PERSPECTIVAS

Revista de Análisis de Economía, Comercio y Negocios Internacionales

Volumen 13, Número 1 Enero - Junio, 2019

Sumario

PERSPECTIVAS, Volumen 13, No. 1, Enero - Junio de 2019, es una publicación semestral editada por la Universidad Autónoma de San Luis Potosí, a través de la Facultad de Economía. Av. Pintores s/n, Col. Burócratas del Estado, C.P. 78213, San Luis Potosí, S.L.P., México. Tel. (444) 8131238, (444) 8135558. http://publicaciones.eco.uaslp.mx/ Editor responsable: Dr. Elvio Accinelli Gamba. Reserva de Derechos al Uso Exclusivo No. 04-2017-111616093200 – 102; ISSN 2007-2104, ambos otorgados por el Instituto Nacional del Derecho de Autor. Impresa por Astra Ediciones S.A. de C.V., Avenida Acueducto 829, Colonia Santa Margarita, C. P. 45140, Zapopan, Jalisco, México. Este número se terminó de imprimir en julio de 2019.

Bases de datos y repositorios en los que aparece:

- Sistema Regional de Información en Línea para Revistas Científicas de América Latina, el Caribe, España y Portugal (Latindex).

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Revista de Análisis de Economía, Comercio y Negocios Internacionales

Presentación

"PERSPECTIVAS: Revista de Análisis de Economía, Comercio y Negocios Internacionales" es un publicación semestral cuyo objetivo principal es la difusión de artículos académicos de alto rigor teórico y metodológico, abarcando temas sobre distintos campos de la teoría económica, el comercio y negocios, permitiéndose también la divulgación de artículos de discusión y aplicaciones que enriquezcan el pensamiento económico y/o contribuyan a la consolidación de la utilización de técnicas económicas en el entorno actual. Su misión es ser referencia para investigadores, estudiantes e interesados en cuanto a temas contemporáneos y discusiones actuales en la economía, así como crear un espacio para dar la bienvenida a autores de los sectores público y privado con el fin de vincular el estudio y la práctica de esta disciplina.

La cobertura temática de la revista es multidisciplinaria en cuanto a los ejes fundamentales que se mencionan en el título, aunque principalmente se enfoca en las siguientes áreas:

- Microeconomía teórica y aplicada
- Macroeconomía teórica y aplicada
- Econometría
- Teoría económica
- Economía internacional
- Matemática económica (Teoría de juegos, economía dinámica, optimización)
- Finanzas
- Comercio internacional
- Regulaciones internacionales
- Organización industrial

Así mismo, la revista está dirigida hacia economistas, profesionales en los negocios, comercio internacional y política pública, actuarios, administradores y profesionistas en matemática aplicada a las ciencias sociales.

En esta ocasión "PERSPECTIVAS: Revista de Análisis de Economía, Comercio y Negocios Internacionales", presenta a sus lectores el contenido del Volumen 13 (1) correspondiente al período enero – junio de 2019.

En el presente volumen de *Perspectivas* se presentan cuatro trabajos, tres de ellos con alta formalización matemática y otro destinado al estudio de las posibilidades de comercio con los países asiáticos del Pacífico. Este es el contenido del trabajo: *La Alianza del Pacífico como una perspectiva de plataforma comercial con Asia Pacífico hacia 2030*. Dos trabajos relacionados con la teoría de juegos. En el trabajo: *Axiomatic solutions for network situations*, los autores analizan soluciones para juegos en red que satisfacen las propiedades elementales de linealidad y simetría, para los casos de tres y cuatro jugadores. Las características de las soluciones de los juegos evolutivos con dos estrategias, son analizadas en el trabajo titulado: *Two popultions, two strategies and a conflict: An evolutionary approach*. La inflación y su persistencia es analizada en el trabajo: *Mexico's Monetary Policy under changing inflation persistence*.

Entendemos que, el desarrollo de la teoría económica altamente formalizada es de gran interés para el crecimiento y el bienestar de los países del continente. La velocidad creciente con que los modelos más abstractos de la teoría económica logran una rápida aplicación a problemas empíricos, muestra la necesidad de impulsar el estudio y la investigación en las diferentes áreas de la moderna teoría económica. Los eventos organizados por redes de trabajo tales como JOLATE (Jornadas Latino Americanas e Teoría Económica) y DGS (*Dynamics, Games and Science*) se convierten en un fuerte estímulo para el desarrollo de la investigación conjunta entre investigadores e instituciones latinoamericanas y europeas, en las diferentes áreas de la moderna teoría económica y en particular de la economía matemática.

La organización periódica de eventos de este tipo y la difusión de los avances de los grupos de trabajo, contribuirá a enriquecer la interacción entre estudiantes, profesores e investigadores, y permitirá cumplir con una de las funciones sustantivas de la Universidad, que consiste en la difusión de las ideas y pensamientos críticos que se dan en el seno del quehacer educativo universitario.

Es al servicio de la difusión y desarrollo de la investigación en la moderna teoría económica, en sus diferentes aspectos, que pretendemos poner nuestra publicación.

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PERSPECTIVAS *Revista de Análisis de Economía, Comercio y Negocios Internacionales*
Volumen 13 / No. 1 / Enero - Junio 2019 / 5 -38
ISSN 2007-2104

Mexico's Monetary Policy under changing inflation persistence

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September 5, 2019

Abstract

At present, one of the most interesting problems posed to monetary policy is the fact that it seems to have lost control of its targets. There is doubt whether the reduction in inflation levels has been accompanied by a reduction in its inflationary persistence, in this case, authors such as Watson (2014) found that this is due to changes in inflation persistence. We perform a statistical analysis of the relationship between monetary policy instrument and target in Mexico to see that the relationship has indeed changed over time. The main objective of this research is to find the number of lags included in the polynomial of lags of the model proposed by Watson (2014). So, it is explored if inflation persistence may be the underlying reason. First, we perform a structural breakpoint analysis of the Mexican Consumer Price Index. Second, we perform statistical analysis of the different subsamples of the CPI and of its sub-index. We find Granger causality and cointegration between the time series of the central bank?s policy interest rate: Fondeo and inflation —Banxico's objective—. When we study the complete series, the relations vary significantly when we analyze each subsample separately. Then, based on Watson (2014), we build a Phillips curve and observe the behavior of inflationary persistence against the unemployment gap, energetic prices, exchange rate, and Banxico's policy interest rate.

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1 Introduction

The understanding of the degree of inflationary persistence is of paramount importance for the management of the monetary policy. The economic literature and the consensus on the subject point out that for the monetary authority persistent inflation can be more difficult to manage than a less persistent one. Likewise, the more difficult it is to control inflationary shocks, the more expensive will be the monetary adjustment, in terms of the loss of output, necessary to redirect inflation to a low and stable path.

An environment of high and volatile inflation represents a greater degree of uncertainty for decision making, this can discourage the generation of projects of high social performance and reduces the potential growth of the economy. Nowadays, the Bank of Mexico adjusts its monetary policy stance when the need to modify the interest rate so that it is consistent with the inflation target arises. Specifically, the Central Institute will use the Target Interest Rate, by adopting a more restrictive monetary policy, mainly under the following scenario: When inflationary shocks occur. In particular, monetary policy will seek in all circumstances to neutralize the secondary effects of exogenous price shocks and, occasionally, will act in a cautionary way to partially offset the direct inflationary effects caused by movements in key prices in the economy. The objective is that the necessary adjustments only affect the Consumer Price Index (CPI) moderately, avoiding the deterioration of inflationary expectations.

It is pertinent to remember that policy measures have a certain lag regarding the behavior of inflation. This is even more relevant when the short-term inflation dynamics have been strongly influenced by perturbations that are considered transitory in nature. Derived from the issues that generate inflationary pressures, is why we are interested in studying how monetary policy works when there is inflationary persistence in the economy. In this context, the application of monetary policy within a framework of transparency is highly relevant and based on a communication strategy regarding the objectives, plans, and decisions of the monetary authority, as has been the case in Mexico. In particular, the Central Bank carries out a detailed analysis of the determinants of inflation, for decision making.

Studies on the effectiveness of monetary policy have focused mainly on the American economy, one of the authors in this regard is Stephen G. Cecchetti, a professor at the University of Chicago who in turn relied on the authors Rudebusch and Svensson (1998) who built their model and method of efficiency with respect to those used by the Federal Reserve Bank from a practical monetary policy point of view.

Laurence Ball (1997) defines an effective rule of monetary policy as one that minimizes the weighted sum of the product variance and inflation. It suggests several results about

the effectiveness of monetary policy rules in a simple macroeconomic model. First, efficient rules can be expressed as "Taylor rules" where interest rates respond to the variance between production and inflation. But the coefficients inefficient Taylor rules differ from the coefficients of the current policy in the United States. In this sense, Taylor (1979) proposes that there is a long-term trade-off between the volatility of the product and the inflation determined by the supply shocks that affect the economy. In recent documents, Woodford (2010) reviews the optimal monetary policy in the new Keynesian models and provides a detailed analysis of the conditions under which the monetary policy rules are in line with Ramsey's optimal policies.

