

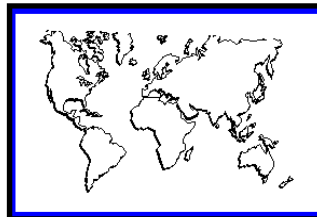
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Fiscal dynamics in a dollarized, oil-exporting country: Ecuador.

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Abstract

This paper examines the relationship between fiscal variables and economic activity in Ecuador. We use a macro-level dataset covering twelve years of full dollarization to explore the link between government spending, oil revenues, non-oil tax revenues and the economic activity index. The cointegrated VAR approach is adopted to identify the permanent and transitory shocks that affect both fiscal and macroeconomic variables. We identify two forces that push the fiscal system out of equilibrium: namely, economic activity and fiscal spending. The tax revenues variable is purely adjusting, consistent with the tax smoothing theory (Barro, 1979), but risking fiscal discipline. In a dollarized country, since there is no possibility of earning the “inflation tax” or printing new money, taxes should not be the adjusting forces, but the pushing ones. Our results suggest that Ecuador should recover control of its monetary policy to enable and promote both economic and tax diversification in order to find a substitute for oil exports, the main source of government revenues.

JEL Classification: C32, E62, H60.

Keywords: Cointegrated VAR, fiscal sustainability, fiscal shocks, debt, Ecuador.

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1. Introduction

Ecuador adopted the U.S. dollar as legal tender, replacing its own currency, the Sucre, in January 2000. One of the arguments used by the country's Central Bank¹ to justify the new exchange rate regime was that dollarization enhances fiscal discipline². Under this kind of fixed exchange rate regime, the government cannot print money to finance its fiscal deficits (i.e., the government's ability to generate seigniorage disappears). Without this possibility, the Ecuadorian government was obliged either to look for alternative revenue sources, such as new taxes or loans (commercial, bilateral and/or multilateral)³ or to reduce its expenditure. But, on the one hand, tax increases entail an immediate political cost, and, on the other, indebtedness is limited by both the intertemporal budget constraint and by external constraints imposed by financial institutions. Hence, by giving up control of its money supply, a full dollarization regime encourages fiscal discipline (enhancing policy credibility) but also constrains the fiscal response in order to stabilize the economy in difficult times.

Nevertheless, since the literature on emerging economies has provided evidence of a lack of responsible indebtedness and credit policies of both governments and financial institutions⁴, on which debt constraint depends, one would expect Ecuador to have a huge debt-to-GDP ratio. However, Figure A.1 in Annex A shows that the country's total debt-to-GDP ratio has fallen since 2000. This trend must be understood in the light of certain significant events in the country: (1) the default on its

¹ Available at <http://www.bce.fin.ec/documentos/PublicacionesNotas/Notas/Dolarizacion/dolarizar.html>

² Others authors state that dollarization discourages fiscal discipline. Tornell and Velasco (1998, 2000) point out that dollarization differs from flexible exchange rate regime not in preventing lax fiscal discipline but in shifting its cost to the future. Under flexible exchange rates the cost of borrowing today will be higher interest rates tomorrow, while under dollarization it entails either higher taxes or expenditure cuts. In addition, the empirical studies of Goldfajn and Olivares (2000), Vuletin (2003) and Duttagupta and Tolosa (2006) do not find evidence of fiscal discipline in countries with fixed exchange rate regimes.

³ The IMF (2002) classifies loans depending on the type of debtor-creditors: (i) bilateral (government-government); (ii) commercial (government-commercial banks) and (iii) multilateral (government-IMF, World Bank).

⁴ See, for example, Edwards (2008, 1988), FDCI (1997) and Aggarwal (1996) who analyze the history and causes of debt crises in Latin American countries and assess theoretical models.

Brady bonds in the summer of 1999, (2) the debt reduction fiscal policy involving debt-buyback operations, and (3) the default on its external debt on December 2008⁵.

Figure A.2 in the same Annex shows the new expansive pattern of fiscal policy imposed by Correa's government⁶. Against this background, this paper applies a cointegrated VAR approach to examine how taxes, as well as other macroeconomic variables, respond to government spending shocks in a dollarized, oil-exporting country such as Ecuador.

Some of the research to date has focused on the analysis of the impact of fiscal policies on macroeconomic variables in order to provide robust stylized facts regarding the effects of fiscal policy shocks. The discrepancies that exist, it is argued, result from the different methodologies adopted to analyse these shocks (see Caldara and Kamps, 2008). However, regardless of the identification approach selected, all studies concur that positive government spending shocks have persistent positive effects on output, inflation and short term interest rates⁷.

The same holds for tax shocks. Studies using either the sign-restrictions approach (Mountford and Uhlig, 2009) or the narrative approach (Romer and Romer, 2010) agree that unanticipated tax increases have strongly negative output effects. However, the results obtained using the structural VAR approach are conflicting: while Blanchard and Perotti's (2002) findings coincide with the studies

⁵ At the peak of a devastating economic crisis, Ecuador was forced to default on its Brady bonds (\$6.6 bn of the total debt) in the summer of 1999. The restructuring process, officially implemented in August 2000, resulted in a reduction of close to 40 per cent in the face value of the tendered bonds. After this, Ecuador focused its fiscal policy on debt reduction. The 2002 Fiscal Responsibility, Stabilization and Transparency Act, created the Stabilization Fund for Social and Productive Investment and Debt Reduction (FEIREP), a special trust fund managed by the Central Bank. The FEIREP funds earmarked 70 per cent for debt-buyback operations; 20 per cent to stabilize oil revenues and for emergency spending, and 10 per cent for education and health spending. The Fund was replaced in 2005 by the Special Account for the Productive and Social Reactivation, Development of Science and Technology and the Fiscal Stabilization (CEREPS). The 70 per cent earmarking to debt reduction was reduced to 35 per cent. The debt-to-GDP ratio fell from 86 per cent by end-2000 to about 34 per cent by end-2006. However, the government's targeted debt reduction policy caused the revalorization of its international bonds, making the debt buyback even more onerous and sparking President Correa's debt repudiation rhetoric. In December 2008 the debt-to-GDP ratio fell to around 23 per cent. The public external debt was at its lowest level for over three decades. Nevertheless, Ecuador decided to default again, emphasizing that it was "unwilling" rather than "unable" to pay".

⁶ Ray and Kozameh (2012) and The World Bank (2005) offer more details about the expansive programs addressed to reduce poverty level or to rise education level.

