Structural Economic Model for Ecuador: a Dollar-ized and Oil-ized Economy

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Structural Economic Model for Ecuador: a Dollar-ized and Oil-ized Economy

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Abstract

The paper develops a Structural Model with the main macroeconomic features of the Ecuadorian economy. It models the main transmission channels of a small open and dollarized economy, highly dependent on oil production and foreign remittances. It is estimated by Bayesian methods for the period 2001-2010. The framework highlights the main risks affecting the macroeconomic performance, including the importance of international shocks. It also underscores the importance of the fiscal policies and the independent and significant role of the oil value added in the domestic economy.

Resumen

El trabajo desarrolla un Modelo Estructural con las principales características macroeconómicas de la economía ecuatoriana. Modela los principales canales de transmisión de una economía pequeña, abierta y dolarizada, altamente dependiente de la producción de petróleo y las remesas del exterior. Se estima por métodos bayesianos para el período 2001-2010. El modelo permite analizar los principales riesgos que afectan el desempeño macroeconómico, incluyendo los shocks externos. También se subraya el efecto de la política fiscal así como el papel independiente y significativo del valor agregado petrolero en la economía doméstica.

JEL classification no: E02, O11, Q43.

Key words: New Keynesian model, Bayesian methods, Oil Value Added, Fiscal policy.

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1 Introduction

The Ecuadorian economy is an small and open economy with exports plus imports above 70% of the GDP. Dollarized since 2000, the economy has a significant energy sector. Indeed, the country is an important crude oil producer and the value added by crude oil production represents almost 15% of the non-oil gross domestic product. The crude oil exports account for more than 50% of total exports while refined oil imports are approximately 20% of total imports of the country. Also, the country receives an important amount of remittances from migrants living in developed countries (mainly Spain and US). The dollarization scheme introduced in 2000 generated an important structural change in the economy. In this economy, oil production and exports and remittances generate a supply of foreign exchange that helps to maintain a level of domestic liquidity necessary for the macroeconomic balance under the dollarization scheme.

After assuming the office in January 2007, the President Correa Administration introduced several social and economic changes, including a New Constitution (2008) and changes in several major economic and social laws. These reforms were aimed at strengthening the state's role in the economy with the goal of advancing the social and inclusive economic development . The economic and social results of the reforms have been important and highligthed.[1] Shortly after assuming and at the commencement of the ambitious reforms, the economy was affected by the severe international crisis of 2007.

The 2007 international crisis generated dramatic changes in the main economic variables that could exogenously affect a small and dollarized economy. Indeed, the international inflation peaked as oil prices and remittances dropped. During 2007, international inflation experienced a significant acceleration. In developed countries, headline inflation and coreinflation almost doubled in less than one year (between 2006 and 2007), 2.5% to 4.1% in the US, 1.9 % to 3.1% in Europe. The most significant changes were observed in developing economies.[2] .Ecuador, has been no exception to the rule, especially facing the inability to correct the inflationary effects through the use of monetary and exchange rate policies. The domestic inflation rate rose from 3.3% in 2007 to 8.83% in 2008. In this context the government applied both price and income policies, as well as foreign trade policies to reduce the inflationary impact. In addition, oil prices fell by nearly 80% in mid-2008, only recovering in 2009. In the case of remittances received, the crisis in the US and Europe, led to a reduction of around 11% between 2007-2009.

As emphasized by Weisbrot et.al. (2013), the combined effect of an increased commodity inflation, falling oil prices together with the reduction of remittances received meant for Ecuador a similar or greater shock than the one suffered by US. during the financial crisis However, the economy registered only a mild recession and seven quarters were needed to regain the pre-crisis GDP levels. The combination of price, income and commercial policies in conjuction with fiscal impulses and financial policy measures [Weisbrot et.al. (2013)], were essential to restore growth, reduce inflation and continuing social improvement in the economy.

This document developeds a Structural Economic Model (SEM) describing in a *New Keynesian* environment the main macroeconomic dynamic features of the Ecuadorian economy. As a key feature, the energy sector (crude oil production) plays an important and independent role in the model. The proposed SEM includes the non-oil value added gap as one of the main endogeneours variables. Usually, the GDP (total value added) gap is included as endogenous variable in these type of models. However, we consider the non-oil value added gap and oil production separatelly in order to analyze

[1] Nehring, R. (2012)

[2] In general, the increased in inflation rates at developing countries were below those levels that characterized the 80 or 90s decades.

the relationship between these two indepentent components of the total GDP gap.[3] The model also considers the role of remittances, the fiscal surplus (or deficit) and the terms of trade as relevant to explain the evolution of the main macroeconomic variables. The model was designed and estimated in the context of the recent international financial crisis.of 2007-2008 In that context, the model is used to understand the basic structural relationships and economic features as well as the main risks and transmission mechanisms of this small and dollarized economy. It may also be useful in medium run forecasting.

It should be noted that the core model arises from a *Real Business Cycle* tradition and may have some difficulties in considering structural changes. As mentioned before, the Ecuadorian economy has had a significant structural change since the implementation of dollarization in 2000. However, the use of prior information and exogenously introduced shocks may help to overcome such shortcut by allowing to include expert judgment and structural features.[Canova (2005)] Indeed, the model is solved by using Bayesian methods that allow to use a smaller amount of statistical information by combining it with relevant prior information (including expert judgment)[4].This methodology allows us to use quarterly information from 2001 to 2010.

The structure of the paper includes four sections. The second section introduces the main structure of the economic model with the explanation for each of its equations. The third section analyzes the data and the model estimation. The final section analyzes the main results.

2 Main characteristics of the Model

2.1 The Structural Models

The model belongs to the literature of structural *New Keynesian* models. Structural models may allow understanding the relative importance of the diverse transmission channels of economic policy [Cho, S. y Moreno, A. (2003)]. In fact, central banks make extensive use of macroeconomic models both to analyze the current economic situation and to forecast the evolution of the main economic variables in short and medium run [Elosegui et.al (2008)]. These models emerge from the literature RBC models with the addition of nominal rigidities, as mentioned in Galí and Monacelli (2002). They can be founded in micro fundamentals or not, as it is the case of structural models as the one developed here. Indeed, the model has been adapted to capture the main transmission mechanisms of the Ecuadorian economy. The model allows to analyze some of the main risks affecting the macroeconomic performance of this dollarized economy.