In their document, Garca and Ramos-Francia (2006) describe the dynamics of inflation in the Mexican economy from 1992 to 2006 using the New Phillips curve framework. The purpose is to identify key structural characteristics of the economy (structural parameters) that define the short-run dynamics of inflation, their results show that despite a previous history of high inflation, a hybrid version of the New Phillips curve fits the data well for the studied. Noriega and Ramos-Francia (2008) on empirical research on the degree and stability of inflation persistence in the US, found mixed results: some suggest high and unchanged persistence during the last few decades, while others argue in favor of a decline in persistence since the early 1980s. In another working paper, Noriega and Ramos-Francia (2009) found that (1) With very few exceptions, inflation around the world rejects a unit root, (2) for several countries there is evidence of significant changes in persistence, (3) bursts and drops in the level of inflation and in inflation persistence tend to coincide, (4) these drops occurred during "the Great Moderation" and during the adoption of inflation targeting. On the other hand, Cortez and Islas-Camargo (2009), use structural and statistical methods to estimate the Non-Accelerating Inflation Rate of Unemployment (NAIRU) simultaneously to the Phillips Curve and find that inflation depends on the unemployment gap, monetary policy, and supply shocks. The results of this analysis indicate that for the Mexican case, the idea of Friedman is fulfilled, since inflation has a strong inertial component and that the Phillips Curve exists, we also consider this work as a reference for some estimation methods.

Finally, as mentioned before, this research will be based on the article written by Mark W. Watson (2014), who makes an estimation of the behaviour of inflation over two shorts periods. The data suggest that the NAIRU increased by nearly one percentage point from 2007 to 2013. However, based on the study by Gordon (2013), the estimated NAIRU, concluded that excludes the long-term unemployed is essentially unchanged since 2007.

This investigation is composed as follows: first, it is described the role of NAIRU and its relationship with monetary policy, as well as the detail of some models about the Phillips

curve; Next, the conceptual framework of monetary variables and unemployment in Mexico, from 2000 to 2017, is discussed. Here, we perform a structural breakpoint analysis of the Mexican Consumer Price Index (CPI), then we make statistical analysis of the different subsamples of the CPI and of its subindex. We find Granger causality and cointegration between the time series of the central bank's policy interest rate: Fondeo and inflation—Banxico's objective—. When we study the complete series, the relations vary significantly against when we analyze each subsample separately. Then, based on Watson (2014), we build a Phillips Curve and observe the behavior of inflationary persistence against the unemployment gap, energetic prices, exchange rate, and Banxico's policy interest rate. Followed by the quantitative and econometric analysis, applying an Autoregressive Distributed Lag (ARDL) model in order to find out if there were changes in inflationary persistence; Finally, a conclusion is given based on the empirical results.

2 Unemployment as an indicator of inflation

Unemployment is an empirically successful way to predict changes in the inflation rate. The macroeconomic evidence found by Blanchard and Lawrence (1997), proposes modeling of the natural unemployment rate based on two equations: a "price equation" and a "wage equation", that can be written as

$$\Delta p_t = a_P + \Delta w_t + \epsilon_{pt} \tag{2.1}$$

$$\Delta w_t = a_W + \Delta p_{t-1} - \beta u_t + \epsilon_{wt}, \tag{2.2}$$

where p is the log of the price index and w is the log of nominal wage, u is the unemployment rate, a_p and a_w are constants and ϵ_{wt} and ϵ_{pt} are error terms. Substituting equation (1.2) into (1.1), they obtain the (expectations-augmented) "Phillips curve" as a reduced form relationship between the change in inflation and the unemployment rate.

$$\Delta p_t = a + \Delta p_{t-1} - \beta u_t + \epsilon_t \tag{2.3}$$

where $a = a_p + a_w$, and $\epsilon_t = \epsilon_{wt} + \epsilon_{pt}$. The natural rate of unemployment is typically interpreted as the NAIRU with constant inflation.

Ball and Mankiw (2002) write the short-run tradeoff between inflation and unemployment as follows:

$$\pi = k - aU \tag{2.4}$$

They explain that this equation only tells us that π and U are negatively related and that k and $a > 0$ are parameters. What makes clear this relationship cannot be constant over

time,(Phillips curve). In most standard theories, expected inflation has played center stage in explaining shifts in the inflation-unemployment tradeoff.

$$\pi = \pi^e - a(U - U^*) \tag{2.5}$$

where π^e is expected inflation and U^* is the NAIRU, regarding that U^*, can exhibit substantial high-frequency variation. The simplest version used in the literature is to posit: $\pi^e = \pi_{-1}$. The inflation-unemployment tradeoff then becomes:

$$\pi = \pi_{-1} - a(U - U^*) + v \tag{2.6}$$

where v collects the "supply shock".

They argue that "often, the studies include additional lags of inflation or unemployment or that rather than leaving the supply shock v entirely in a residual, control variables are included, such as food and oil prices, exchange rates and dummies for wage-price controls. The value of the NAIRU (U^*), can then be inferred from the estimated parameters. It is easy to imagine that the supply shocks represented by v are correlated with unemployment".

Although they find two econometric issues, the first difficult issue that they tried to skirt is the identification problem by assuming that "U^* is constant over the interval being studied and that v is contemporaneously uncorrelated with U", so the equation can be estimated with ordinary least squares, and the second issue is about the computation of standard errors. It is here "Until recently, the empirical literature on the Phillips curve rarely provided standard errors for estimates of the NAIRU".

Roughly, these estimates represent the starting point of the whole theory behind this research, however, it will focus on the model described by Mark W. Watson (2014) which methodology is exactly quoted as follows. His document is carried out in the context of a traditional Phillips curve equation:

$$\phi(L)(1 - L)\pi_t = \beta(L)(u_t - \bar{u}_t) + \gamma(L)Z_t + e_t \tag{2.7}$$

where π_t is the level of prices or inflation,$(u_t - \bar{u}_t)$ means the unemployment gap (observed unemployment rate less the NAIRU), Z_t could be additional controls, such as fuels, interest rates, currency, among others and, e_t represents the error. The dynamics of inflation are modeled through the lag-polynomials $\phi(L)$, $\beta(L)$, and $\gamma(L)$.

The previous equation (2.7) may give three explanations of the relationship between employment, inflation and structural changes in the economy; first inflation persistence (captured by $\phi(L)$) may have changed: if lower persistence happens, it means that variations

on the right side of (2.7) have smaller effects on the level of inflation. Then, a higher unemployment rate may cause a smaller impact on inflation, because the coefficients in $\beta(L)$ changed or because increases in the observed unemployment rate, was partially offset by increases in the NAIRU. Finally, other factors (Z_t or e_t) may be the explanation to movements of level prices. His way of seeing the problem in this paper may give us an explanation for the Mexican case.

Later, he begins assuming that the lag polynomial $\phi(L)$ is parameterized as

$$\phi(L) = (1 - \theta L)^{-1} = 1 + \theta L + (\theta L)^2 + ... \tag{2.8}$$

which captures the potentially long-lags in the inflation process. Where

$$\eta_t = \beta(L)(u_t - \bar{u}_t) + \gamma(L)Z_t + e_t \tag{2.9}$$

includes the terms on the right side of equation (2.7), so the Phillips curve equation becomes

$$(1 - L)\pi_t = (1 - \theta L)\eta_t \tag{2.10}$$

Taking equation (2.10) to solve for the change in inflation between time t and $t+k$ remains:

$$\pi_{t+k} - \pi_t = \eta_{t+k} - \theta\eta_t + (1 - \theta)\sum_{i=1}^{k-1} \eta_{t+i}, \tag{2.11}$$

so that θ determines the pass-through of η_{t+i} to π_{t+k}. Here, θ tests how well the trend of inflation is "anchored". The author argues that: "when $\theta = 1$, a one unit change in η_{t+i} has no effect on the long-run level of inflation, while when $\theta = 0$, the long run level in inflation moves one for one with η_{t+i}. In general, (2.11) says that a one unit increase in η_{t+i} leads to a permanent $(1 - \theta)$ unit increase in the level of inflation."

In this research, we are not estimating the variation of NAIRU as it's described by Watson, we are going to model long-term unemployment through a mathematical algorithm that operates as a prediction and correction mechanism: *the Kalman filter*. In Cortez and Islas-Camargo (2009), the estimation process is as follows: taking into account equation (2.7), a specification to estimate the NAIRU is to write the dependent variable in first differences (to give homogeneity to the dynamics)

$$\Delta\pi_t = \alpha(L)\Delta\pi_{t-1} + \beta(L)(u_t - \bar{u}_t) + \gamma(L)Z_t + e_t \tag{2.12}$$

$$e_t \sim N(0, \sigma_\theta^2)$$

The previous equation (2.12) assumes that inflation depends on its first lag with a coefficient that is restricted to taking one as a value to ensure long-term neutrality. The model is completed with the specification of the way the NAIRU varies over time. Equation (2.12) tells us that the time series generated by the NAIRU is a stochastic process that follows a random walk.

$$\bar{u}_t = \bar{u}_{t-1} + \vartheta_t \qquad \vartheta_t \sim N(0, \sigma_\theta^2) \tag{2.13}$$

The NAIRU estimated in (2.12) is the unemployment rate compatible with stable inflation without temporary supply shocks.

