https://doi.org/10.29201/peipn.v17i36.116 -ISSN1870-2171

PANORAMA ECONÓMICO, vol. XVII, núm. 36, enero-junio, 2022, pp. 175-189

Intervention instruments, demand, output, and inflation: evidence for Mexico

Christopher Cernichiaro Reyna[*]

(*Recibido: mayo,* 2021/*Aceptado: septiembre,* 2021)

Abstract

This paper estimates a SVAR to assess Mexican monetary policy responses and effects. To build it Gali & Monacelli (2005) New Keynesian Open Economy Model represents the main tool, but investment and international reserves are artificially added because of its empirical relevance to explain Mexican economy. Using monthly data from January 2002 to September 2018, evince that Mexican government intervenes markets using interest rate and international reserves. Interest rate prioritizes exchange rate stability, but it barely affects it. Both instruments effects on aggregate demand are limited, as income is the main explanatory variable according to variance decomposition, suggesting fiscal policy relevance to explicate aggregate demand.

Keywords: Taylor rule, international reserves, uncovered interest parity, output and inflation.
JEL classification: E12, C32, C50, O11.

* Profesor-investigador en la Universidad Autónoma Metropolitana Unidad Iztapalapa. Av. San Rafael Atlixco 186, Leyes de Reforma 1ra Sección 09340 Ciudad de México, CDMX. <13uam13@gmail.com>.

Instrumentos de intervención, demanda, producción e inflación: evidencia para México

Resumen

En este artículo se estima un SVAR para evaluar las respuestas y efectos de la política monetaria en México. Para construirlo se utiliza el modelo de Gali & Monacelli (2005), pero también se agregan artificialmente inversión y reservas internacionales debido a su relevancia empírica para explicar a la economía mexicana. Usando datos mensuales desde enero de 2002 hasta septiembre de 2018, se encuentra que el gobierno mexicano interviene en los mercados usando tanto tasa de interés como reservas internacionales. La tasa de interés prioriza la estabilidad cambiaria, aunque sus efectos son nulos. Ambos instrumentos tienen impactos limitados en la demanda agregada, mientras que, de acuerdo con el análisis de descomposición de varianza, el ingreso es la principal variable explicativa de la demanda, sugiriendo la importancia de la política fiscal para explicarla.

Palabras clave: regla de Taylor, reservas internacionales, paridad de interés no cubierta, producción e inflación.
Clasificación JEL: E12, C32, C50, O11.

1. Introduction

New Keynesian Model represents the benchmark framework to analyze monetary policy responses and effects, see Clarida, Gali & Gertler (1999) for a closed economy analysis and Gali & Monacelli (2005) for an open one. Its basic macroeconomic structure is characterized by two micro founded equations, an IS dynamic curve and a rational expectation extended Phillips Curve, and a monetary policy rule commonly represented by Taylor Rule. Two fundamental simplifications (for this research purposes) are exogenous investment and interest rate as the only instrument for Central Bank to intervene.

Nevertheless, several theoretical extensions have been developed. For example, Casares & McCallum (2006) derive an IS function with endogenous investment, which exhibits better empirical performance if capital adjustment costs are allowed. Escudero, González & Sola (2014) and Benes, Berg, Portillo & Vavra (2015) add private banking and international reserves as complementary instrument to interest rate. Escudero *et al*. (2014) show that reserves advocating financial stability, and interest rate inflation, favors stabilization.

Benes *et al.* (2015), find that using both instruments is desirable if financial external shocks affect the economy, but hinders exchange rate adjustment after trade term shocks. Gali & Monacelli (2016), adding nominal wage rigidities to a sticky prices environment, expose that wage flexibility reduces welfare if monetary policy focus in exchange rate fluctuations. Corsetti, Kuester & Mueller (2017), compare diverse exchange rate arrangements in a model with Zero Lower Bound restriction, and find that a peg preserves demand and inflation stability after a domestic shock, but, if shock comes from abroad, free floating is more desirable.

Also, researchers also have artificially adapted theoretical models to assess actual intervention. For example, Walsh (2002) intentionally neglects aggregate demand shock to assess monetary policy in an economy where Central bank is unable to detect such perturbations. Castillo (2014) estimates a non-microfounded augmented New Keynesian Model, where interest rate serves an inflation target and international reserves an exchange rate target. Estimations show that, if policy makers don't send mixed signal to economic agents, both instruments intervention stabilizes inflation and exchange rate.