⁷In the case of government spending, Perotti (2008) reports that both private consumption and real wages significantly and persistently increase in response to a positive spending shock, while employment does not react. Mountford and Uhlig (2009) find that the response of private consumption is close to zero and statistically insignificant, while Ramey (2011) reports a negative response to such a shock. Burnside et al. (2004) provide evidence that the real wage persistently and significantly falls while employment persistently and significantly increases.

mentioned, Perotti (2002) suggests that output – as well as inflation and the short-term interest rate – is unaffected⁸.

Recently, these models have been extended to satisfy the government budget constraint⁹. Since the fiscal variables of different countries react differently to macroeconomic variable shocks, analyses of this kind may shed some light on how best to harmonize fiscal policies in monetary unions or dollarized countries (recall that a dollarization can be defined as a unilateral monetary union). Favero *et al.* (2011) identify the existence of heterogeneities between countries due to different fiscal reaction functions, different degrees of openness, and different debt dynamics. They also highlight the importance of including feedback between fiscal and macroeconomic variables in VAR models, since it conditions the reactions of both variables to fiscal shocks.

However, Bohn (1998) proposes error-correction-type policy reactions as a promising alternative for understanding debt and deficit problems, as standard unit root regressions fail to detect mean reversion in the debt income ratio. He also estimates a positive response of primary surpluses to the debt-to-GDP ratio, suggesting the sustainability of US fiscal policy for the sample period 1916-1995. Other empirical studies include Bohn (2005, 2007) for the US; Collignon (2012) for Europe; Fincke and Greiner (2012) for selected countries in the euro area; Kia (2008) and El Anshasy and Bradley (2012) who undertake the analysis for oil-exporting countries and emphasize the procyclicality of fiscal policy in these countries¹⁰; and Martins (2010), who develops a CVAR to assess the dynamic relationships between foreign aid inflows, public expenditure, revenues and debt in Ethiopia¹¹.

⁸ It should be stressed that all these studies were undertaken using a very similar US sample period. Mountford and Uhlig (2009) and Romer and Romer (2010) simply extend the sample period first studied in Blanchard and Perotti (2002) which ran from 1947:1 to 1997:4.

⁹For instance, Favero and Giavazzi (2007) estimate a fiscal VAR applying two approaches: a structural and a narrative VAR approach. They include debt and the stock-flow identity linking debt and deficits, and report more sizeable effects of fiscal policy on output in the narrative approach than in the standard structural VAR.

¹⁰ El Anshasy and Bradley (2012) find that, in the long run, the higher the oil prices the larger government spending, while in the short run government expenditure rises less than proportionately to the increase of oil revenues.

¹¹Actually, we can make an analogy between oil revenues and aid inflows since both variables are affected by external shocks; the former depends on price volatility, and the latter on donors' goodwill.

As far as we know, few studies have examined Ecuador's fiscal policy. Cueva (2008) and Almeida *et al.* (2006) report that the legal framework for the distribution and earmarking of oil and tax revenues is cumbersome and creates large rigidities in fiscal management. They describe a "rigid budget characterized by inertia" which offers just eight percentage points to counteract unpredictable shocks¹². Other articles examining issues of debt sustainability include Barnhill and Kopits (2003) who, in developing a Value-At-Risk approach, find that the volatility of sovereign spreads and of oil prices constitutes a major source of risk for Ecuador's public sector; and Alvarado *et al.* (2004), who calculate debt threshold sensitivities for different assumptions regarding revenue volatility and expenditure adjustments. They emphasize that uncertainty in government tax revenues and the inflexibility in its non-interest expenditure leave Ecuador vulnerable to fiscal crises in the future. Mejía *et al.* (2006) claim that dollarization has limited the range of fiscal instruments available to governments; they warn of the dangers of dependency on oil revenues, which they define as a source of instability in a balanced budget.

Nevertheless, to our knowledge, no empirical study has yet explored the reaction of tax revenues to government spending shocks in Ecuador by means of a cointegrated VAR approach. This paper attempts to fill this gap and to contribute to this empirical literature by focusing on a country which not only has a dollarized exchange rate regime but is also highly dependent on its oil exports. So, with this goal in mind, the main objectives of this paper are, first, to determine the relationships that exists between fiscal and macroeconomic variables; second, to identify the main pushing and adjusting forces interacting in the long run equilibrium, i.e., permanent and transitory shocks; and third, to discuss the impulse responses of the variables included in the study to the already identified shocks. The remainder of the article is organized as follows. Section II briefly describes the theoretical approach. Section III presents the data and methodology. Section IV explains the empirical results. Finally, section VI summarizes the conclusions.

¹² The composition of public expenditure is as follows: 26 per cent for wages, 10 per cent for current transfers, 8 per cent for transfers to regional governments (*gobiernos seccionales*), 3 per cent for investment projects, 10 per cent for interest payments and 32 per cent for amortizations, among other expenditures.

2. Theory

An increasing debt-to-GDP ratio depends on the economic environment $(r_t - g_t)d_{t-1}$, and on the primary surplus. If the interest rate r_t exceeds the growth rate g_t , then the debt-to-GDP ratio d_t will increase indefinitely unless there is a primary surplus which can offset the rising debt service.

The paths of public debt implied by the sequences of primary surplus s_t and economic environment $(r_t - g_t)$ are:

$$d_{t+n} = \left(\prod_{k=0}^n [1 + (r - g)_{t+k}] \right) d_{t-1} - \sum_{j=0}^n \left(\prod_{k=j+1}^n [1 + (r - g)_{t+k}] \right) s_{t+j} \quad (1)$$

Assuming the economic environment as given and constant, the accumulation of debt over several periods $t=1 \dots n$:

$$d_{t+n} = (1+r-g)^n d_t - \sum_{j=0}^n (1+r-g)^{n-j} s_{t+j} \quad (2)$$

If we divide by $(1+r-g)^n$ and arrange terms:

$$\frac{1}{(1+r-g)^{t+n}} d_{t+n} = d_t - \sum_{j=1}^n \frac{s_{t+j}}{(1+r-g)^j} \quad (3)$$

Assuming that the transversality condition holds¹³, fiscal policy will satisfy the intertemporal budget constraint (IBC) because it is on a path in which the present value of expected future primary surpluses equals the initial debt:

$$d_t = E \left(\sum_{j=0}^{\infty} \frac{s_{t+j}}{(1+r-g)^j} \right) \quad (4)$$

Equation (4) states that debt sustainability requires a variation in the primary budget surplus. A surplus is needed when the growth rate falls below the rate of return on government bonds. Thus, whether fiscal policy is sustainable or not depends on the sign of the fiscal policy reaction with respect to the target: i.e., if an increase in debt is followed by an increase in primary surpluses, debt is sustainable. In

¹³ The initial debt equals the expected present value of future primary surpluses if and only if discounted future debt converges to zero (Bohn, 2005).

the long run, the debt-to-GDP ratio is required to converge on an equilibrium position that is determined by the nominal growth rate, target reference values, and adjustment coefficients¹⁴.

