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Taylor rule and monetary policy transmission mechanism in a new keynesian economy: evidence for Mexico

Christopher Cernichiaro Reyna*

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Abstract

This paper estimates two SVAR models to assess Mexican Monetary policy rate for the period 2000-2015, which are recursively identified according to Gali and Monacelli (2005) model. This paper shows that monetary policy rate responds to GDP, inflation and exchange rate as Taylor's Rule predicts. When controlling for General Consumer's Price Index inflation, monetary policy barely affects aggregate demand even if exchange rate appreciates, nevertheless GDP diminish after contractive monetary policy takes place. Inflation rate lightly increases after interest rate rises, which does not coincide with New Keynesian predictions. A second model is estimated controlling for underlying inflation. Its results exhibit more interest rate sensitive consumption and net exports, while real exchange rate and GDP change as New Keynesian model predicts. Inflation decreases after monetary policy rise but its fluctuations are close to zero. According to Gali (2008) such small changes indicate nominal rigidities existence.

Keywords: small open economy, new keynesian model, recursive identification, SVAR, underlying inflation.
JEL classification: E12, C32, C50, O11.

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*Profesor-investigador en la Universidad Autónoma Metropolitana. Correo: 13uam13@gmail.com.
Agradezco a tres dictaminadores anónimos por sus observaciones, mismas que enriquecieron esta investigación.

Regla de Taylor y mecanismo de transmisión de la política monetaria en una economía nueva keynesiana: evidencia para México

Resumen

En esta investigación se estiman dos modelos SVAR para evaluar la política monetaria en México durante el periodo 2000-2015, los cuales son identificados recursivamente a través del modelo de Gali y Monacelli (2005). Los resultados muestran que la tasa de interés responde a la producción, inflación y tipo de cambio como asevera la regla de Taylor. Al controlar la inflación a través del índice general de precios al consumidor, los efectos de la política monetaria en la demanda agregada son muy pequeños a pesar de que se observa una apreciación cambiaria, sin embargo, la producción decrece a causa de la política contractiva. La inflación exhibe un ligero aumento, lo cual no coincide con las predicciones nuevas keynesianas. Se estima un segundo modelo controlando para inflación subyacente. Los resultados muestran que consumo y exportaciones son más sensibles a la tasa de interés, mientras que el tipo de cambio real y la producción cambian como predice el modelo nuevo keynesiano. La inflación disminuye tras el aumento de la tasa de interés, pero sus fluctuaciones son cercanas a cero, de acuerdo con Gali (2008) esto sugiere existencia de rigideces nominales.

Palabras clave: economía pequeña y abierta, modelo nuevo keynesiano, identificación recursiva, SVAR, inflación subyacente.
Clasificación JEL: E12, C32, C50, O11.

1. Introduction

According to authors such as Bajo and Díaz (2016), Andrle *et al*. (2015), Hevia and Nicolini (2013), Alpanda *et al*. (2010), Gupta and Kabundi (2010), Woodford (2007) among others, the model proposed by Gali and Monacelli (2005) is the canonical small open New Keynesian economy. Such context proposes an economy composed by Central a Bank in which consumers and producers anticipate future according to rational expectations hypothesis. This economy is formed by a dynamic IS equation, which is derived from a representative household that maximizes expected utility subject to an intertemporal budget constraint. IS function means that aggregate demand responds to exante real interest rate, through both intertemporal consumption choices and net exports (through expected real exchange rate). This economy is also composed by a Phillips curve, which asserts that inflation responds positively to production, through marginal costs. Producers have market power and set prices a la Calvo (1983), in such way that if their marginal cost rise they stablish higher prices which reflects on higher inflation and vice versa. To close the model, it is assumed that monetary policy is conducted through a Taylor Rule, this is, short run nominal interest rate reacts to GDP and inflation, so monetary policy tries to keep GDP close to its natural level and inflation to its target. Central Bank can affect real sector because nominal interest rate changes in such way that exante real interest rate changes too, so consumer and producer make different choices that reflect on production and inflation.

Recent literature has assessed monetary policy reactions and its consequences. For example, using a New Keynesian small open economy, Corsetti *et al*. (2017) analyze the convenience of setting a flexible or pegged exchange rate. Two of their main findings are that a peg is a better choice if domestic economy experiments a recession, but a flexible one is more beneficial if a negative supply happens abroad. Chen and Yue (2017) use a New Keynesian open economy and a Bayesian approach to evaluate monetary policy effects in Taiwan. They find that exogenous shocks have different effects on welfare depending on the policy target selected. Gali and Monacelli (2016) propose a small open New Keynesian economy and through several simulations argue that labor cost reductions effects on employment stimulus are lesser in a currency union than alternative monetary arrangements, and that an increase in wage flexibility reduces welfare independently of such arrangements. Many researchers have studied monetary policy reactions and its effects on the Mexican economy for different time periods. For example, Loria and Ramirez (2008) estimate a SVAR, identified through the New Keynesian model, using quarterly data ranging from 1985 to 2008, they find that Taylor Rule reacts to inflation but does not respond to output fluctuations, while monetary policy does not affect inflation nor output. Gonzalez and García (2008) estimate a non-lineal VAR using monthly data from

1991 to 2005, their regressions indicate: a 2001 structural change in monetary policy transmission mechanism; monetary policy rate responding to real exchange rate, GDP and inflation (also to expectations but only after 2001); as well, after 2001 contractive monetary policy has the theoretical expected effects on output, inflation and real exchange rate. Using Generalized Method of Moments, Cermeño and Villagómez (2012) estimate a New Keynesian open economy model for Mexican monthly data for the 1998-2008 period, evincing that interest rate reacts to output, inflation and exchange rate; also find output, inflation and exchange rate responding to interest rate. Finally, Galindo and Guerrero (2003) and Loria and Ramirez (2011) argue that Mexican Central Bank respond only to inflation rate variations, the formers also claim that interest rate affects inflation and output but not to exchange rate.