The SEM consists of a dynamic system of equations which includes an equation that describes the dynamics of inflation or "Phillips curve", an equation for the non oil value added gap, or "IS curve", and an equation for the uncovered interest rate parity or "UIP curve". The main endogenous variables are the inflation rate, non oil value added gap, and the real interest rate.The endogenous variables and the corresponding equation are listed in the following table. As usual in this literature, following business cycle analysis the model variables are expressed as deviations from a long run value.[5]

[3] In a close, but not similar venue, Agnani, B. and Iza Padilla, A. (2011) consider a growth accounting model for Venezuela, showing the importance of the *non oil value added* for the long run economic growth rate in Venezuela.

[4] "Bayesian techniques are preferable to standard likelihood methods or to indirect inference (impulse response matching) exercises, because the model we consider is clearly false and possibly misspecified. We show that the method delivers reasonable posterior distributions for the structural parameters when priors are broadly non-informative and the policy reaction function schrewdly chosen." Canova, F. (2005)

[5] A calibrated *non-stochastic steady state*

Endogenous Variable	**Equation**
Inflation rate in domestic prices	*Phillips Equation*
Non oil value added Gap	*IS Equation*
Nominal Interest Rate	*UIP Equation*

The model also introduces some variables that are particulary relevants for the economy under analysis. Indeed, the small structural model, amended for the Ecuadorian case, is a system of stochastic difference equations. As a log linearized model around a long run equilibrium can be expressed as follows:

$$AE_t\widehat{x}(t+1) = B\widehat{x}(t) \tag{1}$$

with $\widehat{x}(t) = (\widehat{x}_1(t), \widehat{x}_2(t))'$

These type of models can arise from a completely microfounded model, as in a *LDRE (linear dynamic rational expectation models)*. The formal equation system includes (i) optimality conditions (or first-order conditions of the model, such as the intertemporal utility maximization for the representative agent and / or profit maximization firms, etc.); (ii) resource constraints and market equilibriums; (iii) intertemporal equations for the exogenous variables.

In the general structure of LDRE solution models, four types of variables are usually included. First, the predetermined or backward looking variables that generally correspond to the endogenous variables such as capital stock, foreign assets or those exogenous shock such as productivity shocks $x_1(t)$. Non predetermined or forward looking variables (or jump variables). The latter usually correspond to policy variables such as consumption or in our case, the *non-oil value added gap*, $x_2(t)$. Innovations on the predetermined variables, $\varepsilon(t)$, and the additional flow variables, $x_3(t)$.

The general specification of the model can be written as:

$$A\widehat{x}(t+1) = B\widehat{x}(t) + \varepsilon(t+1) \tag{2}$$

It can be generalized as,

$$A\begin{pmatrix}\widehat{x}_1(t+1)\\ \widehat{x}_2(t+1)\end{pmatrix} = B\begin{pmatrix}\widehat{x}_1(t)\\ \widehat{x}_2(t)\end{pmatrix} + \begin{pmatrix}\varepsilon(t+1)\\ 0\end{pmatrix} \tag{3}$$

An the additional equation given by,

$$\widehat{x}_3(t) = C\widehat{x}(t+1) + D\widehat{x}(t) \tag{4}$$

Taking into account that the close solution for these type of models is almost impossible, the system has to be solve by using numerical approximations.

Based on a generalization of the Blanchard y Kahn (1980) methology, a numerical solution method was developed by Klein (2000) making use of the Schur matrix decomposition. The methodology begin by solving the system of stocastic differencial equations using a Schur decomposition of the A and B matrices as follows: $A = QSZ^H$ and $B = QTZ^H$. Where Z^H is the traspose of the conjugate of Z. Also, Q and Z are singular matrices, whereas S and T are triangular matrices. The eigenvalues of A and B are equal to the elements of the diagonal of T divided by the element of the diagonal of S.

In such diagonal, the stable eigenvalues are lower than one and the unstable eigenvalues are larger than one in absolute value. The decomposition is reordered and a variable change is performed: $\widehat{y} = Z^H\widehat{x}$. Then the system is multiplied by Q^H, obtaining,

$$SE_tZ^H\widehat{x}(t+1) = TZ^H\widehat{x}(t) \tag{5}$$

Using previous transformation, rearranging and grouping the matrices, we obtain:

$$\begin{pmatrix}\widehat{x}_1(t)\\ \widehat{x}_2(t)\end{pmatrix} = \begin{pmatrix} Z_{x1y_s} & Z_{x1y_u} \\ Z_{x2y_s} & Z_{x2y_u}\end{pmatrix}\begin{pmatrix}\widehat{y}^s(t)\\ \widehat{y}^u(t)\end{pmatrix}\begin{pmatrix}Z_{x1y_s}\\ Z_{x2y_s}\end{pmatrix}\widehat{y}^s(t) \tag{6}$$

given that $\widehat{y}^u(t) = 0$.

As long as $Z_{x_1y_s}$ is invertible, we can find $\widehat{x}_1(t)$. The invertibility assumption holds as long as the following Blanchard and Kahn condition holds: the number of predetermined variables (rows of $Z_{x_1y_s}$) should be equal to the number of stable roots (eigenvalues smaller than one) of the columns of $Z_{x_1y_s}$. Therefore, the solutions as function of the original variables will be given by:

$$\widehat{x}_1(t+1) = Z_{x_1y_s}\widehat{y}^s(t+1) = Z_{x_1y_s}S^{-1}_{x_1x_1}T_{x_1x_1}Z^{-1}_{x_1y_s}\widehat{x}_1(t) + \varepsilon_1(t+1) \tag{7}$$

Whereas,

$$\widehat{x}_2(t) = Z_{x2y_s}Z^{-1}_{x_1y_s}\widehat{x}_1(t) \tag{8}$$

As mentioned before, these type of models can be solve by using numerical approaches. An interesting tool is *Dynare*,[6] a free software platform that helps *MATLAB* to solve the model also allowing bayesian estimation.

2.2 The Equadorian Structural Model

In this section, the main equations of the proposed structural model are developed with detail. As mentioned before, the model includes the usual equations in this type of models. Relevant and characteristics variables of the Ecuadorian economy are added. In fact, the model emphasizes the role of the oil sector, terms of trade and remittances and also considers the dollarization of the economy. As usual in this type of models variables are measured as deviations from its long run trend. It should be noted that this feature may be subjet to criticism in the context of an economy subject to such important structural changes. However, some implications arising from this assumption can be managed by using priors and shocks to incorporate expert judgement and other structural features in the model.