In order to explain the sustainability of oil-producing countries, Kia (2008) extends Barro's (1979, 1986) tax smoothing model by introducing energy revenues. In Barro's approach, the base of real taxable income is a deterministic variable y_t , a fixed fraction of real GDP that generally depends on the path of tax rates. Kia (2008) assumes GDP to be a function of the country's energy income.

Let τ_t be the average tax rate and $\tau_t y_t$ the real tax revenues. The total government revenues of an oil-producing country are, therefore, the sum of $\tau_t y_t$ and EN_t , the oil revenues derived from the exports of the natural resource. The government budget constraint, Equation (4), with constant real interest rate, r , and in a situation in which the country has energy income is:

$$d_t = E \left(\sum_{j=0}^{\infty} \frac{(\tau y_{t+j} + EN_{t+j}) - (Gov_{t+j})}{(1+r-g)^j} \right) \quad (5)$$

where the primary surplus s_{t+j} from Equation (4) now includes energy revenues EN_t ¹⁵. If both primary balance and debt are non-stationary, according to equation (5) the two variables should cointegrate and debt would be sustainable¹⁶.

In line with Kia (2008), we have to make several assumptions for empirical purposes. First, we assume that both the real government expenditure, Gov_t , and the real tax base, y_t , are expected to fluctuate around the current rate of the growth of the economy g . Second, the expected present value of energy income is also its current value. This means that all economic agents expect energy revenues not to

¹⁴ Collignon (2012) adopting the fiscal reaction function for European countries $\Delta s_t = \alpha(def_t - z_1) + \beta(debt_t - z_2)$ relates the deficit and debt ratios with the primary surplus. Z_1 and Z_2 are the target reference values for the deficit and debt ratios respectively under the Stability and Growth Pact; α and β are the adjustment speed coefficients by which governments respond to the deviation from the deficit and debt ratio respectively.

¹⁵ Alvarado (2004) points out that increasing resource exploitation to pay the debt does not affect sustainability since it is assumed that oil reserves have the same return as the government's other financial assets and liabilities.

¹⁶ This concept of debt sustainability is presented by Hamilton and Flavin (1986) and Trehan and Walsh (1991). However, Bohn (1998) shows the existence of cointegration between debt, primary balance and other variables non debt determinant of the primary surplus, such as the level of temporary government spending (GVAR) and a business cycle indicator (YVAR).

change over the remaining life of the oil reserves¹⁷. Third, the oil reserves are expected to last forever. This assumption, however, is unsustainable based on OPEP's Annual Statistical Bulletin which states that Ecuador has about 8.24 bn barrels of proven reserves and an exportable trend of 334 thousand barrels per day in 2011, that is, seventy per cent of its production.

3. Data and Econometric Methodology

The study of the effects of fiscal policy on macroeconomic variables is usually carried out by estimating a vector autoregressive (VAR) model of the form:

$$X_t = \sum_{i=1}^k \Pi_i X_{t-i} + e_t$$

Where X_t includes the minimum set of variables required for the VAR analysis, i.e., government spending net of interest, net tax revenues, output, inflation and interest rate (Perotti, 2002). Here, we extend this set to include the debt level, as Bohn (1998) has shown that the feedback obtained from the debt to tax and government spending ratios is statistically significant and economically relevant. The importance of monitoring debt dynamics when analysing fiscal policy has also been stressed by Romer and Romer (2010), Favero and Giavazzi (2007) and Favero *et al.* (2011)¹⁸. This result has clear implications for countries with fixed exchange rate regimes, including pegged or monetary union regimes.

Following Engle and Granger (1987), Johansen and Juselius (1990, 1992) extend the VAR model by applying the concepts of cointegration and error correction to analyse long run relations among non-stationary variables. This extension is referred to the Cointegrated VAR. The methodology is

¹⁷ Where $t=m$ when the country's energy resources are exhausted, and I_t the information available at time t , including the state of the

economy: $EN_t = E \left[\int_0^m EN_t e^{-rt} dt \mid I_t \right]$

¹⁸ Romer and Romer (2010) claim that the effect of a US tax shock on output depends on whether the change in taxes is motivated by the government's desire to stabilize the debt or not. Favero and Gavazzi (2007) also find that interest rates depend on future monetary policy and the risk premium, both variables being affected by the debt dynamics. Hence, the absence of an effect of fiscal shocks on the long-term interest rates, a frequent outcome in VAR-based research that omits debt level, is due to a misspecification.

extensively described in Juselius (2006). She shows how the VAR model, allowing for unit roots and, hence, cointegration, specifies economically meaningful short and long-run structures, such as steady-state relations and common trends, interaction and feedback effects. In our empirical analysis, equation (5) could be rewritten as:

$$d_t - E \left(\sum_{j=0}^{\infty} \frac{(\tau y_{t+j} + EN_{t+j}) - (Gov_{t+j})}{(1+r-g)^j} \right) = v_t \quad (6)$$

where the deviation from the steady-state value, v_t , measures the extent of excess expected surplus (positive or negative) in the economy at time t relative to its long run value. We need v_t to be a stationary process, implying that the economic forces should be activated when $v_t \neq 0$, pulling the process back towards its long run benchmark value. This approach allows the identification of two sorts of fiscal policy shocks; on the one hand, shocks allowing variables to adjust to the long run relation; on the other, shocks which are pushing the process away from equilibrium.¹⁹

We use monthly data obtained from the Central Bank of Ecuador covering the period 2001:01 to 2013:3²⁰. The fiscal variables are the log of government spending net of interests, $lgov_t$, and also including interests, $ltgov_t$; the log of non-oil tax revenues, $lrev_t$, and the log of oil revenues, $lorev_t$ ²¹. The remaining variables are the log of Economic Activity Index (EAI) represented by $leai_t$; the log of the total (external and internal) debt-to-GDP ratio, $ldebt_gdp_t$, and the log of the active interest rate, $lair_t$.

The $leai_t$ variable was chosen instead of GDP because Ecuador was dollarized in 2000:1 and GDP is only reported annually or quarterly; thus, in order to use the highest number of observations from the

¹⁹Perotti (2002) describes the four approaches to identify fiscal shocks that have been used in the literature. The “narrative approach”; the Cholesky ordering; the sign restrictions on the impulse responses rather than the linear restrictions on the contemporaneous relations between reduced form innovations and structural shocks, and finally the structural VARs. See Annex II for brief explanation of the cointegrated VAR approach to identify fiscal shocks. The advantages of this method over others are clearly presented in Hoover et al. (2007) and Juselius (2009). The empirical application is carried out using CATS software.

