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Les Effets des Chocs Internes et Externes sur une Petite Économie Ouverte: le Cas du Chili

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À ma femme, Rose-Marie
À ma fille, Juliette

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All remaining errors are mine.

Antonio

Résumé

La globalisation est probablement la caractéristique principale de l'économie mondiale du 21ème siècle. Elle se traduit notamment par l'intégration par les canaux commerciaux, financiers et les marchés de matières premières. Elle implique aussi une intensification des interdépendances entre les économies nationales à travers le monde. Si un tel contexte affecte de manière très significative tous les types d'économies, il convient de souligner que les petites économies ouvertes dépendantes des exportations de matières premières, et ouvertes aux marchés financiers globaux, sont en général les plus exposées. L'économie chilienne possède toutes ces caractéristiques. C'est la raison pour laquelle les autorités économiques de ce pays ont construit ces quarante dernières années un solide et effectif cadre de politique macro-économique afin de limiter l'instabilité macro-économique.

Les piliers principaux du cadre de politique macro-économique chilien sont: une banque centrale indépendante responsable des politiques monétaire et de taux de change; un régime de taux de change flexible visant à faciliter l'ajustement de l'économie aux chocs extérieurs; un régime de ciblage direct d'inflation ayant pour objectif d'ancrer les anticipations d'inflation des agents privés; une règle budgétaire d'équilibre structurel qui guide les dépenses publiques à court terme selon les structures de l'économie à moyen terme; des fonds souverains utilisés dans des circonstances très exceptionnelles, par exemple après la crise financière globale de 2008; enfin un ratio dette publique-PIB très bas permettant au pays un accès au crédit dans des conditions favorables. Cependant, malgré un tel cadre de politique macro-économique, l'économie chilienne est très exposée aux chocs, particulièrement ceux provenant de marchés internationaux.

C'est dans ce contexte que cette thèse explore l'efficacité de la politique budgétaire chilienne et les effets des prix des matières premières et des chocs financiers internationaux sur le PIB chilien et d'autres variables macro-économiques importantes. A cette fin, on utilise une approche empirique basée sur des modèles vectoriels autorégressifs.

Pour comprendre l'efficacité de la politique budgétaire visant à garantir la stabilité macro-économique, le Chapitre 1 étudie les effets dynamiques de la politique fiscale sur des variables macro-économiques et la taille des multiplicateurs fiscaux. Au Chili, la littérature empirique étudiant les effets dynamiques de la politique fiscale sur le PIB et l'estimation des multiplicateurs fiscaux en utilisant des données trimestrielles et des modèles vectoriels autorégressifs n'offre pas de consensus sur les effets des dépenses publiques et des impôts sur le PIB. Dans ce chapitre, nous apportons de nouveaux éléments de réponse en évaluant des multiplicateurs fiscaux, et en étudiant la relation qui existe entre la politique fiscale, le PIB et d'autres variables macro-économiques significatives (la consommation privée, le taux de chômage et le taux d'intérêt à court terme). Nos résultats suggèrent que: (i) en utilisant les mêmes données trimestrielles, la taille de multiplicateurs fiscaux (des dépenses publiques et des impôts) varie non seulement selon la stratégie d'identification et le modèle vectoriel autorégressif utilisé, mais aussi selon les définitions des dépenses publiques et des impôts considérées; (ii) les multiplicateurs de dépenses publiques estimés en utilisant un modèle vectoriel autorégressif Bayésien avec des "priors" déterminés à partir de la méthode de Litterman/Minnesota, sont légèrement positifs, conformément à la littérature internationale, avec la politique fiscale ayant seulement une petite influence sur le PIB;

(iii) la dépense publique ne semble pas évincer la consommation privée; (iv) une relation faible de type keynésien est identifiée entre les dépenses publiques et le chômage; et (v) la politique monétaire a une certaine influence sur la taille des multiplicateurs fiscaux.

Comme il a été dit, en raison des caractéristiques de l'économie chilienne, ses principales variables macro-économiques ont été historiquement affectées par des chocs étrangers, notamment des chocs financiers et des prix de matières premières. En considérant les fluctuations des prix des matières premières ces dernières années, le Chapitre 2 analyse comment les chocs des prix des matières premières (du cuivre qui est l'exportation chilienne principale et des exportations hors-cuivre) affecte le PIB chilien, les dépenses publiques, la consommation publique, l'investissement public et la consommation privée.

Plus précisément, le Chapitre 2 examine comment les chocs des prix de matières premières affectent la production économique chilienne, les comptes fiscaux (les revenus publics, la consommation publique et l'investissement public) et la consommation privée, en utilisant une analyse de corrélations et des modèles vectoriels autorégressifs. Nous constatons que le produit intérieur brut chilien, les revenus publics, et la consommation privée sont pro-cycliques en ce qui concerne les chocs des prix de matières premières et les dépenses publiques (la consommation et l'investissement) sont contra-cycliques. En général les effets de chocs des prix du cuivre sur le PIB, les comptes fiscaux et la consommation privée, sont plus importants que les effets des chocs des prix de matières premières hors-cuivre. L'évidence suggère que la règle fiscale chilienne a renforcé la discipline budgétaire déjà adoptée implicitement par les autorités fiscales chiliennes depuis le début des années 90, aidant ainsi à réduire la volatilité.

Quoique significatifs en termes d'effets sur l'économie chilienne, les chocs financiers étrangers ont reçu beaucoup moins d'attention dans la littérature que les fluctuations des termes de l'échange, en particulier les prix du cuivre. Dans le Chapitre 3, nous étudions l'effet des chocs financiers étrangers sur l'économie réelle chilienne. Ce Chapitre 3 vise à combler cet écart en investiguant les effets que les chocs financiers étrangers, mesurés par le "spread" souverain, ont sur le PIB chilien, la consommation privée et l'investissement, et le rôle que la provision de crédit et le "spread" de crédit domestique ont sur les chocs financiers étrangers et les variables macro-économiques mentionnées ci-dessus. Nous utilisons un modèle vectoriel autorégressif standard et la supposition de décomposition de Cholesky. Nous trouvons que les chocs de "spread" souverain affectent l'économie chilienne. Particulièrement une augmentation de "spread" souverain réduit le crédit aux ménages et la consommation privée et mène à une perte de PIB. Nous n'avons pas trouvé effets statistiquement significatifs d'un tel choc sur le "spread" domestique, le crédit total, le crédit aux sociétés et l'investissement.

Mots-clés: Chili, Politique fiscale, Chocs des prix des matières premières, Chocs financiers étrangers, Modèles vectoriels autorégressifs.

The Effects of Internal and External Shocks in a Small and Open Economy: The Case of Chile

Abstract

The economic globalization is probably the main feature of the 21st century world economy, with economic integration and interdependence of national economies across the world particularly common in commodity and financial markets. Such a context greatly affect all types of economies though those small, dependent on commodity exports, and open to global financial markets are usually the most exposed. The Chilean economy has all these characteristics and for this reason the country's economic authorities have progressively built a sound and effective macroeconomic policy framework during the past four decades.

The Chilean macroeconomic policy framework main building blocks are: An independent Central Bank responsible for the monetary and exchange rate policies; A flexible exchange rate regime aiming to help to cushion foreign shocks; An inflation targeting regime to anchor and provide prices certainty; A structural balance fiscal rule which guides the short-term public expenditure depending on the economy medium-term fundamentals; Sovereign wealth funds used under very exceptional circumstances as for example after the global financial crisis of 2008; And very low debt to GDP allowing the country access to credit in convenient conditions. However, in spite of such macroeconomic policy framework the Chilean economy is certainly very exposed to shocks, especially those coming from international markets.

Having in mind this scenario, in this Ph.D. dissertation we explore the effectiveness of the Chilean fiscal policy and the effects of commodity prices and foreign financial shocks, on the Chilean GDP and other macroeconomic fundamentals using an empirical approach based on alternative vector autoregressive models.

To understand the effectiveness of the country's fiscal policy aiming at guarantying macroeconomic stability, in the Chapter 1 of this Ph.D. dissertation we study the dynamic effects of fiscal policy on the Chilean macroeconomic fundamentals and the size of fiscal multipliers. In Chile the empirical literature studying the dynamic effects of fiscal policy on output and estimating fiscal multipliers using quarterly data and vector autoregression models strongly disagrees on the effects of government spending and taxes on the economic output. In this chapter we provide new evidence estimating fiscal multipliers, and studying the relation that exists between fiscal policy, output and other macroeconomic aggregates (private consumption, unemployment and short-term interest rate). We find that: (i) Once using the same quarterly data, the size of fiscal multipliers (government spending and taxes) not only varies depending on the identification strategy and the vector autoregression model used, but also on the definitions of government spending and taxes considered; (ii) Government spending multipliers estimated using a Bayesian vector autoregression model and Litterman/Minnesota prior, are slightly positive, in line with the international literature, with fiscal policy having only a small influence on economic output; (iii) Government spending

seems to not crowd-out private consumption; (iv) Some evidence exists of a Keynesian relation between government spending and unemployment; and (v) The monetary policy has some influence on the size of fiscal multipliers.

As it has been said, due to the Chilean economy characteristics, its macroeconomic fundamentals have been historically affected by foreign shocks, notably commodity prices and financial shocks. Considering the recent years sharp ups and downs in commodity prices, the Chapter 2 of this Ph.D. dissertation studies how commodity price shocks (from copper, which is the main Chilean export, and non-copper exports) affect the Chilean gross domestic product, government spending, consumption and investment, and private consumption. More precisely Chapter 2 examines how shocks to commodity prices affect the Chilean economic output, fiscal accounts (government revenues, consumption and investment) and private consumption, based on correlations analysis and vector autoregression models. We find that the Chilean gross domestic product, government revenues and private consumption are pro-cyclical with respect to shocks to international commodity prices and that government expenditures (consumption and investment) are counter-cyclical. Overall the effects of shocks to copper prices on economic output, fiscal accounts and private consumption, are stronger than shocks to non-copper commodity prices. The evidence suggests that the Chilean fiscal rule reinforced the fiscal discipline already adopted, implicitly, by the Chilean fiscal authorities since the early 90's, helping to reduce volatility.

