Rule, what rule? Argentina and its monetary policy rule

Ángel Enrique Neder, Juan Martín Farias

Ponencia presentada en LIII Reunión Anual de la Asociación Argentina de Economía Política realizado en 2018 en la Facultad de Ciencias Económicas – Universidad Nacional de La Plata. La Plata. Buenos Aires, Argentina

Rule, what rule? Argentina and its monetary policy rule

Á. Enrique Neder[1] and J. Martin Farias[2]

National University of Córdoba, Argentina

LIII Reunión Anual de la AAEP

La Plata – Buenos Aires - Argentina

14, 15 y 16 de noviembre de 2018

Keywords: *Rule, Fiscal Deficit, Real Exchange Rate, Interest Rate.*

JEL Classification: E5, E4.

RESUMEN

La elección de una variable de control para la política monetaria caracteriza a la función de bienestar (pérdida) que un banco central desea maximizar (minimizar). Inclusive, da lugar a la propuesta de seguir una regla vs. aplicar -de manera discrecional- una política monetaria.
Cuando se discute la aplicación de una regla, su manifestación puede que no sea completamente explícita.
En este trabajo tratamos de establecer una regla de política monetaria para Argentina, operando con una Regla de Taylor ampliada, que tiene en cuenta la influencia del tipo de cambio y del déficit fiscal para los últimos trece años.

ABSTRACT

The choice of a control variable for monetary policy characterizes the welfare (loss) function that a central bank will want to maximize (minimize). Even, it gives rise to the proposal of following a rule versus applying -in a discretionally way- a monetary policy.
When discussing the application of a rule, its manifestation may not be completely explicit.
In this paper we try to establish a monetary policy rule for Argentina, working with an extended Taylor Rule, contemplating the influence of the exchange rate and the fiscal deficit during the last thirteen years.

[1] Facultad de Ciencias Económicas. Universidad Nacional de Córdoba. Av. Valparaíso s/n. Córdoba (5000). E-mail: enrique.neder@eco.uncor.edu.
[2] Facultad de Ciencias Económicas. Universidad Nacional de Córdoba. Av. Valparaíso s/n. Córdoba (5000). E-mail: martinfarias@eco.uncor.edu. And student of the Centro de Estudios Monetarios y Financieros (CEMFI), Madrid.

I. Introduction

The choice of a control variable for monetary policy characterizes the welfare (loss) function that a central bank will want to maximize (minimize). Even more, it gives rise to the proposal of following a rule versus applying -in a discretionally way- a monetary policy.

When discussing the application of a rule, its manifestation may not be completely explicit. For example, money issue can be managed sterilizing it with open market operations in local currency or in foreign currency, and also using directly operations with international reserves. This last operation consists in accumulating reserves previously, and these reserves will act as a buffer on possible local currency devaluations. But it is also possible to maintain an interest rate as a policy rule by making it dependent on the inflation gap and the output gap. In this sense, the term *rule* is not easy to be defined. For example, we can be in the presence of conditional versus unconditional rules (see Kuttner, 2004).

Which is the answer that can give the literature on monetary-policy rules? Very often the interpretation of the concept of "policy rule" is too narrow. Following Svensson (2003), a policy rule expresses the central bank's instrument (for instance, a short-term interest rate) as an explicit function of information available to the central bank.

In this paper we try to establish a monetary policy rule for Argentina. Most of the literature focuses on simple instrument rules, where the instrument is a function of a small subset of the information available to the central bank. The best-known simple instrument rule is the Taylor Rule (Taylor 1993), where the instrument (real interest rate) responds only to inflation and output gaps.

Our model is in line with the Taylor Rule, but aggregating the influence of other variables which are considered important for the behavior of the local economy (for example, the exchange rate and the fiscal deficit). Therefore, the research question which we will try to find an answer for, is whether the Argentina's Central Bank (BCRA here in) has been setting rules following the scheme of Taylor, but particularly contemplating the influence of the exchange rate and the fiscal deficit during the last thirteen years. So, we investigate if the BCRA has been implicitly following a Taylor Rule as Ferro and Bour (2007), Juarros *et al* (2013), among others, have shown, but trying to stress the role of the exchange rate and fiscal deficit in monetary policy including them as main determinants of the policy rates.

From the initial adoption of Inflation Targeting by New Zealand in 1990, as its framework to conduct monetary policy, interest rates have been gaining an increasing relevance among central banks´ monetary policy instruments. Particularly, as it is expressed by Abel *et al* (2014), the advocates of the use of simple, prespecifies, and publicly and previously announced rules, encourage central banks to follow this kind of policies. At present, some sort of short-term interest rate is the main instrument for monetary policy in dozens of developed economies and emerging markets. The seminal paper of Taylor (1993), where he explained how interest rates respond to the difference between inflation and its target, and the difference between output and full-employment output, made economist feel enthusiastic about using simple rules to describe and to understand monetary policy. The appeal of Taylor Rule originates, among others, in its simplicity, intuitiveness, the relatively limited information it demands (Asso *et al.*, 2010), and its explanatory power (Taylor, 2007).

The original contribution made by Taylor (1993) was improved, mainly, in three aspects. First, the use of a *hypothetical* Taylor Rule was replaced by econometric estimation of the parameters included in the rule. Second, new specifications of a Taylor Rule were extended by including more variables and different specifications. Clarida *et al* (1997) and Taylor (2001) are among the first who included the exchange rate as a determinant of policy rates, highlighting the importance of using open-economy frameworks to analyze monetary policy. Other authors have extended Taylor Rule by studying the role of, – *inter alia* – credibility, non-linearity and asymmetric reactions (Mohanty and Klau (2004), Tanku *et al* (2007), Neuenkirch and Tillman (2014)), money supply factors and international interest rates (Clarida *et al* (1997), Almounsor (2015)), wealth effects and asset prices (Wang *et al* (2016)) and smooth interest rates adjustments (Neuenkirch and Tillman (2014)). Third, different estimation methods were used to overcome the shortcoming of Ordinary Least Squares (OLS) when dealing with, for instance, endogeneity or unit roots in the data generating processes.

