

## IDENTIFYING FISCAL POLICY SHOCKS IN CHILE AND COLOMBIA

*Jorge E. Restrepo\* and Hernán Rincón\*\**

Structural VAR and Structural VEC models were estimated for Chile and Colombia, aiming at identifying fiscal policy shocks in both countries between 1990 and 2005. The impulse responses obtained allow the calculation of a peso-for-peso (\$/\$) effect on output of a shock to public spending and to the government's net tax revenues, providing a good notion of the incidence of fiscal policy shocks in both countries. When public finances are under control, as they are in Chile, fiscal policy seems to be more effective than when they lack stability and credibility, as seems to be the case of Colombia since the mid-Nineties.

### 1. Introduction

The purpose of this paper is to identify the dynamic effects of taxes and government spending on economic activity in Chile and Colombia. Using Structural Vector Autoregression models (SVAR) and Structural Vector Error Correction Models (SVEC), we isolate structural shocks to taxes and fiscal expenditures and determine their effects on GDP.

Government is an important player in any economy, and its policies regarding taxes and spending affect disposable income, consumption, investment and private agents' decisions, in general. Adequate knowledge of the influence of government on aggregate demand – through its budget policies – is useful for fiscal and monetary authorities, altogether. Indeed, the Central Bank attains its main objective of stabilizing inflation via the regulation of aggregate demand through adjusting the interest rate. Therefore, it should foresee the pressure put on aggregate demand by the government. On the other hand, the bulk of the literature refers to developed economies and very few studies have tried to determine the effects of fiscal policy in developing countries.

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\* Senior Economist at Banco Central de Chile (Central Bank of Chile).

\*\* Senior Researcher at Banco de la República (Central Bank of Colombia).

We thank Adolfo Barajas, Pablo García, Leonardo Luna, Igal Magendzo, Carlos E. Posada, Rodrigo Valdés and, especially, Carlos García and Michael Pedersen for helpful suggestions. We are also grateful to Margit Schratzenstaller (WIFO, Austria) and other participants in the 8th Banca D'Italia Workshop on Public Finance. Consuelo Edwards helped us with the edition. The first version of the paper was written as a requirement for the course "Macroeconomic Management and Fiscal Policy Issues" at the IMF Institute in June 2005. We thank its hospitality.

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Please address any comments to [jrestrepo@bcentral.cl](mailto:jrestrepo@bcentral.cl) or [hrincoca@banrep.gov.co](mailto:hrincoca@banrep.gov.co)

At the outset of the Eighties, Sims (1980) established an already long tradition of vector autoregression models (VARs). It was a reaction to the common practice among macroeconometricians of imposing *ad hoc* restrictions, which had been forcefully criticized by Lucas (1976). Many others contributed to develop the technique: Bernanke and Blinder (1986), Galí (1992), Bernanke and Mihov (1996), Christiano, Eichenbaum and Evans (1999). Most of them concentrated on identifying monetary policy shocks, its effects, and transmission mechanisms. Some of the exceptions include the work by Blanchard and Quah (1989), who used long-run restrictions to identify supply and demand shocks and decompose GDP into a permanent trend and a transitory or cyclical component. Also, Clarida and Galí (1994) identified the sources of real exchange rate fluctuations. More recently, Blanchard and Perotti (2002), Perotti (2002), Fatás and Mihov (2001) and Mountford and Uhlig (2002) used VARs to identify fiscal policy shocks and quantify their consequences.<sup>1</sup>

This article takes advantage of such recent developments by applying them to new data sets from two developing countries: Chile and Colombia. Previous studies addressing the issue in Chile include Cerda, González and Lagos (2005), who find a negative effect of both public spending and taxes on GDP.<sup>2</sup> On the contrary, Franken, Lefort and Parrado (2006) find a positive effect using annual data. Lozano and Aristizabal (2003), the only paper the authors are aware of that addresses the issue in Colombia, find a positive relationship between taxes, expenditures, and output, which may indicate procyclicality of the Colombian fiscal policy.

Next section presents the most important features of recent fiscal policy in each country. The third section includes the econometric approaches. The fourth one presents the data and the estimation results. Section five concludes.

## 2. Recent fiscal policy

The purpose of explaining the main differences between the diverging experiences of Colombia and Chile is twofold: motivating the article and helping understand the econometric results obtained.

### 2.1 Chile

For centuries, austere and countercyclical behavior has been the recipe for long-lasting welfare, but countries seldom follow it in practice. It is even less

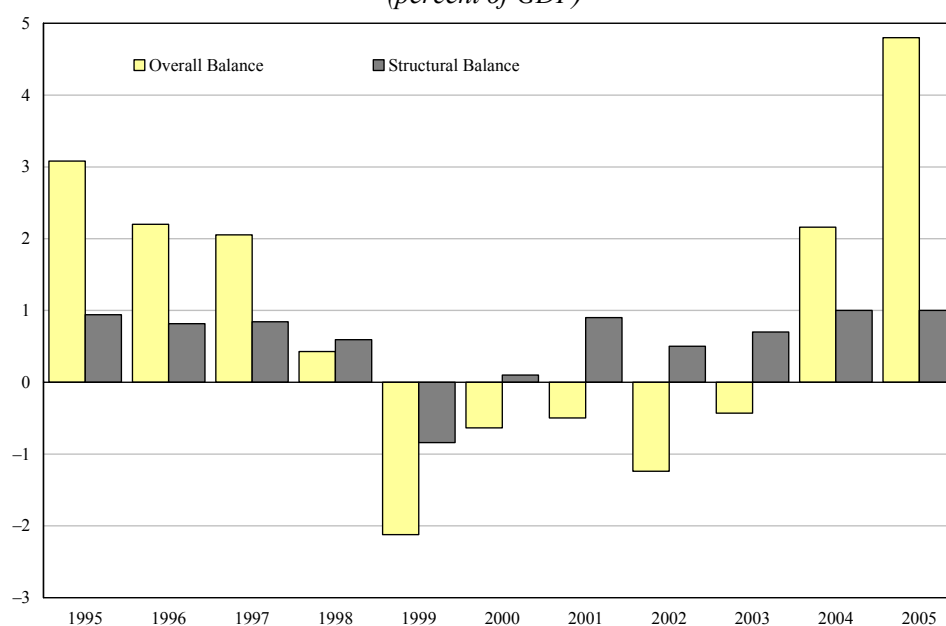
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<sup>1</sup> Stock and Watson (2001) present a survey on Vector Autoregressions (VAR). In addition Galí, López-Salido and Vallés (2006) present a modern theoretical model on the effects of government spending on consumption.

<sup>2</sup> Cerda, González and Lagos (2005) use a cash-based data set with fiscal variables produced by the government's payment office (Tesorería General de la República). On the contrary, our variables for Chile were provided by the Ministry of Finance's budget office (DIPRES) and built on accrual accounting.

Figure 1

**Chile: Central Government's Overall and Structural Balance**  
(percent of GDP)



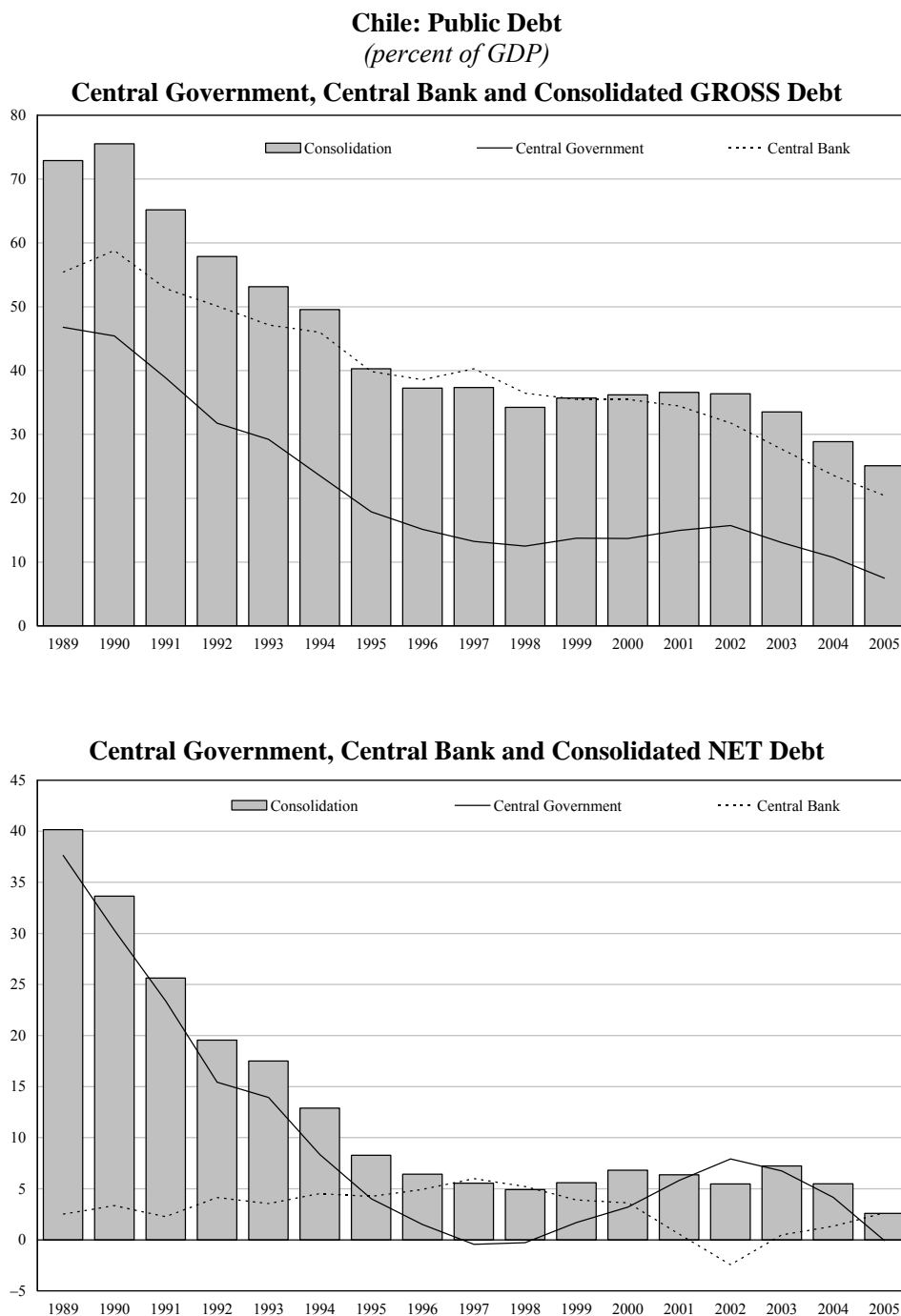
Source: Central Bank of Chile and Budget Office of the Ministry of Finance.

common among emerging commodity-exporting economies, which makes the case of Chile a remarkable exception.

Indeed, since the late Eighties through 1997, Chile ran consecutive fiscal surpluses, which were used to reduce public debt. While in 1990 central government's gross debt amounted to around 40 per cent of GDP, at the end of 1998 it was less than 13 per cent. The economy grew at a fast pace, with annual GDP growth averaging more than 7 per cent between 1990 and 1997. In 1998, after being hit by the Asian crisis, the economy slowed down, and the fiscal accounts began showing moderate deficits. Government debt increased to 16 per cent in 2002 (Figures 1 and 2).