Finally, though quite important in terms of effects on the Chilean economy, foreign financial shocks have received much less attention in the related literature compared to terms of trade fluctuations, copper prices in particular. In the Chapter 3 of this Ph.D. dissertation we study the effect of foreign financial shocks on the Chilean real economy. Chapter 3 intends to help fill this gap by studying the effects that foreign financial shocks, measured by the sovereign spread, have on Chile's business cycle, private consumption, and investment, and the role that the credit supply and the domestic credit spread have relating the foreign financial shocks and the above mentioned macroeconomic variables. We do so using a standard vector autoregression model and assuming Cholesky decomposition. We find that sovereign spread shocks do affect the Chilean economy. In particular, a widening in the sovereign spread reduces credit to households and private consumption, and leads to an output loss. We did not found statistically significant effects of such a shock on domestic spread, total credit, the credit to firms, and investment.

Keywords: Chile, Fiscal Policy, Commodity Price Shocks, Foreign Financial Shocks, Macroeconomic Fundamentals, Vector Autoregression Models.

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Introduction

The economic integration and interdependence among world economies have been deepening over the last few decades, particularly in the commodity and financial markets. After reaching particularly low levels during the global financial crisis, commodity markets have known a very strong growth in their prices mostly driven by the demand for commodities coming from Asia, China in particular, joint by supply constraints. More recently, after three years of remarkably highs since 2011, the commodity prices experimented a sharp decline reaching by the end of 2015 similar levels to those observed before the global financial crisis, notably affecting commodity exporter economies. On its hand, the global financial crisis, which started in the housing loan market in the United States and rapidly reached the American financial sector and the world's biggest real economy, spread its nominal and real effects to financial markets and economies all around the world.

Thus, last decades' ups and downs in the commodity markets as well as the global financial crisis put into evidence how important strong institutions and sound macroeconomic policy frameworks are for natural resource-rich economies, when facing strong exogenous commodity prices and financial shocks. OECD natural resource-rich developed economies such as Australia, Canada, New Zealand and Norway have proved to be much less exposed to commodity price and financial fluctuations, because of their strong institutions, sound economic frameworks and more diversified productivity structures, than developing economies. On its hand, Chile is also a natural resource-rich economy, and it belongs to the OECD, but it is still in the transition to development. Studying the behavior of this small Latin-American economy, when facing endogenous or exogenous shocks, might benefit other natural resource-rich developing economies affected by commodity prices and financial shocks, to understand how important strong institutions and a solid macroeconomic framework are for shocks mitigation.

Because of its size and openness to the world economy, and more specifically because of its deep financial market and economy extremely oriented to the exports of commodities, Chile has been historically affected by shocks coming from the international markets. If the economic integration and interdependence has greatly benefited the Chilean economy increasing the country's exports, rising capital inflows mainly as foreign direct investment, the arrival of multinational companies enhancing competition in the provision of goods and services, etc., it has also put important risks as greater domestic macroeconomic instability caused by exposure to foreign markets. Considering these facts during the last four decades, the Chilean economic authorities have progressively built a sound and effective macroeconomic policy framework comparable to those in place in other OECD natural resource-rich peer economies.

Regarding the Chilean macroeconomic policy framework, its main building blocks are: A Central Bank completely independent of the government in office decisions, responsible for the monetary and exchange rate policies; A flexible exchange rate regime aiming at working as the first defensive line of the Chilean economy against foreign shocks; An inflation targeting regime to anchor prices and provide certainty to the agents in the economy; A structural balance fiscal rule which guides the short-term public expenditure depending on the economy medium-term fundamentals, notably

gross domestic product growth and copper prices, and that allows isolating public expenditure from politically populist driven pressures; Sovereign wealth funds that have been successfully used under very exceptional cases as for example during the period immediately after the global financial crisis of 2008 when the economic authorities put in place a very strong counter-cyclical fiscal policy helping to move the economy out of recession only after a year; And very low public debt to gross domestic product ratio, both compared to OECD and Latin-American peer economies, allowing the country's access to credit in convenient conditions. However, in spite of such a macroeconomic policy framework, the Chilean economy is certainly very exposed to shocks, especially those coming from international markets.

Considering this context, in this Ph.D. dissertation we explore the effectiveness of the Chilean fiscal policy and the effects of commodity price and foreign financial shocks, on the Chilean economic output and other macroeconomic fundamentals, using an empirical approach based on alternative vector autoregressive models.

In spite of its sound macroeconomic policy framework, including an independent Central Bank, a flexible exchange rate regime, inflation targeting, a structural balance fiscal rule, sovereign wealth funds, and very low public debt to GDP, Chile is an economy quite exposed to shocks due to its small size and high openness to the world economy. Then to guarantee its macroeconomic stability, the country's fiscal policy is considered a key tool, with the dynamic effects of fiscal policy on macroeconomic fundamentals and the size of fiscal multipliers a relevant issue. Additionally the related literature that has studied the dynamic effects of Chile's fiscal policy using high frequency data (at least quarterly), i.e.: Cerda *et al.* (2005), Restrepo and Rincón (2006) and Céspedes *et al.* (2011), have found very different results, leaving uncertain the question about the effects of fiscal policy on output and the size of Chile's fiscal multipliers.

The Chapter 1 of this Ph.D. dissertation characterizes the effects of fiscal policy on the Chilean economic activity by estimating impulse-response functions and by calculating government spending and tax multipliers, using quarterly data for the period 1990Q1-2015Q2, alternative definitions of government spending and taxes, and different vector autoregression approaches (vector autoregression, structural vector autoregression, and Bayesian vector autoregression models), motivated by the importance of understanding the effectiveness of the country's fiscal policy, aiming at guarantying macroeconomic stability, and by the strong disagreement in the literature that has studied the case of Chile (Cerda *et al.* (2005), Restrepo and Rincón (2006) and Céspedes *et al.* (2011)).

Chapter 1 finds that: The impulse-response functions obtained and the size of fiscal multipliers not only depend on the identification strategy and the vector autoregressive model used, but also on the definitions of government spending and taxes considered; The impulse-response functions and fiscal multipliers we obtained from the Bayesian vector autoregression models are more in line with the international literature for small open economies, compared to the vector autoregression models and especially to the structural vector autoregression models, with fiscal policy having only a small influence on the economic output; After including private consumption, unemployment and the short-term interest rate to our baseline model, we find that both government spending and tax multipliers are slightly bigger (though still positive and below the unit) than those coming from our baseline model; That government spending seems to not crowd-out private consumption; that a Keynesian relation between government spending and unemployment might exist; and that monetary policy has some influence on the size of fiscal multipliers; And last, evidence suggesting

that the government spending and tax multipliers are very sensitive to the sample size, providing unreliable results when splitting the period of study before and after the exchange rate regime change put in place in Chile in 1999.

It has been said that commodity prices have observed huge volatility during the past years. In the aftermath of the global financial crisis, the strong growth and demand for commodities coming from Asia, particularly China, joint with supply constraints, implied a boom in commodity prices and a consequent fiscal resource abundance well received by commodity exporter economies such as Chile, but since 2011, commodity prices, notably copper prices, have experimented a sharp decline reaching by the end of 2015 similar levels to those exhibited during the global financial crisis.

Then commodity price volatility is an important problem for commodity exporter economies such as Chile, representing a challenge for the country's economic authorities, in terms of economic growth, fiscal management and effects to the private sector. Chilean exports are mainly related to commodities, representing about 85 percent of total exports in 2015, divided in copper and non-copper exports representing in 2015 about 50 and 35 percent of total exports, respectively. On its hand, the structural balance fiscal rule, announced in 2000 and launched in 2001, was designed as an institutional arrangement with the aim of improving Chile's macroeconomic policy framework by reducing the uncertainty in fiscal revenues and then expenditure caused by copper price volatility.

In the second chapter of this Ph.D. dissertation we study how commodity price shocks (from copper and non-copper commodity prices) affect the Chilean gross domestic product, fiscal accounts (government revenues, consumption and investment), and private consumption based on correlation analysis and vector autoregression models for the period 1990Q1-2015Q3, assuming that commodity price shocks are exogenous (i.e. Chile is a price taker in the commodity world markets) and that Chile's fiscal policy cannot react contemporaneously to changes in the economic activity. It also explores if the Chilean structural balance fiscal rule resulted or not in a structural change in the relation between commodity prices (copper and non-copper commodity prices), and the Chilean gross domestic product, fiscal accounts (government revenues, consumption and investment) and private consumption.

Hence, Chapter 2 contributes to the existing literature by extending the estimations and analysis of the impact of copper price shocks on the Chilean gross domestic product made by authors such as Medina and Soto (2007), De Gregorio and Labbé (2011), Pedersen (2014) and Eyraud (2015), by also studying the effects on other important macroeconomic aggregates, named the government revenues, consumption, investment, and private consumption, and providing estimations of the impact that shocks to other non-copper Chilean commodity exports have on the economic output, fiscal accounts (government revenues, consumption and investment) and private consumption. Finally it investigates possible changes in the relation between commodity prices (copper and non-copper prices) and macroeconomic aggregates (gross domestic product, fiscal accounts and private consumption) as a consequence of the structural balance fiscal rule.