²⁰We exclude data corresponding to the first year after dollarization since the different economic variables were still adjusting to the new exchange rate regime.

²¹The oil sector accounts for about 50 per cent of Ecuador’s export earnings and about one-third of all tax revenues (US Energy Information Administration Report 2012).

dollarized period we include $leai_t$, which is generated each month. We also decided to remove the inflation rate from the model since it is stationary and close to zero throughout the sample period as Fig.A.3 in Annex A shows²². The rest of variables are plotted in Fig. A.4 in Annex A. Table A.1 in Annex A shows a brief description of the variables. Hence, the CVAR model comprises the following vector of six endogenous variables: $X_t = [lrev_t, lorev_t, lgov_t, leai_t, lair_t, ldebt_gdp_t]$ ²³.

4. Empirical Results

To analyze whether the long run relation described in equation (6) exists (i.e. whether the fiscal policy of Ecuador is on a sustainable path), and to establish which different shocks may have permanent and transitory effects on the variables, we shall focus on the success of a well-specified empirical model. Once the assumptions upon which our statistical model is based are satisfied, we impose restrictions in order to discover interactions of the variables. This method, described as *general-to-specific*, is best explained in Hendry (1995).

Since statistical inference from the VAR model is only valid provided the parameters are constant and the residuals do not present autocorrelation or skewness²⁴, we choose four lags (k=4) to solve the problem of autocorrelated residuals and include three dummies to eliminate the problem of skewness due to data outliers. The first outlier is associated with the moment when Ecuador restructured its external debt in June 2009²⁵. The second outlier corresponds to a permanent oil price shock which hit

²² The CVAR framework does not require all series to be I(1). All that is required is that they are at most I(1). An I(0) variable in a CVAR model means a cointegrating vector on its own. Using the trace test, we reject non-stationarity for Ecuadorian inflation, but we accept it for the rest of variables included in our models.

²³ Unlike Favero and Giavazzi (2007), we include the debt-to-GDP ratio among the endogenous variables, in order to capture the rich dynamics of fiscal aggregates in the cointegrated VAR. As government debt results from the accumulation of budget deficits, if we include the debt-to-GDP ratio we do not include the interest payments.

²⁴ Simulation studies have shown that valid statistical inference is sensitive to the violation of some of the assumptions, including parameter non-constancy, autocorrelated residuals and skewed residuals, while quite robust to others, such as excess kurtosis and residual heteroscedasticity. See Rahbek et al. (2003) and Cheung and Lai (1993).

²⁵ The total external debt ratio was reduced from 106 per cent GDP at the end of 1999 to around 98 per cent in 2000 (Quispe-Agnoli, 2006). In June 2009 the Correa government defaulted on \$3.2 billion of foreign public debt, and then completed a buyback of 91 per cent of the defaulted bonds (Sandoval, 2009).

the world economy in 2008²⁶ and influenced Ecuadorian budget revenues in February 2008. Therefore, we introduce two permanent dummies, $dum0906_t$ and $dum0802_t$, whose value is 1 if t refers to that date and zero otherwise. We also include a transitory dummy ($dum0609_t$) which has the value 1 if $t=2006:09$, -1 if $t=2006:10$, and zero otherwise, in order to eliminate the third outlier corresponding to the $lovev_t$ residuals.

All our statistical tests are now acceptable²⁷. The univariate normality tests only reject normality on the residuals of $ldebt_gdp_t$ and $lair_t$ because of the presence of some kurtosis, but they show little skewness²⁸. Thus, our model is well-specified and the empirical results are reliable.

We calculate the trace test statistics (Johansen, 1996), one including both seasonal and permanent dummies, and a second without dummies as a sensitivity analysis (See Table C.1 in Annex C). Both tests determine the existence of two cointegrating relations. Thus, the IBC is fulfilled in Ecuador, since the variables involved in equation (5) cointegrate; this was expected, as Fig. A.1. depicts a downward trend for the debt-to-GDP ratio.

Once the CVAR model is restricted to rank=2 and has passed a number of diagnostic tests for parameter constancy²⁹, we begin to impose restrictions on β and α . These are tested with a likelihood ratio test procedure described in Johansen (1996), Johansen and Juselius (1990) and Juselius (2006).

We test three types of restrictions on β vectors: long-run exclusion of a specific variable, stationarity of individual variables and stationarity of linear combinations of variables. These tests allow the identification of the long-run structure of the r stationarity cointegrating relations³⁰. As Table C.2 in

²⁶When both the WTI and the Europe Brent spot price FOB are above \$130 per barrel. Monthly Statistics available in <http://www.eia.gov/>

²⁷ Misspecification tests are available upon request.

²⁸ Our non-normal residuals (from $lair_t$, $ldebt_gdp_t$) present positive and negative skewness less than 0.14, which is inside the range suggesting a normal population (See Doane and Seward, 2011).

²⁹Including the log-likelihood test or recursively calculated trace test statistics. All tests are available upon request.

³⁰ In order to identify the long run structure we need to impose at least $r(r-1)$ restrictions on β vectors.

Annex C illustrates, two variables can be excluded from long run relations, namely the active interest rate, $lair_t$ and $ldebt_gdp_t$ ³¹. So, our new model is $X_t = [lrev_t, lorev_t, lgov_t, leai_t]$ ³².

We repeat all the tests described above for this new model (See Table C.3 and Table C.4). Following Martins (2005), several hypotheses can be tested on the cointegrating vectors. Table C.5 shows some of them. On the one hand, whether Ecuador depends on oil revenues to ensure a balanced budget or whether tax revenues are not sufficient to achieve a balanced budget can be tested by hypotheses H_1 and H_2 , respectively. On the other, the “additionality” hypothesis (H_3) which implies that oil revenues produce an equivalent or higher government expenditure can also be tested, or the “tax displacement” hypothesis (H_4) which relates higher oil revenues to the government’s disincentive to increase taxes or improve the taxation system.

Our results (see Table C.5) suggest that oil revenues are financing fiscal deficit, and that there exists a positive relationship between oil revenues and government expenditure (H_3) and a negative relationship between oil and tax revenues (H_4).

