EXPLAINING INFLATION AND OUTPUT VOLATILITY IN CHILE: AN EMPIRICAL ANALYSIS OF FORTY YEARS

Juan de Dios Tena[1] and Cesar Salazar[2]

Abstract

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We present a data oriented analysis of the effect of different kind of economic shocks on Chilean output growth and inflation over the last 40 years. Two important results are: (1) foreign shocks only explain 17% of the variability of the output growth in the period 1984-2006 whereas it used to account for the 47,2% of output variability in 1966-1983; (2) The participation of foreign shocks to explain the Chilean inflation reaction becomes more important in the last twenty years because of the price liberalization and Chile's openness to international trade. Results highlight specific features of the Chilean economy not present in other countries.

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[1] Corresponding Author. Juan de Dios Tena, Universidad Carlos III, Departamento de Estadística, C/Madrid 126. 28903 Getafe (Madrid), España, e-mail: jtena@est-econ.uc3m.es and Universidad de Concepción, Departamento de Economía, Victoria 471, (Concepción), Chile, email: juande@udec.cl .
[2] César Salazar, Universidad del Bio-Bio, Departamento de Economía y Finanzas, Av. Collao Nº 1202, Concepción- Chile, e-mail: cesalaza@gmail.com.

1. Introduction

This paper is a data oriented analysis of the effect of a number of fundamental shocks in Chilean output growth and inflation over the period 1966-2006. Although, researchers has shown an increasing interest in explaining the factors that accounts for the sudden decline in the output and inflation volatility to fundamental shocks in developed countries since the early 1980s[3], however similar studies are still scarce for developing countries.

Focusing our research on Chile is especially interesting because this allows for the analysis of the influence of trade openness on the aforementioned stabilization process. Three standard explanations already considered in the literature for the moderation of output and inflation are: (1) better monetary policy that helped to stabilize inflation, (2) better inventory management techniques that contributed to reduced output volatility, and (3) good luck in the form of smaller policy price shocks; see Summers (2005). Additionally to these factors, Chile has experienced a trade openness process in the 1990s.

There is a mixed evidence of the effect of trade openness on macroeconomic volatility. For example, Bejan (2004) and Easterly et al. (2001) find a positive output volatility and trade openness correlation. On the other hand, results in Cavallo and Frankell (2004) suggest that trade openness makes countries less vulnerable to international shocks.

An important difference between our work with this previous literature is that we use a structural vector autoregressive (VAR) approach to study the effect of different shocks. There are two important advantages in the use of this methodology in our particular context. Firstly, in our VAR system all the fundamental variables are endogenously determined. Thus, we can

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[3] See Tena and Giovannoni (2005), Leduc and Sill, (2003) and Summers (2005) for some examples.

estimate the effect of unanticipated shocks on Chilean output and inflation. This overcomes some of the problems found in reduced form equations where movements in the explanatory variables fail to be exogenous as they can be anticipated by economic agents. Secondly, our VAR model for a single country allows us for the estimation of the dynamic effect of different types of fundamental shocks over a long period of time. Panel data techniques, on the other hand, usually consider a set of heterogeneous countries for a short period of time and restrict slope parameters to be identical across countries. As discussed by Pesaran and Smith (1995), this can result in highly misleading estimate of the parameters.

The structure of this paper is as follows. The next section presents the data, tests the possible cointegration relationships. Section 3 discusses identification of VAR models and Section 4 analyses responses of Chilean inflation and output growth to a number of fundamental shocks before and after 1983. Some concluding remarks follow in Section 5.

2. Presentation of the Data and Cointegration Analysis

We consider an approach similar to Dale and Haldane (1995) in the specification process. Thus, we test for possible cointegration among the series. When cointegration is found, the system is estimated at unrestricted levels; otherwise, it is estimated in differences.