2.2.1 The IS equation

The demand for goods in this structural model is incorporated through an IS curve. As usual in this literature, the IS curve can be derived from the Euler equation in a micro foundated model and this is reflected in the fact that the equation includes both the expected and the past value of the endogenous variable. In this case, we only consider the *non oil value added gap* as the modeled variable y_t.

$$y_t = \beta_1 y_{t+1} + \beta_2 y_{t-1} - \beta_3 r_{t-1} + \beta_4 sf^{NP}_t + \beta_5 y^P_t + \beta_6 tot_t + \beta_7 re_t + \epsilon y_t; \tag{9}$$

Therefore, the IS equation includes as the determinants of *non oil value added gap* (y_t) evolution variables having independent effect on the aggregate demand. The real interest rate, r_t is included

[6] For more information, visit http://www.dynare.org/. The codes used here are available upon request.

with one quarter lag. The model incorporates the *non oil fiscal surplus* (as a percentage of the GDP), sf_t^{NP}, as a measure of the *fiscal stance* in the economy. Also, re corresponds to the remittances recieved from the rest of the world, a very relevant variable for the domestic economy and an proxy for the domestic liquidity level in the economy. The model also incorporates the direct effect arising from the oil production, through the *oil value added gap, y_t^P*. The lattest variable captures the independent effect generated by the fluctuation in the *oil value added gap*. Other important variable is the terms of trade, tot_t. This variable captures the wealth effect due to changes in the *terms of trade* of the economy.

The interaction between non *oil value added gap* and oil production has marked the development of the Ecuadorian economy since the discovery of this mineral. For this reason, it is considered important to distinguish between the behavior of these two measures of economic activity. Actually, Figure 1 below shows the differente evolution of these two variables (Y and YP), together with the rest of the variables included in the model. It can be noted that the *oil value added gap* (YP) is considerably volatile and, as we will show, its variability is relevant for the evolution of the non-*oil value added gap (Y)*. During the period under consideration, the government pursued legal and tax reforms aimed at obtaining a greater share of oil revenues. Besides the fiscal impact, the investment and production in this sector is relevant to the sustained growth of the non-*oil value added gap*.

2.2.2 The Phillips Curve Equation

As it is usuall in this type of small structural models, the inflation rate dynamic is analyzed through a Phillips Curve. This equation models inflation dynamic with adaptative expectations and it is also extended with forward looking expectations. In a microfounded model the expectations component can be introduced, for instance, by assuming that a fraction of firms must leave fixed the price in each period, while another random fraction may select the price level that maximizes profits. This modelling procedure, due to Calvo generates a Phillips curve as the one included here, and may apply in non-competitive, concentrated or oligopoly markets, an assumption suitable for this economy. Also, the international evidence indicates that the postulated setting is commonly used in inflation rate econometric estimation,

$$\pi_t = \alpha_1 \pi_{t+1} + (1-\alpha_1)\pi_{t-1} + \alpha_3 y_{t-1} + \alpha_4 \pi_t^* + \alpha_5 tot_t + \alpha_6 y_t^P + \epsilon pi_t; \tag{10}$$

In this equation π_t is the inflation gap (as a deviation from long run inflation), y_t is the non oil based output gap, π_t^* measures foreign inflation (the Real Exchange Rate in the dollarized economy),. We also include the *terms of trade (tot_t)* while y_t^P corresponds to the *oil value added gap*. Finally, ϵpi is the random shock.

2.2.3 Interest Rate Parity

The next equation in the system corresponds to the interest rate parity. In the case of a small open and dollarized economy, the equation for the interest rate adjustment relates the domestic interest rate and the international one through a risk premium arising not only from risk consideration but also from other possible rigidities as capital controls and taxes and the like.

$$i_t = i_t^* + \varphi_t \tag{11}$$

The model postulates that in a dollarized economy the differences between the i_t domestic rate (nominal short-term interest rate), and the international interest rate (i_t^*) short-term (US rate) is explained by the risk premium that can be strictly exogenous, or be tied to the level of indebtedness [See Escudé, G. (2014)]. In this case, φ_t is the risk premium.

2.2.4 Fiscal Sector Equation

The system includes several equations modelling the fiscal sector. One is related to the total fiscal result and indebtness (government financial constraint). In a dollarized context this equation does not include the possibility of issuing money to finance the fiscal deficit.

$$B_t^g + SF_t = B_{t-1}^g(1 + i_{t-1}) \tag{12}$$

In addition, the model introduces and explicit equation for the *non oil related fiscal surplus* and another for the *oil related fiscal surplus*.

$$sf_t^{NP} = \rho_1 sf_{t-1}^{NP} + \rho_2 y_t \tag{13}$$

$$sf_t^P = \phi_1 sf_{t-1}^{NP} + \phi_2(p_t^P - p^P) + \phi_3 y_t^P + (1 - \phi_1) sf^{NP} \tag{14}$$

The *non oil fiscal surplus* dynamics is determined by its persistence (captured in the ρ_1 coefficient) and a procyclicality ($\rho_2 y_t$) components. The *oil based fiscal surplus* is explained by its persistance (ϕ_1), the oil price (p_t^P) and the *oil value added gap* (y_t^P).

2.2.5 The Oil Value Added and Price Equation

In the model the oil production and its price are assumed to be determined by the following equations:

$$y_t^P = \theta_1 y_{t-1}^P + \varepsilon_t^{yP} \tag{15}$$

$$p_t^P = \theta_2 p_{t-1}^P + (1 - \theta_2) p^P + \varepsilon_t^{\pi P} \tag{16}$$

2.2.6 Remittances and Terms of Trade Equations

For the case of these two variables the model also assume them to be exogenous. Therefore, an autoregressive movement law is assumed for both gaps.