Even if many researchers have analyzed monetary policy in Mexico, reviewed literature in this work points out that monetary policy stance and its effects on the economy main variables have been neglected for recent years. Therefore, in this paper it is analyzed how monetary policy has been conducted and which are its effects on aggregate demand, production and inflation in recent years. To achieve this goal, two SVAR models are estimated using monthly data for Mexico from January 2001 to December 2015. In the first model inflation is measured through general CPI, nevertheless, results show that contractive monetary policy is associated with an increase in inflation. Therefore, a second model is estimated controlling inflation through underlying CPI,[1] this way consumption and net exports report a greater reaction to monetary policy than in the first model, while real exchange rate appreciates and GDP decreases; inflation diminish after monetary policy rise but its fluctuations are close to zero, Gali (2008) argues that such small changes indicate nominal rigidities presence in the economy analyzed. plarel about foreign sector incidence in domestic economy show that after 12 months real exchange rate fluctuations explain about 2.5% of Mexican GDP variations and 7% of general inflation. In the model with underlying inflation, exchange rate variations explain about 6% of GDP fluctuations and 5% of inflation. The findings of staggered prices and capability of monetary policy to affect real sector justifies the use of models with this characteristics to

[1] This is, the goods which prices are more volatile are excluded, as those prices which government affects its determination.

analyze the Mexican economy at least for the period studied. It is also found that Central Bank must be aware of the foreign shocks in the domestic economy.

In the second section the canonical New Keynesian Model is theoretically developed; in the third section we develop the SVAR model; fourth section concludes.

2. Theoretical model

The model by Gali and Monacelli (2005) is considered the canonical small open New Keynesian economy by authors such as Woodford (2007), Alpanda *et al*. (2010), Gupta and Kabundi (2010), Hevia and Nicolini (2013), Andrle *et al*. (2015), Bajo and Díaz (2016), among others. This is a dynamic stochastic general equilibrium model composed by three blocks, one for consumers, other for producers and the external one, where all agents exhibit rational expectations. Household demands goods and offers labor to maximize expected utility subject to an identical intertemporal budget constraint for each period. Producers wish to maximize the expected benefits subject to a production function which uses labor as an input and exhibits diminishing marginal product and scale product, it produces differentiated goods and set prices a la Calvo (1983) depending on the mark-up, marginal costs and other prices settled by the rest of the domestic producers. Domestic inflation is determined by domestic goods prices and effective terms of trade, which effects increase with greater openness, Law of one price holds, and financial markets are complete. Monetary policy follows a simple Taylor rule, so the interest rate response to macroeconomic fluctuations is given by coefficients that represent policy makers experience and knowledge. In equilibrium aggregate demand for each good comes from within domestic and foreign economy, hence, macroeconomic structural form is given by a dynamic IS Curve, a New Keynesian Phillips Curve and a Taylor Rule. This is

$$\tilde{y}_t = E_t \tilde{y}_{t\,t+1} - \frac{1}{\sigma_\alpha}\left(i_t - E_t \pi_{H,t+1} - r_t^n\right) + \tag{1}$$

$$\pi_{H,t} = \beta E_t \pi_{H,t+1} + k_\alpha \tilde{y}_{t,} \tag{2}$$

$$i_t = \rho + \phi_\pi \pi_{H,t} + \phi_Y \check{y}_t + + \phi_Y \check{q}_t + v_{t.} \tag{3}$$

Where $\tilde{y}_t$ is the output gap; $E_t \tilde{y}_{t\,t+1}$ is expected output gap in t for t+1; i_t is nominal interest rate; r^n_t natural interest rate; $\pi_{H,t}$ is domestic produced goods inflation; $E_t\, \pi_{H,\,t+1}$ is expected domestic produced goods inflation in t for t + 1; $\check{q}_t$ is real exchange rate; v_t is a monetary policy shock; σ_α, k_α, ϕ_π, ϕ_Y, ρ are positive parameters. The monetary policy transmission channel is as follow, if we suppose an increase of the monetary policy rate: because the expected real interest rate increases, households choose to postpone consumption and appreciates the real exchange rate decreasing net exports.[2] Hence, aggregate demand decreases. The producers respond lowering the production, which pushes down their marginal costs; this way the producers that set new prices establish lower ones, reducing inflation. In the case of expansive monetary policy, the inverse logic applies.

Next section introduces a Structural Vector Autoregressive (SVAR) Model is built according to his theoretical framework, we also use it results to evaluate the empirical findings.