The following endogenous variables are used our analysis: the price of Brent, (B_t); price of copper, (C_t); the Dow-Jones index, (D_t); the exchange rate expressed as the number of Chilean pesos for one dollar, (Δe_t) in first differences; the (seasonally adjusted) American GDP in first differences, (Δy_t^{US}); the American Consumer Price Index in annual differences, ($\Delta_4 p_t^{US}$);

the federal fund rate, (i_t^{US}); the (seasonally adjusted) Chilean GDP in first differences, (Δy_t^{Ch}); and the Chilean Consumer Price Index in annual differences, ($\Delta_4 p_t^{Ch}$).[4] All the series are in quarterly basis and cover the period 1966:Q1-2006:Q3. Also, all the series, with the exception of i_t^{US} , are in natural logarithm.

Figures of the series are not exhibited for the sake of brevity; however it is of interest for our analysis to observe the evolution of the Chilean output growth and the annual rate of inflation. Figures 1 and 2 show the evolution of these two variables together with their volatility measures obtained from computing their rolling standard deviation with a window of four years; see Blanchard and Simon (2001) for a similar approach. It can be observed a substantial reduction of inflation volatility through the sample period. The evidence of reduction in output volatility is not so compelling.

[INSERT FIGURES 1 AND 2]

Then, the standard test proposed by Johansen (1991) is used to infer the number of cointegration relationships in our VAR system. We consider a general specification with two lags to allow for short and long run adjustment in the data. This number of lags is also justified based on the Schwarz criterion.[5] Also, following Juselius and Toro (2005), we consider a general specification of a vector equilibrium correction (VeqCM) with intercept and trend in the cointegration equation but only intercept, and no trend, outside of the cointegration equation.

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[4] All these series were obtained from different sources. Concretely, the oil price was obtained of Dow Jones & Company, the American GDP from U.S. Department of Commerce: Bureau of Economic Analysis, the Chilean Consumer Price Index from Statistics National Institute of Chile (ENI) , the Chilean GDP from Tena et al. (2006) based on the information provided by the Central Bank of Chile and the price of copper, the Dow-Jones index, the American Consumer Price Index, the exchange rate and the federal fund rate from Central Bank of Chile.

[5] For example, the values of the Schwarz criterion of a model with two and three lags are respectively -39.65 and -38.22.

The trace test for cointegration indicates that the null of at least 2 cointegration relationships can be rejected at the 1% level. It is of interest to show the equilibrium relationships among these variables over the last forty years. After testing for over-identifying restrictions, the 3 cointegration relationships can be expressed as:

$$\Delta_4 p_t^{Ch} = \Delta y_t^{Ch} + \Delta e_t \qquad (2.1)$$
$$i_t^{US} = 0.6 * \Delta_4 p_t^{US} \qquad (2.2)$$
$$\Delta y_t^{US} = -\Delta_4 p_t^{US} + 0.005 * (B_t + \Delta_4 p_t^{Ch} + \Delta e_t) - 0.001 * trend \qquad (2.3)$$

The value of the likelihood ratio test for the over-identifying restrictions imposed in equations (2.1), (2.2), and (2.3) is $\chi^2(v) = 23.24(18)$. The p-value of the test is 0.18. Hence, over-identifying restrictions can be accepted at conventional levels.

A simple economic interpretation can be found for these equations. The first one relates inflation in Chile to output growth and the devaluation of the Chilean currency. The second one can be interpreted as a Taylor rule showing how the fed rate react to inflationary pressures and the third one indicates the negative effect of inflation on growth in the US.

In the light of these results, we use an unrestricted VAR model to study the effect of different shocks in the Chilean economy. In order to allow the comparison of the effect of different shocks at different moments of time, we split our sample into two periods 1966:Q1-1983:Q4 and 1984:Q1-2006:Q3 and estimate two structural VAR systems.[6]

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[6] In some additional experiments not reported here we split the sample at 1979:Q4, 1980:Q4, 1981:Q4, 1982:Q4 and 1984:Q4. However, main results of the papers were not altered in any of the experiments.