$$tot_t = \rho_{13} tot_{t-1} + \varepsilon_t^{tot} \tag{17}$$

$$re_t = \rho_{14} re_{t-1} + \varepsilon_t^{re} \tag{18}$$

2.3 The Equation System

All variables in the system can be compressed in the following vector,

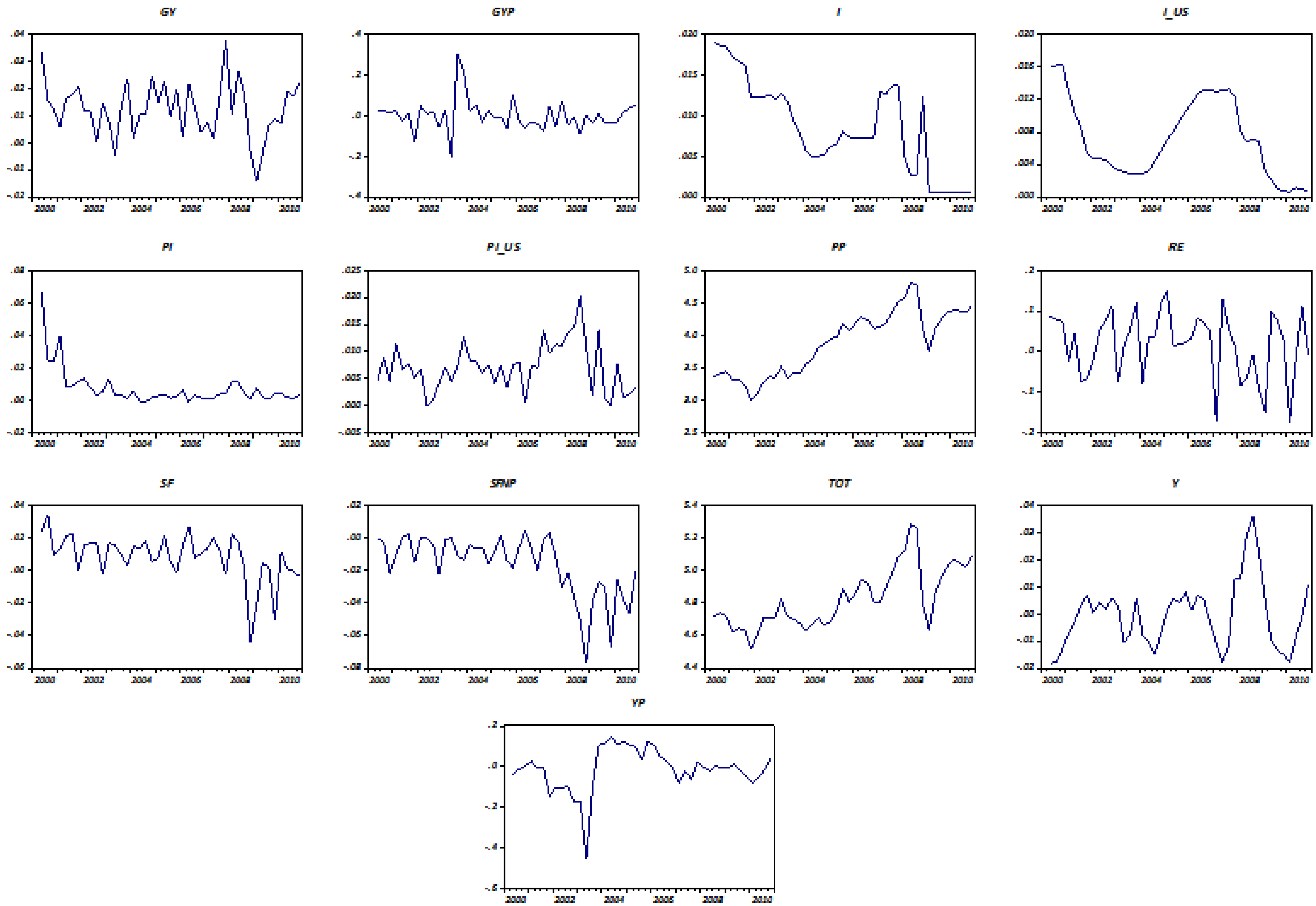
$$s_t = \{y_t, i_t, \pi_t, tot_t, re_t, y_t^P, p_t, sf_t^P, sf_t^{NP}\}, \tag{19}$$

the system of equations is then given by,

$$E_t[f(s_{t+1}, s_t, s_{t-1})] = 0 \tag{20}$$

This is a non lineal difference and estocastic equation system. A numerical solution for this type of model can be approximated by a lineal solution to the steady state deterministic equilibrium.

Figure 1: Economic Variables



3 Model Estimation

The model is estimated by using a Bayesian Methodology. This methodology allows the parameter estimation even with a short sample data. Indeed, it also allows to include *model maker* judgment in the estimation process. It could also be noted that Bayesian Methodology allows to deal with the existence of non obvervable variables in the model by using a Kalman filter.

The bayesian methodology uses the Bayes Theorem,

$$P(\theta/Y_T) = \frac{p(Y_T/\theta)\, p(\theta)}{p(Y_T)} \tag{21}$$

where, Y_T represent the obvervable variables up to the time T and θ is the parameter's vector.

Therefore,

$$P(\theta/Y_T) \propto p(Y_T/\theta)\, p(\theta) = \mathcal{L}(\theta; Y_T)\, p(\theta), \tag{22}$$

the mode of the posterior distribution can be calculated by solving,

$$\max_{\theta} \ln K(\theta/Y_T) = \ln \mathcal{L}(\theta/Y_T) + \ln p(\theta) \tag{23}$$

In this case is possible to use the *Kalman Filter* to evaluate the maximum likelihood function. In addition, subsequent distributions are computed using the *Metropolis-Hastings* algorithm (MCMC). The observables variables are the following,

$$\pi, y, i, sf, sf^{NP}, gy^{P}, gy, p^{P}, \pi^{*}, i^{*}, tot, re \tag{24}$$

For the estimation, we use quarterly information for the period 2000:1-2010:1. The series are *non-oil value added gap*, *oil value added gap*, *consumer price inflation rate*, *nominal interest rate (3 month)*, *fiscal surplus over GDP*, *international inflation rate (US inflation)*, *3 month TB interest rate (international interest rate benchmark)*. As mentioned before, the Bayesian estimation procedure is performed by using Dynare platform in MATLAB.

3.1 Estimation Results

3.2 Main Parameters

The following table shows the estimated parameters, the prior value and the confidence interval. It should be noted that for each parameter it is postulated not only prior value, which can be validated or not according to information obtained from the sample, but also a probability distribution. The latter provides the random support from which the medium value of the parameter is chosen and it is based on the relevant literature.