Testing a zero row in α is equivalent to testing whether a variable is weak exogenous for the long run relation. Accepting that variables are weak exogenous defines common driving trends (the pulling and pushing forces) in the system, since these variables do not adjust to the long run relations. They (through their own shocks) can affect, but not be affected by, the rest of variables. In contrast, testing a unit vector in α reveals which variable is purely adjusting to the long run relations, i.e., its own shocks have only transitory effects on the remaining variables in the system. From Table C.6 in Annex C we can conclude that only two variables are purely adjusting: $lrev_t$ and $lorev_t$ variables; while $lgov_t$ and $leai_t$ variables seem to be the pushing forces of the system.

³¹ This is to be expected since Ecuador does not control monetary policy and its total debt-to-GDP ratio seems to be unrelated to the path of the deficit.

³² The model’s specification has changed to require only three lags and the transitory dummy $dum0609_t$. The inclusion of interests in government expenditure ($ltgov_t$) does not change the main results.

Finally, we decide to identify our $\prod_i = \alpha\beta'$ matrix with the structure that imposes H_3 since it gives the highest p-value. The beta vectors describe two long run relations: the first one entails oil revenues and government expenditure variables, and the other reveals the relation that exists between traditional deficit (government spending minus tax revenues) and economic activity. This structure, which is illustrated in Table C.7, complements the results presented in Table C.6 because it shows to which long run relation the two variables $lrev_t$ and $loreve_t$ are purely adjusting. Tax revenues are adjusting to the second long run relation; and oil revenues adjust to government demands. Note the borderline significance (based on the Student's t statistic) of the adjustment coefficient corresponding to $lgov_t$; this is because this variable generates both transitory and permanent shocks. We will see this afterwards when we analyze the structural moving average representation of the cointegrated VAR.

In Annex B, it is shown that while alpha defines the adjustment to the equilibrium error given by the cointegration relations, alpha orthogonal in the moving average representation of the CVAR defines the common stochastic trends or the variables which are simply pushing the system. Our results suggest that the latter variables are government expenditure and economic activity, but we have to analyze the structural MA representation, which requires structural and uncorrelated residuals in order to interpret the empirical shocks adequately³³.

The impulse response functions are calculated with the following structurally identified MA model:

³³ It can be derived from Annex B that if multiplying by a B matrix, then we add $p \times p$ additional parameters to the cointegrated VAR. This being the case, we need to impose exactly the same number of restrictions on the model's parameters to achieve a just-identification scheme. Since we have four variables, the B matrix adds 16 new coefficients. The assumption that $u \sim IN(0, I)$ implies $((p \times (p+1))/2) = 10$ ten restrictions on B (four unit coefficients on the diagonal elements and six zero restrictions on the off-diagonal elements). Four additional restrictions $((p-r) \times r = 4)$ are necessary to separate transitory from permanent shocks, and two more restrictions are required to achieve a just-identified structural MA model. These two extra restrictions are essential because there are two possible sequences of the transitory shocks and two possible sequences of the permanent shocks. A single specification can be obtained by imposing one exclusion restriction on the common trend and another on the transitory impulse response.

$$\begin{pmatrix} lrev_t \\ lorev_t \\ lgov_t \\ leai_t \end{pmatrix} = \begin{bmatrix} 0 & 0 & * & * \\ 0 & 0 & * & * \\ 0 & 0 & * & 0 \\ 0 & 0 & * & * \end{bmatrix} \begin{bmatrix} \sum_{i=t}^t \mathbf{u}_{s1,i} \\ \sum_{i=t}^t \mathbf{u}_{s2,i} \\ \sum_{i=t}^t \mathbf{u}_{l1,i} \\ \sum_{i=t}^t \mathbf{u}_{l2,i} \end{bmatrix} + \begin{bmatrix} * & 0 & * & * \\ * & * & * & * \\ * & * & * & * \\ * & * & * & * \end{bmatrix} \begin{bmatrix} \mathbf{u}_{s1,t} \\ \mathbf{u}_{s2,t} \\ \mathbf{u}_{l1,t} \\ \mathbf{u}_{l2,t} \end{bmatrix} + \mathbf{C}_1 \mathbf{B}^{-1} \begin{bmatrix} \mathbf{u}_{s1,t-1} \\ \mathbf{u}_{s2,t-1} \\ \mathbf{u}_{l1,t-1} \\ \mathbf{u}_{l2,t-1} \end{bmatrix}$$

The exclusion restriction on the permanent shocks is defined by assuming government spending inertia. The other exclusion restriction on the transitory shocks is defined by assuming “sticky” taxes, so tax revenues do not react immediately to the second transitory shock.

The estimated matrix \mathbf{B} normalized at the largest coefficient in each row in Table C.8, defines how the orthogonalized permanent and transitory shocks are associated with the estimated CVAR residuals. Recovering the last two rows and substituting in the equation: $\mathbf{u}_t = \mathbf{B}e_t$, we obtain the combinations which make up the permanent shocks³⁴:

$$\mathbf{u}_{1,1} = \mathbf{B}'_{1,1} e_t = 0.299e_{lrev,t} + 0.276e_{lorev,t} + e_{lgov,t} - 0.365e_{leai,t}$$

$$\mathbf{u}_{1,2} = \mathbf{B}'_{1,2} e_t = 0.148e_{lrev,t} + 0.012e_{lorev,t} - 0.075e_{lgov,t} + e_{leai,t}$$

We obtain that the first permanent shock is primarily given by shocks to government expenditure and the second one by shocks to economic activity. Our results also suggest that the influence of oil revenue shocks may have fallen, an outcome which, given the finite nature of oil reserves, can be considered as positive. This might be the result of the efforts of the current government to diversify the economy. Table C.7 and Figure C.1 in Annex C describe the dynamic impulse response functions after 21 periods for each of the system’s variables resulting from a one standard deviation shock. We are able to verify that all transitory shocks have a zero long-run impact on the four variables, whereas all permanent shocks have a non-zero impact, except for oil revenues with respect to the second shock and the identifying zero impact on government expenditure. Economic activity shocks have a

³⁴ The first two rows give the combinations which make up the transitory shocks. Note that the second transitory shock is primarily given by shocks to government expenditure.

transitory impact on oil revenues because this latter variable depends on volatile oil prices and government demands. It can also be seen that tax revenues are affected permanently by the two permanent shocks: economic activity and government expenditure.

5. Conclusions

This article seeks to clarify whether fiscal sustainability is possible in Ecuador in view of the fact that it is a dollarized country strongly dependent on oil revenues. These revenues are particularly volatile because of price fluctuations, but have to finance increasing government expenditure. Dollarization has enhanced fiscal discipline in the sense that it prevents the government from financing deficit, but the government has not developed a tax revenue system to substitute oil revenues. Indeed, our estimation of a cointegrated VAR finds a negative relation between these two variables. Moreover, we have identified tax revenues as an adjusting variable, which means that the shocks in tax revenues do not have a permanent impact on the rest of the variables. This is consistent with Barro's (1979) tax smoothing theory but may put the fiscal sustainability of a dollarized country at risk.

