Rate (%)	0.95	0.506	-0.1474	1	
5) (FL) - Interest Rate (%)	0.9327	0.5156	-0.1025	0.9752	1

A. Table 6. Pair-wise correlation matrix (Sub-sample: Financial Crisis)

Variable	(1)	(2)	(3)	(4)	(5)
1) Interest Rate (%)	1				
2) Inflation Index	0.3475	1			
3) Unemployment Rate	-0.6659	0.0818	1		
4) (BL) - Interest Rate (%)	0.2308	-0.0736	-0.3727	1	
5) (FL) - Interest Rate (%)	0.5713	0.0098	-0.5032	-0.3705	1

A. Table 7. Impulse Response Functions Analyses

	II (NP)			UR (NP)			II (FC)		
	IR	FL	BL	IR	FL	BL	IR	FL	BL
1) Mean	0.047	0.057	0.061	0.030	-0.147	-0.086	0.053	0.009	-0.040
2) Median	0.048	0.057	0.049	0.036	-0.155	-0.079	0.066	0.003	-0.065
3) St. Dev	0.063	0.087	0.097	0.035	0.040	0.021	0.059	0.056	0.080

Continuation A. Table 7

UR (FC)	IR	FL	BL
1) Mean	-0.051	0.001	0.008
2) Median	-0.053	-0.002	0.014
3) St. Dev	0.012	0.018	0.013

Legend A. Table 7

II – Inflation Index

UR – Unemployment Rate

NP – Normal Period, FC – Financial Crisis

The Backward-Looking Interest Rate as well the Forward-Looking Interest Rate referred to the variables estimated with the OLS and selected as counterfactuals.

A. Table 8. Pair-wise granger causality test

1. Normal Period
    a. Interest Rate – Ordering (Inflation Index – Unemployment Rate – Interest Rate)

Equation	Excluded	chi2	df	Prob > chi2
cpi_index	unem_rate	40.814	7	0.000
cpi_index	interest_rate	44.052	7	0.000
cpi_index	ALL	97.61	14	0.000
unem_rate	cpi_index	21.457	7	0.003
unem_rate	interest_rate	15.38	7	0.031
unem_rate	ALL	31.025	14	0.005
interest_rate	cpi_index	13.227	7	0.067
interest_rate	unem_rate	19.297	7	0.007
interest_rate	ALL	29.073	14	0.010

    b. Forward-Looking Counterfactual – Ordering (Unemployment Rate – Inflation Index – FL)

Equation	Excluded	chi2	df	Prob > chi2
unem_rate	cpi_index	16.641	7	0.020
unem_rate	IR_OLS_FL	30.045	7	0.000
unem_rate	ALL	46.876	14	0.000
cpi_index	unem_rate	40.24	7	0.000
cpi_index	IR_OLS_FL	58.087	7	0.000
cpi_index	ALL	115.03	14	0.000
IR_OLS_FL	unem_rate	16.868	7	0.018
IR_OLS_FL	cpi_index	9.9947	7	0.189
IR_OLS_FL	ALL	35.083	14	0.001

    c. Backward-Looking Counterfactual – Ordering (BL – Inflation Index- Unemployment Rate)

Equation	Excluded	chi2	df	Prob > chi2
IR_OLS_BL	cpi_index	72.102	7	0.000
IR_OLS_BL	unem_rate	23.706	7	0.001
IR_OLS_BL	ALL	89.697	14	0.000
cpi_index	IR_OLS_BL	63.91	7	0.000
cpi_index	unem_rate	42.993	7	0.000
cpi_index	ALL	122.26	14	0.000
unem_rate	IR_OLS_BL	5.1203	7	0.645
unem_rate	cpi_index	14.159	7	0.048
unem_rate	ALL	19.935	14	0.132

2. Financial Crisis

a. Interest Rate – Ordering (Inflation Index – Unemployment Rate – Interest Rate)

Equation	Excluded	chi2	df	Prob > chi2
ln_cpi_index	ln_unem_rate	10.722	2	0.005
ln_cpi_index	ln_interest_rate	5.1802	2	0.075
ln_cpi_index	ALL	14.246	4	0.007
ln_unem_rate	ln_cpi_index	4.113	2	0.128
ln_unem_rate	ln_interest_rate	15.296	2	0.000
ln_unem_rate	ALL	20.43	4	0.000
ln_interest_rate	ln_cpi_index	1.3177	2	0.517
ln_interest_rate	ln_unem_rate	.50241	2	0.778
ln_interest_rate	ALL	1.9987	4	0.736

b. Forward-Looking Counterfactual – Ordering (FL – Inflation Index - Unemployment Rate)