Table 1: *Estimated parameters*

parameters	prior mean	post. mean	conf. interval		prior	pstdev
α_1	0.5	0.7459	0.608	0.9101	beta	0.2
α_3	0.2	0.0827	0.0086	0.1597	beta	0.1
α_4	0.2	0.2202	0.0741	0.3574	beta	0.1
α_5	0.2	0.0434	0.0166	0.0675	beta	0.1
α_6	0.2	0.015	0.0032	0.0259	beta	0.1
β_1	0.5	0.1515	0.0115	0.2786	beta	0.2
β_2	0.5	0.4655	0.2748	0.6453	beta	0.2
β_3	0.3	0.2404	0.0079	0.4168	norm	0.2
β_4	0.5	0.2483	0.1005	0.3946	beta	0.2
β_5	0.5	0.0113	0.0021	0.02	beta	0.2
β_6	0.5	0.0253	0.014	0.0391	beta	0.2
β_7	0.5	0.0323	0.0095	0.058	beta	0.2
ρ_1	0.5	0.7087	0.5062	0.9183	beta	0.2
ρ_2	0.5	0.9442	0.9087	0.9777	beta	0.2
ρ_3	0.5	0.5771	0.4094	0.7632	beta	0.2
ρ_5	0.5	0.9053	0.8389	0.9834	beta	0.2
ρ_6	0.5	0.5574	0.3602	0.7701	beta	0.2
ρ_7	0.5	0.5539	0.3174	0.7599	beta	0.2
ρ_8	0.5	0.1898	0.024	0.3325	beta	0.2
ρ_9	0.5	0.8211	0.7249	0.94	beta	0.2
ρ_{13}	0.5	0.6096	0.4636	0.7695	beta	0.2
ρ_{14}	0.5	0.2561	0.0747	0.4175	beta	0.2
λ	0.5	0.2519	0.0336	0.4811	beta	0.2
τ	0.2	0.0158	0.0037	0.0255	beta	0.1
θ	0.2	0.0026	0.001	0.004	beta	0.1
ι	0.5	0.0517	0.0151	0.0817	beta	0.2

3.3 Random shocks value

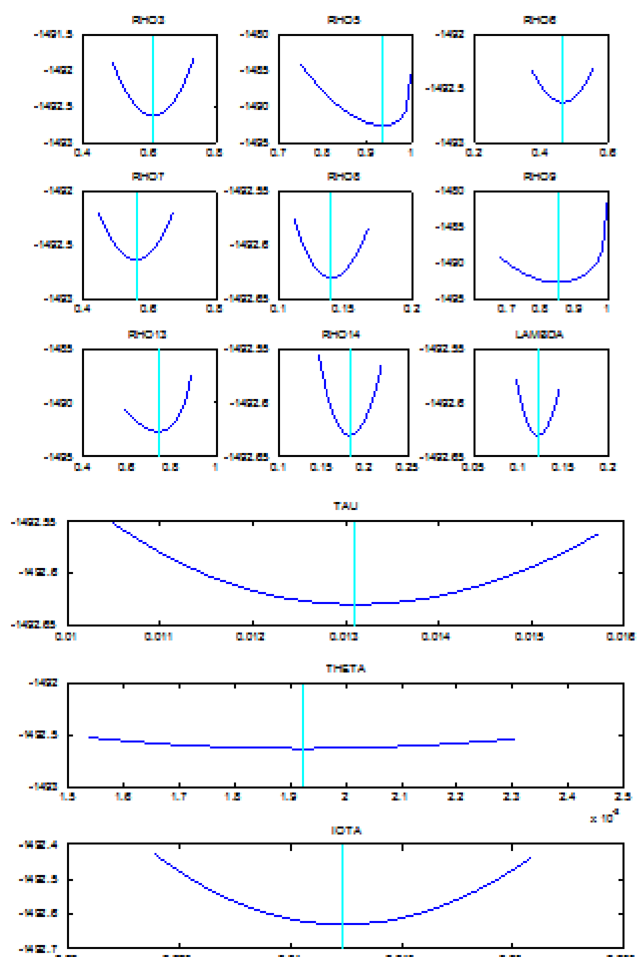
Meanwhile, the table below shows the prior and posterior mean of the standard deviation of shocks in each of the equations. Overall, they take relatively low values. It should also be noted that the deviations of the shocks corresponding both to the inflation and non *oil value added gap* show levels according to the methodology's standart.

Table 2: *Standard deviation of shocks*

	prior mean	post. mean	conf. interval		prior	pstdev
ERP	0.01	0.003	0.0024	0.0035	invg	Inf
EPI_US	0.01	0.0043	0.0035	0.0049	invg	Inf
EI_US	0.01	0.002	0.0017	0.0024	invg	Inf
EPIP	0.01	0.1847	0.1473	0.2145	invg	Inf
EYP	0.01	0.0858	0.0675	0.0998	invg	Inf
EGYBAR	0.01	0.0052	0.0043	0.0063	invg	Inf
EGYBARP	0.01	0.03	0.0243	0.0352	invg	Inf
ESFP	0.01	0.0078	0.0063	0.0092	invg	Inf
ESFNP	0.01	0.0152	0.0119	0.0185	invg	Inf
ETOT	0.01	0.1152	0.0883	0.14	invg	Inf
ERE	0.01	0.0758	0.0633	0.0886	invg	Inf
EPI	0.01	0.0085	0.0056	0.0111	invg	Inf
EY	0.01	0.0075	0.0056	0.0096	invg	Inf

Figure 2 shows the results of the estimation of the above mentioned shocks for the support of the estimation.

Figure 2:*Bayesian estimation*



3.4 The estimated parameters of the model

3.4.1 Preliminary Analysis

The equations for the endogenous variables of the model using the modes estimated for the $2001-2010$ period by Bayesian methodology are showed in the system below. In this case it only includes the two main variables.

$$y_t = 0.1908y_{t+1} + 0.6294y_{t-1} - 0.2526r_{t-1} - 0.4525sf_t^{NP} + 0.0157y_t^P + 0.0309tot_t + 0.0171re_t; \quad (25)$$

$$\pi_t = 0.8030\pi_{t+1} + 0.1970\pi_{t-1} + 0.0622y_{t-1} + 0.2112\pi_t^* + 0.0319tot_t + 0.0076y_t^P; \quad (26)$$

The analysis of the above equations only show the direct effect arising from a possible change in any of them. However, the real value of the structural model lies in the fact that all the structural equations and variables are related. The analysis of the parameters only indicate the sign and the order of magnitude but not final effect on the variable. The latter, must be evaluated using the impulse response (IR) analysis developed below.