3. Identification of the Structural Model

Now, we briefly discuss identification of our structural VAR models following along the lines of Christiano et al. (2000). We estimate two reduced form models:

$$Y_t^1 = \left(\Phi_0^1 + \sum_{j=1}^{2} \Phi_j^1 Y_{t-j}^1 \right) + a_t^1 \quad and \quad Ea_t^1 (a_t^1)' = \Sigma^1 \quad for \quad T \in T^- \quad (3.1)$$

$$Y_t^2 = \left(\Phi_0^2 + \sum_{j=1}^{2} \Phi_j^2 Y_{t-j}^2 \right) + a_t^2 \quad and \quad Ea_t^2 (a_t^2)' = \Sigma^2 \quad for \quad T \in T^+ \quad (3.2)$$

where Y_t^i is a (nx1) vector of endogenous variables. In addition, Φ_j^1 and Φ_j^2 are polynomial matrices, a_t^1 and a_t^2 are (nx1) vectors of zero mean, serially uncorrelated disturbances while T^- represents all observations up to 1983:Q4 and T^+ all observations in 1984:Q1-2006:Q3.

These models do not allow for the computation of the dynamic response function of Y_t^k (for k=1, 2) to the fundamental shocks in the economy. This is because the elements of a_t^k are, in general, contemporaneously correlated and cannot presume that they solely correspond to a single economic shock. To deal with this issue, we consider two structural models defined by

$$A_0 Y_t^1 = \left(\Lambda^1 + \sum_{j=1}^{2} A_j^1 Y_{t-j}^1 \right) + \varepsilon_t^1 \quad and \quad for \quad T \in T^- \quad (3.3)$$

$$A_0 Y_t^2 = \left(\Lambda^2 + \sum_{j=1}^{2} A_j^2 Y_{t-j}^2 \right) + \varepsilon_t^2 \quad and \quad for \quad T \in T^+ \quad (3.4)$$

where $E\varepsilon_t^k (\varepsilon_t^k)' = A_0^k \Sigma^k (A_0^k)' = I$, and A_0 is a nth order matrix. The parameter matrices and errors in (3.1), (3.2), (3.3) and (3.4) are linked by $\Phi_i^k = (A_0^k)^{-1} A_i^k$, $\Phi_0^k = (A_0^k)^{-1} \Lambda^k$ and $a_t^k = (A_0^k)^{-1} \varepsilon_t^k$ with ε_t^k being a (nx1) vector of orthogonal and standarized structural disturbances.

Once consistent estimators of the Φ_i^k in (3.1) and (3.2) are obtained, one can estimate Σ^k from the fitted residuals. All the information about the matrix A_0^k is contained in the relationship $\Sigma^k = \left(A_0^k\right)^{-1}\left(\left(A_0^k\right)^{-1}\right)'$. However, A_0^k has n^2 parameters while the symmetric matrix, Σ^k , has at most $\dfrac{(n^2+1)}{2}$ distinct elements. The order condition specifies that at least $\dfrac{(n^2-1)}{2}$ restrictions are required to obtain a sufficient condition for identification. Additionally, the diagonal elements of A_0^k has to be positive.

The structural VAR system is identified by the recursiveness assumption including (in this order) the following endogenous variables in Y_t : $\Delta_4 p_t^{Ch}$, Δy_t^{Ch} , $\Delta_4 p_t^{US}$, Δy_t^{US} , Δe_t , i_t^{US} , C_t , B_t and D_t . This amounts to assuming that commodity prices and financial variables react faster to the economic information than output and price variables. It also means that Chilean economic variables react with one lag of delay to movements in the US variables. These are reasonable assumptions according to economic theory however main results are robust to changes in the identification assumptions.

Our structural system is also used to decompose the forecast error variance of Y_t^i into the proportions due to each shock; see for example Enders (2004), Chapter 5. This decomposition is very useful in our particular context because it tell us the proportion of the movement of the Chilean variables that is due to internal and external shocks.