In Chapter 2 we find that: The Chilean economic output, government revenues and private consumption are pro-cyclical with respect to shocks to international commodity prices (both copper and non-copper prices) and that government expenditures (consumption and investment) are counter-cyclical (to both copper and non-copper prices); The effects of copper price shocks on

gross domestic product, fiscal accounts and private consumption, are stronger than shocks to non-copper commodity prices; And that the Chilean fiscal rule reinforced the fiscal discipline already implicitly adopted by the Chilean economic authorities since the early 90's, fulfilling the objective of reducing the country's fiscal revenue volatility.

The effects of foreign financial shocks on the Chilean economy have received much less attention in the related literature compared to terms of trade fluctuations, copper prices in particular. The literature using vector autoregression models (Franken *et al.* (2006), Carrière-Swallow and Medel (2011), Sosa (2012) and Cabezón (2012)), as we do in the Chapter 3 of this Ph.D. dissertation, has focused on the effects that foreign financial shocks – alternatively measured by the global markets uncertainty, the foreign interest rate, the spread between the foreign and domestic interest rates, and the net capital inflows – have on the Chilean business cycle leaving in the shade the effects of these shocks on private consumption and private investment. Neither has it studied the role that locally based banks play through credit, relating the foreign financial markets and the Chilean real economy. Such gap is addressed in Chapter 3 by studying the effects of foreign financial shocks (measured by the sovereign spread between the United States and Chile's Treasury Bills interest rates) on domestic credit spread (a measure that intends to reflect the risk of credit in the Chilean domestic market), private consumption, investment (unfortunately Chilean national accounts data does not include private investment, on a quarterly basis) and gross domestic product, and assessing the role of credit (total, to firms, to households) supply from banks locally installed, using quarterly data, a standard vector autoregression model assuming Cholesky decomposition.

Thus in Chapter 3 we respond to the following questions: First, what are the effects of foreign financial shocks, measured by the interest rates spread between the United States and Chile's Treasury Bills, on the Chilean economic output, the total credit supply and the domestic credit interest rates spread, and the role that the total credit supply has affecting the Chilean economic output after such foreign financial shock?; Second, does the credit to households explain the changes in the domestic credit interest rates spread for small credits, private consumption, and GDP, after a shock to the interest rates spread between the United States and Chile's Treasury Bills?; And third, does a foreign financial shock, measured by the interest rates spread between the United States and Chile's Treasury Bills, affect the credit to firms, and hence the domestic credit interest rates spread for big credits, investment and GDP?.

We find that a sovereign spread shock (a widening in this spread) does affect the Chilean economy, by reducing credit to households, negatively affecting private consumption, and leading to an output loss in the medium-term (ten quarters). In addition, after such a shock we did not find statistically significant effects on the alternative domestic credit interest rate spreads we set, total credit, credit to firms, and investment. These findings are robust to different model specifications and time period, and are in line with those presented by Caballero (2002) and Cabezón (2012).

Chapter 1

Dynamic Effects of the Chilean Fiscal Policy *

1.1 Introduction

In spite of its sound macroeconomic policy framework, including an independent Central Bank, inflation targeting, a structural balance fiscal rule, a flexible exchange rate regime, sovereign wealth funds, and very low public debt to GDP, Chile is an economy quite exposed to shocks due to its small size and high openness to the world economy. Then to guarantee its macroeconomic stability, the country's fiscal policy is considered a key tool, with the dynamic effects of fiscal policy on macroeconomic fundamentals and the size of fiscal multipliers a relevant issue.

As far of our knowledge, the applied literature on the dynamic effects of Chile's fiscal policy using high frequency data (at least quarterly), includes three studies: Cerda *et al.* (2005), Restrepo and Rincón (2006) and Céspedes *et al.* (2011), that arrive to very different results, leaving the question about the effects of fiscal policy on output and the size of Chile's fiscal multipliers far from being conclusive.

The aim of this chapter is to contribute to the debate about the effects of Chile's fiscal policy on the economic output and other macroeconomic fundamentals, and about the size of fiscal multipliers. We highlight the methodological differences in terms of period of study, data frequency, definitions of government spending and taxes and vector autoregression approaches implemented, to explain the absence of consensus in the literature about the dynamic effects of fiscal policy on macroeconomic fundamentals and the size of Chile's fiscal multipliers. We question these methodological choices and intend to reach a more conclusive response by estimating impulse-response functions and by calculating fiscal multipliers of government spending and taxes; by analyzing the effect of including additional macroeconomic variables to government spending, taxes and GDP, such as the private consumption, the unemployment and the short-term interest rate; and by studying the effect of Chile's 1999 exchange rate regime change on the size of fiscal multipliers.[1]

This chapter characterizes the effects of fiscal policy on the Chilean economic activity by estimating impulse-response functions and by calculating government spending and tax multipliers, using quarterly data for the period 1990Q1-2015Q2, alternative definitions of government spending and taxes, and different vector autoregression approaches.

First we estimate impulse-response functions and calculate fiscal multipliers based on the definitions of government spending and taxes in the seminal paper by Blanchard and Perotti (2002)

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[1] In September 1999 Chile's exchange rate regime moved from a wide band floating to a flexible one.

(hereafter we refer to these estimations as the "BP baseline model") and the alternative definitions of government spending and taxes in Cerda *et al.* (2005), Restrepo and Rincón (2006) and Céspedes *et al.* (2011) (henceforth we refer to these models as the "alternative baseline models"), using the three vector autoregression approaches we include in this study (vector autoregression (VAR), Structural vector autoregression (SVAR) and Bayesian vector autoregression (BVAR)). Using the same sample period, 1990Q1-2015Q2, in all our estimations, we find that the impulse-response functions obtained and the size of fiscal multipliers not only depend on the identification strategy and the vector autoregressive model used, but also on the definitions of government spending and taxes. The impulse-response functions and fiscal multipliers we obtained from the Bayesian VAR model are more in line with the international literature for small open economies, compared to the VAR and especially to the Structural VAR models, with fiscal policy having only a small influence on the economic output.

Second, building on the "BP baseline model" and using the Bayesian VAR model, we estimate fiscal multipliers including additional endogenous variables, meaning the private consumption (unfortunately private investment quarterly data is not available), the unemployment and the monetary policy through the short-term interest rate, to discuss the net effect of including these variables on the size of fiscal multipliers (in next sections, we refer to these estimations as the "extended model").[2] After including private consumption, unemployment and the short-term interest rate on the "BP baseline model", we find that both government spending and tax multipliers are slightly bigger (though still positive and below the unit) than "BP baseline model" multipliers.

Third, also using a Bayesian VAR model, we study the net effects of adding alternatively the private consumption, unemployment and the short-term interest rate to the "BP baseline model", finding that government spending seems to not crowd-out private consumption, that a Keynesian relation between government spending and unemployment might exists, and that monetary policy has some influence on the size of fiscal multipliers.

And fourth, we study the effect of Chile's 1999 exchange rate regime change on the size of our "BP baseline model" multipliers, using the Chow and Bai-Perron structural change tests, estimating impulse-response functions and calculating government spending and tax multipliers for the periods before (1990Q1-1999Q4) and after (2000Q1-2015Q2) the exchange rate regime change. We find evidence suggesting that the government spending and tax multipliers are very sensitive to the sample size, providing not reliable results when splitting the period of study before (40 quarters) and after (62 quarters) the exchange rate regime change.

We estimate VAR, Structural VAR and Bayesian VAR models because the first two have been used in the previous papers that study the dynamic effects of fiscal policy and fiscal multipliers in Chile (VAR in Céspedes *et al.* (2011), and Structural VARs in Cerda *et al.* (2005) and Restrepo and Rincón (2006)), and Bayesian VAR models because these are considered as a standard tool in modern applied macroeconomics (Koop and Korobilis (2009), Banbura *et al.* (2010) and Lütkepohl (2011)) and, as far as we know, they have not been used to estimate fiscal multipliers in Chile.

[2] Bayesian VAR models do not face the problem of over-parameterization that VAR models do, as they use prior probability distributions that make the large number of parameters depend on a small vector of hyper-parameters, and in comparison to Structural VAR models Bayesian VAR models do not face the critique that small changes in the government spending and taxes to output elasticities might result in large differences in the estimated multipliers (Ramey (2011)).

The rest of this chapter is structured as follows: A literature review is included in Section 1.2. Section 1.3 presents the methodology, i.e. the data, the analytical approaches (VAR, Structural VAR and Bayesian VAR models), and how we calculate the fiscal multipliers. The "BP baseline model" impulse responses and fiscal multipliers, using Blanchard and Perotti (2002) government spending and taxes definitions, are presented in Section 1.4. These are compared to those fiscal multipliers we obtain using the government spending and taxes definitions from Cerda *et al.* (2005), Restrepo and Rincón (2006) and Céspedes *et al.* (2011), "alternative baseline models". Section 1.5 studies an "extended model" that builds on the "BP baseline model", by including the private consumption, the unemployment rate and the short-term interest rate. Section 1.6 focuses on the relation between private consumption and government spending and taxes. Similar procedure is done in Sections 1.7 and 1.8 but including the unemployment rate and short-term interest rate (monetary policy), respectively. Section 1.9 looks for changes in government spending and tax multipliers as consequence of 1999 Chile's exchange rate regime change. Last, Section 1.10 concludes that in Chile government spending multipliers are positive and that tax multipliers are close to zero, with fiscal policy only having a small influence on economic output, that government spending seems to not crowd-out private consumption, that a Keynesian relation might exists between government spending and unemployment, and that monetary policy has some influence on the effectiveness of fiscal policy.

1.2 Literature Review

In the empirical fiscal multipliers literature, the size of fiscal multipliers is far from homogenous among countries. Small open economies like Chile exhibit government spending multipliers of 0.5 or less and tax multipliers about the half of these values (Spilimbergo *et al.* (2009)), with fiscal policy interaction with the monetary policy (through the interest rates) and the exchange rate regime having a probable influence on the size of fiscal multipliers.