There is abundant research that makes a case for including the exchange rate in Taylor rules. As well as Taylor (2001), Galí *et* al (1997) argue that it may be desirable to consider exchange rates as a determinant of policy rates when the pass-through of exchange rate into prices is high.[3] Moreover, they hold that central banks in emerging markets may be interested in reducing exchange rate volatility for reasons other than price stability, such as avoiding sharp output contractions or credibility loses and maintaining financial stability.[4] They find a significant role of exchange rate in Germany, Japan, England and France. Ostry *et al* (2012) use panel regressions to demonstrate that policy interest rate responds to real exchange rate movements in a group of fourteen emerging market Inflation Targeting countries. Including a group of thirteen emerging market in their analysis, Mohanty and Klau (*op cit*) conclude that "the results suggest a high degree of interest rate response to exchange rate". They prove that their results are robust to different model specifications and estimation methods. Finally, Wang *et al* (2016) find a significant response of interest rates to exchange rate movements in United Kingdom, Sweden and Australia, although this result is sensitive to the model specification.

Focusing on Argentina, Ferro and Bour (2007) use 2SLS and GMM to estimate a basic Taylor Rule for the period 2003-2007 and then they extend this simple model by including exchange rate variations (depreciations), among other variables, as an explanatory variable. They found that contemporary depreciations are not statistically significant, but they do are when lagged depreciations are also included.

To our knowledge, since Ferro and Bour, and Juarros *et al*, there have not been further attempts to estimate Taylor Rules to explain monetary policy in Argentina. Moreover, none of the available estimations have considered the possible existence of unit roots in the variables.

Those are the reasons why we propose to estimate an open-economy Taylor Rule for our country, extending the basic specification by including the exchange rate and fiscal deficits and considering explicitly the properties of the time series.

The remain of the paper is organized as follows: in section II we present the different models estimated and data. section III contains the estimations with the analysis of unit roots and cointegration tests, the results of estimated models and the Impulse-Response analysis. Conclusions are presented in section IV, and last section includes the references. An Appendix with tests for exclusion of variables and an analysis for residuals is presented at the end of the paper.

II. Models and data

II.a. The cointegrated VAR model

For a set of K variables $X = (x_1, x_2, \dots, x_K)$ a VAR model of order p (VAR(p)) has the form:

$$X_t = A_1 X_1 + A_2 X_2 + \cdots + A_p X_p + u_t \qquad (1)$$

where $A_i (i = 1, 2, \dots, p)$ are KxK matrices and $u_t \sim N(0, \Sigma)$ is a $Kx1$ vector of unobservable error terms. If the variables are integrated of order one (I (1)) and there exist a linear combination

[3] Castiglione (2018) uses a Vector Error Correction Model to show that pass-through in Argentina is higher than in developed countries and even higher than in other countries of the region.
[4] Redrado (2009) highlights the importance of exchange rate management for financial stability in Argentina.

between them that is I (0), i.e. they are cointegrated CI (1, 1), a Vector Error Correction Model (VECM) is the most suitable type of model. Model (1) has a VECM (p-1) representation as follows:

$$\Delta X_t = \Pi X_{t-1} + \Gamma_1 \Delta X_{t-1} + \cdots + \Gamma_{p-1} \Delta X_{t-p+1} + \varphi \mu_t + u_t \qquad (2)$$

where $\Pi = -(I_K - A_1 - \cdots - A_p)$ and $\Gamma_i = -\left(A_{i+1} + \cdots + A_p\right)$ for $\mathrm{i} = 1, 2, \ldots, \mathrm{p} - 1$; this model also includes a $Kx1$ vector μ of deterministic terms which may contain a constant term, a trend and dummy variables. The information about the short run relationships among endogenous variables is contained in the Γ_i matrices. The specification assumes that Π is a reduced rank matrix that can be decomposed into $\Pi = \alpha\beta'$, where β contains the cointegrating vectors, α is the loading matrix and $rank(\Pi)$ is the cointegrating rank of the system.

Three different specifications are explored in this paper. First, a basic Taylor Rule where $X = (interest\ rate, inflation, output)$ is estimated. Second, the basic model is extended to include the real exchange rate. Finally, the inflation rate is replaced by the fiscal deficit to explore the impact of the latter on the monetary policy. Therefore, the following three models are estimated:

II.a.i. Model 1 (nominal interest rate vs. inflation rate and output)

This model considers the traditional structure of the Taylor Rule, with the particularity of taking into account the nominal (not the real) interest rate as the policy variable to be adjusted in order to control or to combat the "overheating" in the economy or the deviation of inflation rate above its target, as well. The structure for Model 1, which serves as a benchmark model, is the following:

$$\begin{bmatrix} \Delta Int_t \\ \Delta Inf_t \\ \Delta Out_t \end{bmatrix} = \alpha\beta' \begin{bmatrix} Int_t \\ Inf_t \\ Out_t \end{bmatrix} + \Gamma_1 \begin{bmatrix} \Delta Int_{t-1} \\ \Delta Inf_{t-1} \\ \Delta Out_{t-1} \end{bmatrix} + \cdots + \Gamma_{p-1} \begin{bmatrix} \Delta Int_{t-p+1} \\ \Delta Inf_{t-p+1} \\ \Delta Out_{t-p+1} \end{bmatrix} + \varphi \mu_t + u_t \qquad (3)$$

From a theoretical point of view, we should expect raises in interest rate when output or inflation are increasing.

II.a.ii. Model 2 (no minal interest rate vs. inflation rate, output, and real exchange rate)

In Model 2 we add the real exchange rate variable, as many authors have chosen to extend the Taylor Rule. In our case, this obeys to the importance the exchange rate has in an economy as the Argentinian. Most of the population in our country is accustomed to think in dollars, even though the American currency is not legal tender. However, as is shown in Descalzi and Neder (2017), people demand "in advance" the foreign currency, which is provided by the BCRA who gets it from the international indebtedness in which incurs the national government. So, the management of interest rate could be also oriented to avoid important fluctuations in the real exchange rate. Additionally, real exchange rate is the main variable which acts as a signal to orient the behavior of exporters and international investors at the time to decide on capital movements.