4. Analysis of the Results.

Table 1 shows the relative importance of different shocks to Chilean inflation and output growth for the two periods considered in this analysis. At a first glance, two important results can be mentioned from the observation of this table. First, international shocks only accounts respectively for 41.7% and 17% of the inflation and output variance in the period 1984-2006. This is a striking result as one should expect that small open economies are very vulnerable to external shocks; see for example Forbes (2001) and Bejan (2004). Second, comparing the two periods, 1966-1983 and 1984-2006, it can be observed that the relative participation of foreign shocks over Chilean inflation has become more important in most recent period whereas the opposite can be said for Chilean output growth.

[INSERT TABLE 1]

The first result can be explained by the precautionary policies undertook by Chile to decrease the exposure to short term capital flows and pressures toward excessive exchange rate appreciation. Concretely, Chile imposed reserve requirement on short term foreign indebtedness, crawlingbands, and other instruments for reducing domestic vulnerability to capital flows; see Ffrench-Davis and Villar (2003) for a discussion of these policies and their effects.

Together with these precautionary measures, in the 1990s Chile performed a unilateral liberalization strategy signing a number of trade agreements, among others with Canada and Mexico, and becoming a special associate member of Mercosur during this period. The price liberalization induced by these agreements can explain the increasing importance of international shocks to explain the Chilean inflation reaction.

Table 1 is also useful to analyze the importance of each individual shock for inflation and output growth. It can be

observed that shocks in the Chilean inflation and the price of copper are relatively important to explain output variation in the most recent period. However, Chilean inflation is mainly explained by shocks in the US inflation and output growth. The effects of these shocks are exhibited in Figure 3.[7]

[INSERT FIGURE 3]

Notice that an unexpected shock in Chilean inflation only has a clear negative effect on growth in the period 1966-1983. In fact, this is an expected result as the 1970s was characterized by episodes of hyperinflation that affected output negatively. However, inflation is no longer a problem in the 1990s due to the independence of the Central Bank of Chile in 1990 and the adoption of inflationary targets together with the aforementioned price liberalization. Additionally, impulses in the price of copper have a positive effect on output growth that last almost two years in the period 1984-2006.

Figure 3 also shows that, as expected from the discussion in the previous section, Chilean inflation is more sensitive to the different shocks in 1966-1983 compared to 1984-2006. For example, consistently with our insight, impulses in the US growth increases Chilean inflation but the effect is stronger in 1966-1983. Also, unexpected US inflation generate an overreaction of Chilean inflation in 1966-1983 probably motivated by restrictions in the peso/dollar exchange rate that last for about 1 year. This effect is corrected during the next three years. However, in the most recent period, Chilean inflation reacts positively and smoothly to shocks in the US inflation.

To conclude this section it is also important to mention some the changes observed in the relative importance of the different individual shocks observed in Table 1. More

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[7] We do not show reactions to all the possible shocks to save space but they can be obtained from the author upon request.

specifically, comparing the two periods, shocks in the stock market index and the US growth are becoming more important to explain Chilean inflation whereas oil shocks are losing importance. This is a reasonable result if we take into account the oil crises in the 1970s. Regarding Chilean growth, it is important to mention that, due to the measures in the 1990s to reduce the excessive exposure to short term capital flows, movements in the interest fed rates have reduced substantially its importance in the most recent period.

5. Concluding Remarks

We present a data oriented analysis of the effect of different kind of economic shocks on Chilean output growth and inflation over the last 40 years. The first remarkable results found in this study is that foreign shocks only explain 17% of the variability of the output growth in the period 1984-2006 whereas it used to account for the 47,2% of output variability in 1966-1983. Together with this effect, we found that, due to the price liberalization and Chile's openness to international trade, the relative participation of foreign shocks to explain Chilean inflation reaction becomes more important.

In the most recent period shocks associated to inflation and growth in the US have not generated important reactions of the Chilean Inflation in contrast with the observed in the period 1966-1983. This situation is explained for the implementation of monetary policy rules in the 1990s that works as a stabilizing macroeconomic instrument under a credible inflation targeting regime. Additionally, Chilean growth reaction is weaker in the period 1984-2006. The results suggest a major capacity of Chilean economy to confront foreign shocks in the period 1984-2006. However, the evidence is much stronger for the Chilean inflation.