In 2004, the international copper price increased sharply, raising the revenues of the state-owned copper company CODELCO and with them, the transfers to the central government. The economy picked up, and deficits turned into surpluses again. This time, fiscal policy was formally made countercyclical with a fiscal rule that was put in place in 2001. At that time, the Minister of Finance decided that the central government's overall annual balances should be of a 1 percent structural surplus with respect to GDP. More specifically, spending was pegged to structural

Figure 2



Sources: Central Bank of Chile and Budget Office of the Ministry of Finance (2006).

(cyclically-adjusted) revenues in order to generate a 1 percent structural surplus. Both tax revenues and profits transferred from the public copper company are cyclically adjusted. A very significant feature of this adjustment in terms of credibility is that potential (trend) GDP and the long-run price of copper are estimated every year by two groups of independent and well recognized experts. In summary, the rule signaled a prudent fiscal policy while retaining some flexibility (García, García and Piedrabuena, 2005).

Current Chile's fiscal surpluses are used to build assets and prepay debt, which dropped again to 7.5 per cent of GDP at the end of 2005, over 30 GDP percentage points less than in 1990. The consolidated gross debt (central government and central bank) fell from 75 per cent of GDP in 1990 to 25 per cent in 2005. The profile of net debt was similar: in 1990 net debt amounted to 34 per cent, and declined dramatically to become negative in 1997 ( $-0.4$ ). After a moderate transitory growth between 1998 and 2003, net debt declined again, to reach  $-0.1$  per cent of GDP in 2005 (Figure 2).

Finally, it should be stressed that in Chile, public debt figures usually consolidate the central government and the central bank, because most domestic public debt is on the balance sheet of the central bank. The central bank issued debt during the early Eighties in order to finance the rescuing of the banking system, and at the beginning of the Nineties to finance the accumulation of foreign reserves (Figure 2).

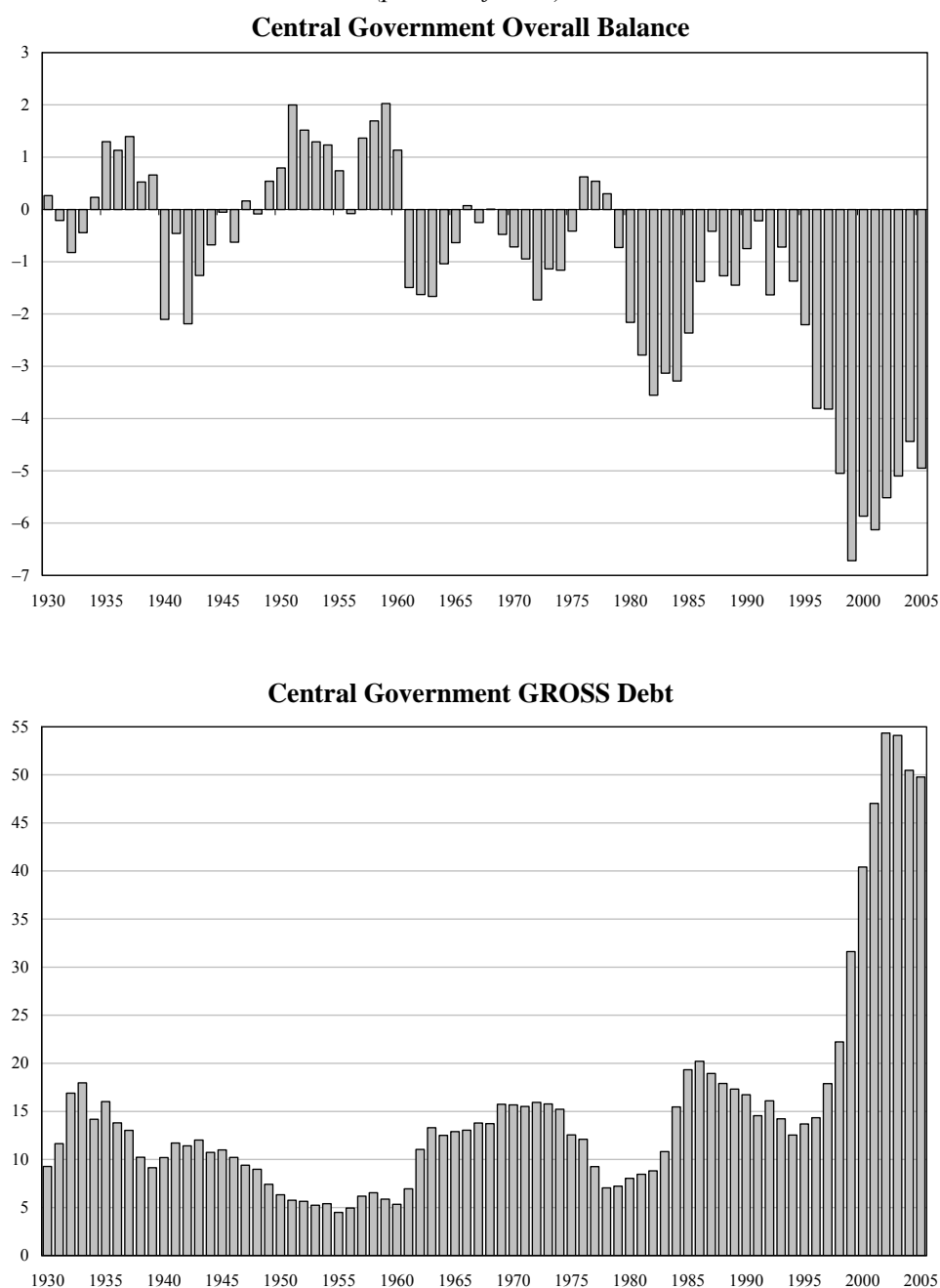
## 2.2 Colombia

For decades, fiscal policy in Colombia was very prudent, with the deficit following business cycles, *i.e.* exhibiting modest deficits (surpluses) during downturns (booms). Both the tax burden and the size of government were small relative to international standards, which resulted in a weak government that did not provided enough public services to match the society's requirements. For instance, the Colombian tax burden was around 10 per cent between the Fifties and the Nineties and the government's size was around 20 per cent in the same period.

During the Nineties and the early 2000s, this picture totally changed. Spending ballooned, with expenditures growing faster than tax revenues. Indeed, by 2002 tax income had increased by 5 GDP percentage points while the government had doubled in size. With respect to the former, ten tax reforms were completed between 1990 and 2002. Expenditures increased to take care of additional responsibilities prescribed by the new constitution (issued in 1991) and several laws ("social spending" and institutional strengthening), to cover increasing pension payments, military expenses, and the growing burden of interest payments on public debt. On top of that, at the end of the Nineties the Colombian economy suffered the deepest recession in almost a century (real GDP fell  $-4.2$  per cent in 1999). Although taxes were also increased, revenues were unable to match expenditures, generating large deficits and building up public debt in an unsustainable trend. As a

Figure 3

**Colombia: Central Government Balance and Debt**  
(percent of GDP)



Source: Junguito and Rincón (2004).

matter of fact, the central government gross debt jumped from around 17 per cent of GDP in 1990 to 54 per cent in 2002 (Figure 3).

In 2005, the fiscal situation of the non-financial public sector had improved as a result of a fiscal adjustment program,<sup>3</sup> the oil prices hike,<sup>4</sup> the accumulation of pension reserves, and the recovery of the economy, which regained its historical growth rate of 5 per cent. At the end of 2005 the tax burden amounted to 20 per cent of GDP, the non-financial public sector size was 35 per cent and the gross debt 55 per cent. Therefore, the Colombian fiscal situation has improved, but much more needs to be done to solve the structural fiscal problem of the central government.

### 2.3 Institutional differences

According to García, García and Piedrabuena (2005), the implementation of such a sound fiscal policy in Chile has been possible thanks to a set of institutional factors:

- a) the spending initiative is the responsibility of the Ministry of Finance, *i.e.* Congress can only reduce – not increase – expenditures included in the budget proposal;
- b) municipalities cannot issue debt unless authorized by the government;
- c) the Constitutional Law grants independence to the central bank and forbids it to finance the government even indirectly;
- d) the tax burden is moderate and a large share of spending goes to social programs;
- e) since banking crises usually become also public finance mishaps, as was the case in 1982, Chile substantially improved prudential regulation and supervision, keeping this source of fiscal risk under control;
- f) the Chilean budget process is determined once a year and is seldom modified.

Below is a comparison of these points:

- a) In Colombia, the Ministry of Finance also has the spending initiative. Therefore, we have to look for differences between both countries elsewhere. The most salient examples are:
- b) Municipalities contributed significantly to the increase in public debt during most of the Nineties in Colombia. For the sake of improving public finances, their ability to issue debt started to be significantly restricted after 2000.
- c) The central bank of Colombia may face more political pressure than its Chilean counterpart due to the process of appointment of the Monetary Board, and, in particular, from the fact that the Minister of Finance chairs the committee with

<sup>3</sup> The adjustment program was implemented since the end of the Nineties under IMF supervision, which included additional tax reforms, expenditure cuts both at the national and sub national levels, pension reform, government downsizing, and privatizations.

<sup>4</sup> Colombia is a medium-sized oil exporter and the government owns the oil resources through a public company (ECOPETROL).

full rights.<sup>5</sup> In fact, the tenure of the Board's members, those members different from the minister and the bank's president, lasts for a twice renewable four-year term. Since the President of Colombia appoints them, he decides who will continue and who will be replaced. Therefore, it is the case that always some members of the board take part, as candidates, in the process of appointment. In Chile, each of the members of the Monetary Board is appointed for a precisely defined ten-year period with only one member being replaced every two years. Besides, the Minister of Finance may attend the meetings of the Board with the right to speak but not to vote.<sup>6</sup>

- d) While the non financial public sector tax effort in Colombia is slightly smaller (20 per cent) than in Chile (21 per cent), the spending requirements are larger, after growing abruptly to finance the rights warranted by the Constitution of 1991, and the decentralization process.<sup>7</sup> Indeed, while the government has to transfer a material portion of its revenues to the regions, decentralization has led to a significant degree of duplication of functions between the central government and the regions.
- e) In fact, spending is extremely rigid given that around 90 per cent of it cannot be adjusted. Moreover, the public debt is so large now that the central government's debt service accounts to 63 per cent of its tax revenues. In addition, pensions' expenses represent about 6 per cent of GDP currently.<sup>8</sup> To top it off, since 1990 military spending has gone up around 3 GDP percentage points to reach 5 per cent of GDP in 2005, due to the ongoing domestic conflict. It is worth noticing that military spending in emerging economies has a weak macro impact, given that a large share of it is used to import weapons.<sup>9</sup>
- f) The latest financial crisis in Colombia is as recent as the end of the Nineties (1998 and 1999). The government had to take control of several institutions committing public resources to rescuing them, which indicates that prudential financial regulation and supervision was not as developed as desired.
- g) Finally, the budget process in Colombia is less predictable, as there are frequent intra year additions to the budget combined with nearly one tax reform approved every other year, that is, the government cannot honor its commitments.

<sup>5</sup> Of course, the Minister of Finance has more objectives than price stability.