Retaking these previously exposed theories. Let's now suppose that economic policy seeks to increase aggregate demand. This policy would shift the economy along the short-term Phillips curve to a point where the price level is higher (*Figure 1 shows it by a shift from point A to B*), as production increases, the level of unemployment decreases and inflation increases. In the long term, inflation expectations increase, causing the short-term curve to move upwards. The economy returns to a new equilibrium level (*point C in Figure 1*) in which employment returns to its natural level.

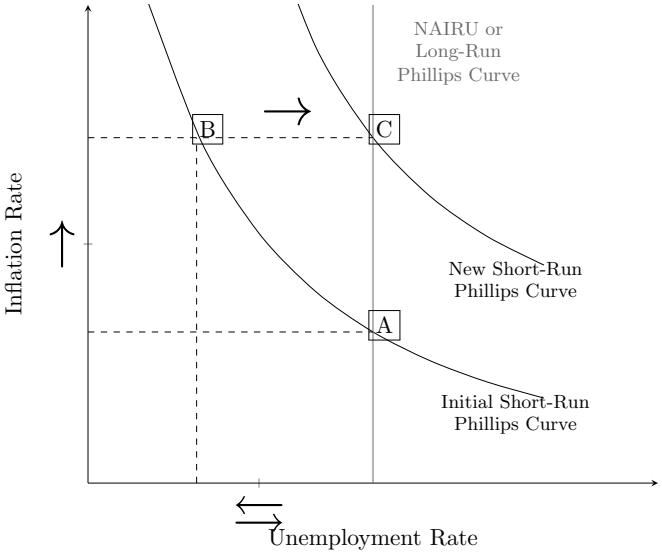
Inflation expectations play a fundamental role in the way Phillips curve is useful for specifying the economic options that authorities have for decision making. A determinant of expected inflation is the assumption that agents form their expectations based on the price level observed recently. If individuals expect prices to rise at the same rate as the previous year, then $\pi^e = \pi_{-1}$ (as stated above).

If the Phillips curve is a function of π_{-1}, means that inflation is nagging. That is, inflation increases unless something stops it. Particularly, if unemployment is in the NAIRU and there are supply shocks (such as a rise in energy prices), the continued rise in the price level neither accelerates nor slows down. This could be due to the fact that past inflation influences expectations about future inflation and that these expectations influence the wages and prices that are determined in the economy.

Recall that the short-term Phillips curve depends on the expected inflation. If this increases, the curve moves upwards and the facing dilemma by the economic authorities is more unfavorable: inflation will be higher at any level of unemployment. Because agents adjust their expectations about inflation over time, the relationship between inflation and unemployment only exists in the short term, which is why the monetary authorities can not keep higher than expected inflation indefinitely. In the long run, expectations adapt to the inflation rate chosen by the monetary authorities. Imagine an economy in which unemployment is at its natural rate and inflation is 6%. What would happen to unemployment and growth if the central bank adopted a policy aimed at reducing inflation from 6% to 2%?. The Phillips curve shows that in the absence of a positive supply shock, a reduction

in inflation requires going through a phase of high unemployment and production decline. But how much does unemployment have to increase above its natural rate and for how long? Before determining whether to reduce inflation, economic authorities should estimate the production lost during the transition phase towards lower inflation, in order to compare this cost with the benefits of lower inflation.

Figure 1: Relationship between inflation and unemployment



Source. Own estimation

Another approach is to assume that agents base their decisions under the assumption of rational expectations. If monetary policy influences inflation, then inflation expectations also depend on monetary policy. According to the theory of rational expectations, a change in monetary policy alters expectations, so any change in policy must take this effect into account. If individuals form their expectations rationally, inflation may have less persistence than it seems. With a credible monetary policy, the costs of reducing inflation can be

much lower than the estimates of the sacrifice rate suggest. The sacrifice rate can be used to estimate how much and for how long unemployment should increase or decrease growth (Okun's Law) to reduce inflation.

In this sense Ben Bernanke (2016) has commented that for the American economy, the Phillips curve is totally flat, so that inflation will tend to be more stable than the previous period although there are disturbances in aggregate demand, since prices are less sensitive to changes in the prices of energy or food and for this reason, although oil prices continue to rise, this does not imply inflationary persistence. The most important is the inflation expectations, he mentions that the fact that the Phillips curve is flat is good for the inflation goals. The question to be answered is: does this also happen for the Mexican economy?

3 Unemployment rate, Consumer Price Index and Inflation Expectations' Context.

The definition of the Mexican Unemployment Rate (UR) refers to the percentage of the Economically Active Population (EAP) that did not work during the survey period but expressed its willingness to obtain employment. For this section, data were taken from the National Occupation and Employment Survey (ENOE) that is drawn up by the National Institute of Geography and Statistics (INEGI) and the Organization for Economic Cooperation and Development (OECD) for the analysis of this variable.

After the economic crisis suffered by Mexico in 1995, employment had a sharp drop derived from the contraction in aggregate demand, however for the coming years, the labor market was encouraged by a recovery in production that increased productivity and therefore, real wages. In 1998, the number of strikes exploded was the lowest of those years. For the year 2000, the demand for work was strengthened and the unemployment rate reached historic lows, in 2002 there was a deceleration of wages which caused a slight contraction of the UR, this led to the workers seeking employment in the informal sector. It was not until 2005 that the labor market achieved significant progress since 2001, and then increased again in an important way in 2008 as a result of the international financial crisis. In that year, there was a loss of 257 thousand jobs, this has been the greatest annual contraction in employment since 1945. With the expansion of the economy in 2010, an important recovery of the formal employment of the economy was observed, however, some indicators suggest that slack conditions persisted in the labor market. Especially in the underemployment rates that remained at levels higher than in 2008. During 2012 and 2014, the unemployment rate had some recovery to exceed the levels before the crisis, and

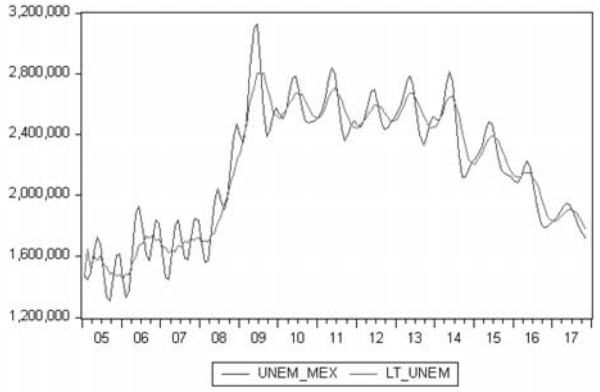
for 2017 even Bank of Mexico estimated that thanks to the good performance of the labor market, it has already practically closed the gap between the observed unemployment rate and the estimate of the unemployment rate consistent with a stable inflation environment[1]. However, these conditions of slack have persisted in the face of the volatility of some advanced and emerging economies that are our trading partners, as well as a strong increase in employment in the informal economy.

Figure 2 shows unemployment in Mexico (blue line) against a trend generated by the Kalman Filter as a proxy for long-run unemployment (red line). Observed unemployment (u) crosses long-run unemployment ($\bar{u}$) three times between 2005 and 2017.

- The fifth, in 2005 $u < \bar{u}$, higher inflation
- The sixth, in 2008 $u > \bar{u}$, lower inflation
- Finally, in 2014 $u < \bar{u}$, higher inflation

Figure 3 indicates that observed unemployment (red line), has been below long-term unemployment (green line) — generated by Bai-Perron breakpoint test—, but inflation has not risen. Maybe the key is in the word "persistently". The question is: How long is persistent?

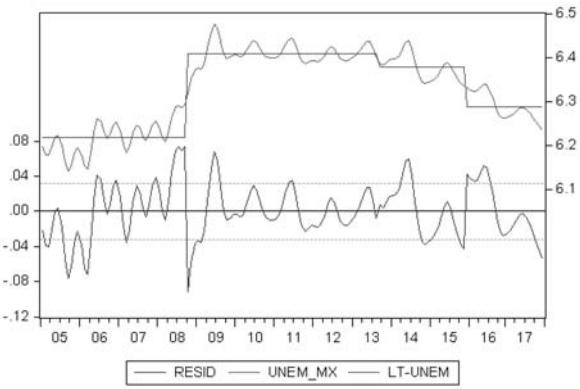
Figure 2: Unemployment in Mexico



Source. Own estimation with Kalman filter using INEGI's data

[1]Compilation of Quarterly Reports, Bank of Mexico (2013 - 2017). pp. 251

Figure 3: Unemployment modeled by Bai-Perron test



Source. Own estimation with INEGI and OECD Data.