The structure of Model 2 is the following:

$$\begin{bmatrix} \Delta Int_t \\ \Delta Inf_t \\ \Delta Out_t \\ \Delta RER_t \end{bmatrix} = \alpha\beta' \begin{bmatrix} Int_t \\ Inf_t \\ Out_t \\ RER_t \end{bmatrix} + \Gamma_1 \begin{bmatrix} \Delta Int_{t-1} \\ \Delta Inf_{t-1} \\ \Delta Out_{t-1} \\ \Delta RER_{t-1} \end{bmatrix} + \cdots + \Gamma_{p-1} \begin{bmatrix} \Delta Int_{t-p+1} \\ \Delta Inf_{t-p+1} \\ \Delta Out_{t-p+1} \\ \Delta RER_{t-p+1} \end{bmatrix} + \varphi \mu_t + u_t \qquad (4)$$

As in the case of Model 1, from a theoretical point of view, we should expect raises in interest rate when output or inflation are increasing. And the relationship between interest rate and real exchange rate can be direct since the foreign currency is considered as an alternative investment asset.

II.a.iii. Model 3 (nominal interest rate vs. fiscal deficit, output, and real exchange rate)

Model 3 operates as Model 2 but considering the fiscal deficit as a proxy of inflation rate. Additionally, fiscal deficit is a variable that can be exerting influences on real exchange rate. As is shown in Descalzi and Neder (*op. cit.*), residents seek to protect themselves avoiding the payment of taxes, particularly being involved in informal activities, and accumulating foreign currency. And because they expect a depreciation in domestic money, they struck a singular accord with the government, because rather than issuing money to finance fiscal deficits, government gets into foreign debt to satisfy the foreign currency demand by residents.

The structure of the Model 3 is the following:

$$\begin{bmatrix} \Delta Int_t \\ \Delta Def_t \\ \Delta Out_t \\ \Delta RER_t \end{bmatrix} = \alpha\beta' \begin{bmatrix} Int_t \\ Def_t \\ Out_t \\ RER_t \end{bmatrix} + \Gamma_1 \begin{bmatrix} \Delta Int_{t-1} \\ \Delta Def_{t-1} \\ \Delta Out_{t-1} \\ \Delta RER_{t-1} \end{bmatrix} + \cdots + \Gamma_{p-1} \begin{bmatrix} \Delta Int_{t-p+1} \\ \Delta Def_{t-p+1} \\ \Delta Out_{t-p+1} \\ \Delta RER_{t-p+1} \end{bmatrix} + \varphi\mu_t + u_t \qquad (5)$$

The expected results should be like those of Model 2, with the addition that we should find some relationships, particularly between fiscal deficit, interest rate, and real exchange rate. By connecting fiscal deficit with interest rate, we should find a positive relationship motivated by a kind of a crowding-out and inflation rate expectations, and a negative relationship between fiscal deficit and real exchange rate due to the inflationary impact generated by fiscal deficit if this is financed with monetary issue or a reduction in the nominal exchange rate if fiscal deficit is financed with external debt.

II.b. Data sources and definitions

Given that in most of the sample period there was no an explicit monetary policy interest rate, the *call* rate, an interbank short-run interest rate for non-guaranteed loans, is used. Inflation rate is measured by the monthly percentage change in the Consumer Price Index (CPI). Output is measured by the *Estimador Mensual de Actividad Económica* (EMAE), a monthly indicator of economic activity. The Real Exchange Rate is represented by the bilateral real exchange rate between Argentina and United States[5]. Finally, fiscal deficit is measured by the national government deficit and it is expressed as a percentage of the gross domestic product.

Data on inflation from January 2004 to December 2006 and January 2016 to December 2017 is obtained from National Institute of Statistics and Censuses (INDEC, *Instituto Nacional de Estadísticas y Censos*), and data from the Statistics Bureau of San Luis Province is used between January 2007 and December 2015. San Luis inflation data is used after 2006 because the INDEC suffered a significant loss of credibility after that year. Data on economic activity and fiscal deficit is obtained from INDEC and the Ministry of Public Finance, respectively. The real exchange rate data is obtained from BCRA for the period January 2004 to December 2011, and January 2016 to December 2017. In between periods, strong capital controls were imposed in Argentina to maintain official exchange rate artificially low and stable.

[5] Despite the fact a multilateral exchange rate could be used (even another foreign currency), US Dollar is particularly relevant to orient the behavior of economic agents in Argentina.

Consequently, a marginal market exchange rate is used from 2012 to 2015. This information is obtained from an argentine newspaper (Ambito Financiero) database.[6]

III. Estimations

III.a. Unit root tests

Stationarity of time series is analyzed using both Augmented Dicky-Fuller (ADF) tests and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) tests on level and on differenced data. The joint application of these two tests increases their statistical power given they have opposite null hypothesis.

The presence of structural breaks in time series may significantly reduce the power of the ADF test. For that reason, the unit root test with structural breaks proposed by Saikkonen and Lütkepohl (2002) and Lanne et al (2002) is used to account for possible structural breaks during the sample period. These tests also generate information about the date of the structural shift which will be valuable in the estimation stage.

The tests´ results, which are displayed in Table 1, suggest the existence of unit roots in the time series. In the cases of inflation rate and fiscal deficit, ADF tests with Constant or Constant and Trend seem to indicate that there are no unit roots in the data generating process, but the opposite conclusion is reached when structural breaks are included in the test.[7] For the same time series, the KPSS test does not reject the null of stationarity around a deterministic trend. According to Juselius (2006), this implies that including a trend in the cointegration relationship should be considered in the estimation stage.[8]

Table 1
Unit root tests

Variable	ADF				KPSS	
	None	Constant	Constant and Trend	Constant and Break	Constant	Trend
Interest	0.9707	-0.5849	-2.2574	-0.6643	1.363501***	0.252442***
Inflation	-1.4043	-6.2177***	-7.3799***	-2.0638	1.038663***	0.094715
Output	1.1748	-2.1311	-2.0481	-2.2866	1.365238***	0.353043***
Deficit	1.4926	-1.1970	-11.1788***	-1.7689	1.566931***	0.034298
RER	-1.7883*	-1.2728	-1.4239	-1.3493	1.482559***	0.308367**

Note: Lag length of ADF test was determined using Schwarz information Criteria (SIC). ***, ** and * mean rejecting null hypothesis at 99%, 95% and 90%, respectively.

III.b. Determining cointegration rank

First, a VAR model in level is estimated, and the optimal number of lags is selected based on different information criteria, such as Akaike Information Criterion (AIC), Final Prediction Error (FPE), Hanna-Quinn Criterion (H-Q) and Schwarz Criterion (SC). Dummy variables were included to take into account structural breaks during the sample period, and

[6] Available on: http://www.ambito.com/economia/mercados/monedas/dolar/info/?ric=ARSB=

[7] Transitory blips were included in March 2008 for output, June 2014 for interest rate, and January 2014 for exchange rate. Shifts were included in March 2014 for inflation rate and January 2009 for fiscal deficit.