<sup>6</sup> In Chile, the Minister has the right to veto the decisions for a two-week period at most, but it can be revoked by the unanimous decision of the Board's members. In addition, the Minister of Finance plays no role in the agenda of the meetings.

<sup>7</sup> The central government tax burden is 15 per cent in Colombia and 19 per cent in Chile.

<sup>8</sup> Chile moved to a fully-funded pension system in 1980; at that time the government issued pension bonds acknowledging a debt with the workers, who had contributed to the old system. The outstanding pension bonds will only amount to around 10 per cent of GDP by the end of 2006. In contrast, Colombian pensions' debt is substantial. The net present value of the public pension debt amounts to at least 150 per cent of GDP, despite the fact that Colombia moved partially to a funded system since 1993.

<sup>9</sup> A significant portion of public spending also goes to social programs, health and education.

In summary, as opposed to Chile, lack of stability and credibility of fiscal policy in Colombia translates into a weak macro impact and reduced ability to use it as a stabilizer or a countercyclical tool.

### 3. Econometric approaches

This section describes the strategies used to estimate the effects of fiscal policy on economic activity.

#### 3.1 Structural VAR

We rely on the recent approach to identifying fiscal shocks developed by Blanchard and Perotti (2002) and Perotti (2002). Their approach is closely related to the one put forward by Bernanke and Mihov (1996) in order to identify monetary policy.

As usual, the strategy to isolate the structural shocks in a VAR consists of imposing restrictions based on economic theory and the behavior of policy makers. This largely used approach allows the identification of genuine shocks that hit the economy and in many cases the parameters of government reaction function as well. In our case study, the specification of the model is, for simplicity, presented as a first-order structural VAR (SVAR).<sup>10</sup>

$$T_t = a_{13}Y_t + d_{11}T_{t-1} + d_{12}G_{t-1} + d_{13}Y_{t-1} + b_{12}\varepsilon_t^G + \varepsilon_t^T$$

$$G_t = a_{23}Y_t + d_{21}T_{t-1} + d_{22}G_{t-1} + d_{23}Y_{t-1} + b_{21}\varepsilon_t^T + \varepsilon_t^G$$

$$Y_t = a_{31}T_t + a_{32}G_t + d_{31}T_{t-1} + d_{32}G_{t-1} + d_{33}Y_{t-1} + \varepsilon_t^Y$$

where  $T$  refers to net taxes,  $G$  corresponds to government spending on wages, goods and services and investment, and  $Y$  is real GDP. In matrix form, the SVAR is expressed as:

$$A \quad X_t = D \quad X_{t-1} + B \quad \varepsilon_t$$

$$\begin{bmatrix} 1 & 0 & -a_{13} \\ 0 & 1 & -a_{23} \\ -a_{31} & -a_{32} & 1 \end{bmatrix} \begin{bmatrix} T_t \\ G_t \\ Y_t \end{bmatrix} = \begin{bmatrix} d_{11} & d_{12} & d_{13} \\ d_{21} & d_{22} & d_{23} \\ d_{31} & d_{32} & d_{33} \end{bmatrix} \begin{bmatrix} T_{t-1} \\ G_{t-1} \\ Y_{t-1} \end{bmatrix} + \begin{bmatrix} 1 & b_{12} & 0 \\ b_{21} & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \varepsilon_t^T \\ \varepsilon_t^G \\ \varepsilon_t^Y \end{bmatrix}$$

<sup>10</sup> In the estimation process the “true” value of the order of the VAR should be determined.

From the last system of equations, it follows that the reduced-form VAR is equal to  $X_t = A^{-1}DX_{t-1} + A^{-1}B\varepsilon_t$  or, equivalently, to  $X_t = FX_{t-1} + u_t$ , where  $X_t$  is the vector  $[T, G, Y]'$  of variables and  $F = A^{-1}D$ :

$$\begin{bmatrix} T_t \\ G_t \\ Y_t \end{bmatrix} = \begin{bmatrix} 1 & 0 & -a_{13} \\ 0 & 1 & -a_{23} \\ -a_{31} & -a_{32} & 1 \end{bmatrix}^{-1} \begin{bmatrix} d_{11} & d_{12} & d_{13} \\ d_{21} & d_{22} & d_{23} \\ d_{31} & d_{32} & d_{33} \end{bmatrix} \begin{bmatrix} T_{t-1} \\ G_{t-1} \\ Y_{t-1} \end{bmatrix} +$$

$$\begin{bmatrix} 1 & 0 & -a_{13} \\ 0 & 1 & -a_{23} \\ -a_{31} & -a_{32} & 1 \end{bmatrix}^{-1} \begin{bmatrix} 1 & b_{12} & 0 \\ b_{21} & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \varepsilon_t^T \\ \varepsilon_t^G \\ \varepsilon_t^Y \end{bmatrix}$$

Therefore, the reduced-form innovations are a linear combination of the structural shocks,  $u_t = A^{-1}B\varepsilon_t$ , where the innovations of the reduced-form VAR can be represented by:

$$\begin{bmatrix} u_t^T \\ u_t^G \\ u_t^Y \end{bmatrix} = \begin{bmatrix} 1 & 0 & -a_{13} \\ 0 & 1 & -a_{23} \\ -a_{31} & -a_{32} & 1 \end{bmatrix}^{-1} \begin{bmatrix} 1 & b_{12} & 0 \\ b_{21} & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \varepsilon_t^T \\ \varepsilon_t^G \\ \varepsilon_t^Y \end{bmatrix}$$

As stated above, in order to recover the structural shocks in vector  $\varepsilon$ , that is,  $[\varepsilon_t^T, \varepsilon_t^G, \varepsilon_t^Y]'$ , and the structural coefficients, once the reduced form VAR is estimated, it is necessary to impose restrictions coming from economic theory and intuition on the relationship between the innovations  $U$  and the structural shocks  $\varepsilon$ .

In this particular strategy, several coefficients were estimated and imposed to the factorization matrix. Indeed, the elasticity of taxes to output  $a_{13}$  allows computing the cyclically-adjusted tax residuals, which are used as instruments to estimate the effect of taxes  $a_{31}$  and government spending  $a_{32}$  on GDP. The effect of output on government spending within the quarter was assumed to be null,  $a_{23} = 0$ . In other words, fiscal authorities do not adjust spending based on the same period's performance of the economy (output growth). Finally, we assumed that within the quarter there is no effect of a structural shock to spending on tax innovations, that is  $b_{12} = 0$ , leaving  $b_{21}$  to be estimated. Alternatively, it could be assumed that within the quarter a tax structural shock has no effect on spending innovations, that is  $b_{21} = 0$ . Both coefficients could also be estimated.

### 3.2 Structural VEC

The second econometric procedure used in this paper is a SVEC following Johansen and Juselius (1990), King *et al.* (1991), Jacobson *et al.* (1997), and Breitung *et al.* (2004). Firstly, tests for cointegration *à la* Johansen are carried out. As it is well known, it consists of a full information maximum likelihood estimation of a system characterized by  $\Pi$  cointegrating vectors. Secondly, in case cointegration exists, a SVEC procedure will be used.

Error-correction estimation is called for when the variables included in the system are nonstationary and cointegrated. In other words, there is a long-run stable relation among them. As will be clear in the next section, the tests performed point out to the existence of such a relationship among the Colombian time series. In that case, a VAR would not be the correct specification, because an error correction term would be missing from the estimated reduced-form VAR. For that reason, the model should take into account that the variables are cointegrated and include the previous period deviation from equilibrium,  $\Pi X_{t-1}$ , in order to identify correctly the dynamics of the system after any shock.

The reduced-form of a first-order VEC can be written as:  $\Delta X_t = \Pi X_{t-1} + \Gamma \Delta X_{t-1} + \eta_t$ , where the forecast errors are:  $\eta_t = A^{-1}B\varepsilon_t$ . In this case, the structural system SVEC would be:  $A\Delta X_t = A\Pi X_{t-1} + A\Gamma \Delta X_{t-1} + B\varepsilon_t$ . Similarly to the SVAR procedure, several restrictions should be imposed to the  $A$  matrix in order to identify the structural shocks and coefficients.

## 4. Data and estimations

The quarterly data for Chile covers the period from 1989:1 through 2005:4 for the central government. The source for both taxes and spending of the central government is the Ministry of Finance of Chile. GDP comes from the national accounts produced by the Central Bank of Chile. In the case of Colombia, the series include quarterly data between 1990:1 and 2005:2 of the non-financial public sector and GDP, and are taken from the Ministry of Finance and the central bank (Banco de la República), respectively. Taxes are net of subsidies and grants, interest payments, social security payments and capital transfers. Government spending includes wages and salaries, goods and services and investment. In other words, we use taxes net of transfers and interest payments, and government spending does not include transfers either. Variables of interest are expressed all as logs of their real value.<sup>11</sup> Figure 7 in the Appendix depicts the main variables.

<sup>11</sup> Variables defined in per capita terms were also used, but results did not change significantly. Here we report only those results in real terms.

Table 1

Unit Roots Tests<sup>(1)</sup>

Variable <sup>(2)</sup>	$\tau^{(3)}$	ADF <sup>(4)</sup>	
		Levels	First difference
<b>Chile</b>			
<i>t</i>	$\tau_u =$	-2.92	-11.52**
<i>g</i>	$\tau_u =$	-0.92	-11.95**
<i>y</i>	$\tau_u =$	-2.48	-8.06**
<i>tt</i>	$\tau_u =$	-2.52	-6.59**
<b>Colombia</b>			
<i>t</i>	$\tau_u =$	-1.72	-6.92**
<i>g</i>	$\tau_u =$	-2.75	9.30**
<i>y</i>	$\tau_u =$	-1.62	-3.56**
<i>tt</i>	$\tau_\tau =$	-4.90**	-

<sup>(1)</sup> Output from Eviews.

<sup>(2)</sup> Variables are in logs of their real or deflated value.

<sup>(3)</sup> Test  $\tau_u$  is the statistics  $\tau$  of a regression that includes an intercept and  $\tau_\tau$  is the one that includes an intercept and a trend. The symbols \* and \*\* indicate statistical significance at the level of 5 and 1 per cent, respectively.

<sup>(4)</sup> The  $Q$  statistic was used for testing serial correlation and the Schwartz and Hannan-Quinn information criteria for choosing the lag length.

#### 4.1 Unit root tests

The standard augmented version of the Dickey-Fuller unit root test (referred to as ADF) was implemented in all series.

Table 1 shows the results of ADF tests for both the levels and the first differences of all the series. The null hypothesis of unit root cannot be rejected at 5 per cent level of significance for all series in levels (Table 1). Notice that we found that the terms of trade (*tt*) series, which is used as an exogenous variable in the estimations, is trend stationary in the case of Colombia. The null hypothesis is rejected for all variables in first differences, indicating that they are  $I(1)$  processes. Therefore, all variables are difference stationary for both countries with the only exception of the terms of trade for Colombia.