This paper estimates a SVAR to assess Mexican monetary policy responses and effects. To achieve such task Gali & Monacelli (2005) New Keynesian Open Economy Model is the main tool to build it, but also investment and international reserves are artificially added because of its empirical relevance to explain Mexican economy. Using monthly data from January 2002 to September 2018, evince that Mexican government intervenes markets using interest rate and international reserves. Interest rate prioritizes exchange rate stability, but it barely affects it. Both instruments effects on aggregate demand are limited, as income is the main explanatory variable according to variance decomposition, suggesting fiscal policy relevance to explicate aggregate demand. Next section presents the theoretical framework that supports the econometrical model, besides empirical evidence that justifies adding investment and international reserves. Later, estimation and results are presented. Finally, conclusions are exposed.

2. Theoretical and empirical justification

This paper estimates a SVAR to assess Mexican monetary policy responses and effects. To achieve such task, Gali & Monacelli (2005) New Keynesian Open Economy Model is the main tool to build it, but also two additional variables are added (investment and international reserves) because of its empirical relevance to explain Mexican economy. This section briefly describes the theoretical Model while also justifies adding investment and reserves to the econometric model.

Gali & Monacelli (2005) New Keynesian Open Economy Model is the benchmark theoretical framework to analyze monetary policy responses and effects, according to Bajo & Díaz (2013), Andrle, Berg, Morales, Portillo & Vicek (2015), Hevia & Nicolini (2013), Woodford (2007), among others. Its basic macroeconomic structure is characterized by two micro-founded equations (IS and CP) and by an artificially introduced Taylor Rule (TR).

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

$$\pi_{H,t} = \beta E_t \pi_{H,t+1} + k_\alpha \tilde{y}_{t,} \qquad (CP)$$

$$i_t = \rho + \phi_\pi \pi_{H,t} + \phi_Y \check{y}_t + v_{t.} \qquad (TR)$$

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_t^n natural interest rate, $\pi_{H,t}$ is domestic produced goods inflation, $Et\ \pi_{H,t+1}$ is expected domestic produced goods inflation in t for $t+1$, v_t is a monetary policy shock and σ_α, k_α, ϕ_π, ϕ_Y, ρ are positive parameters

Such benchmark models assume exogenous investment and that the Central Bank intervenes markets through interest rate instrument only. Nevertheless, these two variables are pertinent to explain Mexican monetary policy because of the following reasons. Galindo & Ros (2008) report that investment represents an important explanatory variable for Mexican output, therefore an empirical model for Mexican economy that lacks investment would be misguiding. On other side, Carvalho & Moura (2010), Cermeño, Villagómez & Orellana (2012), González & García (2006) and Sidaoui & Ramos (2008) analyze Mexican data, and all of them report that Taylor Rule responds to exchange rate. Benes *et al*. (2015) argue that such finding points at a Central Bank that impedes free floating, but it is incomplete to assume that only intervenes through interest rate as international reserves are the most effective way to alter exchange rate whilst preserve capacity to address domestic output and inflation. Therefore, even if the theoretical canonical models do not consider them, investment and international reserves are added to the econometric model as follows.

$$I_t = I_t(i_t - E_t \pi_{t+1}), \qquad \frac{dI_t}{d(i_t - E_t \pi_{t+1})} < 0 \qquad (I)$$

$$F_t = F_t(q_t), \qquad \frac{d\frac{F_t}{P_t}}{dq_t} < 0 \qquad (IR)$$

Where I_t is investment, F_t are international reserves and P_t^* is world Consumer's Price Index in foreign currency. Equation (I) represents investment as an inverse ex-ante real interest rate function and is an alternative channel for interest rate to affect aggregate demand. Equation (IR) presents reserves as an additional monetary policy instrument that reacts to control real exchange rate, Benes *et al*. (2015). Assuming an exogenous monetary policy rate increase, households postpone consumption, investment becomes more expensive and real exchange rate appreciates (through uncovered interest parity) decreasing net exports. Producers respond lowering output, which pushes down marginal costs and stablished prices, therefore inflation diminish. Because of real exchange rate appreciation, international reserves augment to dampen interest rate effects on international competitiveness. In next section estimation and results are presented.