3. SVAR methodology, estimation and results

3.1. SVAR methodology

Following Ouliaris *et al*. (2016), vector autoregressive (VAR) models are linear multivariate time series models designed to capture the joint dynamic of those series; it treats each variable as endogenous and as a function of all variables lagged values

$$X_t = G_0 + G_1 X_{t-1} + G_2 X_{t-2} + \cdots + G_p X_{t-p} + e_t \tag{4}$$

Where G_0 is a nx1 vector of constants; G_j is a nxn coefficients matrix for $J=1,\ldots,p$; e_t is a nx1 vector of white noise innovations. For the adequate VAR specification, residuals must satisfy $E(e_t\, e'_\tau) = 0$, if $t \neq \tau$; also the model must have an appropriate number lags, if it is very small the $e_{n,t}$ may not be white noise residuals, but it must be considered that each lag adds n^2 coefficients to the regression so it sacrifices freedom degrees; also must be covariance stationary, in which case every of its components will be stationary, to verify this two conditions must hold.

[2] Investment is assumed to be exogenous.

$$E(X_t) = E(X_{t+J}) = \mu = \begin{pmatrix} \mu_1 \\ \vdots \\ \mu_n \end{pmatrix} \tag{5}$$

$$E\left[(X_t - \mu)(X_{t+J} - \mu)'\right] = E\left[(X_s - \mu)(X_{s+J} - \mu)'\right] = \Gamma_J. \tag{6}$$

Therefore, for a VAR to satisfy stationary covariance its first and second moments must be finite and time invariant. If the VAR is stationary, then it may be written as the infinite historical white noise shocks sum $X_t = \mu + \sum_{i=0}^{\infty} \psi_i e_{t-i}$, where $\mu = G(L)^{-1} G_0$; the ψ_i matrix describe each the X_t time responses to each shocks sequence e_t. Because this research aims to assess monetary policy rate endogenous reaction to GDP, inflation and real exchange rate fluctuations; as the consumption, net exports, GDP, inflation and real exchange rate response to monetary policy rate stance, the economy's exogenous shocks must be isolated to distinguish why certain variable shows an specific time path, this means to distinguish if its behavior is caused by endogenous contemporary correlations with other endogenous variables or through a structural shock. This is known as the structural vector autoregressive model identification (SVAR).

Data, estimation, matrix A identificaction and results
Data

In this section two VAR models for the Mexican economy from January 2001 to December 2015 are introduced. Which construction and evaluation Ouliaris *et al.* (2016). The main goals are to generate evidence about 1) the nominal interest rate endogenous reaction to fluctuations in GDP, inflation rate and real exchange rate; 2) consumption, net exports, GDP, inflation and real exchange rate endogenous responses to nominal interest rate fluctuations; 3) account for the GDP and inflation rate variance generated by real exchange rate fluctuations. The variables used in the VAR are the relevant to analyze these topics according to Gali and Monacelli (2005) model, which, as was pointed out, is denoted as the canonical New Keynesian framework to analyze monetary policy in an open economy.

Table 1
Data sources

Private consumption index	Nominal exchange rate*	Real net exports, 2008 constant prices**	Real gross domestic product 2008 constant prices **	Consumer's price index	Short run nominal interest rate
INEGI	FED	INEGI	INEGI	INEGI	BANXICO***

Banxico: Mexico's Central Bank; FED: US Federal Reserve; INEGI: Instituto Nacional de Estadística y Geografía (México).
* Mexican pesos amount in exchange of 1 US dollar.
** Mexican real pesos.
*** 28 Mexican T-bonds (CETES) yieldings rate.

Variables are expressed as the logarithm first difference, which besides inducing stationarity has economic meaning as it represents growth rates. Inflation rate is measured through the general consumer's Price Index, while, underlying inflation is measured with CPI less volatile and non-controlled by government prices. Real exchange rate is measured according to $q_t = e_t \frac{P_t^*}{p_t}$, where q^t is the real Exchange rate; e^t is the nominal exchange rate; P^*_t consumer´s Price Index for the US as reported by the US Federal Reserve. P_t is Mexican consumer's Price Index; monetary policy rate is measured through 28 Mexican T-bonds (CETES) yielding rate, according to Cermeño *et al*. (2012) even if this not directly affected by Mexico´s Central Bank it is influenced through its interest rate target scheme.

Each VAR is evaluated according to the following tests: to assess its stability the inverse roots are reported (table 5), which should be lesser than one so the model is stationary. Second, to determine an adequate number of lags the different information criteria is observed to determine is a consensus among them exists (tables 6A and 6B); also, the $np < \frac{T}{3}$ rule of thumb will be considered, where n is the number of exogenous variables, p is the number of lags, T is the sample size.[3] Third, the residuals will be evaluated with correlograms (figures 4A and 4B) and LM test (table 7).

[3] Ouliaris *et al*. (2016) suggest using 1 or 2 years for the lag number for any data frequency (12 or 24 for monthly data). Ivanov and Kilian (2005: 6) gather monthly data researches and point its tendency to stablish 6, 12 and 18 lags.

Estimation

The first VAR has a vector of intercepts, ten lags (see table 7) and six endogenous variables (consumption, net exports, GDP, general inflation, real exchange rate and nominal interest rate)

$$Y_t = G_0 + G_1 Y_{t-1} + G_2 Y_{t-2} + \cdots + G_p Y_{t-p} + e_t \tag{7}$$

Where Y_t is a 6x1 endogenous variables vector; G_0 is a 6x1 vector of intercepts; G_j is a 6x6 matrix coefficients for $J = 1,\ldots 10$; e_t is a 6x1 white noise innovations. Model 1 does not have any roots greater than 1 hence is stable. Lag length criteria does not show a consensus, but the LM test shows no correlation from the tenth lag.[4] The correlogram in figure 4A does not show short run correlation (because there is no autocorrelation in the first lag); neither exhibits sinusoidal movement (it goes constantly from positive to negatives and vice versa); just a few correlations exceed the confidence intervals and many of them tend to zero. Therefore, we can conclude that there are not severe correlations issues.