#### 4.2 Results and impulse responses from the SVAR

All impulse responses were transformed to obtain a peso for peso result. In other words, the multiplier shows how many pesos of GDP are generated by a peso

Table 2

## Contemporaneous Coefficients Estimated with TSLS

1. Dependent Variable: $\Delta T$	Coefficient	<i>t</i> -statistic	1990:1-2005:4
$\Delta Y$	$a_{13} = 3.03^{(1)}$	1.96	Elasticity of taxes to GDP
$\Delta T(-1)$	-0.28	-2.39	To capture tax structure
Dummies for tax reforms			
2. Dependent Variable: $\Delta Y$ residuals			1991:1-2005:3
$\Delta T$ _residuals	$a_{31} = -0.034$	-1.87	Effect of taxes on GDP
$\Delta G$ _residuals	$a_{32} = 0.165$	3.88	Effect of $G$ on GDP
Dummy			

<sup>(1)</sup>The elasticity obtained by Marcel, Tokman, Valdés and Benavides (2001) is much lower than the one obtained here with quarterly data similarly to what Blanchard and Perotti (2002) found.

of government spending.<sup>12</sup>

## Chile

The first estimation corresponds to the reduced-form VAR,  $X_t = FX_{t-1} + u_t$ , where, again,  $X = [T, G, Y]'$ . Since the estimated VAR should be stationary, the variables should be differenced, if it is not possible to reject the unit root hypothesis, or detrended, if they are trend stationary. Following Blanchard and Perotti (2002), three elements of the matrix of contemporaneous relations among the variables were estimated and imposed as restrictions for the identification of the SVAR (Table 2). In both cases we used two stage least squares (TSLS) for the estimation. In the first place, we estimated the within-the-quarter (short-run) elasticity of  $T$  to  $Y$ . The instruments included several lags of  $\Delta Y$  and  $\Delta T$ , the real exchange rate, and several dummies to take account of tax reforms implemented during the Nineties and in 2003, where  $\Delta$  represents the first-difference operator. Next, we estimated the within-the-quarter (short-run) effect of taxes and spending on  $Y$ , running a regression of the residuals of the  $\Delta Y$  equation, on the residuals of the  $\Delta T$  and  $\Delta G$

<sup>12</sup> The shock that hits the VAR in differences is of size 1. Thus the pesos for pesos response is

$$\frac{\Delta Y}{\Delta G} \approx \frac{Y_{t-1} * (\text{Response of } Y)}{G_{t-1} \cdot 1}, \text{ given that } \Delta \log G_t = 1 \approx \frac{G_t - G_{t-1}}{G_{t-1}} \text{ and}$$

$$\Delta \log Y_t = \text{Response} \approx \frac{Y_t - Y_{t-1}}{Y_{t-1}}.$$

equations, all taken from the respective equations of the reduced-form VAR. In this case, an instrument for the residuals  $T_{res}$  of the  $\Delta T$  equation was built by subtracting from them its cyclical component:  $T^* = T_{res} - a_{13}Y$ . Thus, the adjusted variable  $T^*$  is not correlated with the error term of the regression. Other instruments include lagged values of the residuals of the  $\Delta Y$  and  $\Delta G$  equations (spending residuals), terms of trade and a dummy for 1998.

Thus, the identification of the system and impulse responses can be obtained once a sufficient number of restrictions are imposed. Besides running the SVAR with the estimated coefficients plugged into the  $A$  matrix, we also run a SVAR where the effect of  $G$  on  $Y$  ( $a_{32}$ ) is estimated endogenously, as well as the effect of tax shocks on spending innovations  $b_{21}$ . The outcome is very similar but the effect of spending on GDP is slightly larger. In this case,  $a_{32}$  is 0.195, which is larger than the result (0.165) obtained before (Table 2).

The impulse responses computed with Chilean data are consistent with economic intuition (Figure 4 A). Indeed, an increase of one Chilean peso in central government tax revenues has a transitory negative effect on GDP growth of 40 cents, at impact. On the other side, a one Chilean peso increase in real central-government spending has a transitory positive effect of \$1.9 Chilean pesos on real GDP growth, which is only significant at impact. In addition, government spending and output shocks have a positive transitory effect on net tax revenues.

The accumulated responses show that a shock to taxes has a small negative and transitory (one to two quarters) impact on the level of GDP (Figure 4 B). Afterwards, the response is not significantly different from zero.

The accumulated responses also show that the effect on the level of GDP of the one-peso shock to government spending is positive and lasts from two to three quarters. Afterwards, it is statistically non significant. The point estimation quickly stabilizes at a level of 1.37, which implies that one peso \$1 spent by the government generates 37 additional cents of GDP.

In addition, shocks to spending and output increase tax revenues. Therefore, an increase in spending is accompanied by the corresponding raise in taxes, implying sustainability. Tax increases do not result in higher spending however. This may reflect the sound fiscal policy followed in Chile, where the central government had surpluses in at least twelve out of the last sixteen years. In fact, some analysts claim that in the early Nineties, there was an implicit fiscal rule, which consisted in allowing government spending to grow less than GDP and government revenues.

Figure 4 A

Chile: Impulse Responses – Variables in Differences

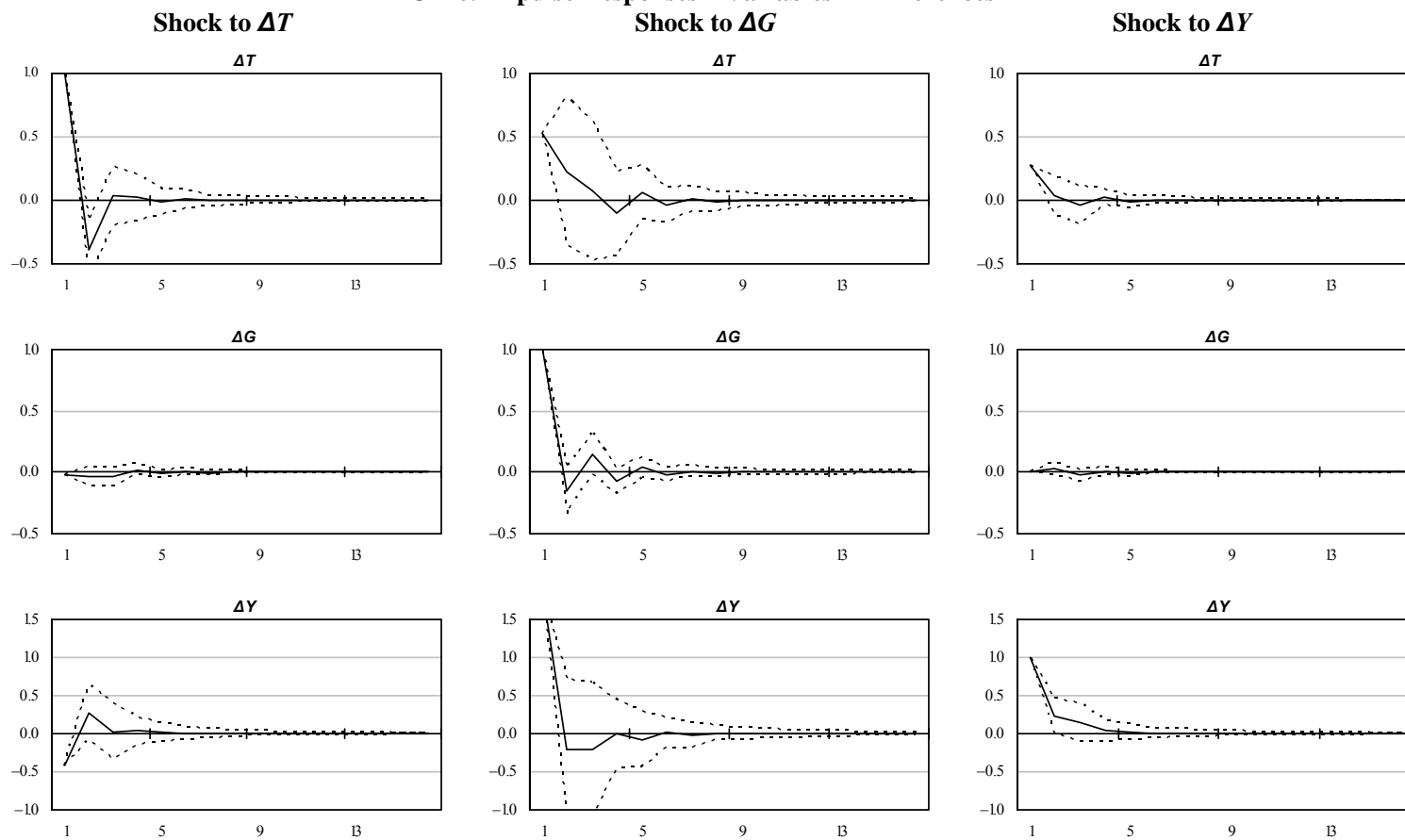
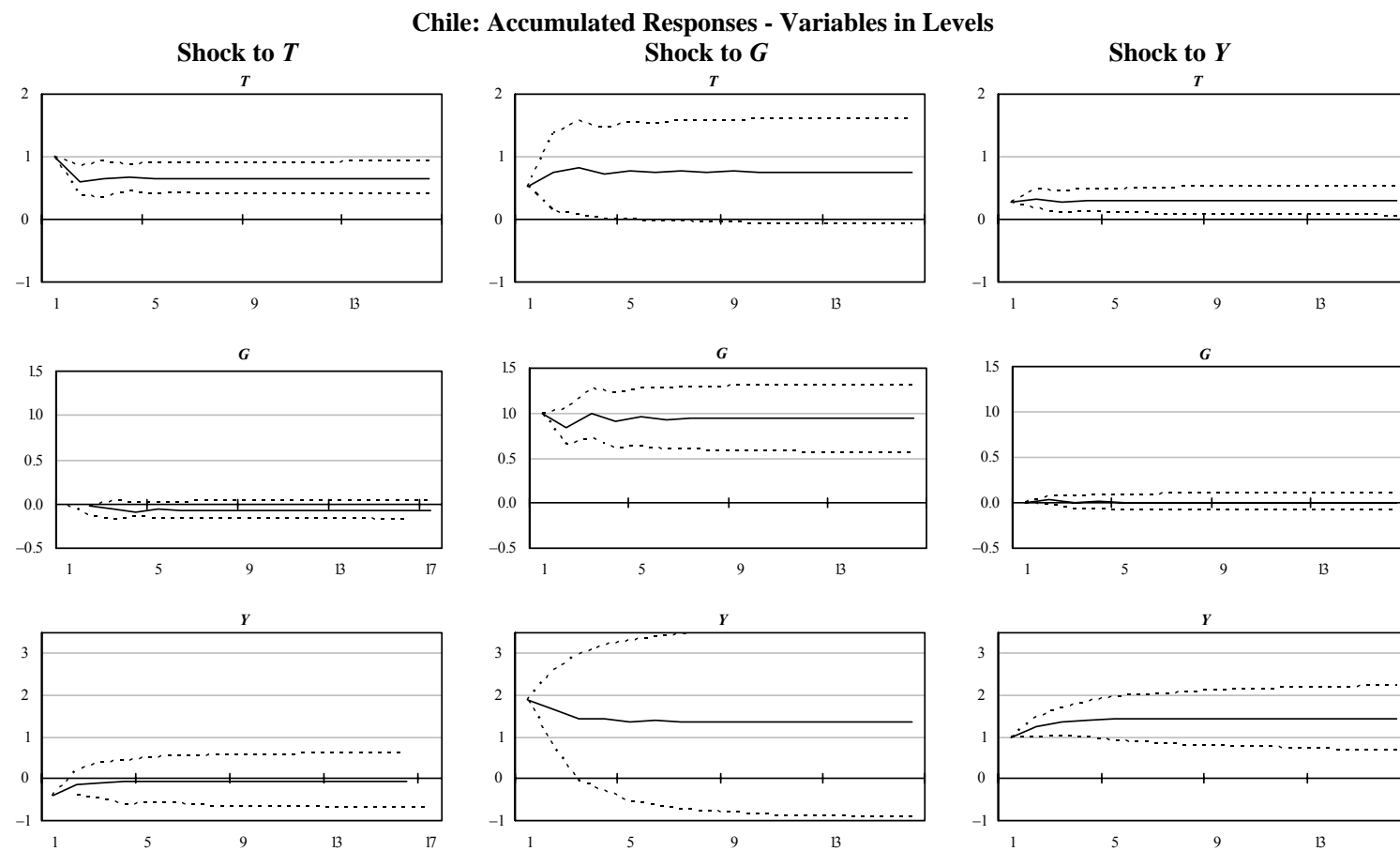