Using graphical and statistical methods, we verify that Ecuador does not have debt problems. The debt-to-GDP ratio can be excluded from the intertemporal budget constraint, as this is a cointegrating relation. However, Ecuador is vulnerable to future debt problems. Since 2007 the gap between government spending and tax revenues has increased, and since 2012 the debt-to-GDP ratio has reversed its downward trend.

The fact that Ecuador is a dollarized country means that it has relinquished control over both its interest rates and exchange rates, the latter being fundamental to launching or encouraging sectors other than the oil sector. Dollarization also prevents the levying of the "inflation tax". In this context, in our opinion, Ecuador should rethink its exchange rate regime, not only because dollarization may become counter-productive for its budgetary positions but also to avoid any "non-odious and legitimate" debt crises that might necessitate a restructuring of the debt.

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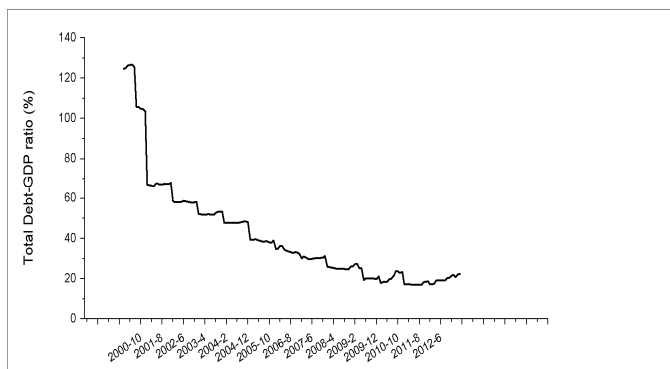
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Annex A. Figures

Fig.A.1 Total Debt-to-GDP ratio



Source: Central Bank of Ecuador and our own estimates.

Fig.A.2 Primary balance variables

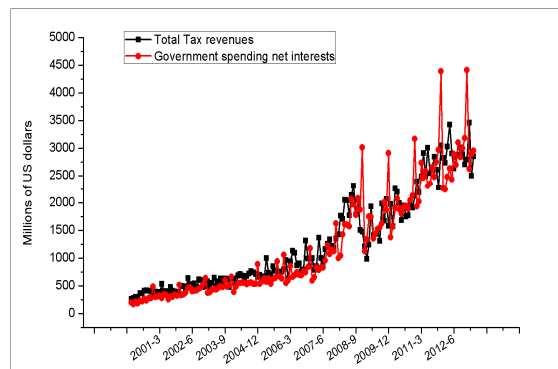
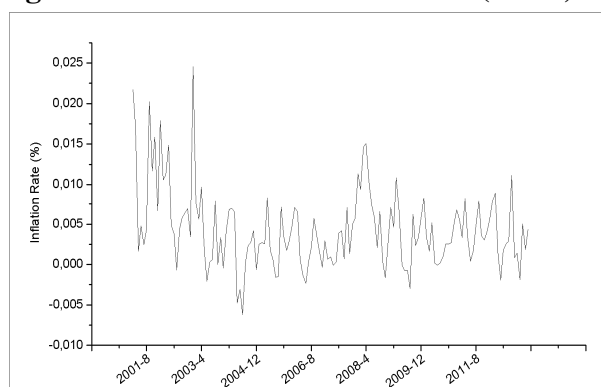


Fig. A.3. Ecuadorian Inflation rate (Δ CPI)



Source: Central Bank of Ecuador

Fig.A.4. EAI and Active interest rate evolution

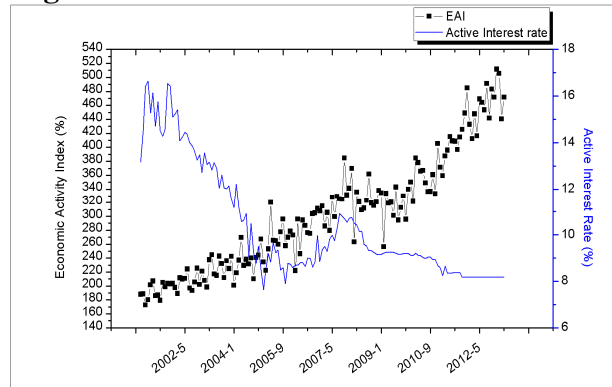


Table A.1. Description of variables

Variable	Description	Unit	Source
Total Government spending (I_{gov}_t)	Government purchases of goods and services (current consumption, gross fixed capital formation, wages) + interests	Millions of U.S. dollars	Monthly Information Bulletin. Central Bank of Ecuador (CBE)
Government spending net interest (I_{gov}_t)	Total Government spending – interests	Millions of U.S. dollars	Monthly Information Bulletin CBE
Interests (I_{int}_t)	Both external and internal debt interests	Millions of U.S. dollars	Monthly Information Bulletin CBE
Economic Activity Index (IDEAC, the acronym in Spanish) ($leai_t$)	Describing the variation in volume of Ecuadorian economic activity	Index	Monthly Information Bulletin CBE
Total Revenues (I_{rev}_t)	Tax revenues + oil revenues + public enterprises surplus	Millions of U.S. dollars	Monthly Information Bulletin CBE

Oil revenues ($lorev_t$)	Oil revenues from exports and sale of its derivatives	Millions of U.S. dollars	Monthly Information Bulletin CBE
Tax Revenues ($lrev_t$)	Revenues from direct and indirect taxes	Millions of U.S. dollars	Monthly Information Bulletin CBE
Inflation	First derivative of monthly consumer price index	Percentage	Monthly Information Bulletin CPI (ECB)
Active interest rate ($lair_t$)	Short term interest rate. Credit cost to three months.	Percentage	CEPAL

Annex B. Econometric Model: Cointegrated VAR

Consider the p - dimensional VAR (k):

$$X_t = \sum_{i=1}^k \Pi_i X_{t-i} + \Phi D_t + e_t \quad (\text{B.1})$$

Where X_t is a $p \times 1$ vector of endogenous variables with $t=1,2,..T$; Π_i is $p \times p$ matrices of parameters to be estimated with $i=1,2,..k$; D_t is a vector of deterministic terms as a constant, trend or dummy variables. Finally, e_t is a $p \times 1$ vector of error terms which follow a Gaussian distribution: $e_t \sim \text{iid}$ with $N(0, \Omega)$. The residual covariance matrix (Ω) is a $p \times p$ matrix containing the information about contemporaneous effects. And k is the number of lags needed to have an appropriate model with no autocorrelated errors.