The combined effect of these results is useful to explain why Chilean growth was almost immune to the tequila crisis in

1995. Moreover, the Asian and Russian crisis in 1997 and 1998 respectively did not have the dramatic consequences observed in other developing countries.

An important lesson from our analysis is that Chile shows very specific features that are not shared with other Latin American countries. Therefore, this paper suggests that an empirical assessment on the importance of different policies to reduce the volatility of inflation and output growth should be based on models that do not impose slope parameters to be identical across countries.

Bibliography

Bejan, M. (2004). "Trade Openness and Output Volatility", October, Mimeo, ITAM.

Blanchard, O. and Simon, J. (2001). "The Long and Large Decline in US Output Volatility", Brookings Papers on Economic Activity, 2001:1.

Cavallo, E. and Frankel, J. (2004). "Does Openness to Trade Make Countries More Vulnerable to Sudden Stops or Less? Using Gravity to Stablish Causality", N*BER Working Papers 10957*, National Bureau of Economic Research.

Christiano, L.J., Eichenbaum, M. and Evans, Ch. (1999). "Monetary shock: What we have learned and to what end" in Handbook of Macroeconomics, Volume A, Editors: John B. Taylor, Michael Woodford, North-Holland, 65-148.

Dale, S. and Haldane, F. (1995). "Interest Rates and the Channels of Monetary Transmission: Some Sectoral Estimates", European Economic Review, 39, 1611-1626.

Easterly, W., Islam, R. and Stiglitz, J.E. (2001). "Shaken and Stirred: Explaining Growth Volatility", Annual World Bank

Conference on Development Economics, Ed. by B. Pleskovic and N. Stern.

Enders, W. (2004). "Applied Econometric Time Series", Wiley and Sons.

Ffrench-Davis, R. and Villar, L. (2003). "The Capital Account and Real Macroeconomic Stabilization: Chile and Colombia", presented at the Seminar on Management of Volatility, Financial Liberalization and Growth in Emerging Economies, ECLAC Headquarters, Santiago.

Forbes, K. (2001). "Are Trade Linkages Important Determinants of Country Vulnerability to Crisis?", NBER Working Paper 8194, National Bureau of Economic Research.

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

Juselius, K. and Toro, J. (2005). "Monetary transmission mechanisms in Spain: The effect of monetization, financial deregulation, and the EMS", Journal of International Money and Finance, Elsevier, vol. 24(3), 509-531.

Leduc, S. and Sill, K. (2003). "Monetary policy, oil shocks, and TFP: accounting for the decline in U.S. volatility", Working Papers 03-22, Federal Reserve Bank of Philadelphia.

Pesaran, M.H. and Smith, R.P. (1995), "Estimating long-run relationships from dynamic heterogeneous panels", Journal of Econometrics, 68, 79-113.

Summers, P.M. (2005). "What caused the Great Moderation? : some cross-country evidence", Economic Review, Federal Reserve Bank of Kansas City, issue Q III, 5-32.

Tena, J.D. and Giovannoni, F. (2005). "Market Concentration, Macroeconomic Uncertainty and Monetary Policy", Bristol Economics Discussion Papers 05/576, Department of Economics, University of Bristol, UK.

Tena, J.D., Sotoca, S., Jerez, M. and Carvallo, N. (2006). "A proposal to obtain a long quarterly GDP series", Latin American Journal of Economics, 43, 285-299.