3. SVAR, estimation and results

Following Ouliaris, Pagan & Restrepo (2016), vector autoregressive (VAR) models are linear multivariate time series models designed to capture its joint dynamic. Assumes each variable as endogenous and as a function of all variables lagged values:

$$X_t = G_0 + G_1X_{t-1} + G_2X_{t-2} + \cdots + G_pX_{t-p} + e_{t.}$$

Where G_0 is a $nx1$ vector of constants; G_j is a nxn coefficients matrix for J=1,...,p; e_t is a $nx1$ vector of white noise innovations. For the adequate VAR specification, residuals must: 1) satisfy Eet $E(e_t e_\tau') = 0$, if $t \neq \tau$. 2) Have an appropriate number lags, if it is very small the $en,_t$ may not be white noise, but it must be considered that each lag adds n^2 coefficients to the regression so it sacrifices freedom degrees. 3) Be stationary in covariance, in which case every of its components will be stationary. If 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. This allows to distinguish if every variable 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).

4. Estimation, results and discussion

A SVAR model is built using Mexican monthly data ranging from January 2002 to September 2018. Consumption, investment, net exports, GDP and

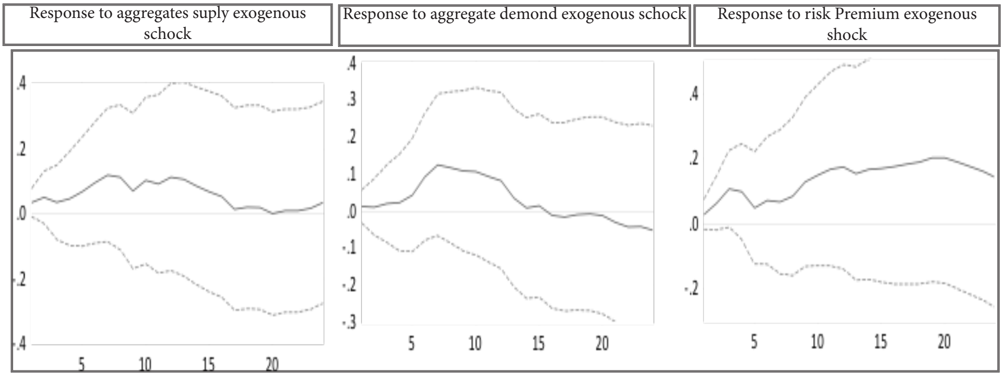
Consumer's Price Index were retrieved from Instituto Nacional de Estadística y Geografía. Whilst real exchange rate, international reserves, US consumer Price index and Three-Month Treasury Bill were downloaded from Banco de México and Federal Reserve Bank of St. Louis. Individual unit root tests, stability VAR proofs and autocorrelation tests are provided. See table and figure section at the end of the text.

The model is identified through recursive ordering (Sims, 1992). SVAR ordering is consumption, investment, real exchange rate, net exports, GDP, underlying domestic inflation, international reserves, and domestic interest rate. While non-underlying domestic inflation and world interest rate are added as exogenous variables. Such ordering implies that both Central Bank instruments are contemporaneously affected by any exogenous shock, while impact other variables until one period after policy instrumentation. Identified matrix is

$$A = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ a_{31} & a_{32} & 1 & 0 & 0 & 0 & 0 & 0 \\ a_{41} & a_{42} & a_{43} & 1 & 0 & 0 & 0 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & 1 & 0 & 0 & 0 \\ a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & 1 & 0 & 0 \\ a_{71} & a_{72} & a_{73} & a_{74} & a_{75} & a_{76} & 1 & 0 \\ a_{81} & a_{82} & a_{83} & a_{84} & a_{85} & a_{86} & a_{87} & 1 \end{pmatrix}$$

First, Taylor Rule responses and effects are evaluated. Then the analysis is replied for international reserves rule.