Figure 4 B



### Colombia

The same procedure was applied to the case of Colombia. The reduced-form VAR:  $X_t = FX_{t-1} + u_t$  and also the same three elements of the matrix of contemporaneous relations among the variables were estimated here (Table 3). Then, they were imposed as restrictions for the identification of the structural VAR. The instruments used in the estimation of the within-the-quarter (short-run) elasticity of  $T$  to  $Y$  were: lags of  $\Delta T$ ,  $\Delta Y$ , terms of trade, and the real exchange rate. Several dummies were also included to capture the tax structure. The coefficient of the elasticity is not significant and the same happens with the response of  $T$  to a shock on  $Y$ .

The within-the-quarter (short-run) effect of taxes and spending on  $Y$  (GDP) was estimated using the same procedure as for Chile. We ran a regression of  $\Delta Y$  residuals on the residuals of  $\Delta T$  (tax) and  $\Delta G$  (public spending) taken from the respective equations of the reduced-form VAR. The instruments used this time were the cyclically-adjusted residuals of the tax equation ( $T^c = T_{res} - a_{13} Y$ ), lags of GDP, and spending residuals, terms of trade, the real interest rate, and the real exchange rate. We used several dummies as well.

It is worth recalling here that the Nineties were turbulent in fiscal terms in Colombia. After decades of moderate deficits, fiscal accounts deteriorated dramatically to the point that in 1999 the deficit of the non-financial public sector

**Table 3**

**Contemporaneous Coefficients Estimated with TSLS**

<b>Dependent Variable <math>\Delta T</math></b>	<b>Coefficient</b>	<b>T_statistic</b>	<b>1990:4-2005:2</b>
$\Delta Y$	$a_{13} = \mathbf{1.87}$	0.7	Elasticity of taxes to GDP
$\Delta T(-1)$	-0.59	-5.03	
$\Delta T(-2)$	-0.29	-2.41	
Dummy 2001:4	-1.19	-31.9	
<b>Dependent Variable: <math>\Delta Y</math> residuals</b>			<b>1991:1-2005:2</b>
$\Delta T$ residuals	$a_{13} = \mathbf{0.002}$	0.52	Effect of taxes on GDP
$\Delta G$ residuals	$a_{13} = \mathbf{0.025}$	1.65	Effect of $G$ on GDP
$\Delta Y$ residuals(-1)	-0.24	-1.71	
Dummies			

reached 5.5 per cent of GDP, and that of the central government around 7 per cent.<sup>13</sup> The consolidated non-financial public sector deficit reached –0.8 per cent of GDP by the end of 2005. However, the central government is still running large deficits, –5 per cent of GDP.

The results obtained using Colombian data are unexpected with regard to the response of GDP to tax revenues and spending shocks (Figure 5 A). Output growth does not move significantly with the impact of a positive shock to taxes.<sup>14</sup> On the other hand, a shock to spending has a significant but small impact on output growth. In fact, an increase of one Colombian peso in public spending generates 12 cents of more output at impact.<sup>15</sup>

In the case of the accumulated responses, Figure 5 B shows that a shock to expenditures has no impact on taxes, consistently with the identification restrictions described above, and with recent history, given that spending has been financed to a large extent with debt. This result might indicate a non sustainable behavior of authorities. For instance, between 1996 and 2002 the non-financial public gross debt increased by 38 GDP percentage points. On the other hand, a positive shock to GDP increases tax revenues also in Colombia but only at impact. In addition, a shock to GDP has a positive effect on government spending, which could be interpreted as a sign of fiscal policy being procyclical: fiscal authorities spend more when the economy grows faster. Surprisingly, the effect of a spending shock on the level of GDP does not disappear as one would expect. It stabilizes at 17 cents of more output for one additional Colombian peso spent by the government.

#### 4.3 VEC Estimations

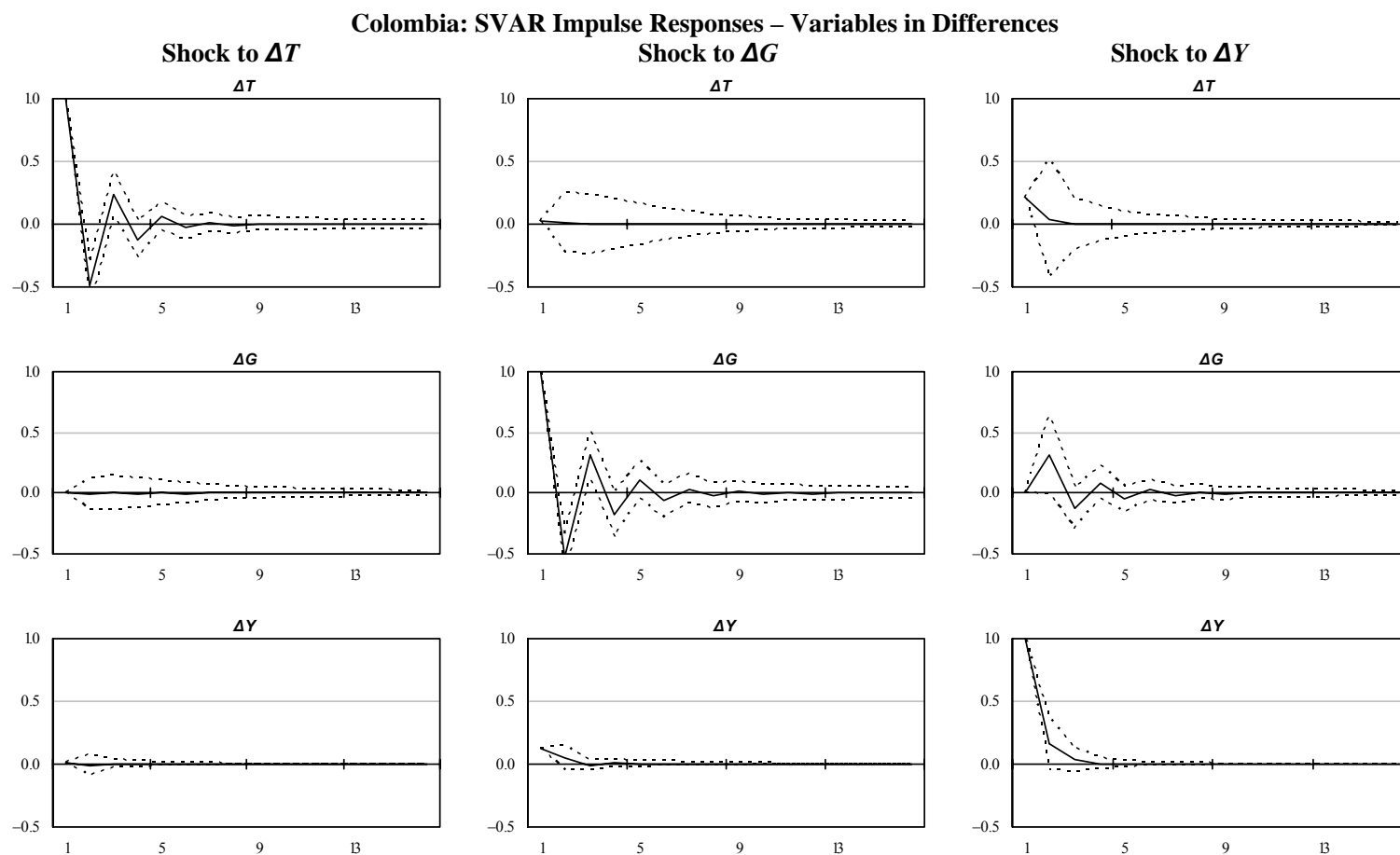
This section tests the hypotheses about the relationship between taxes, expenditures, and real GDP, and estimates a statistical model under the specification vector  $z_t = (t, g, y)_t$ . This vector is augmented with the terms of trade, which is an exogenous control variable, and a deterministic component into the cointegrating relationship. This section starts by testing whether the error-correction model representation of  $z$  (a *VECM representation*) correctly describes the structure of the data. Second, it tests if the matrix  $\Pi$  (using Johansen's notation) is of reduced rank. This test shows whether empirical evidence of cointegrating relations between the variables in the vector  $z$  exists.

<sup>13</sup> For decades, Colombian economic growth rates were among the highest and most stable in Latin America. However, in 1999 Colombian GDP had an unexpected fall of –4.2 percent.

<sup>14</sup> This result is noticeable. For that purpose, the Colombian government implemented almost one tax reform per year from 1998 to 2003.

<sup>15</sup> The size of the multipliers obtained in both Chile and Colombia could be taken into account in future fiscal policy analysis, including the possible calibration of economic models.