In an important literature review, Spilimbergo *et al.* (2009), focusing mostly on developed countries, concludes that: (i) The size of the fiscal multipliers is larger only if: a small part of the stimulus is spent on imports or saved by the private sector; the interest rate does not increase as a consequence of the fiscal expansion; and the country's fiscal position is sustainable after the stimulus (as private agents could perceive the fiscal stance unsustainable); (ii) A rule of thumb government spending multiplier (assuming a constant interest rate) is of 1.5 to 1 for large countries, 1 to 0.5 for medium size countries and of 0.5 or less for small open economies, and tax multipliers being about the half of government spending multipliers; and (iii) The risk of "simultaneity biased" is reduced when using higher frequency data, quarterly at least.

Regarding the literature about dynamic effects of Chile's fiscal policy and fiscal multipliers, its results and conclusions are far from conclusive. The existing papers (as far of our knowledge) that use quarterly data, named Cerda *et al.* (2005), Restrepo and Rincón (2006), and Céspedes *et al.* (2011)), reach very different results.

The first attempt to estimate the dynamic effects of fiscal policy for Chile using quarterly data was achieved by Cerda *et al.* (2005). These authors, using a Structural VAR and data for the period 1986Q1-2001Q4, find that a positive shock to government spending has a negative effect on output

during the first quarter that afterwards dies out, and that a positive shock to taxes also has a very small and negative impact on output during the first quarter.[3] Thus, according to Cerda *et al.* (2005) fiscal policy in Chile has null and even slightly negative effect on the economic activity.

Later, Restrepo and Rincón (2006) also using a Structural VAR finds, for the period 1989Q1-2005Q2, that a one Chilean peso increase in government spending has a positive effect of 1.9 Chilean peso on real GDP growth during the first quarter and about 1.37 Chilean peso in the medium-term meaning that one Chilean peso spent by the government generates about 37 cents, and that an increase in taxes of one Chilean peso has a negative effect on GDP growth of 40 cents during the first quarter that afterwards is not significantly different from zero.[4] Hence Restrepo and Rincón (2006) conclude that in Chile, while government spending might have a positive effect on output, taxes do the opposite.

More recently Céspedes *et al.* (2011), using a VAR estimates government spending multipliers, not tax multipliers, for the period 1990Q1- 2010Q1.[5] Their basic model includes as variables: government spending, real GDP, private consumption and public deficit. They find a large and positive government spending multiplier of 0.7 at impact and a cumulative multiplier of 2.8 after eight quarters. The robustness of their results was checked by extending their model, to include three additional variables: long-term copper real price, investment and real exchange rate, but not taxes. Thus, Céspedes *et al.* (2011)'s results suggest that government spending multipliers are high and positive.

In summary, results and conclusions about Chile's fiscal multipliers are far from conclusive in the literature. Meanwhile Cerda *et al.* (2005) concludes that the Chilean fiscal policy has a null and even a negative effect on the economic activity (both government spending and taxes), Restrepo and Rincón (2006) suggests that government spending might be effective but taxes not, and Céspedes *et al.* (2011) finds that government spending is quite effective. We suspect that these differences might be explained by their methodological choices in terms of period of study, data frequency and alternative approaches used, but also by the variables included, the number of lags their models have, and the government spending and taxes definitions.[6] [7] A summary of these parameters is presented in Table 1.1.

[3] Government spending corresponds to the total spending including: transfers, social security, financial investment, public debt services and other fiscal expenditure. Taxes include all taxes net of subsidies, i.e.: income taxes, VAT, trade taxes, taxes to specific products, juridical acts taxes, and other taxes.

[4] Government spending corresponds to government spending on wages and salaries, goods and services, and investment. Taxes are net of subsidies and grants, interest payments, social security payments and capital transfers.

[5] Government spending corresponds to government consumption and government investment.

[6] Impulse-response functions may depend critically on the lag order of the vector autoregression model (Ivanov and Kilian (2005)).

[7] Regarding the fiscal data sources, while Cerda *et al.* (2005) uses data collected under the "cash principle" (spending and taxes are recorded at the time the cash transaction occurs), sourced by the government's payment office (Tesorería General de la República), Restrepo and Rincón (2006) and Céspedes *et al.* (2011) uses data sourced by the Chilean Budget Office (Dipres) built on the "accrual principle" (spending and taxes are recorded at the time of the activity that generates the obligation to pay them). In this chapter we also use the data sourced by Dipres, built on the "accrual principle".

Table 1.1. Data, Analytical Approaches and Variables Definitions in the Literature on Chile's Dynamic Effects of Fiscal Policy

	Cerda *et al.* (2005)	Restrepo and Rincón (2006)	Céspedes *et al.* (2011)
Period of study	1986Q1-2001Q4	1989Q1-2005Q2	1990Q1-2010Q1
Frequency	Quarterly	Quarterly	Quarterly
Approach	Structural VAR	Structural VAR	VAR
Number of lags included in the vector autoregression model	8 (Akaike information criterion)	Not mentioned	4 (Criterion not mentioned)
Variables included	Government spending, Taxes and GDP	Government spending, Taxes and GDP	Government spending, Private consumption, Public deficit and GDP 1/
Spending definition	Total spending less transfers, social security, financial investment, debt interests and other fiscal expenditure	Wages and salaries, goods and services, and investment; i.e. government spending net of transfers	Government consumption and investment
Taxes definition	Income taxes, VAT, trade taxes, taxes to specific products, taxes to juridical actions, and other taxes net of subsidies	Taxes are net of subsidies and grants, interest payments, social security payments and capital transfers	Not studied. Instead they study the dynamic effects of government transfers
Results of a positive government spending shock	Small and negative effect on output	Positive effect on output	High and positive effect on output
Results of a positive tax shock	Small and negative effect on output	Small and negative effect on output	Not studied

1/ In this paper, the GDP data excludes copper and other natural resources.

The literature that studies the dynamic effects of fiscal policy and fiscal multipliers usually includes additional macroeconomic variables, further than the government spending, taxes and GDP, as it is argued that the interactions between the fiscal variables and other macroeconomic variables might affect the impulse responses and the fiscal multipliers' size. For instance, the effect of the interaction between the fiscal variables and the private consumption is a subject far from agreed among economists. In fact while neo-classical models predict that private consumption should fall following a positive shock to government spending, Keynesian and some neo-Keynesian models predict the opposite. On the empirical side, Blanchard and Perotti (2002) finds a positive effect of government spending on private consumption in the United States, and in a paper that builds on Blanchard and Perotti (2002), Perotti (2005) studies the effects of fiscal policy in Australia, Canada, Germany, Great Britain and the United States, finding that the effect of a positive government spending shock (tax cut) on private consumption is mostly negative in all countries but the United States in the period post-1980. In Chile, Céspedes *et al.* (2011) finds a positive effect of government spending on private consumption and no evidence of crowding-out between these two variables.

Aside from private consumption, evidence on the importance of the interaction between fiscal and monetary policies, as a determinant of the effects of fiscal policy on GDP, is provided by Spilimbergo *et al*. (2009) and Ilzetzki *et al.* (2011). Their results relate to the notion that monetary policy accommodation plays an important role in determining the expansion effect of fiscal policy, showing that fiscal multipliers are larger when central banks' policy interest rate is at the zero lower bound.

In a recent contribution, Vegh and Vuletin (2014) study the interaction between the social variables and fiscal policy responses to crisis in Latin America over the last 40 years and in the Eurozone during the aftermath of the global financial crisis. It focuses on the behavior of: unemployment, poverty, income inequality and domestic conflict, finding that counter-cyclical (pro-cyclical) fiscal policy reduces (increases) all four social indicators.[8] [9]

Last, the fiscal multipliers literature also argues that the size of fiscal multipliers depends on the interaction between fiscal policy, monetary policy and the exchange rate regime degree of flexibility. For example, Ilzetzki *et al.* (2011) finds that countries with flexible exchange rate regimes tend to have multipliers close to zero, as the exchange rate flexibility compensates fiscal policy effects.

1.3 Methodology

In this section we present the data, describe the variables (also their arrangements and modifications), list the statistical tests we apply to them (unit root and cointegration tests), and select the number of lags to include in our models. Then we describe the analytical approaches (VAR, Structural VAR, and Bayesian VAR models) discussing their strengths and weaknesses. Last we argue about the impulse-response functions and how we calculate the fiscal multipliers (impact, one year, two years and long-term).

1.3.1 Data

This chapter covers the period 1990Q1-2015Q2. The data have a quarterly frequency, sourced by the Chilean Budget Office (Dipres), the Chilean National Bureau of Statistics (INE), the Central Bank of Chile and the Organization for Economic Co-operation and Development (OECD). The nominal government spending and taxes come from Dipres; the nominal GDP, consumer price index (of all items) and short-term interest rate are sourced by the INE, the Central Bank of Chile and the OECD; the nominal private consumption comes from the Central Bank of Chile and the OECD; the population and unemployment rate come from the INE.

Variables

The variables included in the "BP baseline model" and the "alternative baseline models" in Section 1.4 are the log of real per capita GDP in differences "$dlog\ Y_t$", the log of real per capita government spending in differences "$dlog\ G_t$", and the log of real per capita taxes in differences "$dlog\ T_t$". Section 1.5 also includes the log of real per capita private consumption in differences "$dlog\ c_t$", the unemployment rate (percentage) in differences "du_t", and the short-term interest rate (percentage) in differences "di_t". Then, the log of real per capita private consumption in differences, the unemployment rate in differences, and the short-term interest rate in differences, are added individually to the "BP baseline model" in Sections 1.6, 1.7 and 1.8, respectively. To

[8] "Domestic conflict" is an index set by these authors that comprises variables such as assassinations, strikes, guerrilla warfare, government crisis, purges, riots, revolutions, and antigovernment demonstrations.