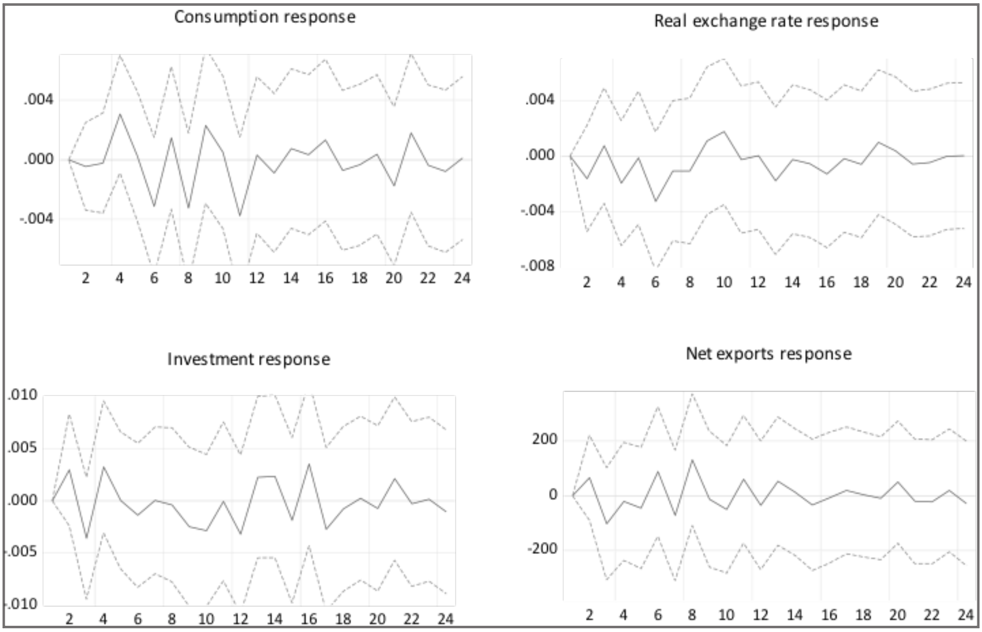
Taylor Rule reactions and effects are statistically significant through twenty-four months. See table and figure section at the end of the text. According to figure 1 Mexican monetary authority follows a flexible inflation target. It intervenes not only when inflation rate changes, but also when output and exchange rate does. Figure 6 shows that after twelve months real exchange rate explains almost 6% of monetary policy rate variance and more than 17% after two years, albeit net exports account for 6%. Therefore, Foreign developments are the most prioritized elements by Mexican Taylor Rule, as it accounts for almost 25% of its adjustment.



Fuente: elaboración propia.

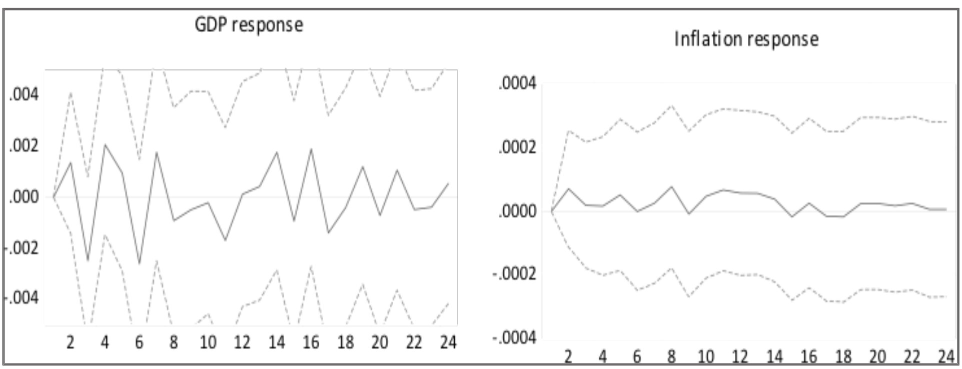
Figure 1
Domestic interest rate response to positive exogenous shocks

Even if monetary policy reacts to output and inflation is not so certain that it has relevant impacts on them, evidence shows that it hardly impacts domestic aggregate demand (figures 2 and 3). Consumption and investment exhibit decrease and sudden raises across the first year after interest rate changed. Such low incidence is probably explained through consumption and investment variance decomposition (figure 7), as income accounts for 17% of consumption volatility and 13% for investment. Hence, income causes about one third of domestic aggregate demand variation. This result suggests fiscal policy relevance to impact Mexican domestic aggregate demand. As for foreign variables, real exchange rate appreciates when interest rate is higher, evincing that uncovered interest parity holds for Mexican data. Nonetheless, only 2% of its changes are explained through interest rate. Therefore, even if nominal interest rate prioritizes real exchange rate stability, narrowly affects it.



Fuente: elaboración propia.