Figure 5 A



**Figure 5 B**

**Colombia: SVAR Accumulated Responses – Variables in Levels**

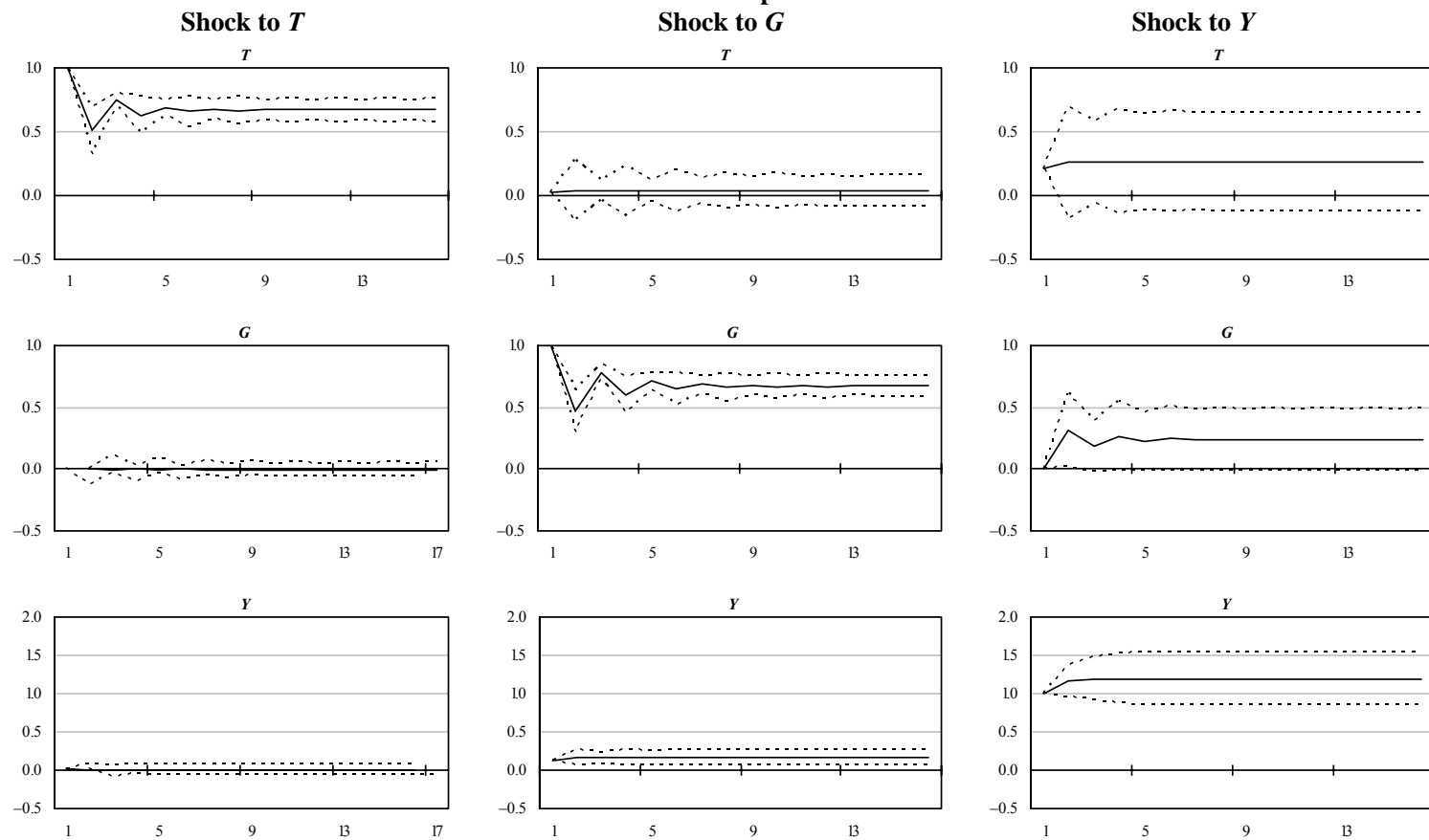


Table 4

Specification and Misspecification Tests<sup>(1)</sup>

Univariate Statistics			Multivariate Statistics		
Chile					
Equation	ARCH ( <i>k</i> )	Normality	Q ( <i>j</i> )	LM (4)	Normality
	<i>K</i> =2		<i>j</i> =16; 128.7 (p-val=.57)	12.3 (p-val=.20)	15.9 (p-val=.01)
$\Delta T_t$	1.00	8,79			
$\Delta G_t$	0.94	3.47			
$\Delta Y_t$	0.24	1.08			
Colombia					
Equation	ARCH( <i>k</i> )	Normality	Q( <i>j</i> )	LM(4)	Normality
	<i>k</i> =1		<i>j</i> =15; 153.6 (p-val=.10)	5.2 (p-val=.81)	15.6 (p-val=.02)
$\Delta T_t$	4.31	10.57			
$\Delta G_t$	6.96*	3.98			
$\Delta Y_t$	2.66	1.90			

<sup>(1)</sup> Output from CATS. *T* is the log of taxes in real terms, *G* is the log of public expenditures real terms, and *Y* is the log of the real GDP. All tests are asymptotically  $\chi^2$ -distributed. For univariate tests, \* means significance at the 5 per cent level. An exogenous variable measuring the terms of trade was included for each country.

## Specification and Misspecification Tests

One of the most critical parts of Johansen's procedure is determining the rank of matrix  $\Pi$  since the approach relies primarily on having a well-specified regression model. Thus, before any attempt to determine this rank or to present any estimation, the empirical analysis begins with specification and misspecification tests. They are used primarily to choose an 'appropriate' lag structure and to identify the deterministic components to be included in the model (e.g., whether or not to include an intercept in the cointegration space to account for the units of measurement of the endogenous variables, or to allow for deterministic trends in the data).

Once the lag structure and the deterministic component of the model are chosen, additional specification and misspecification tests are implemented. The first tests are multivariate tests for serial correlation (Ljung-Box Q test and Godfrey LM test) and normality (Hansen and Juselius, 1995). The second ones are a univariate type of test for autoregressive conditional heteroskedasticity (ARCH), normality

Table 5

Tests of Cointegration Rank<sup>(1)</sup>

Ho:	Ha:	$\lambda_{max}$	ACV (5%)	Ho:	Ha:	$\lambda_{Trace}$	ACV (5%)
<b>Chile</b>							
$r=0$	$r=1$	12.9	20.9	$r=0$	$r>0$	21.5	29.7
$r=1$	$r=2$	5.4	14.1	$r\leq 1$	$r>1$	8.6	15.4
$r=2$	$r=3$	3.2	3.8	$r\leq 2$	$r>2$	3.8	3.8
<b>Colombia</b>							
$r=0$	$r=1$	59.4*	20.9	$r=0$	$r>0$	75.2*	29.7
$r=1$	$r=2$	13.3	14.1	$r\leq 1$	$r>1$	15.2	15.4
$r=2$	$r=3$	2.5	3.8	$r\leq 2$	$r>2$	2.5	3.8

<sup>(1)</sup> Output from CATS. The test statistics have a small sample correction as suggested by Ahn and Reinsel (1990). It consists of using the factor  $(T - kp)$  instead of the sample size  $T$  in the calculation of the tests. The critical values are taken from Osterwald-Lenum (1992). "ACV" stands for Asymptotical Critical Values. The symbol \* means statistical significance at the 5 per cent level.

(Hansen and Juselius, 1995), and univariate serial correlation (Breusch and Godfrey test).

According to Table 4, the multivariate tests for serial correlation show that it is not present. They also show that the multivariate normality assumption fairly holds. The univariate tests are all met, except for heteroskedasticity in the case of the expenditures equation for Chile.

#### Finding the Rank of Matrix $\Pi$

Table 5 shows the tests of the rank of matrix  $\Pi$ . The null hypothesis of  $r = 0$  (no cointegration) is not rejected in favor of  $r = 1$  by either test at the 5 per cent level for the case of Chile. The null hypothesis of  $r = 1$  (or  $r \leq 1$  using the  $\lambda_{Trace}$  test) in favor of  $r = 2$  is not rejected by either test for this country. For the case of Colombia, one cointegration vector is found. Therefore, there is a long-run equilibrium relationship between tax revenues, public consumption, and real GDP for Colombia, but not for Chile.

It is worth mentioning that alternative specifications were run for Chile (excluding and including variables, and changing the lags of the VEC system) and the results of the tests changed significantly in some cases. The null hypothesis of no cointegration is rejected in some of them, that is  $T$  and  $Y$  might be cointegrated but the results of the tests are not as conclusive as desired. For completeness, however, we decided to also estimate a SVEC for Chile. No significant changes with respect to the SVAR findings were observed (the SVEC impulse responses for Chile are shown in the Appendix).

In conclusion, cointegration tests suggest that a VAR model may not be the correct specification for the case of Colombia, given that an error correction term would be missing from the estimated structural VAR. For that reason, the SVEC would be more appropriate since it takes into account that the variables are cointegrated and includes the error correction.

The results obtained by applying the SVEC procedure discussed above for Colombian data show again, that the response of GDP growth to a tax shock is nil, and to a spending shock is statistically significant but small (Figure 6 A).

It is worth pointing out that several results changed with respect to the ones obtained with the SVAR. For instance, a shock to spending had no impact on taxes (and vice versa), which was interpreted as a sign of a non sustainable fiscal policy, since spending should increasingly be financed with debt – as seem to be the case in Colombia from the second half of the Nineties onwards. However, this result changes when the model estimated is the SVEC, where the two shocks affect each other positively (Figure 6 B).

In fact, a shock to spending has now a significant and positive impact on taxes: one additional Colombian peso in public spending generates about 38 cents of more tax revenues. Conversely, an increase in taxes raises expenditures. If the country starts with a deficit, fiscal adjustment looks more difficult or, at least, will take longer, considering this result. Moreover, in the estimated SVAR impulse responses, a shock to GDP growth had a positive impact on public spending indicating a procyclical fiscal policy (Figure 5) but now, with the SVEC, this effect disappears (Figure 6). In this case the effect of spending on the level of GDP stabilizes at 14 cents – it does not disappear either.

In conclusion, when the estimated model for Colombia includes the error correction (SVEC), fiscal policy looks in better shape than it does with the SVAR model.

## **5. Conclusions**

SVAR and SVEC models were estimated for Chile and Colombia aiming at identifying fiscal policy shocks in both countries, using quarterly data over 1989:1 through 2005:4 and 1990:1 and 2005:2, respectively.

The main findings for Chile indicate that a one Chilean peso (\$1) increase in tax revenues has a transitory negative effect on GDP growth of 40 cents. On the other hand, a one peso increase in government spending has a transitory positive effect of \$1.9 pesos on real GDP growth, which stabilizes at 1.37 cents. In addition, government spending and output shocks have a positive transitory effect on net tax revenues. With respect to the accumulated effects, the most important result shows that shocks to spending and output increase tax revenues, which implies fiscal sustainability. However, tax increases or GDP growth shocks do not result in higher