Now, the Mexican Consumer Price Index (CPI) is composed as follows. It is first divided into 1) core and 2) non-core prices. We found no Structural Breakpoints (SBs) in non-core prices between 2000 and 2016 so we focused on core prices only. The core prices subindex is further divided into 1.1) Total merchandises and 1.2) Total services. Which in turn are subdivided as follows:

1) Total Merchandises

   1.1) Food, beverage and tobacco; and

   1.2) Non-edible merchandise.

2) Total Services

   2.1) Housing services;

   2.2) Education services; and

   2.3) Other services.

In this section, we analyze the period between January 2005 and December 2017, and we find:

1) Five Structural Breakpoints (SB) in core inflation rate: December 2007, April 2010, March 2012, March 2014, and February 2016. .

1.1) The total merchandise subindex has 3 SBs: September 2007 (same year that core inflation), June 2009 and, January 2013.

1.1.1) The sub-subindex of Food, beverage, and tobacco has two SB: August 2006 and, June 2009 (this last SB coincides with the Total Merchandise Subindex but not with the Core).

1.1.2) The Non-edible merchandise sub-subindex has two SBs as well (non-coincide with the mayor higher level subindex or index). The dates are January 2008 and February 2010.

1.2) The total services subindex just has one SB: in April 2010. The latter happened at the same time as the SB in the core index.

1.2.1) The Housing services sub-subindex has 7 SB. Matching the Total services subindex and the Core inflation index. The dates were: 2005/12, 2006/06, 2007/12, 2008/05, 2009/03, 2009/11, 2010/04.

1.2.2) The Education services sub-subindex does not present SB.

If, trying to identify what caused an SB in CPI, we restrict our attention to the cases where the nodes of a branch are connected, then the December 2007 and April 2010 SB was caused by the Housing services subindex.

Summing up, the behavior of the Mexican monthly CPI inflation between 2005 and 2017 was caused by changes in the core prices index. The core prices had five SBs. The first could have been caused by housing services. The second SB falls closer with the non-edible products; the housing services subindex also has an SB in April 2010. The final SB in core prices does not goes together with an SB in merchandises and/or services sub-subindex.

Table 1 presents selected statistics of Mexican core inflation. The first three columns show monthly average core inflation, its standard deviation and the slope of average monthly core inflation during each *stage*—the period in between SBs—. The three columns "% change in..." depict relative variations from one stage to the next of average monthly core inflation, its standard deviation and, its slope.

Table 1. Mexican monthly core inflation selected statistics and variations

	Average inflation	Std. Dev.	Slope	% change in Average	% change in Std. Dev.	% change in Slope
01-2005/12-2007	0.0029	0.0010	0.0621			
01-2008/04-2010	0.0039	0.0014	0.1820	0.0344	0.4	1.9307
05-2010/03-2012	0.0027	0.0012	0.1832	-0.3076	-0.1428	0.0065
04-2012/03-2014	0.0024	0.0017	0.1892	-0.1111	0.4166	0.0327
04-2014/02-2016	0.0020	0.0009	-0.0165	-0.1666	-0.4705	-1.0872
03-2016/12-2017	0.0196	0.0364	0.2212	0.0881	0.3944	-0.1440

Source. Own Estimation

Observe that the average inflation and the standard deviation in inflation have fallen since May 2010. For example, from the 01-2008/04-2010 stage to the 05-2010/03-2012 stage average monthly inflation dropped 30.76% and its standard deviation fell 14.28%. More interestingly is the slope of inflation during each stage. Observe that from the first to the second stage the slope of average monthly inflation grew by more than 100 percent: from 0.0621 to 0.1820; however, it has dropped ever since at an increasing rate.

Were the SB between indices fortuitous? We now look for dependence between indices to determine who caused who. Tables 2, 3, 4, 5, 6 and 7 show correlation matrices between the core subindex, the 2 main subindices and Fondeo for the four time subsamples.

Table 2. Correlation matrix 1st sub-sample: January 2005-December 2007.

	CORE	MERCH	SERV	FONDEO
CORE	1.000000	0.642874	0.829406	−0.127812
MERCH	0.642874	1.000000	0.105301	0.181044
SERV	0.829406	0.105301	1.000000	−0.298317
FONDEO	−0.127812	0.181044	−0.298317	1.000000

Source: own estimation

Table 3. Correlation matrix 2nd sub-sample: January 2008- April 2010.

	CORE	MERCH	SERV	FONDEO
CORE	1.000000	0.737569	0.766224	0.293919
MERCH	0.737569	1.000000	0.131283	−0.002050
SERV	0.766224	0.131283	1.000000	0.435687
FONDEO	0.293919	−0.002050	0.435687	1.000000

Source: own estimation

Table 4. Correlation matrix third sub-sample: May 2010- March 2012.

	CORE	MERCH	SERV	FONDEO
CORE	1.000000	0.782056	0.535208	0.253774
MERCH	0.782056	1.000000	−0.107587	0.117009
SERV	0.535208	−0.107587	1.000000	0.246434
FONDEO	0.253774	0.117009	0.246434	1.000000

Source: own estimation

Table 5. Correlation matrix fourth sub-sample: April 2012-March 2014.

	CORE	MERCH	SERV	FONDEO
CORE	1.000000	0.692537	0.731581	−0.093306
MERCH	0.692537	1.000000	0.014860	0.026716
SERV	0.731581	0.014860	1.000000	−0.154372
FONDEO	−0.093306	0.026716	−0.154372	1.000000

Source: own estimation

Table 6. Correlation matrix fifth sub-sample: March 2014 - February 2016.

	CORE	MERCH	SERV	FONDEO
CORE	1.000000	0.464906	0.760279	−0.001264
MERCH	0.464906	1.000000	−0.221664	0.223368
SERV	0.760279	−0.221664	1.000000	−0.165576
FONDEO	−0.001264	0.223368	−0.165576	1.000000

Source: own estimation

Table 7. Correlation matrix last sub-sample: March 2016 - December 2017.

	CORE	MERCH	SERV	FONDEO
CORE	1.000000	0.741910	0.536877	−0.091902
MERCH	0.741910	1.000000	−0.167357	−0.476747
SERV	0.536877	−0.167357	1.000000	0.463397
FONDEO	−0.091902	−0.476747	0.463397	1.000000

Source: own estimation

Several SB in core prices could have been caused by either Services or Merchandises. They both have an important correlation with core prices in every stage of our sample. As can be seen in every subsample, the correlation between core inflation and it's subindex is higher than 50%. What exhibits a great variation and, even negative numbers is the correlation between the Central Bank's Fondeo interest rate, the core prices and it's subindex.

Observe that the Mexican Central Bank's monetary policy instrument, Fondeo, went from a negative -12.78% correlation with core prices in the first subsample (Table 2) to only -9.19% (Table 7) correlation in the last subsample. Furthermore, the effect of monetary policy on the services subindex augmented from negative -29.83% in the first subsample to 46.33% in the last subsample. It can be argued that the correlation between the services/merchandises sub-subindex and the core subindex have remained relatively stable over the 12-year sample that we study. However, the relation between the services sub-subindex

and the merchandises sub-subindex has experienced a dramatic change. It went from a positive 10.53% correlation in the first subsample to a negative -16.73% in the last subsample. We observed in the previous results that the April 2010 SB in the core subindex coincided with SBs in services sub-subindices. Correlations alone do not help us determine who caused who, this only indicates linear dependence between variables.

We now expand our study of the relation between prices and monetary policy to Granger-causality (the Granger causality test is a statistical hypothesis test for determining whether a one-time series is useful in forecasting another). Here, we include the FIX exchange rate into the analysis to observe its relationship with core inflation, tables 8 to 13 show the oputputs, this will help us to visualize a priori if the exchange rate explains the behavior of inflation.