[9] This finding motivates us to study the impact of fiscal policy on unemployment. Unfortunately, we cannot study the effect of fiscal policy on poverty, income distribution and domestic conflict, because data are not available on a quarterly frequency for these variables, as this chapter approach requires.

obtain these variables, but those in percentages, we deflate the nominal time series by the consumer price index (of all items), divided by the population, transformed into logarithms, seasonally adjusted using the Census X-12 seasonally adjustment method, and set their differences.

Unit Root Tests

The standard Augmented Dickey-Fuller, Elliot-Rothenberg-Stock, Phillips-Perron and Kwiatkowski-Phillips-Schmidt-Shin unit root tests were implemented with constant and time trend to the series in logarithms, with constant to the series in percentages, and without constant nor time trend to those in differences. The inclusion of the constant and/or time trend in the unit root tests was decided after data inspection. Meanwhile the time series in logarithms indicate non-stationarity (unit root), the series in percentages observe mix results (unit root and stationarity) depending on the specific test, and the data in differences result always stationary.[10]

Johansen Cointegration Tests

Cointegration was studied by applying the standard Johansen cointegration test, with constant and with and without a time trend, to the variables of study. We found that in most of the cases the "Trace" and "Maximum eigenvalue" Johansen cointegration tests, could not reject the null hypothesis of none cointegration among the variables we tested, meaning no evidence of cointegration among them, allowing the estimation of vector autoregression models.[11]

Lags Selection

It is well known that the lag selection has important quantitative implications for the accuracy of the vector autoregression impulse-responses (Ivanov and Kilian (2005)) but at the same time the number of lags chosen by the lag selection criteria existing in the literature (Schwarz Information Criterion (SIC), Hannan-Quinn Information Criterion (HQC) and Akaike Information Criterion (AIC), among others) can be somehow contradictory. In the literature that uses quarterly data, four lags are usually chosen (see for instance Blanchard and Perotti (2002), Caldara and Kamps (2008), Ilzetzki *et al.* (2011), González-García *et al.* (2013) and Karagyozova-Markova *et al.* (2013)), however such practice does not take into consideration the specificities of the data used by the researcher. In this chapter we follow a more "statistically based" approach to choose the number of lags included in our models, finding important differences in the results depending on the number of lags chosen, and even autocorrelation in the residuals when using four lags.

In a vector autoregression model, the lag selection process first considers choosing the maximum number of lags, which depends on the data frequency. For quarterly data, the maximum number of lags should be between six and eight lags (Canova (2007)).[12] Usually the lag selection information criteria give different answers to the question of what lag length should be chosen. For vector

[10] These unit root tests are not reported in this chapter, having in mind space constraints, but they can be asked to the author.
[11] These Johansen cointegration tests are not reported in this chapter, having in mind space constraints, but they can be asked to the author.
[12] The lag order obtained with sequential testing or with information criteria depends on the choice of the maximum number of lags (Lütkepohl (2011)).

autoregression models with quarterly data Ivanov and Kilian (2005) recommend to follow the SIC if the sample size is smaller than 120 (our sample includes 102 quarters) and the HQC if it is bigger than 120. Also they find that AIC is less accurate than SIC and HQC when using quarterly data. Hence, as lag selection criterion in this chapter our first best is SIC, followed by HQC and then by AIC. Last, we check for autocorrelation in the models' residuals, modifying the lag length if evidence of autocorrelation is found.[13]

1.3.2 Analytical Approaches

In the empirical literature that studies the dynamic effects of fiscal policy and fiscal multipliers, three main approaches are used: (i) The estimations based on vector autoregression models; (ii) Structural model-based evaluations as dynamic stochastic general equilibrium models (DSGE); and (iii) Case studies based on well documented changes in government spending or taxes. Among the vector autoregression models, four major strands of research stand out (Jemec *et al.* (2011)). First, short-term restrictions as the recursive Cholesky decomposition of the variance-covariance matrix of the models residuals (Fatas and Mihov (2001)). Second, Structural VAR models based on institutional information coming out of the model (Blanchard and Perotti (2002)). Third, imposing sign restrictions to the variables in the model (Mountford and Uhlig (2009)). And, "event studies" which require long data series of well-established exogenous shocks (Ramey and Shapiro (1998)).

In this chapter we estimate VAR and Bayesian VAR models, with Cholesky decomposition as identification scheme, and a Structural VAR model using elasticities of government spending and taxes to output and contemporaneous coefficients coming out of the model. We do so because VAR and Structural VAR models have been used in the previous papers that study the dynamic effects of fiscal policy and fiscal multipliers in Chile (VAR in Céspedes *et al.* (2011), and Structural VARs in Cerda *et al.* (2005) and Restrepo and Rincón (2006)), and Bayesian VAR models because on one hand these are currently considered as a standard tool in modern applied macroeconomics (Koop and Korobilis (2009), Banbura *et al.* (2010) and Lütkepohl (2011)) and on the other hand because, as far as we know, they have not been used to estimate fiscal multipliers in Chile.

Vector Autoregression (VAR) Models

VAR models are dynamic systems of equations that examine the relationship between economic variables, in which each variable is explained by its own lags, plus the current and past values of the remaining variables in the system, using very limited assumptions regarding the underlying structure of the economy, and aiming to provide a good statistical representation of the past interactions between the variables. VAR models have the advantage of being able to characterize any vector of time series under a minimal set of conditions, but have the weakness of requiring to estimate an important number of parameters leading to possible imprecision in the coefficients estimated.

VAR models in their reduced-form can be represented as follows:

$$Z_t = \alpha_0 + C(L)Z_{t-1} + U_t \qquad (1.1)$$

[13] We use a serial correlation LM test at 99% of statistical significance.

Where "Z_t" is a vector of "*k*" endogenous variables; "α_0" is a constant, $C(L)$ is a n[th]-order lag polynomial, and "U_t" is a vector of reduced form residuals, with $E[U_0] = 0$, $E[U_t U_t'] = \Sigma_U$ and $E[U_t U_s'] = 0$ for s ≠ t.[14] In the "BP baseline model" and the "alternative baseline models" the vector of endogenous variables, "Z_t", includes: the log of real per capita government spending in differences, "$dlog\ G_t$", the log of real per capita GDP in differences, "$dlog\ Y_t$", and the log of real per capita taxes in differences, "$dlog\ T_t$".[15]

To recover the structural shocks that affect the endogenous variables of the VAR, we use Cholesky decomposition as identification strategy, allowing the identification of the fiscal policy shocks. In this identification strategy the ordering of the variables has important implications. In the baseline models, the variables are ordered starting with the log of real per capita government spending in differences "$dlog\ G_t$", then the log of real per capita output in differences "$dlog\ Y_t$", and last the log of real per capita taxes in differences "$dlog\ T_t$", this in line with Fatas and Mihov (2001), Caldara and Kamps (2008) and Karagyozova-Markova *et al.* (2013). It implies that: (i) government spending does not react contemporaneously to shocks neither to output nor taxes; (ii) output is affected contemporaneously by government spending but not by taxes shocks; and (iii) taxes respond contemporaneously to government spending and output shocks.

Structural Vector Autoregression (Structural VAR) Models

Structural VAR models are also dynamic systems of equations that intend to reflect the relationships among economic variables, but they also include elements from the more structural and traditional macroeconomic models. These models are not difficult to implement and do not require extensive data gathering but small changes in the coefficients coming out of the model might lead to obtain very different results. In the case of the dynamic effects of fiscal policy on GDP, small changes in the elasticities of government spending and taxes to output might result in large differences in the impulse-response functions and fiscal multipliers (Ramey (2011)).

Starting from the VAR model in its reduced-form (equation (1.1)), the reduced-form residuals "U_t" can be written as linear combinations of the underlying structural innovations "e_t" as follows:

$$AU_t = Be_t \qquad (1.2)$$

Where matrices "A" and "B" describe the instantaneous relations between the reduced and the structural innovations, and $E(e_t e_t') = I$, i.e. the covariance matrix of the structural innovations is assumed to be an identity matrix. Thus, the structural-form VAR can be obtained by pre-multiplying the reduced form model (equation (1.1)) by the matrix A:

$$AZ_t = A\alpha_0 + AC(L)Z_{t-1} + Be_t \qquad (1.3)$$

In our baseline models the vector of endogenous variables "Z_t", correspond to: $Z_t = [dlog\ T_t, dlog\ G_t, dlog\ Y_t]$, the vector of reduced form residuals "U_t", to: $U_t = [t_t, g_t, y_t]$, and the

[14] Trends and dummy variables, among other specifies, could also be added to the VAR model represented by Equation (1.1).

[15] The exception is the VAR model following Céspedes *et al.* (2011) government spending definition, as it does not study taxes, so it includes government spending and GDP.

identification strategy follows Blanchard and Perotti (2002). Thus, equation (1.4) states that unexpected movements in taxes "t_t", can be due to three factors: the response to unexpected movements in GDP "y_t", the response to structural shocks to government spending "e_t^g", and to structural shocks to taxes "e_t^t". A similar interpretation applies for unexpected movements in government spending "g_t", represented by equation (1.5). The unexpected movements in output "y_t", can be due to unexpected movements in taxes "t_t", to unexpected movements in government spending "g_t" and to other unexpected shocks to output "e_t^y", equation (1.6).

$$t_t = a_1 y_t + a_2 e_t^g + e_t^t \tag{1.4}$$

$$g_t = b_1 y_t + b_2 e_t^t + e_t^g \tag{1.5}$$

$$y_t = c_1 t_t + c_2 g_t \ + e_t^y \tag{1.6}$$

The task of identifying the structural shocks is equivalent to finding a linear relation between the reduced-form residuals, "U_t", and the uncorrelated structural shocks, "e_t" (Franta (2012)). As the reduced-form residuals are a linear combination of the structural shocks, $U_t = A^{-1}Be_t$, they can be represented by equation (1.7).[16]

$$\begin{bmatrix} t_t \\ g_t \\ y_t \end{bmatrix} = \begin{bmatrix} 1 & 0 & -a_1 \\ 0 & 1 & -b_1 \\ -c_1 & -c_2 & 1 \end{bmatrix}^{-1} \begin{bmatrix} 1 & a_2 & 0 \\ b_2 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} e_t^t \\ e_t^g \\ e_t^y \end{bmatrix} \tag{1.7}$$

With: $U_t = \begin{bmatrix} t_t \\ g_t \\ y_t \end{bmatrix}$; $A = \begin{bmatrix} 1 & 0 & -a_1 \\ 0 & 1 & -b_1 \\ -c_1 & -c_2 & 1 \end{bmatrix}$; $B = \begin{bmatrix} 1 & a_2 & 0 \\ b_2 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$; and $e_t = \begin{bmatrix} e_t^t \\ e_t^g \\ e_t^y \end{bmatrix}$

The elements of matrix A can be interpreted as elasticities that capture the immediate effect that a change in one variable has on another variable, while the elements of matrix B represent the immediate effect of a structural shock on a variable.