Equation	Excluded	chi2	df	Prob > chi2
ln_IR_OLS_FL	L3.ln_cpi_index	5.2634	2	0.072
ln_IR_OLS_FL	L3.ln_unem_rate	3.8438	2	0.146
ln_IR_OLS_FL	ALL	8.9862	4	0.061
L3_ln_cpi_index	ln_IR_OLS_FL	3.2288	2	0.199
L3_ln_cpi_index	L3.ln_unem_rate	12.268	2	0.002
L3_ln_cpi_index	ALL	13.876	4	0.008
L3_ln_unem_rate	ln_IR_OLS_FL	2.5052	2	0.286
L3_ln_unem_rate	L3.ln_cpi_index	.73676	2	0.692
L3_ln_unem_rate	ALL	3.2141	4	0.523

c. Backward-Looking Counterfactual – Ordering (Inflation Index – BL - Unemployment Rate)

Equation	Excluded	chi2	df	Prob > chi2
ln_cpi_index	L2.ln_IR_OLS_BL	10.893	2	0.004
ln_cpi_index	ln_unem_rate	11.065	2	0.004
ln_cpi_index	ALL	21.796	4	0.000
L2_ln_IR_OLS_BL	ln_cpi_index	.60793	2	0.738
L2_ln_IR_OLS_BL	ln_unem_rate	6.2053	2	0.045
L2_ln_IR_OLS_BL	ALL	7.8667	4	0.097
ln_unem_rate	ln_cpi_index	3.212	2	0.201
ln_unem_rate	L2.ln_IR_OLS_BL	.29781	2	0.862
ln_unem_rate	ALL	3.4209	4	0.490

A. Table 9. Eigenvalue Stability Condition.

1. Normal Period

a. Interest Rate

Eigenvalue	Modulus
.963603	.963603
.8067375 + .4850043*i*	.941305
.8067375 - .4850043*i*	.941305
-.4480448 + .7997203*i*	.916677
-.4480448 - .7997203*i*	.916677
.4374019 + .7961261*i*	.908371
.4374019 - .7961261*i*	.908371
.8985337	.898534
-.8957258	.895726
.8919649	.891965
.05685446 + .8477145*i*	.849619
.05685446 - .8477145*i*	.849619
-.7132666 + .4271395*i*	.831383
-.7132666 - .4271395*i*	.831383
-.593105 + .4181798*i*	.725705
-.593105 - .4181798*i*	.725705
.1130296 + .656668*i*	.666325
.1130296 - .656668*i*	.666325
.4959776 + .2588896*i*	.55948
.4959776 - .2588896*i*	.55948
.1447037	.144704

All the eigenvalues lie inside the unit circle.
VAR satisfies stability condition.

b. Forward-Looking

Eigenvalue	Modulus
.9572724 + .00600487*i*	.957291
.9572724 - .00600487*i*	.957291
.8137334 + .4966724*i*	.953334
.8137334 - .4966724*i*	.953334
.4263001 + .816455*i*	.921049
.4263001 - .816455*i*	.921049
-.4432086 + .799681*i*	.914289
-.4432086 - .799681*i*	.914289
-.8788755	.878876
.04225043 + .8606303*i*	.861667
.04225043 - .8606303*i*	.861667
-.7233668 + .4146418*i*	.833779
-.7233668 - .4146418*i*	.833779
.7718211	.771821
-.6006697 + .3798636*i*	.710704
-.6006697 - .3798636*i*	.710704
.1179265 + .6461716*i*	.656844
.1179265 - .6461716*i*	.656844
.5688747 + .3228084*i*	.654082
.5688747 - .3228084*i*	.654082
-.01987061	.019871

All the eigenvalues lie inside the unit circle.
VAR satisfies stability condition.

c. Backward-Looking

Eigenvalue	Modulus
.8237173 + .487699*i*	.957267
.8237173 - .487699*i*	.957267
.9522447	.952245
.90959 + .03697224*i*	.910341
.90959 - .03697224*i*	.910341
-.4430954 + .7897667*i*	.905574
-.4430954 - .7897667*i*	.905574
.4270362 + .793972*i*	.901527
.4270362 - .793972*i*	.901527
.03125014 + .8863031*i*	.886854
.03125014 - .8863031*i*	.886854
-.7157161 + .4609975*i*	.851333
-.7157161 - .4609975*i*	.851333
-.8319302	.83193
.5402493 + .4074905*i*	.676696
.5402493 - .4074905*i*	.676696
.1279028 + .5881647*i*	.601911
.1279028 - .5881647*i*	.601911
-.5123438 + .2339565*i*	.563233
-.5123438 - .2339565*i*	.563233
.1708662	.170866

All the eigenvalues lie inside the unit circle.
VAR satisfies stability condition.