Table 8. Granger Causality Tests, sample: 2005M01-2007M12

	Lags	F-Statistic	Prob.
CORE does not Granger Cause FONDEO	4	2.3517	0.0841
MERCH does not Granger Cause CORE	2	4.4450	0.0207
SERV does not Granger Cause CORE	2	4.4335	0.0209
SERV does not Granger Cause FONDEO	2	2.5010	0.0995
FIX does not Granger Cause CORE	2	2.8380	0.0755
FIX does not Granger Cause SERV	2	3.9383	0.0311

Source: own estimation

Table 9. Granger Causality Tests, sample: 2008M01-2010M04

	Lags	F-Statistic	Prob.
MERCH does not Granger Cause FONDEO	2	4.4112	0.0252
FONDEO does not Granger Cause SERV	2	5.8905	0.0093
FONDEO does not Granger Cause CORE	2	3.1071	0.0476

Source: own estimation

Table 10. Granger Causality Tests, sample: 2010M05-2012M03

	Lags	F-Statistic	Prob.
CORE does not Granger Cause FIX	2	2.7767	0.0922
MERCH does not Granger Cause FIX	2	2.9494	0.0812
FIX does not Granger Cause MERCH	3	3.0313	0.0676

Source: own estimation

Table 11. Granger Causality Tests, sample: 2012M04-2014M03

	Lags	F-Statistic	Prob.
FONDEO does not Granger Cause CORE	2	2.8335	0.0867
SERV does not Granger Cause FIX	4	3.8443	0.0343
FONDEO does not Granger Cause FIX	4	3.9592	0.0314

Source: own estimation

Table 12. Granger Causality Tests, sample: 2014M04-2016M02

	Lags	F-Statistic	Prob.
FIX does not Granger Cause MERCH	2	2.8258	0.0889

Source: own estimation

Table 13. Granger Causality Tests, sample: 2016M03-2017M12

	Lags	F-Statistic	Prob.
CORE does not Granger Cause FIX	2	7.7967	0.0048
FIX does not Granger Cause CORE	3	3.1089	0.0668

Source: own estimation

For the January 2005-December 2007 subsample. We find that services sub-subindex Granger-caused Core and Fondeo with 2 lagged months; and merchandises also Granger-caused Core with 2 lagged months. FIX caused both Core and services with 2 months lagged. Furthermore, all three subindices Granger-caused Fondeo with 2 and 4 lagged months. Monetary policy was reacting to changes in prices with four lags.

Table 9 and 10, show that Fondeo caused both services and Core inflation with 2 and four months lagged respectively, merchandises caused fondeo with 2 months lag and, finally Core and merch sub-index caused FIX exhange rate with 2 months lagged. In 2010 the final inflation data was below the forecast. Open CPI inflation was 4.16% for the whole year. There was nominal exchange rate appreciation in favor of the Mexican Peso; the GDP gap was negative avoiding demand side pressures; the increase in the main wage indicators was moderate. The services subindex was stable during 2010.

There was an increase in Value Added Tax rate from 15 to 16% and in the prices of government-controlled products, but the effect was temporary. Furthermore, the Bank of Mexico indicates that it found no second order effects from these increases in price formation in the economy. Regarding policy, in view of the hike in the price of commodities at the beginning of the year, the Mexican Government adopted a gradual increase policy in the price of energy and the Bank of Mexico adopted a policy that was able to avoid that the increase in prices would contaminate price formation in the economy. By the end of the year, the monetary policy had accomplished a downward trend in prices.

Considering that monetary policy decisions have an important impact on the behavior of inflation (through different transmission channels), it is essential that the central bank communication with economic agents would be clear and transparent. In this sense, a good trajectory of inflation expectations, combined with better management of the inflation targeting policy, increases the credibility of the central bank, making the management of monetary policy variables more efficient.

Granger causality tests show that Fondeo Granger-causes core anf exchange rate with a lag that starts at 2 months and goes up to 4 months (Table 11). Table 12 shows FIX Granger-caused merch and with 2 lags. Last Core has Granger causality with FIX with 2 months lagged and then relation gets inverted with 3 months lagged, now prices react to currency, and has a long-lasting effect.

After the adoption of the free-floating exchange rate regime, the exchange rate ceased to function as the policy instrument that coordinated inflation expectations around the objectives of the authority. Under these circumstances, monetary policy focused on achieving the proposed inflation targets, whose characteristics are cited below [2]:

a) The recognition of price stability as the fundamental objective of monetary policy.

b) The announcement of medium-term inflation targets.

c) Have an autonomous monetary authority.

d) The application of monetary policy in a framework of transparency, which is based on a communication strategy regarding the objectives, plans, and decisions of the monetary authority.

e) An analysis of all sources of inflationary pressures in order to evaluate the future trajectory of price growth. This analysis is the main reference for monetary policy decisions.

f) The use of alternative measures of inflation, such as core inflation, to separate those phenomena that temporarily affect inflation and identify the medium-term trend of price growth.

Since 2001, the monetary policy of the Bank of Mexico has been conducted under a scheme of inflation targets. Among the most important elements of this scheme are:

a) The announcement of a multi-year inflation target for the CPI;

[2]Outline of inflation targets, (Bank of Mexico, 2008).

b) The use of a systematic approach that seeks to identify the origin and characteristics of inflationary pressures;

c) The description of the instruments used by the Bank of Mexico to achieve its objectives, and

d) The conduct of the monetary policy that is carried out under a communication scheme that promotes transparency and credibility in the announced goals, which facilitates the decision making of the public.

In the Inflation Report corresponding to the second quarter of 2002, the Governing Board of the Central Bank announced that from that moment the monetary policy would be conducted in order to reach, in December 2003, an annual CPI inflation of 3 percent, considering a variability interval of plus/minus one percentage point. On the other hand, during 2003 two technical modifications were made related to the implementation of monetary policy:

a) The replacement, as of April 10, of the regime of accumulation balances in the current accounts that the Bank of Mexico takes to the bank for one of the daily balances (short).

b) The constitution of a deposit of monetary regulation in the Bank of Mexico by credit institutions for 30 billion pesos.

As announced in the Inflation Report corresponding to the third quarter of 2007, on January 21, 2008, the Bank of Mexico adopted the one-day interbank interest rate as an operational objective. Change that facilitated the understanding of monetary policy actions, harmonized its implementation along with the adoption by several central banks of the world as well and signed the conclusion of a transition process in the implementation of monetary policy in Mexico, which began in 2003.

After maintaining the target for the Interbank Interest Rate to 1 day without change at a level of 7.50 percent from January to May 2008, in the months of June, July and August, Bank of Mexico decided to restrict this target by 25 points basis on each occasion, with which it increased from 7.50 percent to 8.25 percent. These actions sought that the upturn observed in inflation, derived from the increase in the prices of raw materials, will not affect the "anchoring" of medium-term inflation expectations and, consequently, the process of price formation in the economy.

Subsequently, in 2009, Banxico's Governing Board implemented a relaxation cycle in its monetary policy stance. The reduction of the objective for the 1-day Interbank Interest

Rate took place during the first 7 months of the year. In this way, this objective was reduced from a level of 8.25 percent registered at the end of 2008 to 4.50 percent as of July 17, 2009, accumulating a decrease of 3.75 basis points, in congruence with the monetary policy measures taken by the Federal Reserve derived from the international financial crisis, this generated upward inflating pressures and widening the gap between expectations and observed inflation.

During 2010, the Governing Board of the Bank of Mexico decided to maintain the target for the overnight interbank interest rate at 4.5 percent, at the level it had been since July 17, 2009. It also announced that as a measure to reinforce the communication with the economic agents, from 2011 the minutes of the meetings of the governing board for decision making of monetary policy would be published, in this way it contributed to that the inflation registered in that year, was lower than that of 2009, neutralizing the fiscal and monetary effects that had arisen, the average of the expectations corresponding to the closing of 2011 for general inflation was 3.53 percent, the objective interest rate remained at 4.5% and during that year there were no pressures on prices derived from the conditions in the labor market, since the wage increases were moderate, and the unemployment rate remained relatively high.

During 2012, inflation was slightly above its target (4.11 %), however, it showed a downward trend. In the annual report[3], Bank of Mexico argued that the pressure came from the supply side, due to changes in the relative prices of some agricultural goods and exchange rate adjustments. The interest rate remained at 4.5%. Inflation expectations were around 4.16% for the close of that year (see figure 4), which confirms that expectations remained anchored according to the central bank's position to act in the face of distortions that could affect the macroeconomic environment.

Having achieved a stable level of inflation, in 2013, the governing board decided to relax the monetary policy, reducing the target for the target interest rate by 50 basis points in March, then in September and October, there was a reduction of 25 basis points respectively, leaving the Interest rate at 3.5%. The financial markets favorably viewed these changes, thanks to the anchoring of inflation expectations. One of the reasons for adjusting the interest rate was that there were certain risks for the Mexican economy, one of them was the slack conditions in the labor market, moderate variations were observed in wage indicators of the economy, as well as slight increases in the average productivity of labor[4].

Years 2014 and 2015 were of low and stable inflation, expectations remained anchored to the economic performance and the interest rate remained unchanged at 3 %, however,

[3]Annual report. Bank of Mexico (2000 - 2012)

[4]See graphic 177 of the quarterly report 2013 of the Bank of Mexico

by December 2015, it was decided to increase the base rate by 25 basis points. interest due to the high volatility that occurred in the financial markets and the depreciation of the currency, which resulted from the increase in the same score as the federal reserve implemented, this with the objective of homologating the differential of interest rates between both economies. For February 2016, in an extraordinary meeting of the governing board, the target for the Interbank Interest Rate was increased by 50 basis points, while the Ministry of Finance announced a preventive adjustment to public expenditure for 2016, meanwhile The Exchange Commission decided to suspend the mechanisms for selling dollars, without ruling out discretionary intervention in case of exceptional conditions in the exchange market. The economic situation for this year was complicated, especially in the last months by the elections in the United States, this generated a strong exchange rate depreciation and the Bank of Mexico, decided to bring the interest rate to 6.25%, this led to a widespread increase in short and medium term inflation expectations.