To identify the system of equations, represented by equation (1.7), information about the elasticities of government spending and taxes with respect to output, "a_1" and "b_1", and the effects of taxes and government spending on output, "c_1" and "c_2", need to be estimated out of the model. In this chapter we use alternatively the elasticities of government spending and taxes to output and the contemporaneous coefficients produced by Cerda *et al.* (2005) and Restrepo and Rincón (2006) (Table 1.2).[17] Such procedure leaves two coefficients to estimate, "a_2" and "b_2". As we do not have a clear idea if government spending decisions come before taxes decisions, or viceversa, we follow Blanchard and Perotti (2002) assuming that taxes decisions come before the government spending

[16] In equation (1.7), for simplicity, we have omitted the endogenous variables lags. For an explanation that includes the treatment of a first-order Structural VAR see Restrepo and Rincón (2006).

[17] We do not calculate government spending and taxes to output elasticities and contemporaneous coefficients to avoid an additional source of differences in the impulse responses and fiscal multipliers we estimate, though that could also be done.

decisions, meaning that $a_2 = 0$ and estimating "b_2", and alternatively that government spending decisions come first so that $b_2 = 0$ leaving to estimate "a_2".

Table 1.2. Elasticities of Government Spending and Taxes to GDP and Contemporaneous Coefficients

Source:	a_1	b_1	c_1	c_2
Cerda *et al.* (2005)	1.31	1.92	-0.03	-0.25
Restrepo and Rincón (2006)	3.03	0.00	-0.034	0.165

Bayesian Vector Autoregression (Bayesian VAR) Models

Vector autoregression (VAR) models are a standard tool in empirical macroeconomics that compared to structural models (Structural VAR) do not impose restrictions on the parameters. However, VAR models need to estimate a large number of parameters entailing the risk of over-parametrization when using data samples of limited size. Bayesian VAR models deal with the problem of over-parametrization by using prior probability distributions to shrink the unrestricted models, thus reducing the parameters uncertainty, becoming increasingly popular as a way of overcoming these problems (Koop and Korobilis (2009)).

Compared to VAR and Structural VAR models, Bayesian VARs treat the model parameters as random variables, assigning prior probabilities to them, imposing prior information in the model in addition to that provided by the data. As this chapter data includes time series for the period 1990Q1-2015Q2, i.e. 102 quarters, over-parameterization might be a problem not previously addressed by VAR and Structural VAR models in Cerda *et al.* (2005), Restrepo and Rincón (2006), and Céspedes *et al*. (2011), all using even shorter time series than in this chapter. Thus, Bayesian VAR models are an attractive alternative to VAR and Structural VAR models, which additionally as far as we know, has not been used yet in the case of Chile to estimate the dynamic effects of fiscal policy and fiscal multipliers.

The implementation of Bayesian VAR estimations requires knowledge about the distributional properties of the "prior", "likelihood" and "posterior" distributions, where the "prior" is the external distribution information based on researchers' beliefs in parameters of interest, and the "likelihood" is the data information contained in the sample probability distribution function. The combination of the "prior" and the "likelihood", through Bayes theorem, results in the "posterior" distribution.

The reduced-form VAR model represented by equation (1.1) can be rewritten for compactness as:[18]

$$z = (I_m \otimes \mathrm{X})\theta + \mu \qquad (1.8)$$

Where "z" represents the data set, "I_m" is the identity matrix of dimension "m", $\mathrm{X} = (x_1, \dots, x_t,)'$ is a $T * (mn + 1)$ matrix with $x_t = \left(1, z'_{t-1}, \dots, z'_{t-q}\right)$, $\theta = vector(C)$ that represents the parameters of interest; and $\mu \sim N\left(0, \sum_\mu \otimes I_T\right)$.

[18] For further explanation see Canova (2007).

Considering a "prior" distribution "$f(\theta)$", equation (1.9), and a "likelihood" function "$l(z/\theta)$", equation (1.10):

$$f(\theta) \propto |V_\theta|^{-1/2} exp\left\{-\frac{1}{2}(\theta-\bar{\theta})' {V_\theta}^{-1}(\theta-\bar{\theta})\right\} \quad (1.9)$$

$$l(z/\theta) \propto |\sum_U \otimes I_T|^{-1/2} exp\left\{-\frac{1}{2}(\mu'(\sum_U \otimes I_T)\mu)\right\} \quad (1.10)$$

Where "θ" are the parameters of interest, "$\bar{\theta}$" the prior mean and "V_θ" the prior covariance matrix, we have that through the Bayes theorem:

$$f(\theta/z) = \frac{f(\theta)l(z/\theta)}{\int f(\theta)l(z/\theta)d\theta} \quad (1.11)$$

As $\int f(\theta)l(z/\theta)d\theta$ is a normalizing constant without randomness, the "posterior" distribution can be obtained, as equation (12) reflects.

$$f(\theta/z) \propto f(\theta)l(z/\theta) \quad (1.12)$$

Regarding the "priors", due to its simplicity and success in many applications Litterman/Minnesota prior have been substantially used in the empirical time series research, and considered a standard tool in applied macroeconomics (Koop and Korobilis (2009), Banbura *et al.* (2010) and Lütkepohl (2011)). With this in mind in this chapter we estimate the Bayesian VAR models using a Litterman/Minnesota prior.

The Litterman/Minnesota prior is based on a normal distribution prior on the parameters of interest, "θ", and the initial residual covariance matrix, "Σ_U", which is fixed. The estimation of $\widehat{\Sigma_U}$ can be univariate AR, diagonal VAR, and full VAR. A main advantage of the Litterman/Minnesota prior is that it leads to simple posterior inference, but also it does not provide a full Bayesian treatment of $\widehat{\Sigma_U}$ (Koop and Korobilis (2009)).

The Litterman/Minnesota "prior" set the values of "$\bar{\theta}$" and "V_θ" based on a small number of hyper-parameters. First, the prior mean "$\bar{\theta}$" which is set to zero to all its elements but the elements corresponding to the first own lag of the dependent variable in each equation ($\bar{\theta}_1 = 1$) (Canova (2007) and Koop and Korobilis (2009)). However, when using data found to be stationary, like in our case, it is sensible to simply set ($\bar{\theta}_1 = 0$) (Canova (2007), Abrego and Österholm (2008) and Koop and Korobilis (2009)). And second, those hyper-parameters that determine "V_θ", i.e: (i) The tightness on the variance of the first lag controlling the relative importance of the sample and prior information, set to $\lambda_0 = 0.2$ (if this hyper-parameter is small, prior information dominates over the sample information); (ii) The relative tightness of the variance of the other variables, set to $\lambda_1 = 0.5$ (a value less than 1 suggests that the other variables have less information than the lags of the own variable); and (iii) The tightness of the variance of lags other than the first one, set to 1 as we assume a linear decay ($\lambda_3 = 1$) (Canova (2007)).[19]

[19] The hyper-parameters ($\bar{\theta}_1, \lambda_0, \lambda_1$ and λ_3) used in this chapter Bayesian VAR estimations correspond to those suggested by Canova (2007).

The identification strategy, as in the VAR model, is Cholesky decomposition. Therefore the variables ordering in the baseline models starts with the log of real per capita government spending, the log of real per capita GDP goes second, and the log of real per capita taxes last, all in differences. As in the VAR and Structural VAR models, the number of lags included in the Bayesian VAR models follows the procedure we discussed in the previous sub-section.

1.3.3 How the Fiscal Multipliers are Calculated

Along with the literature tradition, in this chapter we measure the fiscal multipliers as the ratio between the changes in GDP to the exogenous change in a fiscal variable (government spending or taxes) that causes an effect on output.[20] Hence, from the impulse-response functions we calculate four different multipliers: at impact, after one year, at the second year, and in the long-term. The impact multiplier quantifies the contemporaneous effect of a unit increase in a fiscal variable, "f", on economic output, "y". The impact multiplier can be expressed as:

$$\text{Impact Multiplier} = \Delta y_t / \Delta f_t \tag{1.13}$$

The cumulative multiplier, that allows to calculate multipliers at any horizon after impact, results from the ratio between the cumulative effect on GDP ($\sum_{t=1}^{T} \Delta y_t$) and the accumulation of variations in the fiscal variable after an unexpected shock ($\sum_{t=1}^{T} \Delta f_t$).

$$\text{Cumulative Multiplier} = \sum_{t=1}^{T} \Delta y_t / \sum_{t=1}^{T} \Delta f_t \tag{1.14}$$

The fiscal multipliers at the first and second year correspond to those when $T = 4$ and $T = 8$, respectively. The long-term multipliers are defined as the multiplier when $T \to \infty$, but in practice after a sufficiently large number of periods, the cumulative multiplier reach a constant level. In this chapter we refer to the long-term multiplier, when the cumulative multiplier reaches twenty quarters, i.e. $T = 20$.