2. Financial Crisis

a. Interest Rate

Eigenvalue	Modulus
.9693148 + .2260875*i*	.995333
.9693148 - .2260875*i*	.995333
-.7535273	.753527
.06198794 + .6610262*i*	.663926
.06198794 - .6610262*i*	.663926
.5591376	.559138

All the eigenvalues lie inside the unit circle.
VAR satisfies stability condition.

b. Forward-Looking

Eigenvalue	Modulus
.9869521	.986952
.2750454 + .6071109*i*	.666509
.2750454 - .6071109*i*	.666509
.6206006	.620601
-.4425547	.442555
.0806035	.080603

All the eigenvalues lie inside the unit circle.
VAR satisfies stability condition.

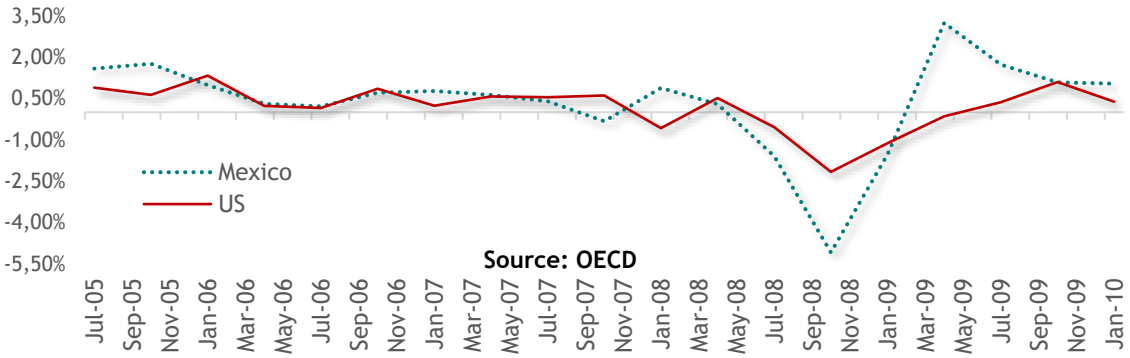
c. Backward-Looking

Eigenvalue	Modulus
.8868839 + .2607292*i*	.924415
.8868839 - .2607292*i*	.924415
-.6693716	.669372
.1924377 + .5186344*i*	.553185
.1924377 - .5186344*i*	.553185
.4056965	.405697

All the eigenvalues lie inside the unit circle.
VAR satisfies stability condition.

2. Figures

A. Figure 1. GDP Growth Rate: Mexico & US

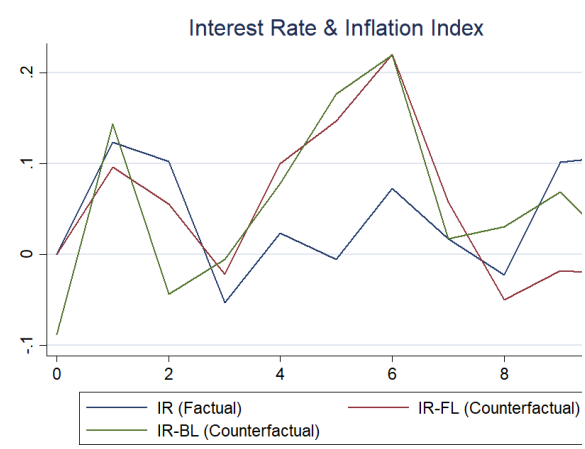


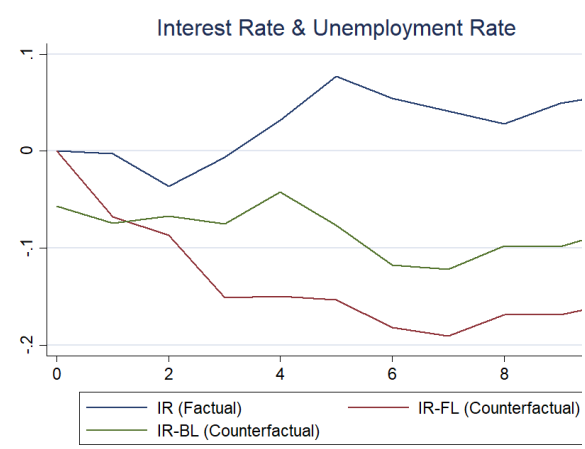
A. Figure 2. Histogram: Sub-Samples: Normal Period & Financial Crisis

A. Figure 3. Impulse Response Function: SVAR

a. Sample: Normal Period

Period: January 2001 – January 2006





b. Sample: Financial Crisis

Period: February 2007 – October 2009