[8] Tests over variables in differences rejected the existence of unit roots in the data generating processes.

residual analysis was performed to assure that the selected models comply with basic requirements.

For Model 1, a lag length of two was selected, and four lags were selected for Model 2 and Model 3. When one lag was chosen, a noticeable worsening of residuals´ properties was observed in the three models.

Table 2
Optimal lag length

Criteria	Model 1	Model 2	Model 3
Akaike Information Criterion	2	10	4
Final Prediction Error	2	4	4
Hannan-Quinn Criterion	2	4	1
Schwarz Criterion	1	1	1

Once the optimal lag length was selected, the trace test proposed by Johansen (1991) is used to determine the cointegrating rank. For the three proposed model, the cointegrating tests suggest the existence of one cointegrating relation among variables.

Juselius (2006) states that if the cointegration rank does not change when a new variable is included, and the Wald Test concludes that the variable should be excluded from the model, the variable seems not to add useful information. It does not imply, however, that the variable must be excluded from the model because it may become highly significant when combined with other variables. Moreover, there may be economic reasons to maintain this variable in the model.

Table 3
Cointegration tests

r	Model 1		Model 2		Model 3	
	LR	**P-value**	**LR**	**P-value**	**LR**	**P-value**
0	109.05	0.0000	99.54	0.0000	126.33	0.0000
1	21.74	0.1517	48.98	0.0296	50.37	0.0206
2	6.08	0.4612	19.10	0.4370	24.12	0.1569
3	------------------------------		5.66	0.6455	8.68	0.3111

III.c. Estimated models

The estimated cointegration vectors and loading matrices are displayed in Table 4. In Model 2, the coefficients of inflation and exchange rate show the expected signs, although the same does not hold for output. The coefficient for output suggests that the BCRA has tended to reduce (increase) interest rates during expansions (recessions), in contrast to the empirical evidence and what is expected from a theoretical point of view. However, Ferro and Bour (2007) also found the same result in their estimations for Argentina in the period 2003-2007.

The t-tests on output and exchange rate show that these variables present a low level of significance and the Wald tests for exclusion of variables, whose results are available in the Appendix, conclude that there is enough evidence to exclude them from the model. Consequently, the long run structure of Model 2 should be interpreted cautiously. However, as was discussed in section III.b., output and real exchange rate were kept because, in addition to the economic reasons to support their inclusion, they become highly significant when combined with another new variable in Model 3.

Table 4
Estimation results

	Variable	Model 1	Model 2	Model 3
Cointegrating vectors	β_i	**1.000**	**1.000**	**1.000**
	β_π	**-2.134** (-6.595) {0.000}	**-3.135** (0.404) {0.000}	--------------
	β_d	--------------	--------------	**-10.200** (-8.044) {0.000}
	β_o	**0.066** (2.632) {0.008}	**0.045** (0.063) {0.470}	**-0.062** (-3.069) {0.002}
	β_e	--------------	**-0.020** (0.027) {0.451}	**-0.023** (-1.826) {0.068}
	Shift2016M3	**-0.014** (-1.890) {0.059}	**-0.010** (0.007) {0.179}	--------------
	Shift2009M1	--------------	--------------	**0.009** (2.490) {0.013}
	Trend	--------------	--------------	**0.00032** (4.058) {0.000}
Loading matrices	α_i	**-0.003** (-0.398) {0.690}	**-0.008** (-2.254) {0.024}	**-0.025** (-1.926) {0.054}
	α_π	**0.223** (6.279) {0.000}	**0.167** (9.265) {0.000}	--------------
	α_d	--------------	--------------	**0.112** (8.919) {0.000}
	α_o	**-0.086** (-1.148) {0.251}	--- ( ) { }	**-0.006** (-1.997) {0.046}
	α_e	--------------	**0.191** (2.919) {0.004}	**0.009** (2.755) {0.006}

Note: **Coefficients**, (t-values) and {p-values}.

In Model 3, where inflation was replaced by fiscal deficit, all coefficients, including the one that correspond to output, present the expected signs. In this model output and exchange rate are more significant than in Model 2, and Wald tests do not provide strong evidence to exclude them. Additionally, the value of the coefficient of Fiscal Deficit (used as a *proxy* for inflation rate) is higher than the coefficient of inflation rate in Model 2. This may reflect a crowding-out effect and the impact of fiscal deficit on expected inflation rate and exchange rate.

The high significance of exchange rate in the estimated rule indicates that BCRA cares about this variable beyond the immediate impact it has on inflation. A direct explanation is that central bank is concerned about the impact of devaluations on future inflation, but other reasons like considerations about currency mismatches or self-fulfilling expectations, for instance, can also explain this phenomenon.

In Model 2, a shift in March 2016 was included in the cointegration vector to consider a possible structural break as a consequence of the implementation of Inflation Targeting in Argentina. The lack of strong evidence of a structural break in that moment does not necessarily mean that there was no change in the implementation on monetary policy. An adequate test of this hypothesis would be possible when more information became available. A trend inside the cointegration relationship was also included in a preliminary model but it was excluded based on the result of the Wald test.

In Model 3, a shift in January 2009 and a trend were included inside the cointegration relationship based on the results of the unit root tests with structural breaks presented in Table 1.

III.d. Impulse response analysis

Impulse response functions display the reaction of an estimated model to a structural shock in one of the endogenous variables. In order to recover the structural representation from the estimated reduced-form model, additional restrictions have to be imposed in the matrix B_0^{-1}, where B_0 governs the contemporaneous interactions between variables. To identify the model, $K(K-1)/2$ restrictions must be introduced.

The Chollesky Decomposition is the simplest way to identify the model by an orthogonalization of the reduced-form residuals. Despite its simplicity, the Chollesky Decomposition has, among others, the following disadvantages: First, the orthogonalization of the reduced-form residual, which imposes a particular chain among the variables, is appropriate only if it has an adequate economic justification. Second, the solution differs depending on the ordering of variables, which sometimes forces to conduct sensitivity analysis based on alternative orderings. And last but not least, it only imposes short-run restrictions, ignoring the long-run properties of the model.