However, the parameter values in the previous equations indicate an important role for the *real interest rate* and the *pseudo fiscal impulse* (*non oil based fiscal surplus*) on the *non-oil value added gap*. The *oil value added gap* parameter shows a positive and relevant (in magnitud) impact on the *non-oil value added gap*. However, the order of magnitud seems to be smaller than the one corresponding to, for example, the *terms of trade* and *remittances*. Also, it is interesting to note, that the *domestic inflation* shows a low persistence level with a small lagged parameter.

The *non-oil value added gap* captures the potential demand pressures. It should be notice that the *pseudo fiscal impulse* shows a positive and significant impact. That impact is lower than the one captured by the *foreign inflation*. Indeed, the estimated parameter for *foreign inflation* may be reflecting the importance of this variable for the *domestic inflation*. Indeed, the impact arising from international inflation seems to be captured both, by *US inflation (foreign inflation)* and by the change in the *terms of trade*. Finally, the *oil based value added gap* seems to have no effect on *domestic inflation*. Any possible effect on this side, seems to be operating only through its effect on the *non-oil value added gap*.

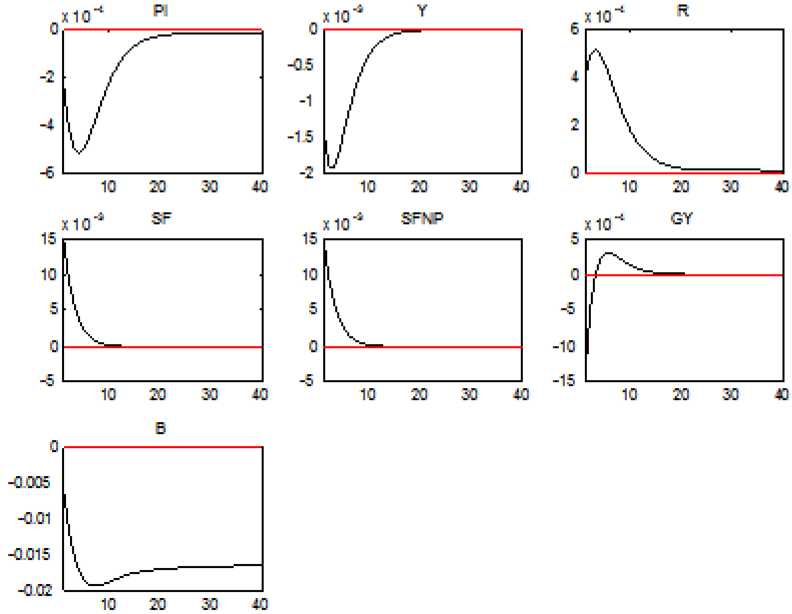
3.5 Impulse Response Analysis

The impulse response (IR) analysis is probably the most useful tool to analyze model performance.The IR analysis, considers the system response to a shock in any of the equations. In that sense, it indicates the systemic impact together with the convergence once the system has been disturbed from its initial equilibrium. It shows the interaction between the various endogenous variables in the model and the effects arising from shocks in the exogenous variables. Indeed, it can be used to analyze the presence of unwanted deviations from the normal (or usual) expected behavior of the model variables.

These features make IR analysis and interesting tool to analyze the main policy options to different possible scenarios. The information analyzed from the impact IR can be easely summarized. This fact makes the model analysis simple and may be use to understand different economic policy situations in a structural system environment. In short, the IR analysis add some more valuable information to the direct analysis of the estimated parameters. Impulse response analysis allows a better understanding of the relationship and interactions between model variables.

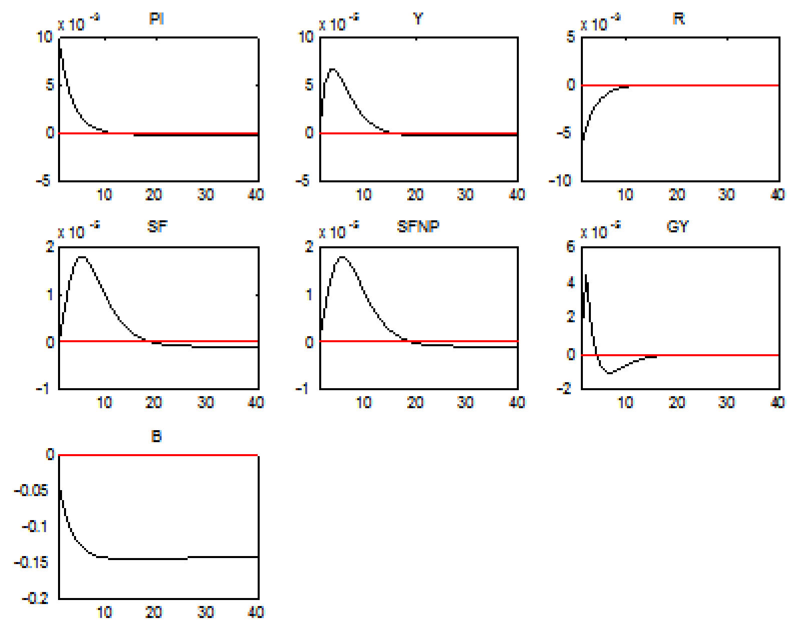
For instance, the next Figure 3 shows the effect of a positive disturbance (an expenditure reduction) of a *non-oil fiscal surplus* exogenous shock. The shock has an effect (for a short- term) on the *non oil value added* growth rate (GY). Also, there is an effect on *inflation rate* (PI) but it is revealed only a few quarters later and does not seem to be persistent. This result indicates a positive effect of the *pseudo fiscal impulse (or public investment)*, given by a decrease in the *non-oil fiscal surplus*, over the GDP with only a minor impact on inflation rate.