Figure 2
Domestic interest rate effect on consumption, investment, real exchange rate and net exports

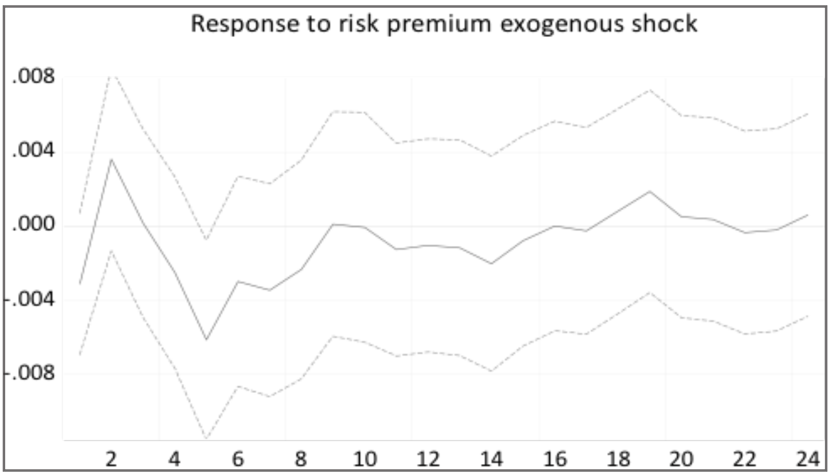


Fuente: elaboración propia.

Figure 3
Interest rate effect on GDP and inflation rate

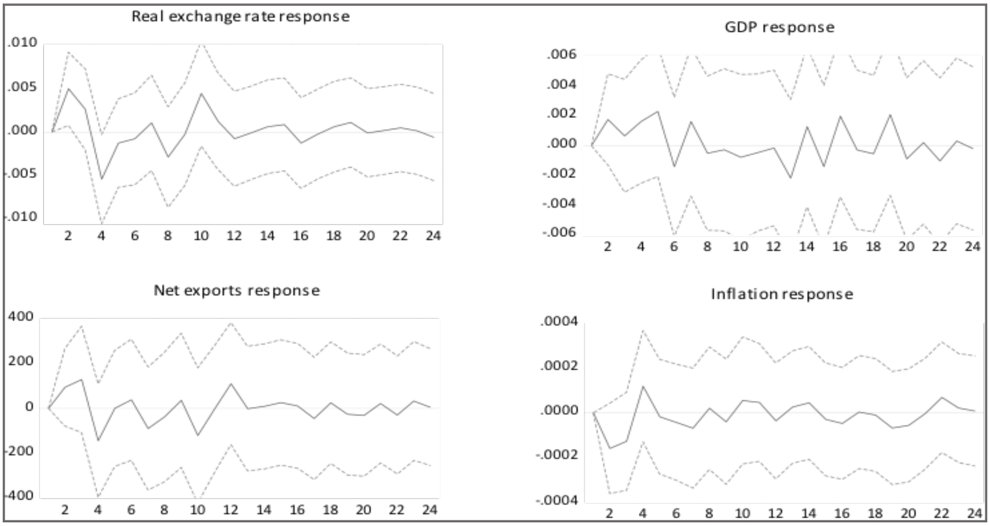
Next, evidence about international reserves as policy instrument and its effects on aggregate demand, GDP and inflation rate is assessed. International reserves response is statistically significant for five months. figure 4 shows an inverse causality among international reserves and real exchange rate. Reserves raise when real exchange rate decreases (appreciates) and vice versa.

Following a real exchange rate depreciation, reserves diminish to attempt to preserve domestic economy competitiveness. In other hand, international reserves explicate around 10% of real exchange rate variations, but its effects are not statistically significative at 95% (figure 5). However, net exports contracts for three quarters, its response is statistically significative for two years. Nevertheless, reserves explain just 3% of net exports volatility, which are more sensitive to income and domestic consumption (figure 8). Such result points international reserves limited ability to impact aggregate demand, whilst signals fiscal policy as the main way to affect Mexican domestic aggregate demand.



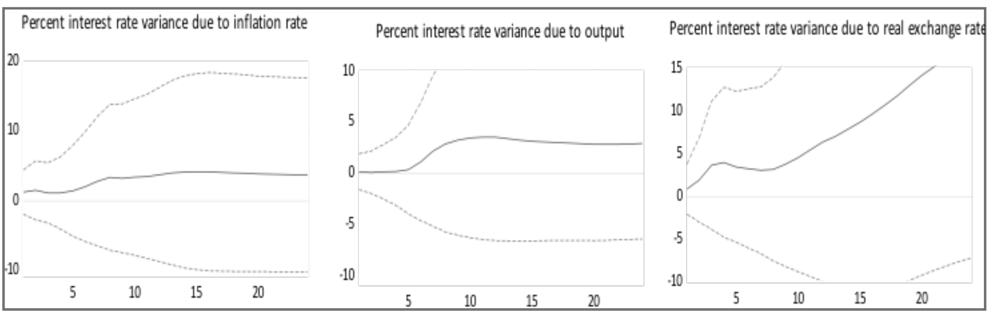
Fuente: elaboración propia.