One alternative idea, following Kilian and Lütkepohl (2017), is to combine short and long-run restrictions and focus on the long-run properties of the VEC model. Although this strategy may be more complicated, it considers the fact that some shocks are restricted to the short-run whereas other can have long-run effects, something that is crucial for the models estimated here.

The VECM presented in (2) has the following Granger Representation:

$$X_t = \Xi \sum_{i=1}^{t} u_i + \Xi^*(L)u_t + X_0^* \quad (6)$$

where $\Xi = \beta_\perp\left[\alpha_\perp'\left(I_K - \sum_{i=1}^{p-1}\Gamma_i\right)\beta_\perp\right]^{-1}\alpha_\perp'$, $\Xi^*(L)u_t = \sum_{j=0}^{\infty}\Xi_j^* u_{t-j}$ is an $I(0)$ process, and X_0^* contains the initial values. The term $\sum_{i=1}^{t} u_i$ is a K-dimensional random walk process but Ξ is a reduced rank matrix such that $\text{rank}(\Xi) = K - r$. Consequently, the term $\Xi\sum_{i=1}^{t} u_i$ is a (K-r)-dimensional random walk process, which means that X_t is driven by K-r common trends. Since the structural errors are recovered from the reduced-form model as $w_t = B_0 u_t$, the Granger Representation (6) turns into:

$$X_t = \mathbf{\Upsilon} \sum_{i=1}^{t} w_i + \Xi^*(L)B_0^{-1}w_t + X_0^* \qquad (7)$$

where $\Upsilon = \Xi B_0^{-1}$ is the matrix of long-run multipliers, which shows the long-run effects of the structural shocks on the endogenous variables. Restrictions on the long-run effects of the shocks can be imposed on Υ and some or all the restrictions can be introduced in this matrix. For instance, if a certain shock is considered to have no long-run effect on a particular variable, a zero restriction is placed on the corresponding coefficient, or if the effects of shocks on a particular variable are restricted to the short-run, the corresponding column is restricted to zero.

It is important to consider the properties of this matrix when imposing restrictions. In particular, $\mathrm{rank}(\Upsilon) = \mathrm{K} - \mathrm{r}$ implies that at most r shocks can have short-run effects only (at most r columns can be zero).

In Models 2 and 3 [equations (4) and (5)], $\mathrm{rank}(\Upsilon) = 3$ and the structural shocks are:

$$w_{mod\ 2} = \begin{bmatrix} w_{int} \\ w_{inf} \\ w_{out} \\ w_{RER} \end{bmatrix} \qquad w_{mod\ 3} = \begin{bmatrix} w_{int} \\ w_{def} \\ w_{out} \\ w_{RER} \end{bmatrix}$$

where $\mathrm{w_{int}}$, $\mathrm{w_{out}}$, $\mathrm{w_{RER}}$ and $\mathrm{w_{def}}$ can be interpreted as monetary policy shocks, productivity shocks, external shocks and fiscal policy shocks, respectively. $\mathrm{w_{inf}}$ is an inflation shock that, according Descalzi and Neder (2017), is strongly related to fiscal policy in Argentina. Because the cointegration relationship is interpreted as a stationary Taylor Rule relation, restrictions are imposed on Υ such that the impacts of changes in the interest rate are merely transitory; additionally, output is determined only by productivity shocks in the long run. Therefore, the resulting Υ matrix is:

$$\begin{array}{cc} & \begin{array}{cccc} \mathbf{w_{Int}} & \mathbf{w_{inf\text{-}def}} & \mathbf{w_{out}} & \mathbf{w_{rer}} \end{array} \\ \boldsymbol{\Upsilon} = & \begin{bmatrix} 0 & * & * & * \\ 0 & * & * & * \\ 0 & 0 & * & 0 \\ 0 & * & * & * \end{bmatrix} \end{array}$$

On the short run side, one restriction is introduced so that changes in real exchange rate do not have an instantaneous impact on inflation in Model 2, and that changes in fiscal deficit do not have an immediate impact on real exchange rate, in Model 3.[9] In consequence, the B matrices have the forms:

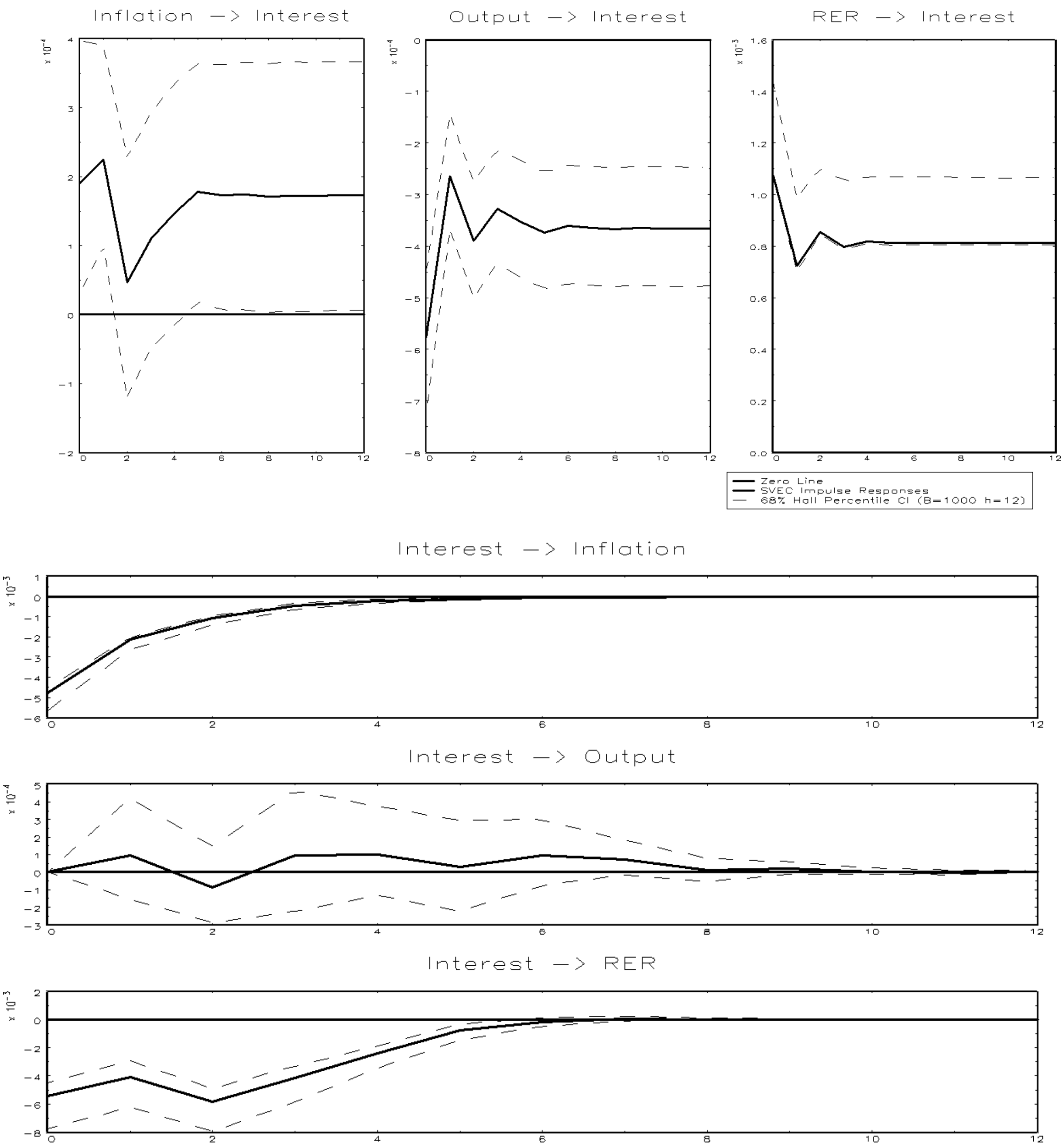
$$B_{0\ mod\ 2}^{-1} = \begin{array}{c} \begin{array}{cccc} \mathbf{w_{Int}} & \mathbf{w_{inf}} & \mathbf{w_{out}} & \mathbf{w_{rer}} \end{array} \\ \begin{bmatrix} * & * & * & * \\ * & * & * & 0 \\ * & * & * & * \\ * & * & * & * \end{bmatrix} \end{array} \qquad B_{0\ mod\ 3}^{-1} = \begin{array}{c} \begin{array}{cccc} \mathbf{w_{Int}} & \mathbf{w_{def}} & \mathbf{w_{out}} & \mathbf{w_{rer}} \end{array} \\ \begin{bmatrix} * & * & * & * \\ * & * & * & * \\ * & * & * & * \\ * & 0 & * & * \end{bmatrix} \end{array}$$

In both models, out of the six restrictions imposed, five are long-run restrictions and only one is a short run restriction. Because $\boldsymbol{\Upsilon}$ is a reduced rank matrix, the zero restriction on the column corresponding to $\mathrm{w_{int}}$ accounts for three restrictions; two more restrictions are introduced on the row corresponding to output and the last restriction is introduced on $\mathrm{B_0^{-1}}$.

[9] Castiglione (2017) shows that there is a pass-through from changes in exchange rate to prices, but it is not significantly different from zero in the moment the shock occurs.

Figure 1 displays the Impulse Response functions of Model 2 and the Hall Percentile confidence interval.[10] The policy response after an inflation or exchange rate shock is an immediate increase in the interest rate, and the opposite happens in the case of an output shock. Given that these shocks have long-run effects, interest rate does not return to its initial value after them.

Figure 1
Impulse Response functions, Model 2



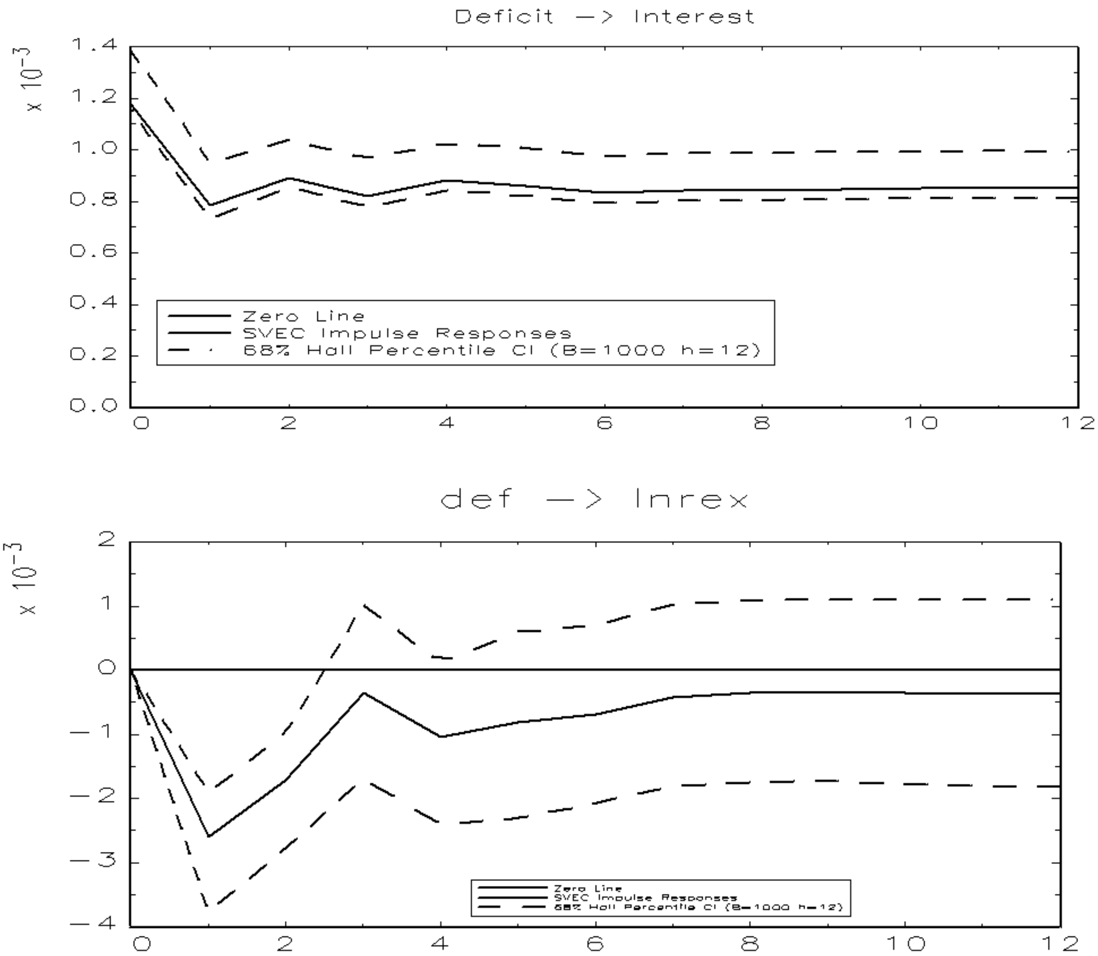
In contrast, monetary policy shocks produce reductions in inflation and exchange rate that tend to disappear after six months. It is worth highlighting that output seems not to react

[10] A confidence Interval of 68% is constructed, as Kilian and Lütkepohl (2017) report that many applied users favor instead of the more usual 95% significance level.

after a monetary policy shock, a result which is in line with the long-run weak exogeneity that was proved in Table 4.