This p - dimensional VAR (k) can be re-written in a Vector Error Correction Model (VECM) form:

$$\Delta X_t = \Pi X_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + \Phi D_t + e_t \quad (\text{B.2})$$

Where $\Pi = \sum_{i=1}^k \Pi_i - I_p$ represents the long run effects and $\Gamma_i = - \sum_{j=i+1}^k \Pi_j$ the short run effects, with $i=1, \dots, k-1$ and $e_t \sim \text{iid} N(0, \Omega)$.

We have that ΔX_t and ΔX_{t-i} are stationary because they perform first difference processes to get rid of the one unit root that the level variables contain. Since a stationary process cannot be equal to a non-stationary process, the estimation results can only make sense if Π_i defines stationary linear combinations of the variables (Juselius, 2006). Π_i can be written $\Pi_i = \alpha \beta'$, where α and β' are $p \times r$ matrices, $r \leq p$.

Thus, under the I(1) hypothesis, the cointegrated VAR model is given by:

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + \dots + \Gamma_{k-1} \Delta X_{t-k+1} + \alpha \beta' X_{t-1} + \Phi D_t + e_t \quad (\text{B.3})$$

where $\beta' X_{t-1}$ is an $r \times 1$ vector of stationary cointegration relations. Under the hypothesis that $X_t \sim I(1)$ all stochastic components are stationary in model (3) and the system is now logically consistent.

Cointegration exists when two or more variables share common stochastic and deterministic trends, they move together in the long run, and therefore they can be interpreted as long-run economic steady-state relations. $\beta' X_{t-1} = \beta_0$ describes a system in equilibrium where there is no economic adjustment force to change the system to a new position. When exogenous shocks affect the system, and $\beta' X_{t-1} - \beta_0 \neq 0$, the adjustment term α , pull the process back towards the long run equilibrium. If $r=1$ there is a unique stationary relation. If $r>1$ only the cointegration space $\prod_i = \alpha\beta'$, and not the cointegration parameters (α and β), is estimated consistently. We have to resolve an identification problem.

The VECM expressed as a function of the innovations of the system shows which common stochastic trends are responsible for the non-stationarity of the process.

$$X_t = C \sum_{i=1}^t (e_i + \Phi D_i) + C^*(L)(e_t + \Phi D_t) + X_0 \quad t=1,2,\dots,T$$

$$\text{Where: } C = \beta_{\perp} (\alpha'_{\perp} \Gamma \beta_{\perp})^{-1} \alpha'_{\perp} \quad \text{or} \quad C = \beta_{\perp}^* \alpha'_{\perp}$$

$$\text{Where: } \beta_{\perp}^* = \beta_{\perp} (\alpha'_{\perp} \Gamma \beta_{\perp})^{-1}$$

The idea is to determine which variables are adjusting to long run equilibrium equations with their corresponding alphas significantly different from zero. Otherwise, they may be the forces pushing the system away from equilibrium, affecting the rest of variables but not being affected by long run relations, i.e. their corresponding alphas can be excluded from the VECM.

Knowing that $\alpha'_{\perp} \alpha = 0$, a zero row in alpha corresponds to a unit vector in α_{\perp} . We say that this variable is long-run weakly exogenous implying that its cumulated residuals can be considered a

common stochastic trend; then $x_{j,t}$ is understood as an estimation of the $p - r$ common stochastic trends.

This does not imply that the variable itself is a common trend. For this we need the rows of the Γ_i matrices associated with the weakly exogenous variable to be zero. Given $X_t \square I(1)$ this is essentially the condition of strong exogeneity, under which the equation for a strongly exogenous

variable in $X_{j,t}$ becomes $\Delta x_{j,t} = e_{j,t}$, in this case $\Delta x_{j,t} = \sum_{i=1}^t e_{j,i} \alpha \beta$: the common stochastic trend

coincides with the variable itself, and then, $x_{j,t}$ will have a unit row vector in the C matrix.

Additional restrictions on β_{\perp}^* and α_{\perp} are needed to constrain the likelihood function. Similar to

α and β , we can transform β_{\perp}^* and α_{\perp} by a non-singular $(p-r) \times (p-r)$ matrix Q without changing the

value of the likelihood function:

$$C^c = \beta_{\perp}^* Q Q^{-1} \alpha'_{\perp} = \beta_{\perp}^{*c} (\alpha'_{\perp})'$$

Even when the unrestricted C matrix gives very useful information about the effects of the stochastic

driving forces in the VECM, and the restricted C^c can be used to check the robustness of the analysis,

the challenge is to recover the structural shocks in order to interpret the results empirically³⁵. This

means that we have to obtain the empirical shocks from a structural MA model, i.e. the structural

C^c matrix³⁶.

³⁵ A column of insignificant coefficients means that the empirical shocks of the corresponding variable only have temporary effects on the variables of the system, while a column of significant coefficients means permanent effects. The rows in C matrix inform us of the weights with which each variable is influenced by any of the cumulated empirical shocks.

³⁶ Juselius (2006) points out that omitted relevant variables generate correlated p residuals in VAR, a feature that is not assumed to be present in the structural VAR model, where the orthogonality of structural VAR errors is based on an assumption that the model contains all the relevant variables. This is the main reason why the labelling of empirical residuals as structural shocks is often misleading.

²⁷ We can find a B matrix to fulfil the following assumptions: (i) A distinction between r transitory and $p - r$ permanent shocks is made, i.e. $u_t = (u_s, u_p)$; (ii) The transitory shocks have no long-run impact on the variables of the system, whereas the permanent shocks have these effects on at least one variable in the system and (iii) $E(u_t u_t') = I_p$, i.e. all 'structural' shocks are linearly independent.

By premultiplying (2) with a non-singular $p \times p$ matrix B we obtain the VECM with simultaneous effect:

$$B \Delta X_t = B_1 \Delta X_{t-1} + b \beta' X_{t-1} + B \Phi D_t + u_t$$

Where $B_1 = B \Gamma_1$, $b = B \alpha$ and $u_t = B e_t$.

The B matrix defines how the structural shocks u_t are associated with the VECM residuals²⁷.