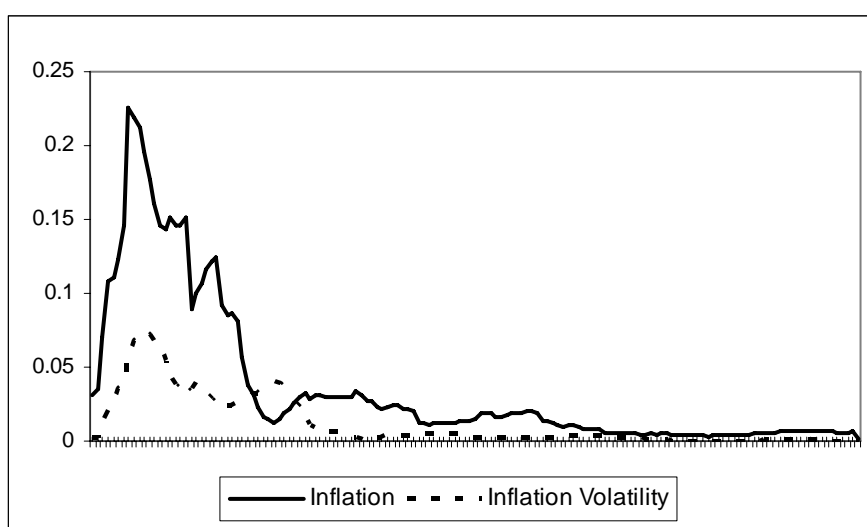**Figure 1. Annual Rate of Inflation and Inflation Volatility.**
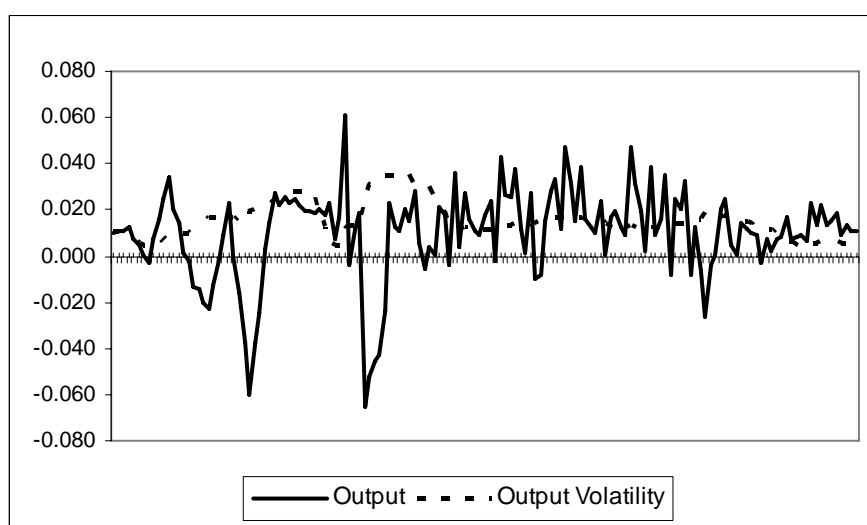