Figure 6 A

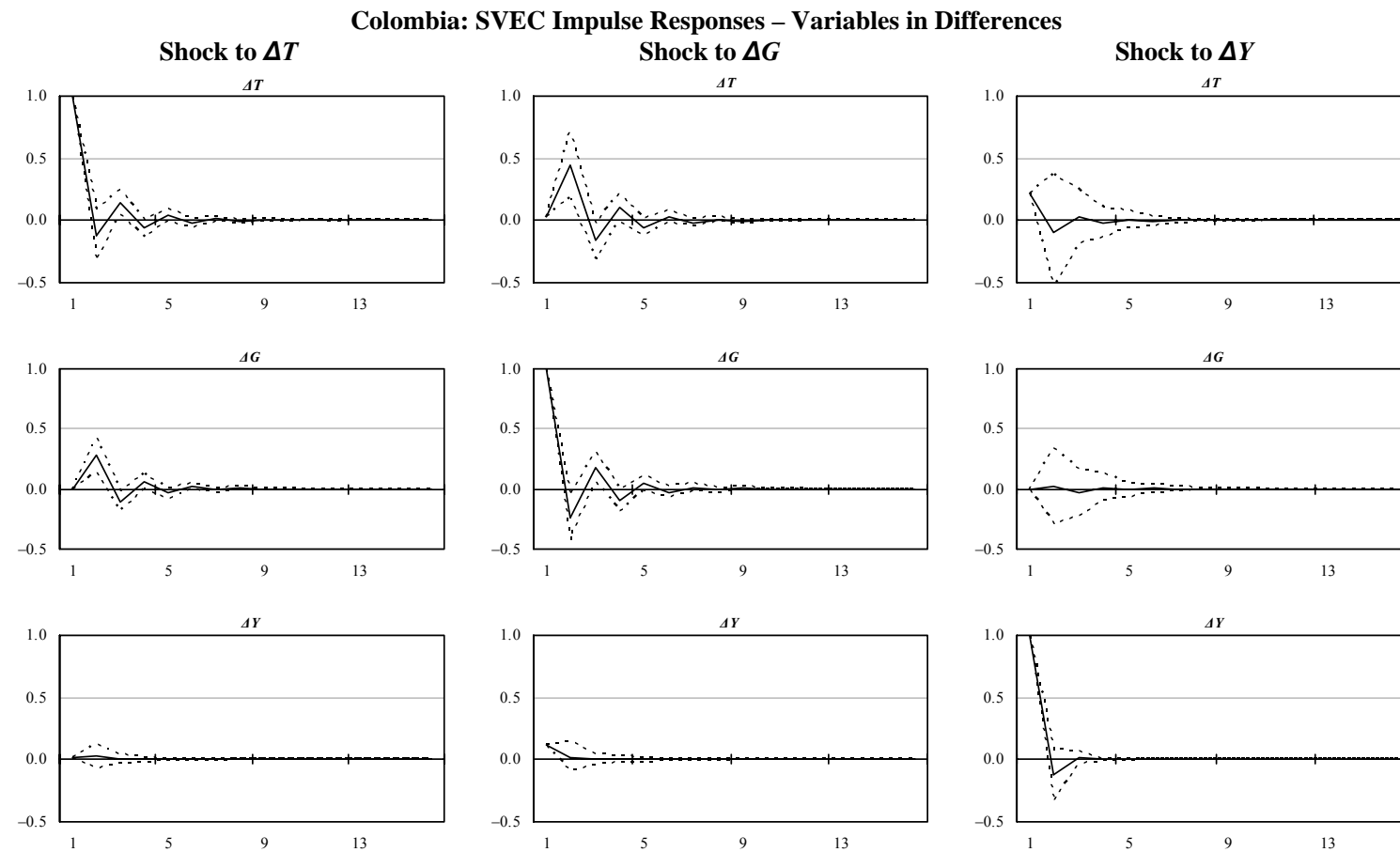
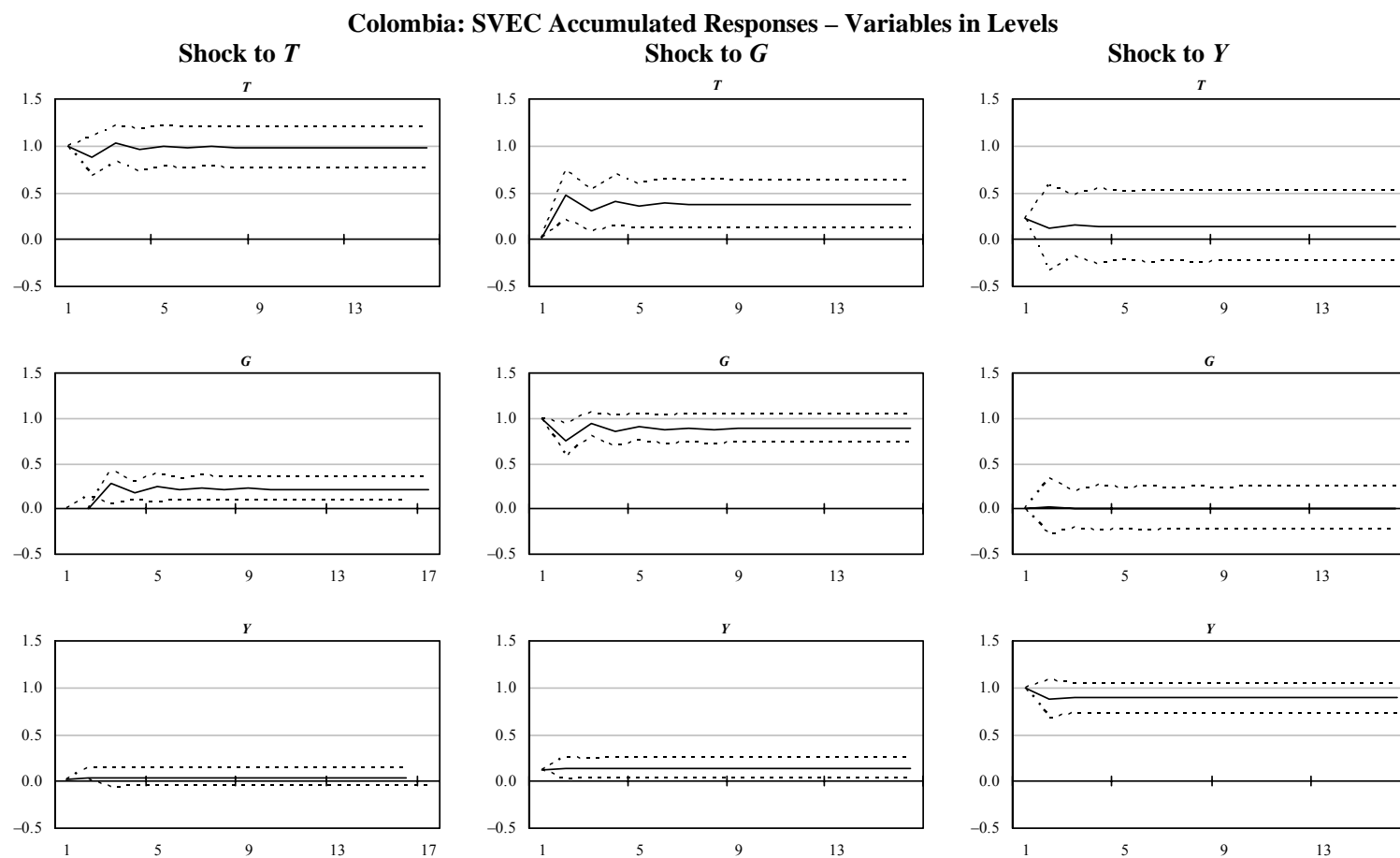


Figure 6 B



spending. This is consistent with the policy of running fiscal surpluses in place in Chile during most of the period considered.

On the other hand, some of the results obtained for Colombia are at odds with intuition at first sight. Indeed, a tax revenue hike has no impact on GDP and the effect of a spending shock is significant, but very small. A one peso increase in public spending translates, at impact, into a \$0.12 increase in the level of GDP and stabilizes at \$0.15 peso. The effect of a shock to GDP on taxes is not different from zero. Other results, change depending on the model estimated. As opposed to the SVAR, with the SVEC, tax and spending shocks affect each other positively, and GDP has no impact on public spending. In summary, fiscal policy in Colombia looks in a slightly better shape when the model estimated includes the error correction than when it does not.

The estimates provide a good notion of the effects of fiscal policy shocks in both countries. As an explanation for the differences found between them, we think that when public finances are under control, as is the case in Chile, fiscal policy is more effective, than when they lack stability and credibility as apparently is the case of Colombia from the mid-Nineties on.

As usually happens with empirical exercises, the analysis could be enriched by considering additional variables in the models, namely interest rates, consumption and investment. We leave it for future work.

## APPENDIX

**Figure 7**

**Chile: Observed Variables**  
(logs of 1996 million pesos)

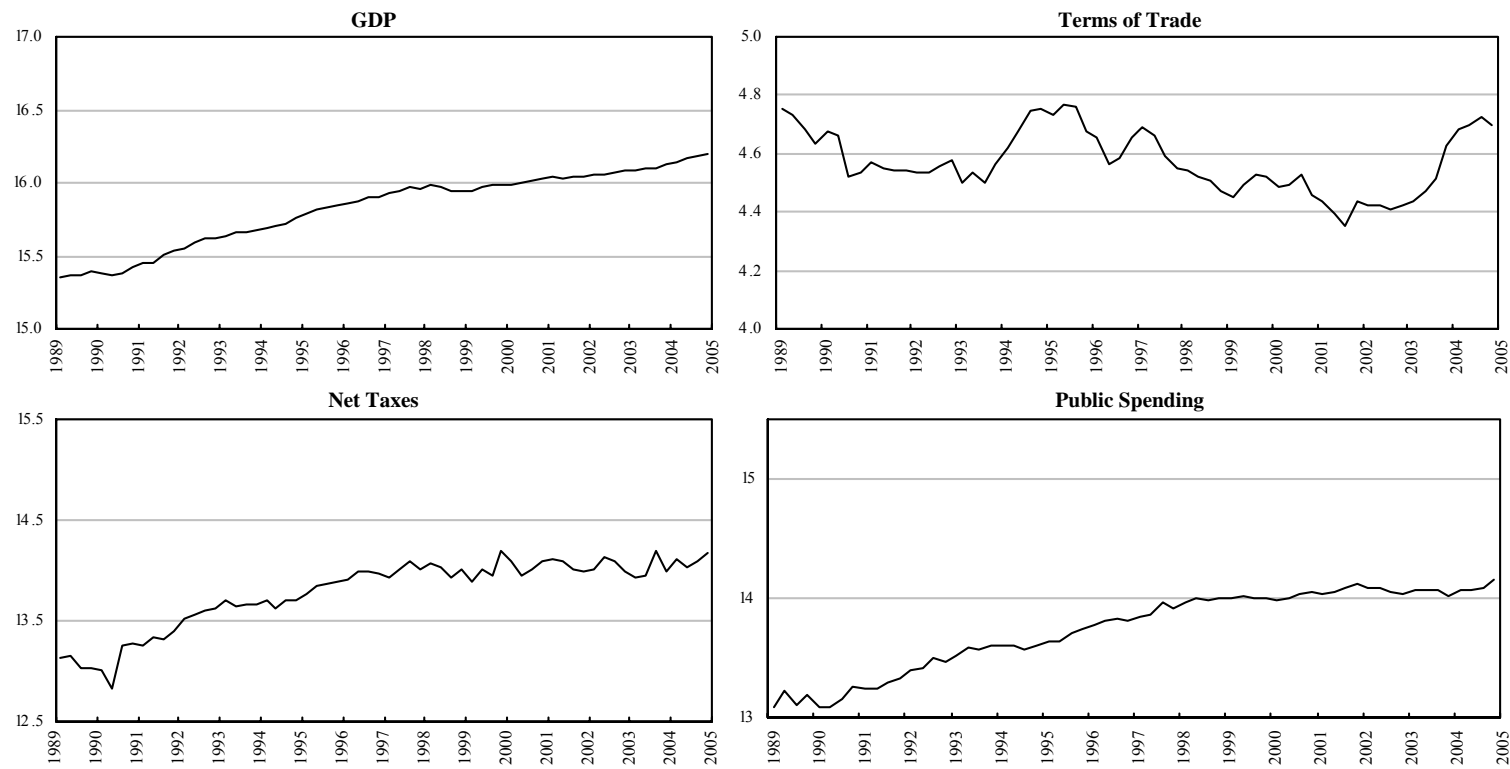


Figure 7 (continued)

Colombia: Observed Variables  
(logs of 1994 million pesos)