Undoubtedly, 2017 was a complicated year for inflation, standing at 6.07%, therefore, the government board took the interest rate to a level of 7.5% to face the balance of risks that represented for the economy, both the volatility in the exchange rate (derived from the negotiations in the NAFTA), as well as the inflationary effects that brought the generalized increase in the energetics (gasoline and LP gas). As of February 18, 2017, the maximum prices of gasoline began to be determined on a daily basis using a new formula that, while still contemplating the prices of international references converted to pesos, seeks to mitigate the effect of excessive fluctuations in those references[5]. All this led to an increase in inflation expectations that were modified downward along the central bank's releases[6].

Once the consolidation of macroeconomic stability and the further development of financial markets have been achieved, establishing an operational objective on interest rates was a natural step. In this way, the adoption of the one-day overnight interbank funding rate as an operational objective to replace the "short" concludes the transition that began in 2003. Monetary policy announcements as of April 2004 have established minimum interest rates, for what the market has operated "de facto" following a rate indicated by the Bank of Mexico. It is worth noting that the last movement of interbank funding rates related to a change in the "short" was in February 2005. In this sense, the formal migration to an operational target of interest rates will be implemented without altering the form in which the Bank of Mexico carries out its operations. Additionally, the change will facilitate the

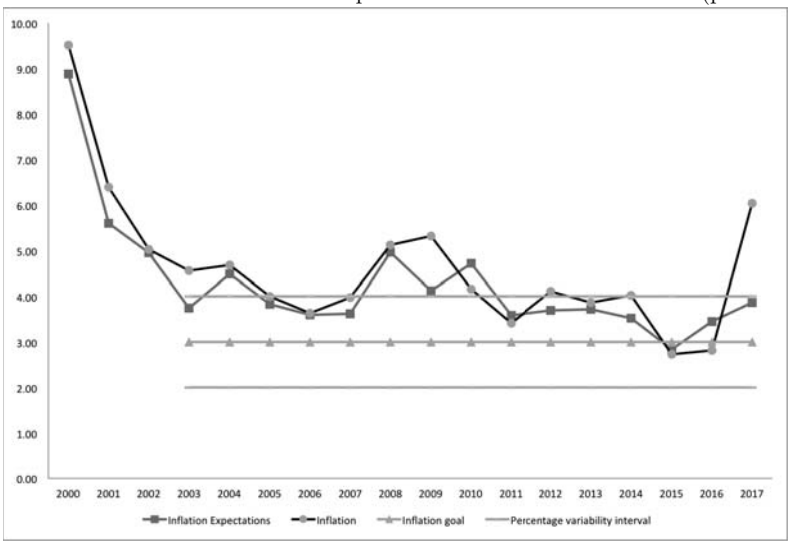
[5]Energy regulatory commission

[6]To know how the Mexican bank performs the estimation of long-term inflation expectations, see the box "Decomposition of the Compensation for Expected Inflation and Inflationary Risk" in the Quarterly Report 2013 of Bank of Mexico (2013 - 2017)

understanding of monetary policy actions and will standardize their implementation with which several central banks of the world follow.

As shown in figure 4, the behavior of inflation expectations have been consistent and adjusted favorably in the decision-making process by the central bank. There have been unexpected movements on the supply side, the reason why they have been distorted the gap between observed and expected inflation. For all the above, the Bank of Mexico enjoys today a well earned and deserved prestige. Independently of its legal faculties, nobody disputes the rectora of the financial and monetary systems and the regulatory functions that in the monetary matter are their own. Hence it's an indisputable, intellectual, and moral authority.

Figure 4: Contrast between inflation expectations and observed inflation (percentages)



Source. Own elaboration with Banxico's Data

4 The ARDL Model.

Autoregressive Distributed Lag Models (ARDL) are popular for their method of finding cointegration relationships. In this regard, Pesaran and Shin (1998) argued that ARDL models have the advantange to handle cointegration with inherent robustness to misspecification of integration orders of relevant variables.

In econometrics, the ARDL models are standard least squares regressions that include lags of both the dependent variable and explanatory variables as regressors (Greene, 2008). An $ARDL(p, q)$ will be stable if the roots of the characteristic endogenous polynomial fall within the unit root circle, i.e. it is stationarity at levels.

As mentioned before, Mark W. Watson (2014) proposes a traditional Phillips Curve context for explaining the dynamics of inflation, given by

$$\phi(L)(1 - L)\pi_t = \beta(L)(u_t - \bar{u}_t) + \gamma(L)Z_t + e_t \tag{4.14}$$

where $\phi(L)$, $\beta(L)$ and $\gamma(L)$ are lag polynomials of orders p, q and s, and e_t is a serially uncorrelated error term. This one is the model that we will estimate as an *ARDL(p,q,s)*, and whose results are described below.

4.1 Model data

The data used in this study consist of 156 monthly observations of the variation in mexican core inflation index (reported by INEGI) as the dependent variable π_t, the independent variable of unemployment gap $(u_t - \bar{u}_t)$ was built by the logarithm of the number unemployed population that is reported in the ENOE by INEGI, minus its long-term trend which was estimated by the Kalman filter (represented graphically in the previous section), we know there are several ways to calculate the NAIRU, and that all of them are subject to measurement error, therefore we took the risk; and last for modeling the parameter of Z_t, we use three time series: 1) The variation in price of the energy assets (reported by INEGI) , 2) The variation in average monthly computation of the exchange rate to settle obligations of payment in foreign currency (FIX, reported by Bank of Mexico) and 3) The variation in Fondeo rate (reported by Bank of Mexico).

All of the variables were obtained during the study period: January 2005 to December 2017. In order to not disaggregate the observations into short periods, it was chosen to divide the time series into two subsamples: from January 2005 to March 2012 (the first three subsamples of Table 1) and from April 2012 to December 2017 (last 3 subsamples of the previous section).

4.2 Stationarity of the series

The first step of this econometric exercise is to examine the order of integration of the time series that we are going to use, this can be done by calculating the Dickey-Fuller Augmented (DFA) test. This theory suggests to reject the null hypothesis ($H_0 : \gamma = 0$) and accept the alternative hypothesis ($H_1 : \gamma > 1$) if the series is stationarity. So, the index of core inflation has zero integration order $I(0)$ (what gives stability to the model); the unemployment gap, shows stationary at levels too, is $I(0)$; the three variables representing parameter $\gamma(L)$: Fondeo, FIX exchange rate and the price of energetics, also showed stationarity at levels, so are all $I(0)$. In fact, the residuals have zero integration order $I(0)$ too, this tells us that all the variables we are working with are cointegrated, a very important assumption for the functionality of the model. Table 14, shows the computation of the Dickey-Fuller tests to prove the stationary mentioned.

Table 14. Dickey-Fuller Augmented Test

Variable	Augmented DF test statistic	Critical value 5% level	Prob.
π_t	-3.582088	-2.881260	0.0072
$\Delta\pi_t$	-5.584512	-2.881541	0.0000
$\Delta^2\pi_t$	-5.402934	-2.881978	0.0000
$(u_t - \bar{u}_t)$	-2.230671	-1.943090	0.0253
$\Delta(u_t - \bar{u}_t)$	-4.344323	-1.943107	0.0000
$\Delta^2(u_t - \bar{u}_t)$	-8.644569	-1.943123	0.0000
Fondeo	-4.347574	-2.880336	0.0005
Δ*Fondeo*	-6.848959	-2.880987	0.0000
Δ^2*Fondeo*	-7.700025	-2.881541	0.0000
Exchange rate	-9.056725	-2.880211	0.0000
Δ*Exchange rate*	-6.943660	-2.881541	0.0000
Δ^2*Exchange rate*	-6.457688	-2.882279	0.0000
Energy assets	-12.43497	-2.880211	0.0000
Δ*Energy assets*	-7.057438	-2.881541	0.0000
Δ^2*Energy assets*	-7.031219	-2.882127	0.0000
e_t	-6.956589	-2.913549	0.0000

Source: Own estimation.

4.3 Estimation outputs

Estimation of equation (4.14) can be a little complicated because of the time variations of its components. However, let's proceed to the estimation of the ARDL models.

Table 15 shows the outputs where variable Z_t is the energetics' prices, the best-selected

model under the Akaike Information Criteria (AIC) for subsample one was $ARDL(1,2,0)$ wich means that core inflation reacts to itself with only one month lag in almost 21.48% at a level of 95% statistical significance, unemployment gap (captured by $\beta(L)$), reacts to core inflation with two months lagged, this parameter is statistically significant at 90% of statistical significance, it means that a move of 1% in the unemployment gap, affects the level of core index in 50.83% negatively, so the Phillips curve is achieved but only for this period. For the second subsample the best elected model was $ARDL(3,0,0)$. Here core inflation reacts to itself with 3 lags, and unemployment gap and energetics prices react to core index on its contemporary value. Observe that inflation changes almost 25% for the second period for the next quarter. Conversely, the parameter of $(u_t - \bar{u}_t)$ is not significant.