Figure 2, where some Impulse Responses functions from Model 3 are presented, shows that the policy response after a shock in fiscal deficit is an increase in interest rate that does not disappear in the long run.[11] Besides, a fiscal deficit shock leads to a transitory reduction in real exchange rate that seems to disappear after two months. In this case, the relationship proves the expected results mentioned in section II.a.iii. This means that the real exchange rate decreases because of the inflationary impact generated by fiscal deficit if this is financed with monetary issue or a reduction in the nominal exchange rate if fiscal deficit is financed with external debt.

Figure 2
Impulse Response Functions, Model 3



IV. Conclusions

The implementation of a rule to be applied for monetary policy is an action that it is far from being considered an easy stuff. This is showed by the answers given by economic

[11] The explanation for this response is the same as for the long run.

literature, where we can find a great number of interpretations about rules to be considered, but the concept of policy rule is very narrow.

It is said that the simpler the rule, the better the result, and additionally, the easier the control. A good example of this is the very well-known Taylor Rule.

Taking into account all the above mentioned, in this paper we try to find a rule to be applied for monetary policy in Argentina, taking as a basic one the Taylor Rule but extending it, adding other variables as the exchange rate. And we go beyond, changing the traditional inflation rate variable by a *proxy*: the fiscal deficit. Exchange rate was included because the bilateral relationship between the currencies of United States and Argentina are a kind of indicator for many activities (i.e. international trade and capital movements, fixing local prices, a saving mean, etc.). And fiscal deficit because it is the main driver for inflation.

Considering the three models estimated, the best results were obtained in Model 3, which included the variables interest rate, fiscal deficit, output and real exchange rate. All the coefficients presented the expected signs and the coefficients of output and real exchange rate resulted more significant than in Model 2, and the value of fiscal deficit coefficient is higher than that of the inflation rate, reflecting a crowding-out effect and the impact on expected inflation rate and on exchange rate. This indicates that exchange rate is a sensitive variable for BCRA because of its impact on inflation rate beyond the immediate impact. This means that BCRA cares about the impact of devaluations on long-run inflation rate.

Analyzing some Impulse-Response functions from Model 3, after a shock in fiscal deficit, the policy response is an increase in interest rate that does not vanish in the long run. And the same shock provokes a transitory reduction in real exchange rate.

In few words, a fiscal deficit that provokes an increase in inflation rate, generates a decrease in real exchange rate when fiscal deficit is financed issuing money or due to a diminishing nominal exchange rate provoked by external indebtedness.

V. References

Abel, Andrew B., Ben S. Bernanke, and Dean Croushore (2014) *Macroeconomics*. Eighth Edition. Boston. Pearson.

Almounsor, A. H. (2015). “Monetary Policy in Saudi Arabia: A Taylor-Rule Analysis”. *International Journal of Economics and Finance*, 7(3).

Asso, P. F., G. A. Kahn, and R. Leeson (2010). “The Taylor Rule and the Practice of Central Banking”. Available at SSRN: https://ssrn.com/abstract=1553978 or http://dx.doi.org/10.2139/ssrn.1553978.

Castiglione, B. (2018). “El traspaso a precios de las depreciaciones cambiarias: Una estimación VECM para el caso argentino”. Banco Central de la República Argentina, *Ensayos Económicos*. Available at: http://www.bcra.gob.ar/Institucional/Resumen.asp?id=1216&prevPage=4.

Clarida, R., J. Galí, and M. Gertler (1997). “Monetary policy rules in practice: Some international evidence”. *NBER Working Paper Series*. Working Paper 6254.

Descalzi, Ricardo L. and Á. Enrique Neder (2017). “Financing Fiscal Deficits. Intertemporal approach under different exchange rate regimes”. Anales. Asociación Argentina de Economía Política. LII Reunión Anual. Río Negro. Noviembre. ISSN 1852-0022. ISBN 978-987-28590-5-3.

Ferro, G. y A. Bour (2007). “¿Es posible determinar una regla implícita de política monetaria en Argentina?”. Anales de la Asociación Argentina de Economía Política. ISSN 1852-0022, ISBN 978-987-99570-5-9.

Johansen, S. (1991). "Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models".Econometrica.59 (6): 1551–1580.JSTOR 2938278.

Juarros, P., J. Puig y L. Salinardi (2013). “Reglas de política monetaria en el MERCOSUR”. Anales de la Asociación Argentina de Economía política. ISSN 1852-0022, ISBN 978-987-28590-1-5.

Juselius, K. (2006). *The Cointegrated VAR Model: Methodology and Applications*. Oxford University Press.

Kilian, L. and H. Lütkepohl (2017). *Structural Vector Autorregresive Analysis*. Cambridge University Press. Available in http://www-personal.umich.edu/~lkilian/book.html

Kuttner, K. N. (2004). “The Role of Policy Rules in Inflation Targeting”. Federal Reserve Bank of St. Louis *Review*, July/August, pp. 89-111.

Lanne, M., H. Lütkepohl, and P, Saikkonen, P. (2002). “Comparison of unit root tests for time series with level shifts”. *Journal of Time Series Analysis*. Vol. 23, pp: 667-685.

Mohanty, M. S. and M. Klau (2004). “Monetary policy rules in Emergin Market Economies: Issues and Evidence”. In Langhammer, R. J. and L. Vinhas De Souza (eds), Monetary Policy and Macroeconomic Stabilization in Latin America, Springer, Berlin.