Figure 2. GDP Growth and Output Growth Volatility

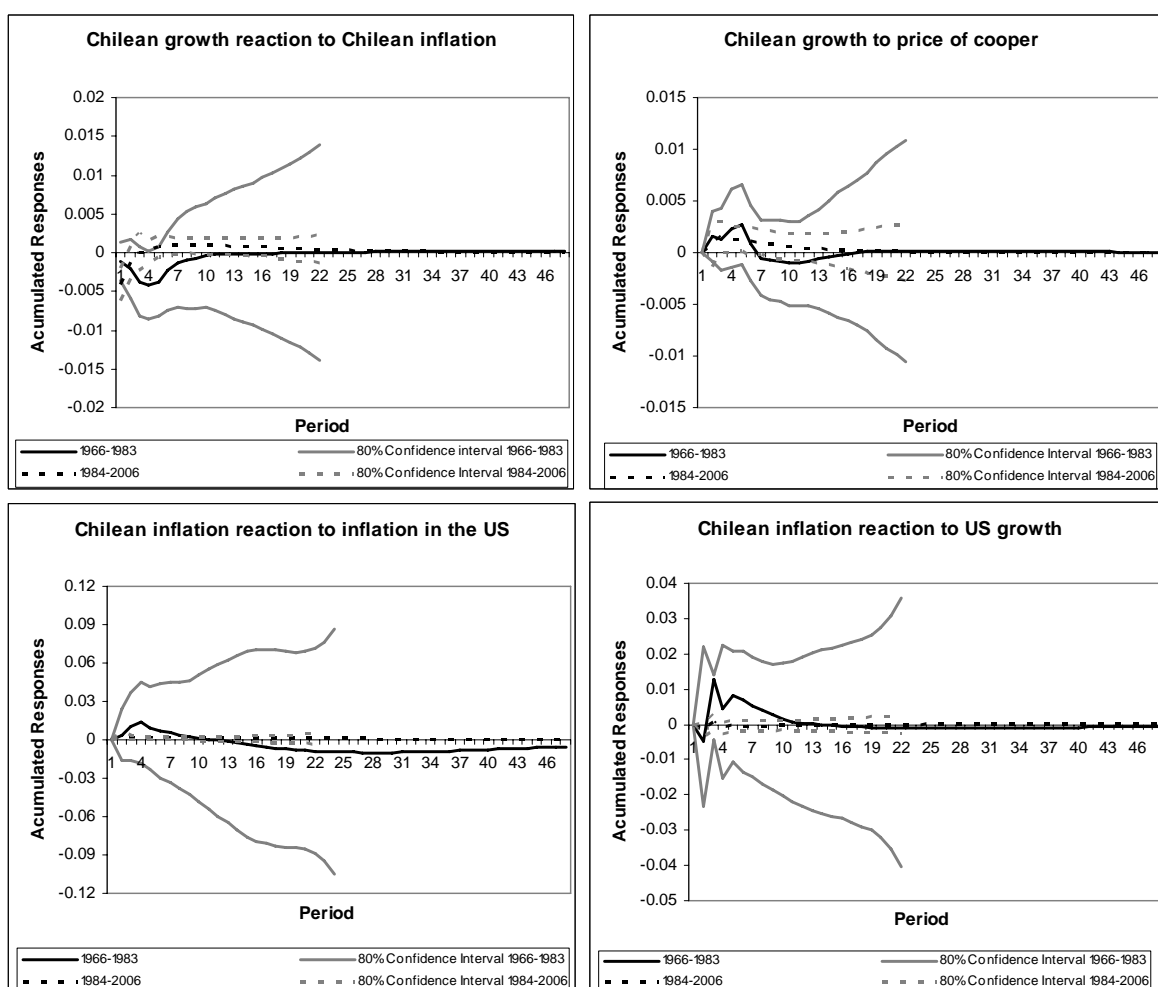**Figure 3. Response of Chilean growth and Inflation to Different Shocks**

Chilean growth reaction to Chilean inflation

Chilean growth to price of cooper

Chilean inflation reaction to inflation in the US

Chilean inflation reaction to US growth

Table 1. Relative Importance of Different Shocks.

Variables	Inflation			GDP Output Growth		
	1966-1983	1984-2006	Change[*]	1966-1983	1984-2006	Change[*]
Chilean Inflation	72.4%	56.7%	-15.7%	8.4%	12.5%	4.1%
Chilean Growth	0.5%	1.6%	1.1%	44.4%	70.5%	26.1%
Inflation in the US	8.7%	10.1%	1.3%	4.8%	1.6%	-3.1%
Growth in the US	1.2%	9.1%	7.9%	6.5%	2.1%	-4.4%
Exchange rate	2.1%	1.6%	-0.5%	0.7%	1.4%	0.6%
Fed rate	2.2%	2.5%	0.2%	29.3%	2.5%	-26.9%
Price of cooper	2.4%	5.4%	3.0%	3.2%	4.6%	1.4%
Oil price	9.2%	4.3%	-4.9%	1.4%	3.5%	2.1%
Dow Jones	1.1%	8.7%	7.6%	1.2%	1.3%	0.2%

(*) Refers to the change in the relative importance of the different shocks between the two periods.