Going to parameter $\gamma(L)$, prices of energetics only reacts to the core index on its contemporary value, for both subsamples the value is not statistically significant, this can be explained by the fact that till beginnings of 2017 in the Mexican economy, the energetic assets were subsidized by the government and therefore in our sample of time, do not have a direct effect on prices.

Table 15. ARDL estimation with Z_t as energetics' prices.

	First Subsample: 2005-01/2012-03		Second Subsample: 2012-04/2017-12	
Selected Model	(1, 2, 0)		(3, 0, 0)	
Variable	Coefficient	Prob.	Coefficient	Prob.
$\phi(-1)$	0.214849	0.0146	0.257884	0.0394
$\phi(-2)$	-	-	-0.101543	0.4186
$\phi(-3)$	-	-	0.252096	0.0422
$\beta(0)$	-0.318736	0.2355	-0.044322	0.9080
$\beta(-1)$	0.475340	0.3443	-	-
$\beta(-2)$	-0.508380	0.0901	-	-
$\gamma(0)$	0.000185	0.7168	0.000512	0.5416
AIC	-4.164947		-2.810135	

Source: Own estimation.

Table 16 shows the output of the estimation of our model ARDL with the parameter Z_t as the exchange rate for both subsamples of time, as can be observed in the table, the best selected models where $ARDL(1,2,0)$ for subsample number one and $ARDL(3,0,2)$ for subsample number two, under the AIC. It is remarkable to say that as in the previous model, once again the first lag of $\phi(L)$ remains as statistically significant at 95% level of significance, i.e. core inflation has a reaction to itself on the nex month in 20.68% period number one, for the second period the core reacts with three lags to itself in 26.09% at 95% level of significance. About the parameters of the unemployment gap ($\beta(L)$), they remain

significant but only for the first subsample, the effect is negative 52.5% on core inflation, the Phillips curve is worth again only in the first subsample, for the 2012-04/2017-12 period the parameter is not significan.

Then, table 16 shows the effects on the exchange rate ($\gamma(L)$), although core index reacts on its contemporary value, this is not statically significant in the first period. But, for the second one, there is a reaction of two months lagged in almost 55.29% on core inflation, this could be explained by the factors that put pressure on the exchange rate towards closing the 2017, such as:

i) the normalization processes of the monetary policy in the United States,

ii) the renegotiation of the NAFTA and

iii) the electoral process in Mexico.

In this way, the monetary policy stance was modified to allow the adjustment in relative prices derived from these shocks to occur in an orderly manner, without second order effects on the price formation process of the economy. [7]

Table 16. ARDL estimation with Z_t as FIX exchange rate

	First Subsample: 2005-01/2012-03		Second Subsample: 2012-04/2017-12	
Selected Model	(1, 2, 0)		(3, 0, 2)	
Variable	Coefficient	Prob.	Coefficient	Prob.
$\phi(-1)$	0.206828	0.0207	0.321770	0.0024
$\phi(-2)$	-	-	-0.124822	0.0652
$\phi(-3)$	-	-	0.260992	0.0018
$\beta(0)$	-0.325143	0.2136	0.079481	0.8213
$\beta(-1)$	0.504117	0.3147	-	-
$\beta(-2)$	-0.525079	0.0799	-	-
$\gamma(0)$	0.092389	0.3658	0.366708	0.0064
$\gamma(1)$	-	-	-0.536924	0.2063
$\gamma(2)$	-	-	0.552973	0.0203
AIC	-4.173069		-2.830266	

Source: Own estimation.

Finally, Table 17 shows the output of the models estimated with Z_t as fondeo rate, here, the best-performed models (in line with AIC) were $ARDL(1, 2, 0)$ for subsample one and $ARDL(3, 0, 0)$ for subsample two. Similarly to the estimation of Tables 15 and 16, $\phi(L)$

[7] Quarterly Report October - December 2017, Bank of Mexico.

once again reacts at the first lag an then changes to a quarter lag. Core inflation changes in almost 21.28% to itself during the next month in the first period and almost 25% in the second period (as can be seen this parameter is statistically significant at 95% level). Parameter $\beta(L)$ of unemployment gap is reacting -51.75% with two lags but only for the first subsample, the effect for the next period is not significant, so the Phillips curve remains significant again but only in the first period. The estimation of parameter $\gamma(L)$ seems weird because inflation has no reaction to interest rate, one of the most significant instruments of monetary policy, this result might be explained by the fact that inflation is giving more weight to their own expectations that the instrumentation of monetary policy, this would give us notions that the transmission channel of interest rates is losing strength.

Table 17. ARDL estimation with Z_t as Fondeo

	First Subsample: 2005-01/2012-03		Second Subsample: 2012-04/2017-12	
Selected Model:	(1, 2, 0)		(3, 0, 0)	
Variable	Coefficient	Prob.	Coefficient	Prob.
$\phi(-1)$	0.212878	0.0515	0.230878	0.0635
$\phi(-2)$	-	-	-0.101205	0.4215
$\phi(-3)$	-	-	0.245936	0.0506
$\beta(0)$	-0.328918	0.2271	0.000968	0.9978
$\beta(-1)$	0.490125	0.2691	-	-
$\beta(-2)$	-0.517579	0.0623	-	-
$\gamma(0)$	-0.000176	0.7155	0.001306	0.4349
AIC	-4.165265		-2.796885	

Source: Own estimation.

In summary, this results might tell us (as Watson describes), that inflationary persistence in Mexico reacted with a lagged month and then changes every quarter due to the good anchoring of expectations, this means that variations in the right-hand side of the model have smaller effects on the trend inflation rate. Nevertheless, the Phillips curve worked only in the first subsample for all the estimations, this tells us that in a certain way, core index is also explained by the variations of unemployment, this could be an interesting contribution to consider for the policymakers.

4.4 Correlation and homocedasticity of the models' estimation

Since ARDL models are estimated by simple least squares, it's important to verify that the residuals from the model are serially uncorrelated, as well as the testing for residual homoscedasticity (if not, the parameter estimates won't be consistent, because of the lagged

values of the dependent variable that appear as regressors in the model). Tables 18 and 19 show the outputs.

First, for correlation, let's remember that the null hypothesis $H_0 : \{\rho_i = 0 \quad \text{for all} \quad i\}$ that holds there is no serial correlation of any order up to p, so, as can been seen in table 18, for all the models (with 2 lags), the probability value is higher than 0.10, so we accept the null and say that we do not have problems of serial correlation. In this regard, to prove if σ_i^2 are homoscedastic, we can test the hypothesis that $\alpha_2 = \alpha_3 = \cdots = 0$. This is the basic idea of the Breusch-Pagan test. Which is estimated by the following regression (Gujarati, 2009).

$$\sigma_i^2 = \alpha_1 + \alpha_2 Z_{2i} + \cdots + \alpha_m Z_{mi}$$

Table 19 shows the output of this test, whose p-value (greater than 0.10) indicates that we can accept the null and we do not have heterocedasticity problems either.

Table 18. Breusch-Godfrey Serial Correlation LM Test

Model	F-statistic	Prob. F
(1, 2, 0)	1.127350	0.3291
(3, 0, 0)	0.965220	0.3865
(1, 2, 0)	1.896230	0.1570
(3, 0, 2)	0.014795	0.9853
(1, 2, 0)	1.206499	0.3133
(3, 0, 0)	1.249090	0.2924

Source: Own estimation.

Table 19. Heteroskedasticity Test: Breusch-Pagan-Godfrey

Model	F-statistic	Prob. F
(1, 2, 0)	0.046722	0.9987
(3, 0, 0)	0.147877	0.9800
(1, 2, 0)	0.104774	0.9909
(3, 0, 2)	1.206499	0.3133
(1, 2, 0)	0.603760	0.6972
(3, 0, 0)	0.893496	0.4911

Source: Own estimation.

5 Post-Estimation.

5.1 Computation of the long-run effect.

In accord with Greene (2008), an ARDL in its distributed lag form is

$$\begin{aligned} y_t &= \frac{\mu}{C(L)} + \frac{B(L)}{C(L)}x_t + \frac{1}{C(L)}\delta w_t + \frac{1}{C(L)}\epsilon_t \\ &= \frac{\mu}{1-\phi_1-\phi_2-\cdots-\phi_p} + \sum_{l=0}^{\infty}\alpha_j x_{t-j} + \delta\sum_{j=0}^{\infty}\theta_l w_{t-l} + \sum_{j=0}^{\infty}\theta_l\epsilon_{t-l}. \end{aligned}$$

The lag coefficients in x_t, x_{t-1}, x_{t-2}, and so on, are the individual terms in the proportion of polynomials that appear in the form of distributed lags. They are denoted as coefficients

$$\alpha_0, \alpha_1, \alpha_2, \cdots = \text{the coefficient on} \quad 1, L, L^2, \ldots \text{in} \quad \frac{B(L)}{C(L)} \tag{5.15}$$

An easy way to calculate this coefficient that for the purposes of this research we will call the *total multiplier* is to write (5.15) as $A(L)C(L) = B(L)$.