Figure 4
International reserves response



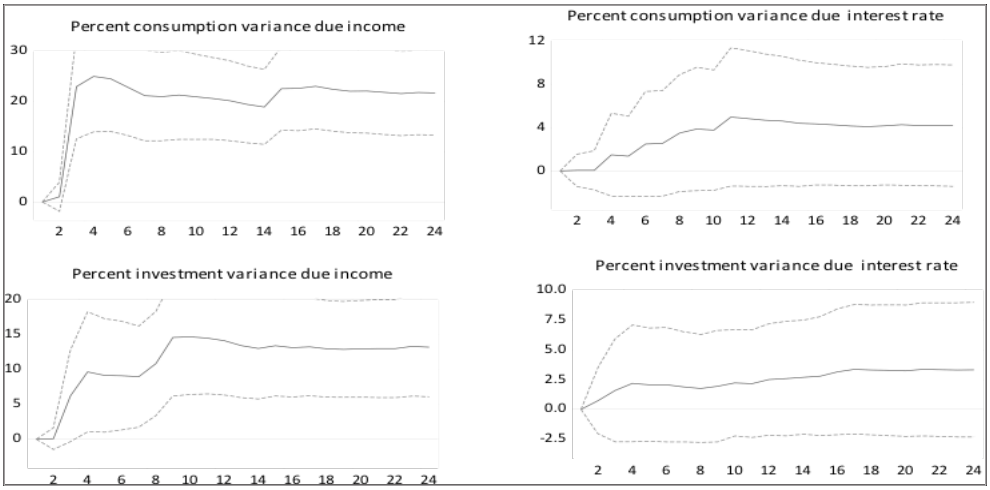
Fuente: elaboración propia.

Figure 5
International reserves effects



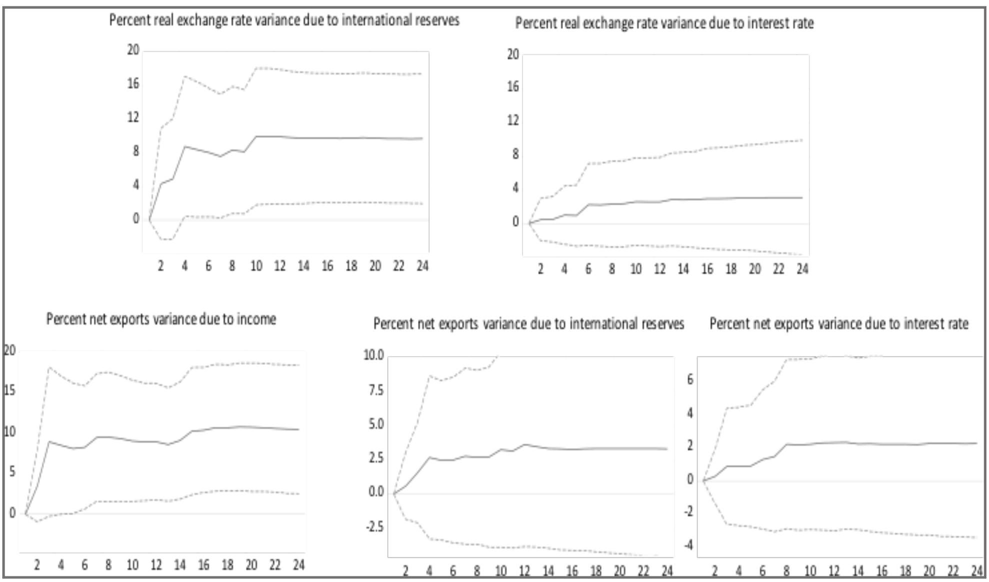
Fuente: elaboración propia.

Figure 6
Interest rate variance decomposition



Fuente: elaboración propia.

Figure 7
Consumption and investment variance decomposition



Fuente: elaboración propia.

Figure 8
Real exchange rate and net exports variance decomposition

Therefore, evidence shows that Mexican government intervenes markets using interest rate and international reserves. Nevertheless, its effects on aggregate demand are limited, while income is the main explanatory variable according to variance decomposition analysis, suggesting fiscal policy relevance to alter it. Next section concludes.