Matrix A identification is made through Sims (1992) recursive method, therefore matrix A will be inferior triangular, which economic interpretation indicates the existence of a sequential events chain. Structural shocks identification is theoretically justified in Gali and Monacelli (2005). Recursive ordering for the VAR is ($c_t\, xn_t\, y_t\, q_t\, \pi_t\, i_t$); where c_t is consumption; xn_t are the net exports; y_t is the GDP; q_t is the real exchange rate; π_t is the inflation rate measured by the consumer's Price Index; i_t is the nominal interest rate. Then the identified matrix is.

$$A = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 & 0 \\ a_{31} & a_{32} & 1 & 0 & 0 & 0 \\ a_{41} & a_{42} & a_{43} & 1 & 0 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & 1 & 0 \\ a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & 1 \end{pmatrix} \tag{8}$$

Where each a_{ij} represents endogenous variables contemporary correlations. Hence, monetary policy rate i_t reacts contemporaneously to every structural exogenous shocks, it also means that monetary policy affects macroeconomic variables one period after interest rate changed.

[4] Even if rule of thumb suggests less than 10 lags.

Results

First monetary policy interest rate responses are presented. It must be recalled that according to Taylor Rule we expect find a positive causality with GDP, inflation and real exchange rate fluctuations. If these variables increase it should be observed a contractive policy and vice versa

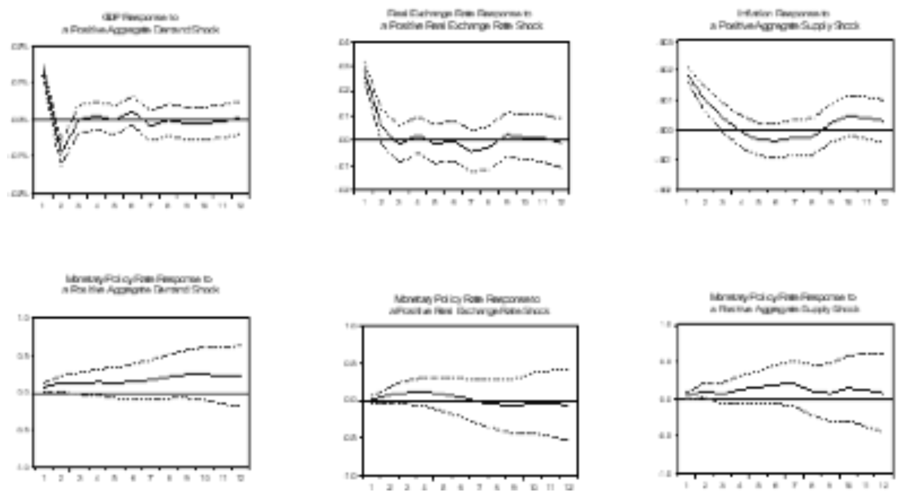

Figure 1
Monetary policy rate endogenous response to Aggregate demand, aggregate supply and real exchange rate shocks in model 1 (Inflation measured as consumer's Price Index).

Central Bank responds as expected to each shock. Aggregate demand shock, which is statistically significative for the second month, shows that monetary policy rises if GDP growth increases. González and García b(2006), Sidaoui and Ramos (2008) and Cermeño *et al*. (2012) have found similar results for different time periods. Nevertheless, Galindo and Guerrero (2003), Carvalho and Moura (2010) and Loria and Ramírez (2011), claim that the Mexican Central Bank does not respond to production variations.[5] On the other hand, aggregate supply shock has statistical significance until the

[5] We also find that monetary policy rate does not react to aggregate demand fluctuations (consumption and net exports), in this sense Walsh (2002: 337) claim that in practice Central Banks cannot observe non-systematic aggregate demand variations.

third month, as it shows that interest rate rises when inflation increases. Monetary policy response to inflation fluctuations are a common result among the Mexican economy analysis (table 2). Finally, Mexican Central Bank applies a contractive monetary policy if real exchange rate depreciates. This finding is shared with Sidaoui and Ramos (2008), Carvalho and Moura (2010), Cermeño *et al*. (2012) and González and García (2012).

Table 2
Monetary policy impulse-reaction functions for Mexico from 1970 to 2008.

Authors	**Frequency and period**	**Δi response to**			**Reaction to Δi**			**Δq effects on**	
		$\Delta \pi$	ΔY	Δq	$\Delta \pi$	ΔY	Δq	$\Delta \pi$	ΔY
Loria and Ramírez (2011)	Annual 1970-2009	1	0	0	1	1	0	1	-
Loria and Ramírez (2009)	Quarterly 1985-2008	1	0	0	0	1	0	-	1
Galindo and Guerrero (2003)	Quarterly 1990-2000	1	0	-	-	-	-	-	-
González and García (2006)	Monthly 1991-2005	1	1	1	1	1	0	1	1
Cermeño et al. (2012)	Monthly 1998-2008	1	1	1	1	1	1	1	1
Carvalho and Moura (2010)	Monthly 1999-2008	1	0	1	-	-	-	-	-
Sámano (2011)	Quarterly 2003-2010	1	1	-	-	-	-	-	-
Sidaoui and Ramos (2008)	-	1	1	1	1	1	-	-	-
Ros (2015)	-	-	-	-	1	1	1	1	1

1 means Yes. 0 means No. –means does not apply.
The papers are sorted according to sample starting date.