So, the long-run effect of an ARDL can be computed as

$$\sum_{i=0}^{\infty}\alpha_i = \frac{B(1)}{C(1)} \tag{5.16}$$

The total multiplier measures the whole influence of the exogenous variable on the endogenous throughout the relationship in the entire sample, this we could say, is an equivalent to the parameter θ, proposed by Watson that measures how well the trend level of inflation is anchored. So, as the reader will remember from equation (2.11) that was desribed in chapter one, when $\theta = 1$, a one unit change in η_{t+i} has no effect on the long-run level of inflation, while when $\theta = 0$, the long run level in inflation moves one for one with η_{t+i}.

So, the long-run effect of a change in inflation ($\Delta\pi_t$) on unemployment will be

$$\bar{\beta} = \frac{\beta(1)}{\phi(1)} \tag{5.17}$$

and the long-run effect on Z_t is

$$\bar{\gamma} = \frac{\gamma(1)}{\phi(1)} \tag{5.18}$$

Now, we will proceed to compute the long-run effect of the models estimated before. The outputs are shown in Tables 20, 21 and 22.

Observe that for Table 20 the long-run effect of the unemployment gap in the level of inflation is negative in 44.80% for the first period and then the relationship gets reversed positively in 17.35% for the second period. We know then that the relationship between inflation and unemployment is inverse, so the Phillips curve is satisfied for the Mexican economy (although it was not used as an instrument for making policy), but only for the first five years of our analysis, then surprisingly the Phillips curve is reversed. The effect of energetics' prices is hardly 0% for both periods, this is a very small effect caused by the subsidy of the energetic prices that remained for many years as a fiscal policy. For Table 21, wich is very similar to the previous one, the inverse relationship between unemployment and inflation is met for the firs subsample, the effect is 43.62% negative for 2005-01/2012-03 and then, the Phillips curve gets reversed in 14.64% for 2012-04/2017-12. The long-run effect of the exchange rate over the inflation remains low along the first subsample, IT reaches an 11.64%, but for the second one is high in almost 70.54% for the reasons we exposed before, causing second order effects on inflation. In this regard, the monetary authority has placed great emphasis on the care of this transmission mechanism in such a way that it minimizes the effects on the price index. Finally, in Table 22, similar results as above remains, the inverse relationship between inflation and unemployment is kept in 45.26% for 2005-01/2012-03 and then the Phillips curve gets inverted (once again) and drops strongly to 0.16% positive for the second subsample. Even the long-run effect of interest rate over the core index is nearly to zero, the considered assumption that may explain this, is that Bank of Mexico has reinforced the channel of communication with the economic agents and so the anchor of inflation expectations plays a bigger role in inflation than the main policy instrument.

Table 20. Long-run effect for the ARDL of energetics' prices.

	First Subsample: 2005-01/2012-03	Second Subsample: 2012-04/2017-12
Variable	Coefficient	Coefficient
$\bar{\beta}$	-0.4480	0.1735
$\bar{\gamma}$	0.0002	0.0010

Source: Own estimation.

Table 21. Long-run effect for the ARDL of FIX exchange rate.

	First Subsample: 2005-01/2012-03	Second Subsample: 2012-04/2017-12
Variable	Coefficient	Coefficient
$\bar{\beta}$	-0.4362	0.1464
$\bar{\gamma}$	0.1164	0.7054

Source: Own estimation.

Table 22. Long-run effect for the ARDL of Fondeo.

	First Subsample: 2005-01/2012-03	Second Subsample: 2012-04/2017-12
Variable	Coefficient	Coefficient
$\bar{\beta}$	-0.4526	0.0016
$\bar{\gamma}$	-0.0002	0.0021

Source: Own estimation.

In brief, we have quite evidence to say that structural changes or supply shocks in the economy do not have such an impact in the behavior of inflation. On the other hand, we may say that the Phillips curve worked Mexican between 2005 and 2010 what explained in some way the inflationary dynamics. Nevertheless, this changes for the second subsample and the level of inflation reacts strongly to itself every quarter, and the effect of unemployment gets backward (a curious output) that can be explained by the fact that lately, low inflation post-Keynesian studies have focused on how economic agents form expectations to explain the relationship between prices and unemployment. In this regard, Akerlof, Dickens, Perry, Bewley, and Blinder (2000) say that not taking care of inflationary expectations when fixing wages may lead to a wrong projection of inflation generating consequences on the prices-employment relationship.

Another perspective on the positive sloped Phillips Curve can be found on Palley (2009), he proposes a new concept instead of the NAIRU, the minimum unemployment rate of inflation (MURI) that is the inflation rate that obtains when the labor market and nominal demand growth are maximized. This point of view sees monetary policy working on its impact on nominal demand growth. So, monetary policy effectively manages nominal demand growth, to obtain the desired rate of inflation or unemployment (Palley, 2009).

For all the above we could say that the argument of Watson is fulfilled: inflation persistence has changed and is well anchored for the Mexican case. Our research hypothesis is proved: a change in inflationary persistence changes the relationship between other variables of monetary policy.

6 Conclusions

In this research work, we took the framework previously made by Watson (2014), where it is shown a change in the persistence of inflation between two-time samples. We tried to apply the same theory to the Mexican case with the objective of modeling the inflationary dynamics by measuring and explain the effect of a change in the inflationary persistence in the monetary policy of the Bank of Mexico using the NAIRU.

In the first place, we described an extense framework of literature addressed to inflationary dynamics, the Phillips curve, and the NAIRU. Later we did statical analysis to observe and describe the evolution as well as the relationship between inflation, unemployment, and monetary policy variables, even though the NAIRU is not an observable variable, we calculated the level of long-run of unemployment through the Hodrick-Prescott filter, in addition, we found and explained several structural breakpoints along the sample and did correlation matrices, as well as test of Granger's causality, where we find causality between variables and the remain question was if inflationary persitence played a relevant role in this relationships. Then, we intend to model the inflation expectation graphically to observe the level of anchor as an explanatory variable for the further calculations, and to see how well the central bank communicates with the economic agents in the formation of inflation expectations. Finally, to find out the answer we did econometric analysis by the implementation of several ARDL models that shown curious results.

We divided our sample by two due to the change of basis year in final 2010 to find out how the dynamics of inflation behaves and if there was a change in inflationary persistence. Our results suggested that the core index of inflation has a reaction on itself one month lagged for the first period and then changes, so, the persistence last a quarter of the time for the second subsample. Also, we found an inverse relationship between inflation and unemployment, so Friedman's idea that inflation has a strong inertial component and that Phillips curve exists is met here, but only in the first subsample of our analysis, and then changes to a positive relationship that could be explained with a post-Keynesian approach. An important highlight here is that the inverted Phillips curve may work under low inflation rates returning stability between prices and level of employment. In this sense, it would be good for monetary policy to give greater emphasis on the role of employment in the inflation dynamics since it is an important variable for economic growth and development of the Mexican economy. Now, if the monetary authority is aiming for the lowest possible sustainable rate of unemployment, it should aim for an inflation rate equal to the MURI (Palley, 2009).

Others factors considered as Z_t, such as energetics' prices or interest rate were not

significant, we found a possible explication in the fact that the central Mexican bank has been careful with the implementation of monetary policy so that these factors interact issueless with inflation to achieve their objectives. Nevertheless, only the exchange rate was significant for the second subsample due to the fact that the Mexican peso had a strong depreciation against the dollar mainly because of the uncertainty generated by the political decisions in the United States, and the renegotiation of the free trade agreement, in this regard Bank of Mexico and the and the exchange rate commission remained alert to avoid second-order effects in the inflation.

But, mostly, *inflation reacts to its own lags*, due to the good anchoring of inflation expectations, so, we can argue that the central bank has served as a good intermediary between the behavior of inflation and economic agents. Finally, we did further estimation as the long-run effect and the bound tests to prove if the models we worked with had long-run relationship and stability, this was achieved without any problem.

The intent of contribution of this research is to determine if the labor market has implications on the behavior of prices in the Mexican economy, as well as detail the instrumentation of monetary policy in order to achieve their inflation objectives. Although this kind of topics are broadly studied, not so many consider the unemployment rate on the analysis, and this is why we consider the work of Watson as top.

For all the above we can broadly conclude that the hypothesis raised in this paper: *that the relationship between monetary policy variables is affected by a change in the persistence of inflation* is achieved. We know there are some other issues that we could have missed, the door stays open to deepening the analysis in further research.

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