5. Conclusions

A SVAR model is built using Mexican monthly data ranging from January 2002 to September 2018. Results show that Mexico's Central Bank intervenes markets through interest rate and international reserves. Interest rate reacts to output, inflation and real exchange rate. Variance decomposition points that Taylor rule prioritizes exchange rate over output and inflation fluctuations. Even if evidence suggests that uncovered interest parity holds, interest rate only explains about 2% of exchange rate variations. Besides, aggregate demand scarcely responds to interest rate, while income is its main explanatory variable.

As for international reserves, evidence shows that Mexican government employs an international reserves instrument to intervene markets, trying to stabilize exchange rate. Even if international reserves influence net exports, it only explicates about 3% of its changes. Net exports are also mainly explained by income.

Hence, Mexico's Central Bank intervenes market through exchange rate and international reserves. Nevertheless, both instruments barely influence aggregate demand, which explains Mexico's Central bank difficulty to affect inflation Ros (2015). Results show that income is the main variable that explains aggregate demand, which also points this research limiting character, as such instrument is not considered. Therefore, future researches must introduce fiscal policy as explanatory variable for the Mexican case. Also, other models that account for international reserves consider relevant to introduce debt to monetary policy transmission channel, see for example Benes et al (2015), Castillo (2014), Escudero *et al.* (2014). Also, may utilize different data to control for relevant variables. For example, measure inflation through a different index than Underlying Consumer's Price Index; use another proxy for net exports: try distinct techniques to approach output or even different data sources, especially those that are not provided by Mexican government.

References

Andrle, M.; A. Berg; R. A. Morales; R. Portillo and J. Vlcek (2015). On the Sources of Inflation in Kenya: A Model-Based Approach. *South African Journal of Economics,* 83(4), 475-505.

Bajo-Rubio, O., and C. Díaz-Roldán (2013). Open economy Keynesian macroeconomics without the LM curve. *Journal of Economics and Economic Education Research*, 17(2), 1-17.

Benes, J.; A. Berg; R. A. Portillo & D. Vavra (2015). Modeling sterilized interventions and balance sheet effects of monetary policy in a new-keynesian framework. *Open Economies Review*, 26(1), 81-108.

Calvo, G. (1983). Staggered prices in a utility-maximizing framework. Journal of monetary Economics. *Journal of Monetary Economics*, vol. 12, No. 3, pp. 383-398.

Carvalho, A., and M. L. Moura (2010). What can Taylor rules say about monetary policy in Latin America? *Journal of Macroeconomics*, 32(1), 392-404.

Casares, M., & B. T. McCallum (2006). An optimizing IS-LM framework with endogenous investment. *Journal of Macroeconomics*, 28(4), 621-644.

Castillo, C. (2014). Inflation targeting and exchange rate volatility smoothing: A two-target, two-instrument approach. *Economic Modelling,* 43, 330-345.

Cermeño, R.; F. Villagómez and J. Orellana (2012). Monetary policy rules in a small open economy: An application to Mexico. *Journal of Applied Economics*, 15(2), 259-286.

Clarida, R.; J. Gali & M. Gertler (1999). "The Science of Monetary Policy: A New Keynesian Perspective", *Journal of Economic Literature,* vol. 37, No. 4, pp. 1661-1707.

Corsetti, G.; K. Kuester & G. J. Muller (2017). Fixed on flexible: Rethinking exchange rate regimes after the great recession. IMF *Economic Review,* 65(3), 586.

Escudero, M.; M. González-Rozada & M. Sola (2014). Toward a" New" Inflation-Targeting Framework: The Case of Uruguay. *Economía*, 15(1), 89-131.

Gali, J., & T. Monacelli (2005). Monetary policy and exchange rate volatility in a small open economy. *The Review of Economic Studies*, 72(3), 707-734.

Gali, J. (2008). Monetary policy, inflation, and the business cycle: an introduction to the New Keynesian framework and its applications. *Princeton University Press*.

Gali, J., & T. Monacelli (2016). Understanding the gains from wage flexibility: The exchange rate connection. *American Economic Review*, 106(12), 3829.

Galindo, L. M., & J. Ros (2008). Alternatives to inflation targeting in Mexico. *International Review of Applied Economics,* 22(2), 201-214.

González, A. G., & J. García (2006). Structural changes in the transmission mechanism of monetary Policy in Mexico: *A non-linear VAR approach*. No. 2006-6. Banco de Mexico Working Paper.