Hence, endogenous monetary policy rate responses evidence for Mexico dating from 2001 to 2015 coincides with the movements predicted by Taylor Rule. Next, monetary policy causality on consumption, net exports, GDP, inflation and real exchange rate is assessed. Is worth reminding that (assuming high substitutability among goods according to where they were produced and higher openness grade) New Keynesian model claims that an interest rise increase will decrease consumption, decrease exchange rate (appreciate), decrease net exports, decrease GDP and decrease inflation, and vice versa.

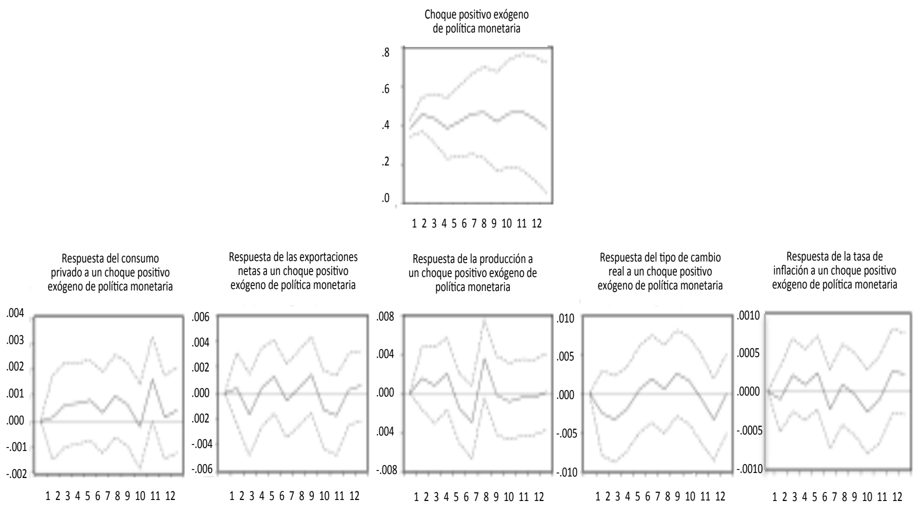

Figure 2
Consumption, exchange rate, net exports, GDP and inflation endogenous responses to positive exogenous monetary policy shock

Consumption and net exports responses to interest rate fluctuations seems to be null or, in the best of cases, slightly positive, which suggests low openness degree and low goods substitutability. Anyway, GDP decreases four months after contractive monetary policy started.[6] Real exchange rate appreciates after a contractive monetary policy as New Keynesian model predicts. It is worth noting the contrasting evidence among monetary policy effects on real exchange rate, in one hand Cermeño *et al.* (2012) and Ros (2015) assert that monetary policy is capable of influence real exchange rate, but

[6] According to Ros (2015) GDP's sensitivity to interest rate fluctuations has decreased since 2001 when inflation targeting scheme was adopted. Also claims that the Mexican economy exhibits low openness degree and substitutability among goods.

Loria and Ramírez (2009) and González and García (2006) claim otherwise. Cermeño *et al.* (2012), Loria and Ramirez (2009; 2011), González and García (2006), Sidaoui and Ramos (2008) and Ros (2015), also find evidence about non-neutral monetary policy for the Mexican economy, which reinforces using New Keynesian framework to asses it. Contrary to New Keynesian predictions, empirical evidence does not show lower inflation after Central Bank increased interest rate. According to the New Keynesian model, a contractive monetary policy is related to lower aggregate demand, to which producers react decreasing aggregate supply and this way its marginal costs diminish, which motivates producers to reset lower prices, reflecting on lower inflation. In other words, it is not possible to relate higher interest rate to greater inflation. Sims (1996) reports similar evidence denoted as inflation puzzle, argues that the reason for this kind of finding is due to omitted variables in the model, this means that maybe Mexican monetary authority respond to a different inflation index than the one used. This also means that exogenous shocks have not been adequately isolated and that the assumed exogenous fluctuation may obey to an endogenous variable absent in the SVAR.

Table 3A
Accumulated responses to a positive monetary exogenous shock in model 1 (general consumer´s Price Index inflation)

Period	DLC	DLQ	DLXN	DLY	DLP
2	0.000147	0.000356	0.00153	-0.002508	-9.44E-05
	-0.0008	-0.00137	-0.00165	-0.0027	-0.00021
6	0.002588	-0.000193	-0.000272	-0.00536	0.000227
	-0.00172	-0.00156	-0.00212	-0.00722	-0.0007
12	0.006154	-0.000581	0.001402	-0.004736	0.000416
	-0.00314	-0.0016	-0.00309	-0.01	-0.00083

Cholesky ordering: DLC DLQ DLXN DLY DLP I
Standard errors: Monte Carlo (15000 simulations).
Where DLC is the first difference for General Consumers Price Index logarithm; DLQ does the same for real exchange rate; DLXN for net exports; DLY for GDP; DLP for inflation measured by general CPI.