Neuenkirch, M and P. Tillman, P. (2014). “Inflation Targeting, Credibility, and Non-Linear Taylor Rules”. *Journal of International Money and Finance*, (41), pp 30-45.

Ostry, J. D., A. R. Ghosh, and M. Chamon (2012). “Two Targets, Two Instruments: Monetary and Exchange Rate Policies in Emerging Market Economies”. *IMF Staff Discussion Note* No. 12/1.

Redrado, M. (2009). “La Política Monetaria y Financiera Argentina frente a la Crisis”. Escuela de Negocios, Universidad Católica Argentina, *Documento de Trabajo* Nro. 3.

Saikkonen, P. and H. Lütkepohl (2002). “Testing for a unit root in a time series with a level shift at unknown time”. Econometric Theory,18: 313-348.

Svensson, Lars E. O. (2003). “What is wrong with Taylor Rules? Using judgment in monetary policy through targeting rules. Journal of Economic Literature.Vol. XLI, June. pp 426-477.

Tanku, A., I. Vika, and M. Gjermeni (2007). “The Role of Exchange Rate in an IT Framework, What do We Do?” Bank of Albania. Available at: https://www.bankofalbania.org/Publications/Research/Research_Papers/The_Role_of_Exchange_Rate_in_an_IT_Framework_What_do_we_do.html.

Taylor, J. B. (1993). “Discretion versus policy rules in practice”. Carnegie-Rochester *Conference Series on Public Policy* 39, pp. 195-214.

Taylor, J. B. (2001). “The Role of the Exchange Rate in Monetary-policy Rules”. *American Economic Review* 91, pp. 263–267.

Taylor, J. B. (2007). “The Explanatory Power of Monetary Policy Rules”. *NBER Working Paper Series*, Working Paper 13685.

Wang, R., B. Morley, J. Ordóñez, (2016). “The Taylor Rule, Wealth Effects and the Exchange Rate”. *Review of International Economics*, 24(2), pp 282–301.

Appendix

Wald tests for long-run exclusion of variables were implemented and their results are presented in Table A.1. In Model 2, only inflation seems to be relevant in the long-run whereas in Model 3 there is no strong evidence to exclude any of the endogenous variables.

A shift in March 2016 and a Trend were included in the cointegration relationship for Model 2, and the Wald tests indicate that both variables should be excluded from the model. Nevertheless, the shift was kept, and the model was estimated again without a trend.

In Model 3, a trend and two shifts were included in January 2009 and March 2016 in a preliminary model. According to the Wald tests, the evidence of a possible structural change in 2016 is not as strong as it is in 2009, and the former was excluded from the final model. This is reasonable because interest rate responses to fiscal policy, and in 2016 there were no significant changes in fiscal policy. The final model was estimated excluding the shift in March 2016.

Table A.1
Tests for exclusion of variables

Variable	Estadístico [P-value]		
	Model 1	Model 2	Model 3
Inflation	43.4886 [0.0000]	60.2662 [0.0000]	----------
Déficit	----------	----------	64.7017 [0.0000]
Output	6.9269 [0.0085]	0.5209 [0.4705]	9.4205 [0.0021]
Exchange rate	----------	0.5679 [0.4511]	3.3332 [0.0679]
Shift2016M3	3.5722 [0.0588]	1.8033 [0.1793]	4.0914 [0.0431]
Shift2009M1	----------	----------	6.2012 [0.0128]
Trend	0.1759 [0.6749]	1.9801 [0.1594]	16.4664 [0.0000]

Residual analysis was conducted for all models, and the result of all tests are presented in Table A.2. LM and Pormanteau tests do not provide enough information to reject the null hypothesis of absence of autocorrelation up to order 12 in the residuals. There is enough evidence to reject the null hypothesis of normality in residuals but mainly because of kurtosis is different than expected in the distribution of residuals. Finally, the Multivariate ARCH test point to the existence of heteroskedasticity in residuals. When the Univariate ARCH tests were implemented, they show that heteroskedasticity is caused by inflation and real exchange rate – two variables that experienced a high increase in their volatility in the last years on the sample period.

Table A.2
Residual analysis

Test	Estadístico [P-value]		
	Model 1	Model 2	Model 3
LM (1)	42.1680 [0.0000]	25.5057 [0.0614]	40.6692 [0.0006]
LM (3)	76.0148 [0.0000]	66.3807 [0.0405]	73.7179 [0.0099]
Portmanteau (1)	---------------------	-------------------	--------------------
Portmanteau (3)	34.7798 [0.0026]	38.5374 [0.0223]	41.6832 [0.0046]
Portmanteau (6)	56.0179 [0.0725]	77.3705 [0.2827]	88.5933 [0.0562]
Portmanteau (9)	88.1022 [0.0603]	135.5311 [0.1427]	137.2766 [0.0970]
Portmanteau (12)	125.3078 [0.0239]	185.7133 [0.1529]	177.8048 [0.2346]
Multivariate ARCH (1)	79.5421 [0.0000]	161.7312 [0.0001]	142.4120 [0.0034]
Multivariate ARCH (1-3)	170.3517 [0.0001]	448.0456 [0.0000]	424.6916 [0.0000]
Multivariate ARCH (1-6)	289.4964 [0.0006]	797.7534 [0.0000]	782.4854 [0.0000]
Multivariate ARCH (1-9)	397.2600 [0.0033]	1089.4438 [0.0000]	1099.5243 [0.0000]
Multivariate ARCH (1-12)	490.2516 [0.0273]	1327.8697 [0.0056]	1330.9961 [0.0047]
Normality Test	88.6040 [0.0000]	92.1041 [0.0000]	94.0110 [0.0000]

Finally, the eigenvalues of the inverse of the characteristic equations, which are displayed in the following lines, show that the three estimated models are stable.

- **Model 1:**

|z| = (2.2138 6.5795 2.9661 5.2040 1.0000 1.0000)

- **Model 2:**

|z| = (1.5855 1.5855 1.7376 2.9624 2.8802 2.8802 1.9736 1.9736 2.8569 2.8569 1.9700 1.9700 3.3091 1.0000 1.0000 1.0000)

- **Model 3:**

|z| = (1.4603 1.4603 1.5960 1.9300 2.0935 2.0935 53.1653 1.5612 1.5612 1.6415 1.6415 1.9843 1.9843 1.0000 1.0000 1.0000)