Hevia, C., and J. P. Nicolini (2013). Optimal devaluations. *IMF Economic Review*, 61(1), 22-51.

Ouliaris, S.; A. Pagan & J. Restrepo (2016). Quantitative Macroeconomic Modeling with Structural Vector Autoregressions, *An EViews Implementation*. I, 238 pp., E-views publishing.

Ros, J. (2015). Central bank policies in Mexico: Targets, instruments, and performance. *Comparative Economic Studies*, 57(3), 483-510.

Sidaoui, J., & M. Ramos-Francia (2008). The monetary transmission mechanism in Mexico: recent developments. Transmission mechanisms for monetary policy in emerging market economies, 363-394.

Sims, C. (1992). Interpreting the macroeconomic time series facts: The effects of monetary policy. *European Economic Review*, vol., 36, No. 5, pp. 975-1000.

Walsh, C. E. (2002). Teaching inflation targeting: An analysis for intermediate macro. *The Journal of Economic Education*, 33, 333-346.

Woodford, M. (2007). Globalization and monetary control, No. w13329. *National Bureau of Economic Research.*

Tables and figures

Table 1

Every table and figures show own estimations

		ADF	PP			ADF	PP
Consumption	Test statistic Test critical values 1% Test critical values 5% Test critical values 10%	-1.981942 -2.577255 -1.942517 -1.615583	-25.2427 -2.57646 -1.942407 -1.615654	Domestic interest rate	Test statistic Test critical values 1% Test critical values 5% Test critical values 10%	-0.550154 -2.577454 -1.942545 -1.615565	-0.373007 -2.576576 -1.942423 -1.615644
Investment	Test statistic Test critical values 1% Test critical values 5% Test critical values 10%	-2.808741 -2.57719 -1.942508 -1.615589	-25.39372 -2.57646 -1.942407 -1.615654	Underlying inflation	Test statistic Test critical values 1% Test critical values 5% Test critical values 10%	-9.650007 -3.463235 -2.875898 -2.574501	-9.650007 -3.463235 -2.875898 -2.574501
Net exports	Test statistic Test critical values 1% Test critical values 5% Test critical values 10%	-5.101368 -2.577387 -1.942536 -1.615571	-56.78278 -2.576634 -1.942431 -1.615638	International reserves	Test statistic Test critical values 1% Test critical values 5% Test critical values 10%	-12.54935 -3.462737 -2.87568 -2.574385	-12.54935 -3.462737 -2.87568 -2.574385
"Real exchange rate (Mexican peso per US dollar)"	Test statistic Test critical values 1% Test critical values 5% Test critical values 10%	-11.89524 -2.576634 -1.942431 -1.615638	-11.79813 -2.576634 -1.942431 -1.615638	World interest rate	Test statistic Test critical values 1% Test critical values 5% Test critical values 10%	-4.74461 -2.576576 -1.942423 -1.615644	-9.084449 -2.57646 -1.942407 -1.615654
Real gross domestic product	Test statistic Test critical values 1% Test critical values 5% Test critical values 10%	-3.147942 -2.577387 -1.942536 -1.615571	-37.44665 -2.576634 -1.942431 -1.615638	World inflation	Test statistic Test critical values 1% Test critical values 5% Test critical values 10%	-4.74461 -2.576576 -1.942423 -1.615644	-9.084449 -2.57646 -1.942407 -1.615654
Non-underlying inflation	Test statistic Test critical values 1% Test critical values 5% Test critical values 10%	-5.243766 -3.465202 -2.876759 -2.574962	-8.027513 -3.463235 -2.875898 -2.574501				

Every variable is expressed as its logarithm first difference, except by domestic interest rate which is expressed as level.

Table 2
Modulus

0.988244
0.988244
0.982216
0.982216
0.959884

VAR stability test

Table 3
VAR Residual serial autocorrelation test

Lag	Probability LRE statistic	Lag	Probability LRE statistic
1	0.066	13	0.2668
2	0.0926	14	0.2883
3	0.0129	15	0.1754
4	0.0078	16	0.6409
5	0.0476	17	0.4783
6	0.0196	18	0.4562
7	0.0874	19	0.9704
8	0.2479	20	0.0799
9	0.7360	21	0.7005
10	0.5075	22	0.8785
11	0.7027	23	0.7532
12	0.2832	24	0.0158