1.4 "BP Baseline Model" and Comparison with the "Alternative Baseline Models"

To respond to the question about the size of government spending and tax multipliers, we analyze the potential sources of differences described in Table 1.1, meaning, the period of study, the data frequency, the analytical approach, the number of lags, the variables included, and the definitions of government spending and taxes. In our estimations we control for all these differences with the exception of the alternative vector autoregression approaches and the definitions of government spending and taxes, implying that the differences we find following Cerda *et al.* (2005), Restrepo and Rincón (2006) and Céspedes *et al.* (2011) are due to these two reasons.

[20] To obtain the fiscal multipliers from the impulse-response functions we follow the standard transformation: $dy_{t+j}/df_t = \left(dlog\ y_{t+j}/dlog\ f_t\right)/\left(f_t/y_{t+j}\right)$ where y_{t+j} corresponds to the real per capita GDP, f_t to the fiscal variable (government spending or taxes) in real and per capita terms, and "j" is the number of periods after the shock.

In this section we estimate impulse-response functions and calculate fiscal multipliers of government spending and taxes using Blanchard and Perotti (2002) definitions of government spending and taxes ("BP baseline model"), comparing them with those we obtain following the alternative definitions of government spending and taxes in Cerda *et al.* (2005), Restrepo and Rincón (2006) and Céspedes *et al.* (2011), "alternative baseline models", using a VAR (Table 1.3), a Structural VAR (Table 1.4), and a Bayesian VAR (Table 1.5).[21] All models include the log of real per capita government spending in differences, the log of real per capita GDP in differences, the log of real per capita taxes in differences, and a constant, for the period 1990Q1-2015Q2.

Appendix 1.A reports the SIC, HQC, and AIC criteria, including six, seven and eight lags, for the "BP baseline model" and the "alternative baseline models". When we tested for autocorrelation (Appendix 1.B) we found that the residuals of the vector autoregression models using the number of lags proposed by the SIC were autocorrelated. This was not the case when using the number of lags recommended by the HQC. Hence, in this section we include as benchmark the number of lags suggested by the HQC. The models using the number of lags suggested by the SIC are estimated only for robustness (Appendices 1.E, 1.F and 1.G). In all "Baseline models" but Céspedes *et al.* (2011), the number of lags that HQC chooses is two, and SIC chooses one (Appendix 1.A). Last, the vector autoregression models using one and two lags satisfy the stability condition, with no root of the charactheristic polynomial outside the unit circle (Appendix 1.C).

Table 1.3. Government Spending and Tax Multipliers (VAR Model)
VAR model with constant and the number of lags suggested by the HQC 1/

Government Spending Definition	Impact	1 year	2 years	Long-term
Blanchard and Perotti (2002)	0.21	0.33	0.32	0.32
Cerda *et al.* (2005)	0.30	0.62	0.56	0.56
Céspedes *et al.* (2011) 2/	0.02	0.42	0.42	0.42
Restrepo and Rincón (2006)	0.43	1.63	1.48	1.50

Taxes Definition	Impact	1 year	2 years	Long-term
Blanchard and Perotti (2002)	0.00	-0.07	-0.12	-0.11
Cerda *et al.* (2005)	0.00	-0.17	-0.23	-0.22
Restrepo and Rincón (2006)	0.00	-0.06	-0.06	-0.06

1/ As suggested by the Hannan-Quinn information criterion (HQC) the VAR model include 2 lags for all the "Baseline models" but Céspedes *et al.* (2011) which includes 1 lag.

2/ The VAR model that follows Céspedes *et al.* (2011) definitions does not include taxes.

[21] "We define expenditure as total purchases of goods and services, i.e. government consumption plus government investment." (Blanchard and Perotti (2002)). In this chapter we call it "government spending". "We define the revenue variable as total tax revenues minus transfers (including interest payments)." (Blanchard and Perotti (2002)). This definition of government revenue is equivalent to the sum of personal taxes and nontax receipts, corporate profits taxes receipts, indirect business taxes and nontax accruals, and contributions for social insurance, less net transfer payments to persons and net interest paid by government". In this chapter we call it "taxes".

Table 1.3 displays the government spending and tax multipliers calculated using a VAR model and the alternative definitions of government spending and taxes available in Blanchard and Perotti (2002), Cerda *et al.* (2005), Restrepo and Rincón (2006) and Céspedes *et al.* (2011).[22] The government spending multiplier at impact goes from 0.02 (Céspedes *et al.* (2011) definition) to 0.43 (Restrepo and Rincón (2006) definition), and in the long-term it is also positive, ranging between 0.32 (Blanchard and Perotti (2002) definition) to 1.50 (Restrepo and Rincón (2006) definition). Yet different, all government spending multipliers are positive at impact, and below the unit in the long-term in all cases but Restrepo and Rincón (2006) definition. In contrast, the taxes multiplier by definition (Cholesky decomposition identification strategy assumes that taxes do not affect contemporaneously neither government spending nor output during the first period) are always null at impact, while in the long-term are slightly negative in all cases (Blanchard and Perotti (2002) definition, -0.11; Cerda *et al.* (2005) definition, -0.22; and Restrepo and Rincón (2006) definition, -0.06).

By using the same quarterly data for the period 1990Q1-2015Q2 and a VAR model including the government spending, taxes and GDP as endogenous variables (hence it does not consider Céspedes *et al.* (2011) definitions), we found that independent of the fiscal variables definitions: (i) the government spending multiplier is slightly positive at impact and below the unit in the long-term (the exception is with Restrepo and Rincón (2006) definition), and (ii) the taxes multiplier is zero at impact (because the Cholesky decomposition assumption) and slightly negative in the long-term.[23]

Hereafter we do not calculate fiscal multipliers following Céspedes *et al.* (2011) definitions because we want to keep this chapter within the fiscal multipliers tradition where vector autoregression models include government spending, taxes and output (Fatas and Mihov (2001), Blanchard and Perotti (2002), among others).

[22] This VAR model impulse-response and accumulated-response functions are presented in the Appendix 1.D.

[23] Appendix 1.E presents the government spending and tax multipliers using alternative VAR models, meaning: A VAR model that includes a constant, the number of lags suggested by the HQC, and time trend, with results in line with those in Table 1.3; and a VAR model with constant and the number of lags suggested by the SIC, which also finds positive government spending multipliers at impact and in the long-term, but instead slightly positive (not negative) tax multipliers in the long-term. This suggests that the VAR model tax multipliers sign might be sensible to the number of lags selected and/or the presence of autocorrelation in the model residuals.

Table 1.4. Government Spending and Tax Multipliers (Structural VAR Model)
Structural VAR model with constant and the number of lags suggested by the HQC 1/

Government Spending Definition	Coefficients	Impact	1 year	2 years	Long-term
Blanchard and Perotti (2002)	2/	0.75	2.08	1.82	1.85
	3/	0.81	2.37	2.15	2.18
Cerda *et al.* (2005)	2/	0.75	2.10	1.77	1.79
	3/	0.79	2.34	2.01	2.03
Restrepo and Rincón (2006)	2/	1.87	6.02	5.39	5.43
	3/	1.93	6.29	5.66	5.70

Taxes Definition	Coefficients	Impact	1 year	2 years	Long-term
Blanchard and Perotti (2002)	2/	-0.25	-0.97	-1.14	-1.13
	3/	-0.16	-0.65	-0.80	-0.80
Cerda *et al.* (2005)	2/	-0.28	-1.07	-1.15	-1.15
	3/	-0.21	-0.85	-0.94	-0.93
Restrepo and Rincón (2006)	2/	-0.28	-0.90	-0.91	-0.91
	3/	-0.21	-0.65	-0.66	-0.66

1/ The Structural VAR model includes a constant and the number of lags suggested by the Hannan-Quinn information criterion (HQC), i.e. 2 lags.

2/ Restrepo and Rincón (2006) coefficients: $a_1 = 3.03$; $b_1 = 0$; $c_1 = -0.034$; $c_2 = 0.165$; $a_2 = 0$ (Taxes decisions come before government spending decisions).

3/ Restrepo and Rincón (2006) coefficients: $a_1 = 3.03$; $b_1 = 0$; $c_1 = -0.034$; $c_2 = 0.165$; $b_2 = 0$ (Government spending decisions come before taxes decisions).