Following Cermeño *et al*. (2012) and Mexico's Central Bank claims, a second VAR is estimated using underlying inflation rate (π^{s}_{t}) as an endogenous variable that substitutes for general inflation (π_t), and non-underlying inflation rate (π^{ns}_{t}) as exogenous variable. Underlying inflation is a better Price Index to assess fluctuations generated by aggregate demand shocks.[7] Hence, this second model has non-underlying inflation as exogenous variable and six endogenous variables (consumption, net exports, GDP, underlying inflation, real exchange rate and nominal interest rate). This model is stationary (table 5), has 15 lags (table 7), also correlogram in figure 4B is well behaved. Next, the monetary policy effects in the remaining endogenous variables is analyzed.

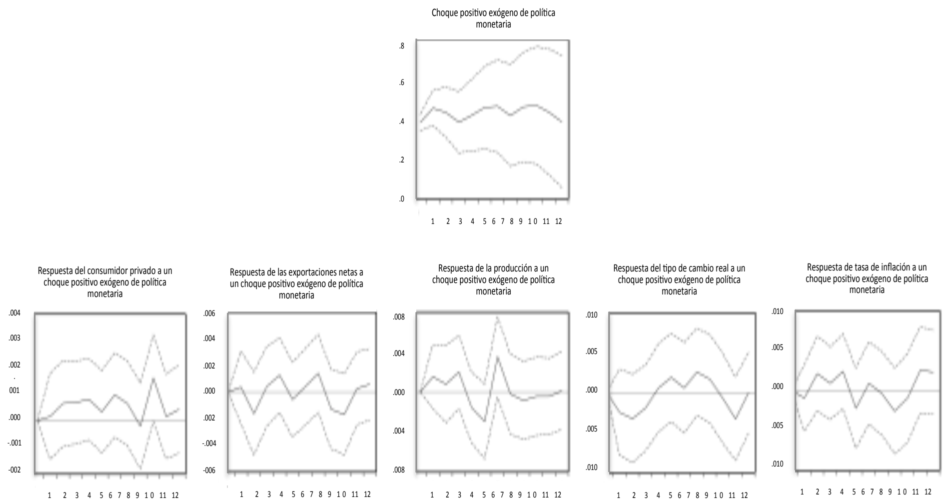

Figure 3
Consumption, exchange rate, net exports, GDP and underlying inflation endogenous response to positive exogenous monetary policy shock

[7] According to Mexico's Central Bank website, underlying inflation excludes volatile prices and those not entirely market conditions dependent. Therefore, excludes agricultural goods prices and any tariff settled by the government (energy, fuel, water, among others).

After controlling for underlying and non-underlying inflation, consumption and net exports response to monetary policy seems to approach the New Keynesian predictions since both variables decrease immediately and for two months, because GDP also decreases, the non-neutral monetary policy finding holds. Real exchange rate falls until the third month and then alternate increases and decreases, nevertheless its accumulated effects exhibit depreciation. Underlying inflation diminish until the second month and then its changes oscillate around zero. It is revealing that both inflation measures (general and underlying) exhibit null fluctuations, since Gali (2008) suggests it as a reason to think the economy has nominal rigidities, which reinforces (just as the non-neutrality evidence does) the importance to analyze the Mexican economy through the models with this qualities at least during the sample period specified in this paper.

Table 3B
Accumulated responses to a positive monetary exogenous shock in model 1
(Underlying consumer´s price index inflation)

Period	DLC	DLQ	DLXN	DLY	DLPU
2	0.000147	0.000356	0.00153	-0.002508	-9.44E-05
	-0.00081	-0.00136	-0.00163	-0.00268	-0.00021
6	0.002588	-0.000193	-0.000272	-0.00536	0.000227
	-0.0017	-0.00156	-0.00215	-0.0072	-0.0007
12	0.006154	-0.000581	0.001402	-0.004736	0.000416
	-0.00307	-0.00158	-0.00307	-0.00999	-0.00083

Cholesky ordering: DLC DLQ DLXN DLY DLPU I Where DLC is the first difference for General Consumers Price Index logarithm; DLQ does the same for real exchange rate; XN for net exports; DLY for GDP; DLPU for Underlying Consumers.
Standard errors: Monte Carlo (15000 simulations).

Finally, as tables 4A and 4B show, after twelve months exchange rate variations explain about 2.5% GDP's variance, and 7% for general inflation rate. When controlling for underlying inflation, foreign shocks influence on GDP increases almost three times as it explains around 6% of its fluctuations; while exchange rate effects on underlying inflation variance barely change at 5%. González and García (2006), Sidaoui and Ramos (2008), Loria and Ramírez (2009), Cermeño *et al*. (2012) also account for external influence on Mexican domestic economic activity. Ros (2015) argues that such sensitivity has slowed down since the inflation targeting scheme was implemented.

Table 4A
Variance decomposition in model 1
(General Consumer´s Price Index inflation).