The structural MA representation of the CVAR:

$$X_t = \tilde{C} \sum_{i=1}^t u_i + C^{*\sim} u_t + X_0$$

Where $\tilde{C} = C B^{-1}$ and $C^{*\sim} = C^*(L) B^{-1}$

Annex C Econometric Results

Table C.1. Trace test for the first model: $X_t = [lrev_t, lorev_t, lgov_t, leai_t, lair_t, ldebt_gdp_t]$

r	p - r	Eig. Value	Trace	Trace*	Frac95	p-value	p-value*
0	6	0.366	142.561	130.628	95.514	0.000	0.000
1	5	0.234	77.321	71.979	69.611	0.010	0.031
2	4	0.181	39.272	35.205	47.707	0.252	0.442
3	3	0.042	10.666	9.780	29.804	0.964	0.980
4	2	0.022	4.518	4.049	15.408	0.853	0.893
5	1	0.009	1.278	0.483	3.841	0.258	0.487

Trace test without seasonal or dummies variables. *Bartell correction for small samples.

Table C. 2. Tests of stationarity and long-run exclusion for the first model

Test	5%C.V.	$lrev_t$	$lorev_t$	$lgov_t$	$leai_t$	$lair_t$	$ldebt_gdp_t$	<i>trend</i>
Stationarity	11.070	25.016	27.368	26.015	25.133	28.136	25.096	---
p-value	---	0.000	0.000	0.000	0.000	0.000	0.000	---
Exclusion	5.991	19.360	13.775	18.447	14.391	2.359	1.257	2.079
p-value	---	0.000	0.001	0.000	0.001	0.307	0.533	0.354

Table C.3. Trace test for the second model: $X_t = [lrev_t, lorev_t, lgov_t, leai_t]$

r	p - r	Eig. Value	Trace	Trace*	Frac95	p-value	p-value*
0	4	0.327	89.950	87.297	47.707	0.000	0.000
1	3	0.140	32.994	32.200	29.804	0.020	0.025
2	2	0.072	11.346	10.973	15.408	0.194	0.217
3	1	0.004	0.600	0.564	3.841	0.439	0.453

Trace test without seasonal or dummies variables. *Bartell correction for small samples.

Table C.4. Tests of long-run exclusion for the second model

Test	5%C.V.	$lrev_t$	$lorev_t$	$lgov_t$	$leai_t$
Exclusion	5.991	46.948	10.421	37.265	19.977
p-value	---	0.000	0.005	0.000	0.000

Table C.5. Tests of hypothesis on β for the second model

Hypothesis*	Test of stationarity of linear combinations	Degrees of Freedom	Statistic	p-value
H_1 : Balanced budget	$lgov_t - c * lrev_t - (1 - c) * lorev_t$	$\chi^2(1)$	0.050	0.822
H_2 : Balanced budget without oil revenues	$lgov_t - lrev_t$	$\chi^2(2)$	18.235	0.000
H_3 : Additionality	$lgov_t - c * lorev_t$	$\chi^2(1)$	0.018	0.895
H_4 : Tax displacement	$lrev_t - c * lorev_t$	$\chi^2(1)$	0.963	0.326

*Hypothesis on one specific vector without imposing restrictions on the other.

Table C.6. Tests of hypothesis on α for the second model

Test	5% C.V.	$lrev_t$	$lorev_t$	$lgov_t$	$leai_t$
Exogeneity	5.991	35.032	7.241	7.871	2.377
p-value	---	0.000	0.027	0.020	0.305
Unit Vector	5.991	4.641	4.517	8.040	11.751
p-value	---	0.098	0.105	0.018	0.003

Table C.7. Just identifying restriction imposed on the 2nd beta vector and the H_3 imposed on the first one.

	$\hat{\beta}_1$	$\hat{\beta}_2$
$lrev_t$	0	1
$lorev_t$	-0.881 [-16.317]	0
$lgov_t$	1	-0.541 [-15.866]
$leai_t$	0	-0.636 [-6.783]
	$\hat{\alpha}_1$	$\hat{\alpha}_2$
$lrev_t$	-0.006 [-0.148]	-0.878 [-6.281]
$lorev_t$	0.359 [3.466]	0.101 [0.274]
$lgov_t$	-0.102 [-2.572]	0.290 [2.074]
$leai_t$	-0.011 [-0.424]	0.151 [1.624]

Fig. C.1 The impulse response functions for the two permanent shocks and transitory shocks.

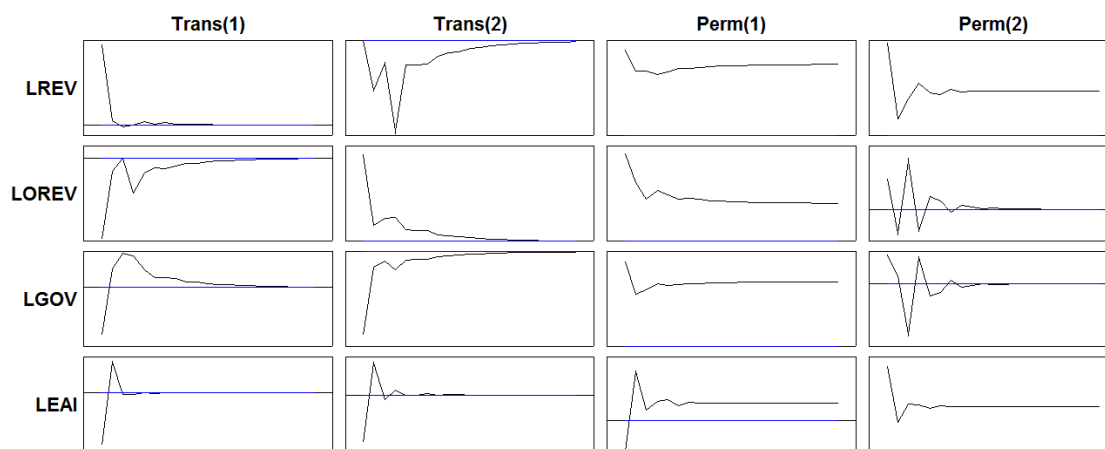


Table C.8 Impact after 21 periods

	Trans(1)	Trans(2)	Perm(1)	Perm(2)
$lrev_t$	0.005	-0.013	3.386	2.138
$lorev_t$	-0.027	0.065	7.008	0.007
$lgov_t$	0.006	-0.014	6.143	-0.002
$leai_t$	-0.000	0.000	0.107	3.364

Table C.9 Normalized B matrix [U(t)=B*e(t)]

	e_{lrevt}	e_{lorevt}	e_{lgovt}	e_{leait}
Trans(1)	1.000	-0.108	-0.300	-0.643
Trans(2)	-0.248	-0.434	1.000	0.233
Perm(1)	0.299	0.276	1.000	-0.365
Perm(2)	0.148	0.012	-0.075	1.000