Figure 3: *non-oil fiscal surplus shock*



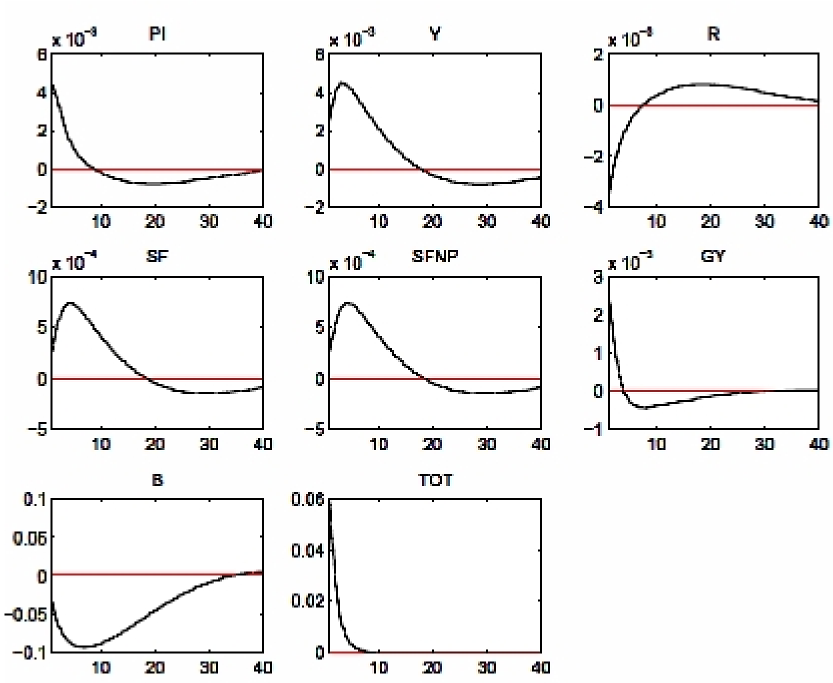
The impact of the *inflation rate* shock on the other relevant variables is depicted on Figure 4.

Figure 4: *inflation rate shock*



Finally, Figure 5 shows the effect of a shock in *Terms of Trade* (rigth hand side) over the other relevant variables. It should be noted a positive effect on *inflation rate*. Indeed, the order of magnitud for the *Terms of Trade* shock is 10 times larger than the one corresponding to the *non-oil* *fiscal surplus* shock. This shows the relevance of foreign shocks on domestic inflation, an expected result in a dollarized open economy that is also underscored by the variance decomposition analysis.

Figure 5: *TOT shock*



3.6 Variance Decomposition

The endogenous variable *variance decomposition* is an interesting tool to understand the transmission mechanisms of shocks affecting the modelled economy. As can be seen in the Table 2 below, the variance decomposition analysis shows that the variance of *inflation rate* is mainly explained by shocks in the *terms of trade* and, to a lesser extent by shocks to the *oil and non-oil value added gap*. The impact of the *pseudo fiscal stimulus* over *inflation rate* variance is low. The same is true for *remittances*, that have an effect greater than the latter.

Regarding the *non-oil value added gap*, the main determinant of its variance are the shocks to the *pseudo fiscal stimulus,* with an explanatory power around 30%. Meanwhile, shocks to the *terms of trade* and *remittances* along with shocks in *oil value adde gap* account for about 50% of the variance.

Table 2: Variance Decomposition

	ERP	EPI_US	EI_US	EPIP	EYP	EGYBAR	EGYBARP	ESFP	ESFNP	ETOT	ERE	EPI	EY
PI	4.51	3.74	5.84	2	7.38	1.72	0	0.65	2.92	14.61	0.48	54.75	1.4
Y	3.67	0.49	3.58	0.91	10.63	0.78	0	0.3	32.21	11.89	4.59	1.16	29.8
I	48.51	0	51.49	0	0	0	0	0	0	0	0	0	0
R	20.42	4.32	18.99	4.17	12.73	3.59	0	1.36	5.25	15.96	0.9	9.87	2.43
SF	0.31	0.04	0.3	11.69	7.14	0.07	0	43.77	33.45	0.88	0.36	0.09	1.91
SFNP	0.8	0.1	0.79	0.21	2.12	0.18	0	0.07	87.28	2.3	0.93	0.24	4.98
SFP	0	0	0	21.69	5.44	0	0	72.87	0	0	0	0	0
GY	0.46	0.18	0.37	0.04	3.85	31.94	0	0.01	16.42	5.47	1.61	0.34	39.3
GYP	0	0	0	0	96.39	0	3.61	0	0	0	0	0	0
RP	100	0	0	0	0	0	0	0	0	0	0	0	0
PIP	0	0	0	100	0	0	0	0	0	0	0	0	0
PP	0	0	0	100	0	0	0	0	0	0	0	0	0
YP	0	0	0	0	100	0	0	0	0	0	0	0	0
PI_US	0	100	0	0	0	0	0	0	0	0	0	0	0
I_US	0	0	100	0	0	0	0	0	0	0	0	0	0
B	20.84	2.11	26.28	11.53	8.84	4.27	0	0.91	1.88	9.75	0.91	10.14	2.54
GYBAR	0	0	0	0	0	100	0	0	0	0	0	0	0
GYBARP	0	0	0	0	0	0	100	0	0	0	0	0	0
TOT	0	0	0	0	0	0	0	0	0	100	0	0	0
RE	0	0	0	0	0	0	0	0	0	0	100	0	0

3.7 Projection Programming

The model can be use to perform the projetion of the endogenous variables. In that case, the model makes use of (i) the parameters arising from the estimation, (ii) the initial conditions coming from the associated database and (iii) the calculation of the stochastic projection path done by the Dynare program. The programed model is basically simple involving modifying the code by directly incorporating the estimated parameters. Therefore, the new code performs calculations with the specified projection parameters. The code would contain the initial point values for the endogenous variables from which the model projects with the exogenously added random shocks. Needless to say, the inclusion of shocks to the programming code helps both, to incorporate information to the model (as an expert judgment), and to allow conducting the desired simulations. The command for Dynare projection is *forecast*, which computes a stochastic simulation model from a certain *state* or *initial value* for the endogenous variables. It also sets the number of periods to project and the level of confidence bands This feature will be included in future extensions of the model.

4 Conclusion

The paper presents a structural macroeconomic model with *New Keynesian* features for the Ecuadorian economy. It allows to identify the main macroeconomic risks and transmission channels of this dollarized economy. The main endogenous variables in the model are the *non-oil value added gap* and the *domestic inflation*. The *oil value added gap*, the *non oil fiscal surplus*, the *international inflation rate*, the *terms of trade* and the *international remittances* are among the main exogenous variables. The model is solved and estimated by using a Bayesian methodology.