For DLY							
Period	**DLY S.E.**	**DLC**	**DLXN**	**DLY**	**DLQ**	**DLP**	**I**
2	0.020993	2.458592	1.089264	93.59276	0.206958	2.121041	0.531389
		-3.02782	-2.13855	-4.43193	-1.08307	-2.21646	-1.33835
6	0.024433	2.677647	2.032163	79.07996	2.590692	10.51354	3.106002
		-3.3214	-3.1633	-6.32634	-2.8826	-4.82823	-2.54001
12	0.027662	4.175078	8.129615	66.52021	2.473586	14.46487	4.236641
		-4.24399	-4.81255	-6.55569	-3.15678	-4.9875	-2.87354
For DLP							
Period	**DLP S.E.**	**DLC**	**DLXN**	**DLY**	**DLP**	**DLQ**	**I**
2	0.002451	0.434558	0.414673	0.344163	4.48904	94.1693	0.14827
		-1.80657	-1.55441	-1.41026	-3.29593	-4.21526	-1.08804
6	0.002851	2.082547	2.417351	12.55702	5.512412	75.32727	2.103397
		-3.31701	-3.16934	-4.7561	-4.0524	-6.59106	-2.63277
12	0.00327	2.200971	8.823815	12.7383	7.338337	65.37778	3.520797
		-3.60249	-5.1672	-4.23369	-4.83106	-6.96997	-3.24622

Cholesky's ordering: DLC DLXN DLY DLQ DLP I
Estándar errors: Monte Carlo (15000 repetitions)
Where DLC is the first difference for General Consumers Price Index logarithm; DLQ does the same for real exchange rate; XN for net exports; DLY for GDP; DLP for inflation measured by general consumer's Price Index.

Table 4b
Variance decomposition in model 2
(Underlying consumer´s price index inflation)

For DLY							
Period	DLY S.E.	DLC	DLXN	DLY	DLQ	DLP	I
2	0.016934	7.54287	0.323009	1.252068	86.0395	3.277361	1.565188
		-4.13828	-1.81494	-2.63739	-6.08106	-3.49259	-2.51805
6	0.018661	9.807525	3.691079	1.762746	72.74813	8.053208	3.937313
		-5.08069	-3.90742	-3.86112	-7.48454	-5.12032	-4.32873
12	0.021815	9.600926	6.326866	5.341629	57.5647	11.89413	9.271745
		-4.93616	-4.67457	-5.21828	-7.27643	-5.43744	-5.4334
For DLPU							
Period	**DLPU S.E.**	**DLC**	**DLXN**	**DLY**	**DLPSUB**	**DLQ**	**I**
2	0.001163	0.502627	0.310052	1.379531	6.441088	91.36313	0.00357
		-2.24901	-1.8608	-2.38278	-3.92336	-5.29586	-1.5197
6	0.001337	0.899746	4.110549	11.34965	8.151656	73.29303	2.195364
		-3.05867	-4.52013	-6.01478	-4.00242	-7.58144	-3.44899
12	0.001506	3.60113	5.163858	11.34481	9.904741	66.19374	3.791726
		-3.9825	-5.19595	-5.46659	-4.54727	-7.81909	-4.30951

Cholesky's ordering: DLC DLXN DLY DLQ DLP I
Standard errors: Monte Carlo (15 000 repetitions)

The results obtained using two SVAR models show that the Mexican monetary policy rate for the period 2000-2015 responds to GDP, inflation and exchange rate as Taylor Rule asserts. When controlling for General CPI, monetary policy barely affects aggregate demand even if exchange rate appreciates, nevertheless GDP diminish after contractive monetary policy takes place. Inflation rate increases after interest rate rises, which does not coincide with New Keynesian predictions. A second model is estimated, which controls for underlying inflation (endogenous) and non-underlying inflation (exogenous), this way consumption and net exports report a greater reaction to monetary policy, while real exchange rate appreciates and GDP decreases. Inflation decreases after monetary policy rise but its fluctuations are close to zero. Gali (2008) argues that such small changes indicate nominal rigidities existence. Results also show that foreign shocks have influence on domestic GDP and inflation.

4. Conclusions

Estimating two SVAR models recursively identified according to Gali and Monacelli (2005) model, for Mexican data from January 2000 to December 2015, it is shown that monetary policy rate reacts to GDP, inflation and exchange rate as Taylor's Rule predicts. When controlling for General Consumer's Price Index, monetary policy barely affects consumption and net exports (even if exchange rate appreciates), nevertheless GDP decreases after contractive monetary policy takes place. Nonetheless, inflation rate lightly increases after interest rate rises, which does not coincide with New Keynesian predictions. A second model is estimated, which controls for underlying inflation (endogenous) and non-underlying inflation (exogenous), this way consumption and net exports report a greater reaction to monetary policy, while real exchange rate appreciates and GDP decreases. Inflation decreases after monetary policy rise but its fluctuations are close to zero. Gali (2008) argues that such small changes indicate nominal rigidities existence. Hence, nominal rigidities and monetary non-neutrality evidence are strong justifications to analyze the models with such characteristics at least during the sample period from 2001 to 2015. Results also show that foreign shocks have influence on domestic GDP and inflation, exchange rate variations explain about 2.5% GDP's variance and 7% for general inflation rate. If the model controls for underlying inflation, foreign shocks explain about 6% of GDP's variance; while exchange rate effects on underlying inflation variance barely change at 5%.

Some extensions from this paper could be to assess the empirical performance for models that depart from the canonical model. For example, adding investment as another channel for the interest rate to affect aggregate demand, compare different exchange rate regimes or assume that Law of One Price does not hold, or controlling with different information for the variables used.

This paper results suggest that to assess Mexico's Central Bank monetary policy measures to keep inflation close to its target, underlying inflation must be taken into account and not only general CPI inflation, volatile and legally stablished prices prevent monetary policy from controlling inflation even if it affects aggregate demand and producers alter prices as response.