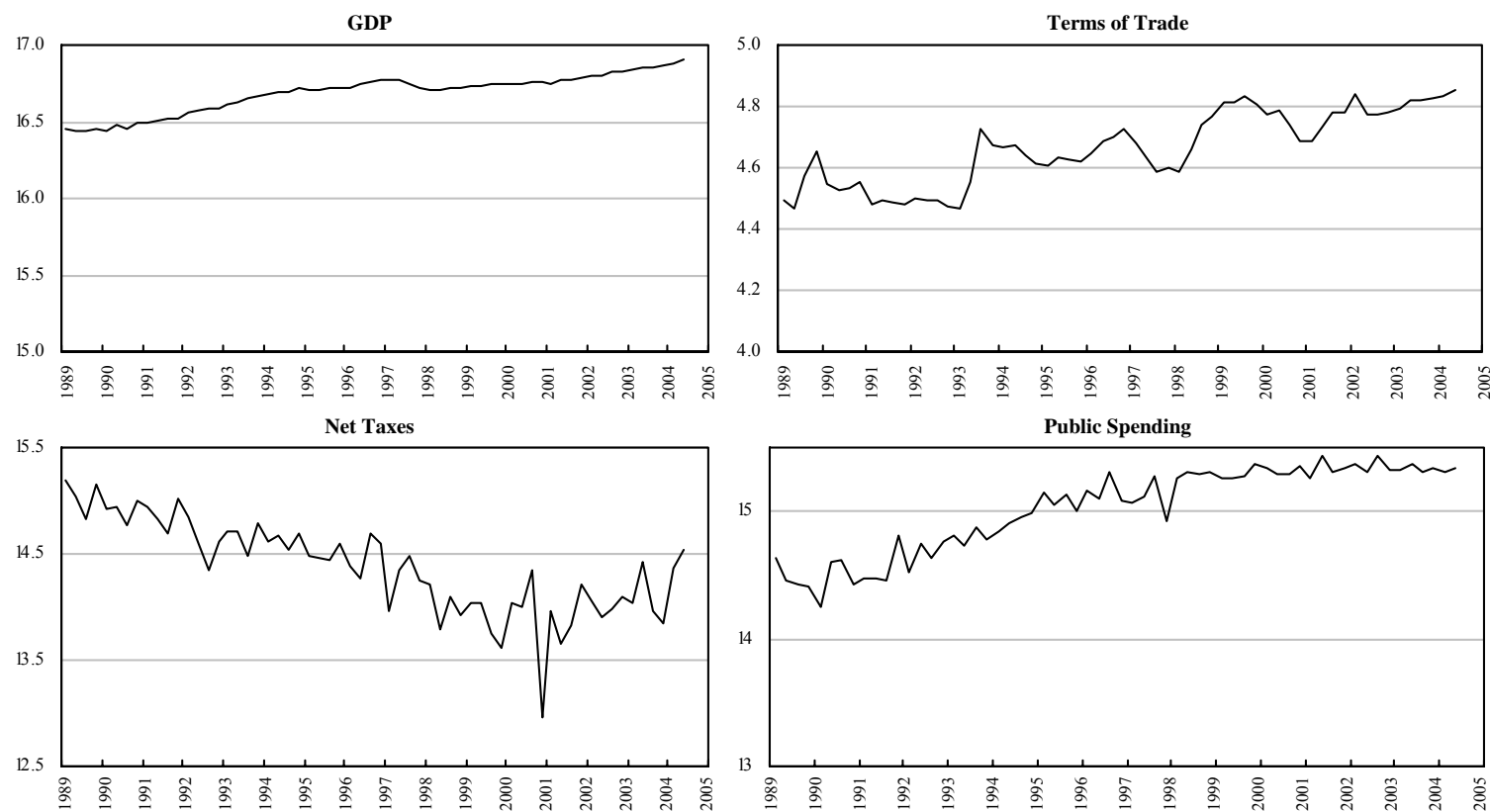


Figure 8

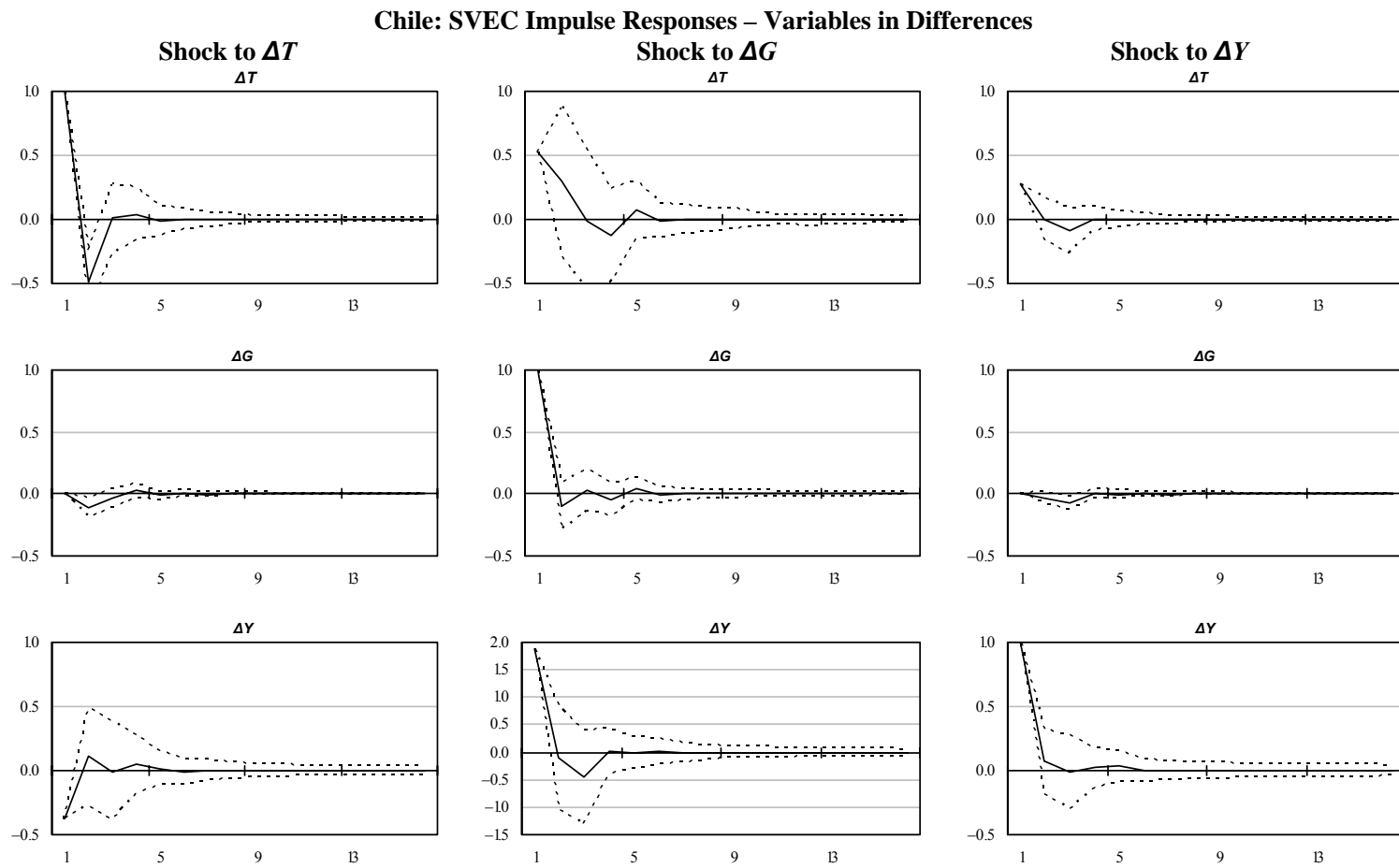
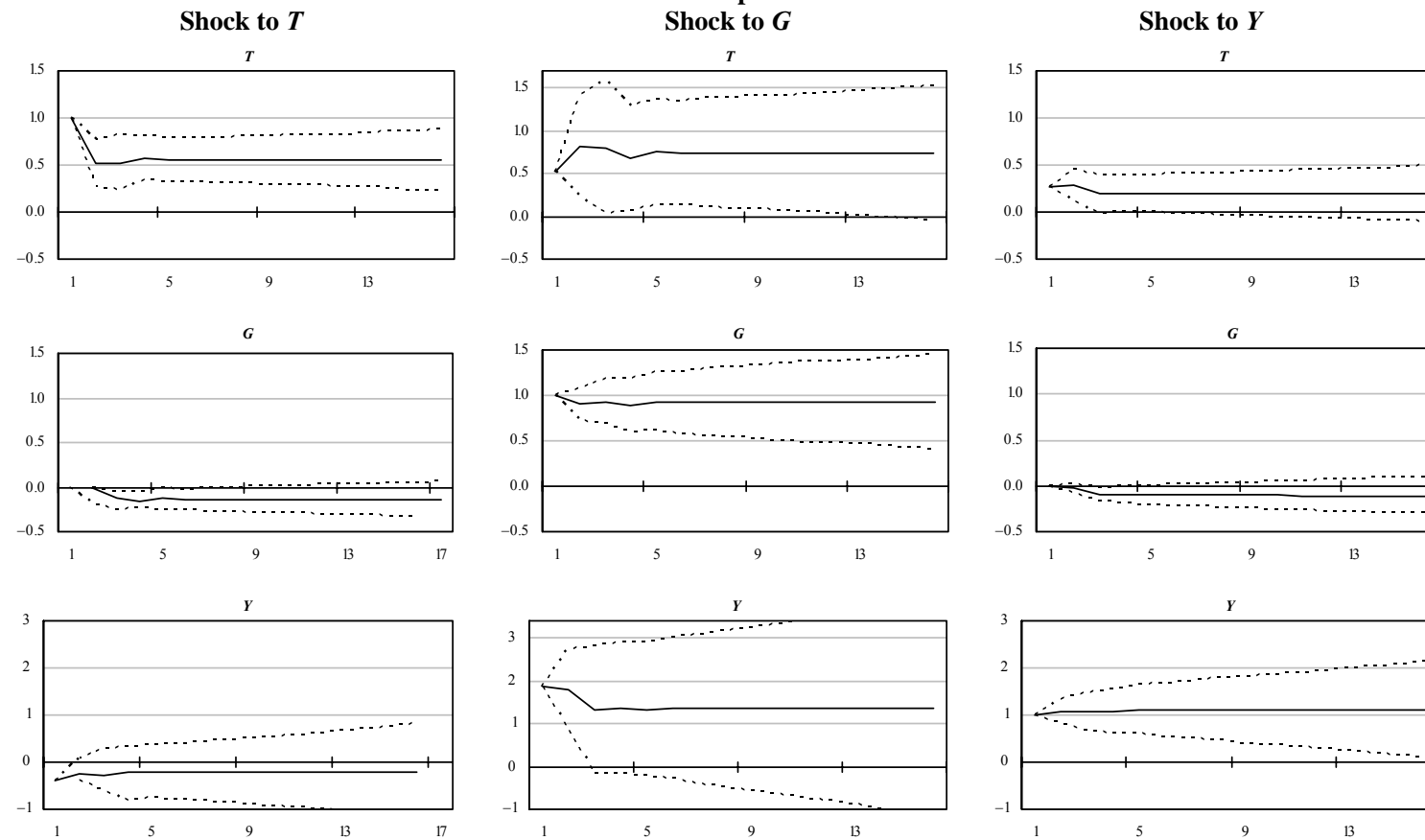


Figure 8 (continued)

## Chile: SVEC Accumulated Responses – Variables in Levels



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