The results show that the *non-oil value added gap* of Ecuador is mainly determined by the *pseudo fiscal stimulus* and the *real interest rate* .The *oil value added gap* has a positive, significant and independent impact on the *non-oil value added gap*. However, the order of magnitude is lower than both the *terms of trade* and *remittances* effects .

It should be noted that *domestic inflation rate* level was an issue in this dollarized economy during 2008. The rise in commodities prices in 2008 led to an increase in international inflation rate (measured with the *US inflation rate* in the model). The increase in international inflation rates generated significant impact on the *domestic inflation rate*. From the analysis of *domestic inflation rate* determinants, the model shows a low persistance level (small lag inflation rate impact on current inflation rate) of the phenomenon. This finding is consistent with the reversal in the inflationary phenomenon observed after the decline of international inflation. Future inflation expectations also emerges as an important determinant of *domestic inflation rate*. However, the most direct effect comes from *foreign inflation*. The *non-oil value added gap* shows a positive sign, but the order of magnitude is lower than the *international inflation* effect. *Oil value added gap* seems to have no economic significant effect on *domestic inflation rate*. The main effect of this variable over *domestic inflation rate* is indirect, through its effect on the *non-oil value added gap*. Finally, *fiscal policy* does not show a significant role in explaining *domestic inflation rate*. However, it shows an important role as a determinant of the *oil value added gap*.

The variance decomposition analysis shows the importance of the *terms of trade* shocks and *oil and non-oil value added gap* on *inflation rate variance*. The *pseudo fiscal stimulus* has a small explanatory power with respect to the *inflation* rate variance. But has an important effect over the *non-oil value added gap* variance. Also, the shocks to the *terms of trade* and *remittances* along with shocks in *oil value adde gap* account for about 50% of the *non-oil value added gap* variance.

It should be noted, the relevance of *public investment* (measured by *non oil based fiscal surplus*) which has a major effect on the *non-oil value added gap* and a low effect on *domestic inflation*. Also, it is significant the role played by the resources flowing from the *oil sector* to the *non-oil economy*. The impact of *public investment* on the *non-oil value added gap* is an argument supporting its use as a countercyclical economic policy instrument and helps to support the use done by the government to push social development investment [Weisbrot, M. (2013)]. The next step would be to advance in a microfounded model with an explicit and independent oil producer sector in a dollarized economy.

References

[1] Agnani, B. and Iza Padilla, A., 2011. "Growth in an oil abundant economy: The case of Venezuela," *Journal of Applied Economics*, 2011

[2] Blanchard, Olivier Jean & Kahn, Charles M, 1980. "The Solution of Linear Difference Models under Rational Expectations," Econometrica, Econometric Society, vol. 48(5), pages 1305-11, July.

[3] Canova, F. (2005) Monetary Policy and the evolution of US economy. Working Paper Universitat Pompeu Fabra, CREI and CEPR November 2005

[4] Cho, Seonghoon & Moreno, Antonio, 2006. "A Small-Sample Study of the New-Keynesian Macro Model," Journal of Money, Credit and Banking, Blackwell Publishing, vol. 38(6), pages 1461-1481, September.

[5] Elosegui, P. & Guillermo Escudé & Lorena Garegnani & Juan Martín Sotes Paladino (ed.), 2007. "A Small Economic Model for Argentina," BCRA Paper Series, Central Bank of Argentina, Economic Research Department, number 03, December.

[6] Guillermo Escudé, 2009. "ARGEMmy: An Intermediate DSGE Model Calibrated/Estimated for Argentina: Two Policy Rules are Often Better than One," BCRA Working Paper Series 200942, Central Bank of Argentina, Economic Research Department.

[7] Jordi Gali & Tommaso Monacelli, 1999. "Optimal Monetary Policy and Exchange Rate Volatility in a Small Open Economy," Boston College Working Papers in Economics 438, Boston College Department of Economics, revised 15 Nov 1999.

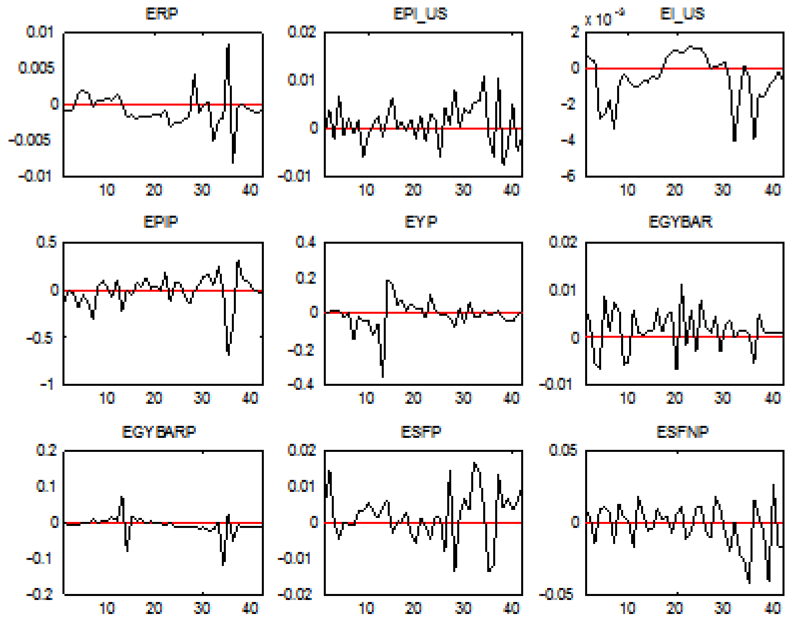
[8] Klein, Paul, 2000. "Using the generalized Schur form to solve a multivariate linear rational expectations model," Journal of Economic Dynamics and Control, Elsevier, vol. 24(10), pages 1405-1423, September.

[9] Nehrig, R., 2012. "Social Protection in Ecuador:A New Vision for Inclusive Growth." The International Policy Centre for Inclusive Growth is jointly supported by the Bureau for Development Policy, United Nations Development Programme and the Government of Brazil. International Policy Research Brief August no. 28

[10] Mark Weisbrot, Jake Johnston and Stephan Lefebvre, 2013. "Ecuador's New Deal: Reforming and Regulating the Financial Sector." Center for Economic and Policy Research. February.

5 Appendix

5.1 Additional estimation results:



Smoothed shocks