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Appendix

Stability tests
Only the roots closer to 1 are reported

Table 5
Characteristic polynomial inverse roots modulus

Modulus for model 1	**Modulus for model 1 2**
0.97392	0.996968
0.97392	0.996968
0.970214	0.995382
0.970214	0.988741
0.964921	0.988741

Fuente: estimaciones propias

Lag lenght criteria

Table 6.A
Lag lenght criteria for model 1

Rezago	LogL	LR	FPE	AIC	SC	HQ
12	2762.687	49.4904	6.14E-21	-29.99596	-21.39583	-26.50278
13	2841.027	76.8239	4.12E-21	-30.54228	-21.23529	-26.76199
14	2895.795	49.46765	3.88E-21	-30.78445	-20.7706	-26.71705
15	2939.082	35.74652	4.40E-21	-30.87847	-20.15776	-26.52396
16	3020.953	61.27182	3.19E-21	-31.47037	-20.0428	-26.82874
17	3083.479	41.95285	3.16E-21	-31.81264	-19.67821	-26.8839
18	3171.986	52.53312*	2.42E-21	-32.49014	-19.64885	-27.2743
19	3245.511	37.94827	2.48E-21	-32.97434	-19.42618	-27.47138
20	3329.91	37.02668	2.52E-21	-33.59884	-19.34383	-27.80877
21	3441.33	40.25509	2.18E-21	-34.572	-19.61013	-28.49483
22	3548.979	30.55827	2.63E-21	-35.4965	-19.82777	-29.13221
23	3722.803	35.88624	2.13e-21*	-37.27487	-20.89928	-30.62348
24	3949.367	29.23416	2.17E-21	-39.73377*	-22.65132	-32.79527*

Table 6.B
Lag lenght criteria for model 1

Rezago	LogL	LR	FPE	AIC	SC	HQ
12	2857.444	67.10614	1.81E-21	-31.21863	-22.6185	-27.72545
13	2918.358	59.73511*	1.52e-21*	-31.54011	-22.23311	-27.75981
14	2964.228	41.43064	1.60E-21	-31.66746	-21.6536	-27.60005
15	3010.555	38.25727	1.75E-21	-31.80071	-21.08	-27.4462
16	3077.394	50.02135	1.54E-21	-32.19863	-20.77106	-27.55701
17	3127.558	33.65828	1.79E-21	-32.38139	-20.24696	-27.45266
18	3193.918	39.38799	1.82E-21	-32.77313	-19.93184	-27.55729
19	3265.079	36.72852	1.92E-21	-33.22683	-19.67868	-27.72388
20	3310.675	20.00306	3.23E-21	-33.35064	-19.09563	-27.56057
21	3398.899	31.87472	3.78E-21	-34.02451	-19.06264	-27.94733
22	3518.95	34.07903	3.87E-21	-35.10904	-19.44031	-28.74475
23	3676.969	32.62313	3.85E-21	-36.68347	-20.30787	-30.03207
24	3926.963	32.25736	2.90E-21	-39.44469*	-22.36224	-32.50618*

LM Serial correlation test

Table 7
LM serial correlation test
H_0: No serial correlation.

Rezago	Probabilidad del estadístico LM para el Modelo 1	Probabilidad del estadístico LM para el Modelo 2
9	0.0041	0.5114
10	0.3921	0.4241
11	0.1346	0.1193
12	0.0039	0.0189
13	0.9623	0.2415
14	0.317	0.0978
15	0.1356	0.5853
16	0.5869	0.2582
17	0.6338	0.7443
18	0.867	0.2082
19	0.5486	0.6507
20	0.5724	0.3711
21	0.8701	0.7813
22	0.3341	0.7549
23	0.9949	0.3252
24	0.5824	0.0329

Figure 4A
Correlogram model 1

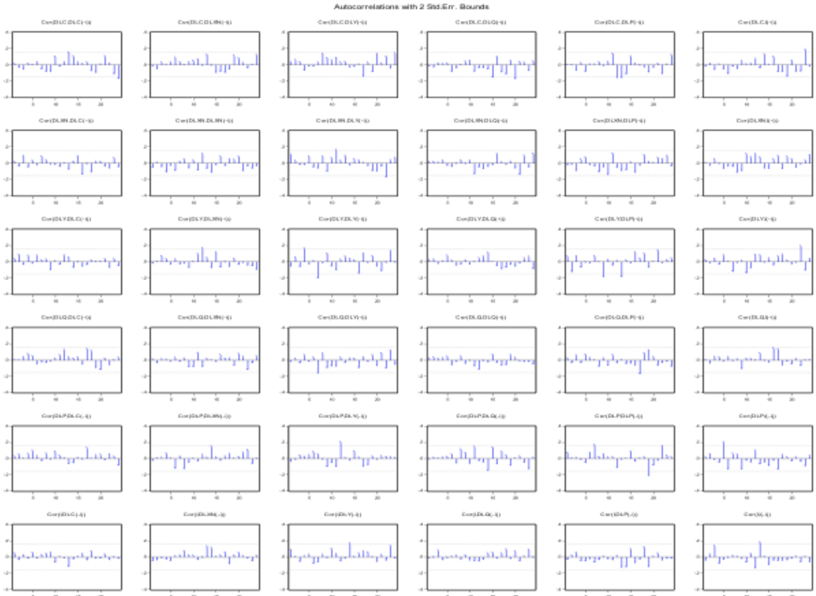

Figure 4B
Correlogram model 2