In Table 1.4 we present the fiscal multipliers of government spending and taxes using a Structural VAR model with constant and the number of lags suggested by HQC, i.e. two lags. The elasticities of government spending and taxes to output and the contemporaneous coefficients we use to estimate the Structural VAR model are sourced by Restrepo and Rincón (2006). The results we found for government spending and tax multipliers differ depending on the definition used, and are in general bigger, in absolute terms, than those obtained using a VAR model (Table 1.3). Meanwhile government spending multipliers at impact are all about the unit, ranging between 0.75 (Blanchard and Perotti (2002) and Cerda *et al.* (2005) definitions) to 1.93 (Restrepo and Rincón (2006) definition), in the long-term they are higher than one, 1.79 (Cerda *et al.* (2011) definition) on one extreme and 5.70 (Restrepo and Rincón (2006) definition) on the other. Tax multipliers are all negative, close to -0.2 at impact and ranging between -0.66 and -1.15 in the long-term. These results suggest that when using a Structural VAR model the fiscal multipliers size seems very

sensitive to the elasticities of government and taxes to output and the contemporaneous coefficients estimated out of the model.[24]

Table 1.5. Government Spending and Tax Multipliers (Bayesian VAR Model)
Bayesian VAR model with constant and the number of lags suggested by the HQC 1/ 2/

Government Spending Definition	Initial Residual Covariance	Impact	1 year	2 years	Long-term
Blanchard and Perotti (2002)	Univariate AR estimate	0.21	0.39	0.39	0.39
	Diagonal VAR estimate	0.21	0.39	0.38	0.39
	Full VAR estimate	0.20	0.40	0.40	0.40
Cerda *et al.* (2005)	Univariate AR estimate	0.30	0.68	0.64	0.64
	Diagonal VAR estimate	0.30	0.67	0.63	0.63
	Full VAR estimate	0.30	0.70	0.65	0.65
Restrepo and Rincón (2006)	Univariate AR estimate	0.43	1.52	1.45	1.45
	Diagonal VAR estimate	0.43	1.54	1.46	1.46
	Full VAR estimate	0.43	1.55	1.46	1.47

Taxes Definition	Initial Residual Covariance	Impact	1 year	2 years	Long-term
Blanchard and Perotti (2002)	Univariate AR estimate	0.00	0.01	-0.01	-0.01
	Diagonal VAR estimate	0.00	0.00	-0.03	-0.02
	Full VAR estimate	0.00	0.03	0.01	0.02
Cerda *et al.* (2005)	Univariate AR estimate	0.00	-0.05	-0.08	-0.08
	Diagonal VAR estimate	0.00	-0.06	-0.10	-0.10
	Full VAR estimate	0.00	-0.06	-0.10	-0.10
Restrepo and Rincón (2006)	Univariate AR estimate	0.00	0.01	0.00	0.01
	Diagonal VAR estimate	0.00	0.00	-0.01	0.00
	Full VAR estimate	0.00	0.00	0.00	0.00

1/ As suggested by the Hannan-Quinn information criterion (HQC) the Bayesian VAR models include 2 lags for all the "Baseline models".

2/ Litterman/Minnesota Prior. Hyper-parameters: $\bar{\theta}_1$ (AR(1) coefficient) = 0; $\lambda 0$ (tightness on the variance of the first lag) = 0.2; $\lambda 1$ (relative tightness on other variables) = 0.5; $\lambda 3$ (harmonic lag decay) = 1.

The Bayesian VAR results using a Litterman/Minnesota prior are presented in Table 1.5. The government spending multipliers at impact are consistently positive and smaller than 0.5, independent of the government spending definition. Same occurs in the long-term where government spending multipliers are positive, but smaller than 0.7, with the exception of those using Restrepo and Rincón (2006) definition. As in the VAR model, Table 1.3, all tax multipliers are null by definition (Cholesky decomposition identification strategy assumes that tax multipliers

[24] Appendix 1.F presents government spending and tax multipliers using a Structural VAR model with constant, the number of lags suggested by HQC, but instead the elasticities of government spending and taxes to output and the contemporaneous coefficients sourced from Cerda *et al.* (2005). These government spending multipliers are extremely high and negative, instead of positive. Hence, it seems that Ramey's (2011) critique applies in this case.

do not affect contemporaneously neither government spending nor output). In the long-term these are either negative or positive, though very close to zero, depending on the taxes definition used (slightly negative in the case of Blanchard and Perotti (2002) definition, about -0.1 when using Cerda *et al.* (2005) definition and about zero when considering Restrepo and Rincón (2006) definition).

Hence using a Bayesian VAR with Litterman/Minnesota priors we found that independent of the variables definitions, the government spending multiplier is positive but below 0.5 at impact and above or below the unit in the long-term (depending on the government definition used), and that the taxes multiplier is zero at impact (because the Cholesky decomposition assumption), and slightly negative or positive, though very close to zero in the long-term.

Overall, government spending multipliers are positive at impact and in the long-term. However, their size is very different when using VAR and Bayesian VAR models, vis à vis a Structural VAR model. Tax multipliers in the long-term are negative (VAR and Structural VAR models) and very close to zero (Bayesian VAR), meaning that increases in taxes could decrease or have a null effect, on GDP.

In summary, Tables 1.3, 1.4 and 1.5 show that: (i) Fiscal multipliers differ when using alternative definitions of government spending and taxes; (ii) Fiscal multipliers size differ greatly depending on the vector autoregression model used (VAR and Bayesian VAR vis à vis Structural VAR); and (iii) VAR and Bayesian VAR results are more in line with the international evidence and expected size of fiscal multipliers for a small and open economy than Structural VAR results, with government spending multipliers around 0.3 at impact and 0.5 in the long-term, and tax multipliers slightly negative or very close to zero in the long-term.

1.5 Extended Model

To illustrate the effects that private consumption, unemployment and monetary policy might have on the size of fiscal multipliers (government spending and taxes), in this section we use a Bayesian VAR "extended model" that builds on the "BP baseline model", by including the private consumption, the unemployment rate and the short-term interest rate, as additional endogenous variables. Bayesian VAR models do not face the problem of over-parameterization which could affect systems even fairly modest in size, with few as five or six variables (Banbura *et al.* (2010)), as occurs with VAR models. Compared to Structural VAR models, Bayesian VAR models do no rely on assumptions on government spending and taxes elasticities, and therefore they do not have to face the critique that argues that small changes in the assumed elasticities of taxes and government spending might result in large differences in the estimated multipliers (Ramey (2011)). To deal with the over-parameterization, the Bayesian VAR models use priors that make the large number of parameters depend on a small vector of hyper-parameters. We use Litterman/Minnesota prior, as it is considered a standard tool in modern applied macroeconomics (Koop and Korobilis (2009), Banbura *et al.* (2010) and Lütkepohl (2011)). Having these arguments in mind, in Sections 1.6 to 1.9 we also use a Bayesian VAR model with Litterman/Minnesota prior.

The "extended model" six variables are ordered as follow: first the log of real government spending per capita in differences, followed by the log of real private consumption per capita in differences, then the unemployment rate in differences, the log of real output per capita in differences, the log

of real taxes per capita in differences, and the short-term interest rate in differences. This ordering follows Fatas and Mihov (2001), and Cholesky decomposition is the identification strategy. This section "extended model" also includes a constant and two lags. When choosing the number of lags we found that the SIC and the HQC select one lag, though with residuals autocorrelated, and AIC (our third best option when following Ivanov and Kilian (2005) recommendation) suggests two lags, with errors not autocorrelated. Using two lags also allows comparability with Table 1.5 "BP baseline model" multipliers.

Table 1.6. Government Spending and Tax Multipliers
(Bayesian VAR "Extended Model")
Bayesian VAR model with constant and the number of lags suggested by the AIC 1/ 2/

	Impact	1 year	2 years	Long-term
Government Spending				
Univariate AR estimate	0.22	0.30	0.46	0.46
Diagonal VAR estimate	0.22	0.31	0.48	0.47
Full VAR estimate	0.21	0.31	0.48	0.47
Taxes				
Univariate AR estimate	0.00	0.12	0.04	0.05
Diagonal VAR estimate	0.00	0.12	0.04	0.05
Full VAR estimate	0.00	0.11	0.03	0.04

1/ As suggested by the Akaike information criterion (AIC) the Bayesian VAR models include 2 lags.

2/ Litterman/Minnesota Prior. Hyper-parameters: $\bar{\theta}_1$ (AR(1) coefficient) = 0; λ0 (tightness on the variance of the first lag) = 0.2; λ1 (relative tightness on other variables) = 0.5; λ3 (harmonic lag decay) = 1.

Table 1.6 presents the Bayesian VAR "extended model" government spending and tax multipliers for alternative assumptions about the initial residual covariance matrix. The results suggest that the government spending multiplier is about 0.2 at impact and 0.5 in the long-term, and that the taxes multiplier is null at impact (by assuming Cholesky decomposition) and about 0.05 in the long-term. Comparing these results (Table 1.6) with those we presented in Table 1.5 and in particular those following Blanchard and Perotti (2002) definitions, we do not find very significant differences.

In this section and similar to Section 1.4, we found that after including the private consumption, the unemployment rate and the short-term interest rate as endogenous variables, government spending are positive and tax multipliers are slightly positive but very close to zero, meaning that fiscal policy has limited effect to stimulate the economic output. These results are in line with the international evidence for a small open economy (Spilimbergo *et al.* (2009)) and partially with Cerda *et al.* (2005) and Restrepo and Rincón (2006).

1.6 Fiscal Policy and Private Consumption

Among the economists, the relation between fiscal policy and private consumption is still a subject of disagreement. On one hand, neo-classical models tend to predict that private consumption should

fall (increase) as a consequence of a positive (negative) shock to government spending (taxes), and on the other hand, Keynesian and some neo-Keynesian models predict the opposite.

On the empirical side, Blanchard and Perotti (2002) finds for the United States a positive effect of government spending on private consumption, and Perotti (2005) studying the effects of fiscal policy in five OECD countries (Australia, Canada, Germany, Great Britain and United States), finds that after 1980 the effects of government spending and taxes shocks on private consumption became mostly negative in all countries but the United States. In Chile the effect of fiscal policy on private consumption has been studied by Céspedes *et al.* (2011), finding a positive effect of government spending on private consumption.

In this section, building on the "BP baseline model", we study the relation between fiscal policy (government spending and taxes) and private consumption. To do so, we estimate impulse-response functions and calculate fiscal multipliers using a Bayesian VAR model with Litterman/Minnesota prior, for the period 1990Q1-2015Q2. The model includes the log of real per capita government spending in differences, the log of real per capita private consumption in differences, the log of real per capita GDP in differences, the log of real per capita taxes in differences as endogenous variables, and a constant. As the model residuals are autocorrelated when choosing the number of lags selected by the SIC, i.e. one lag, we choose the number of lags suggested by the HQC, i.e. two lags, without autocorrelated errors, which also allow comparability with Table 1.5 "BP baseline model" multipliers. Cholesky decomposition is the identification strategy and the ordering of the endogenous variables is the one described above.

Figure 1.1. Impulse-Response Functions (Bayesian VAR "BP Baseline Model" Including Private Consumption)

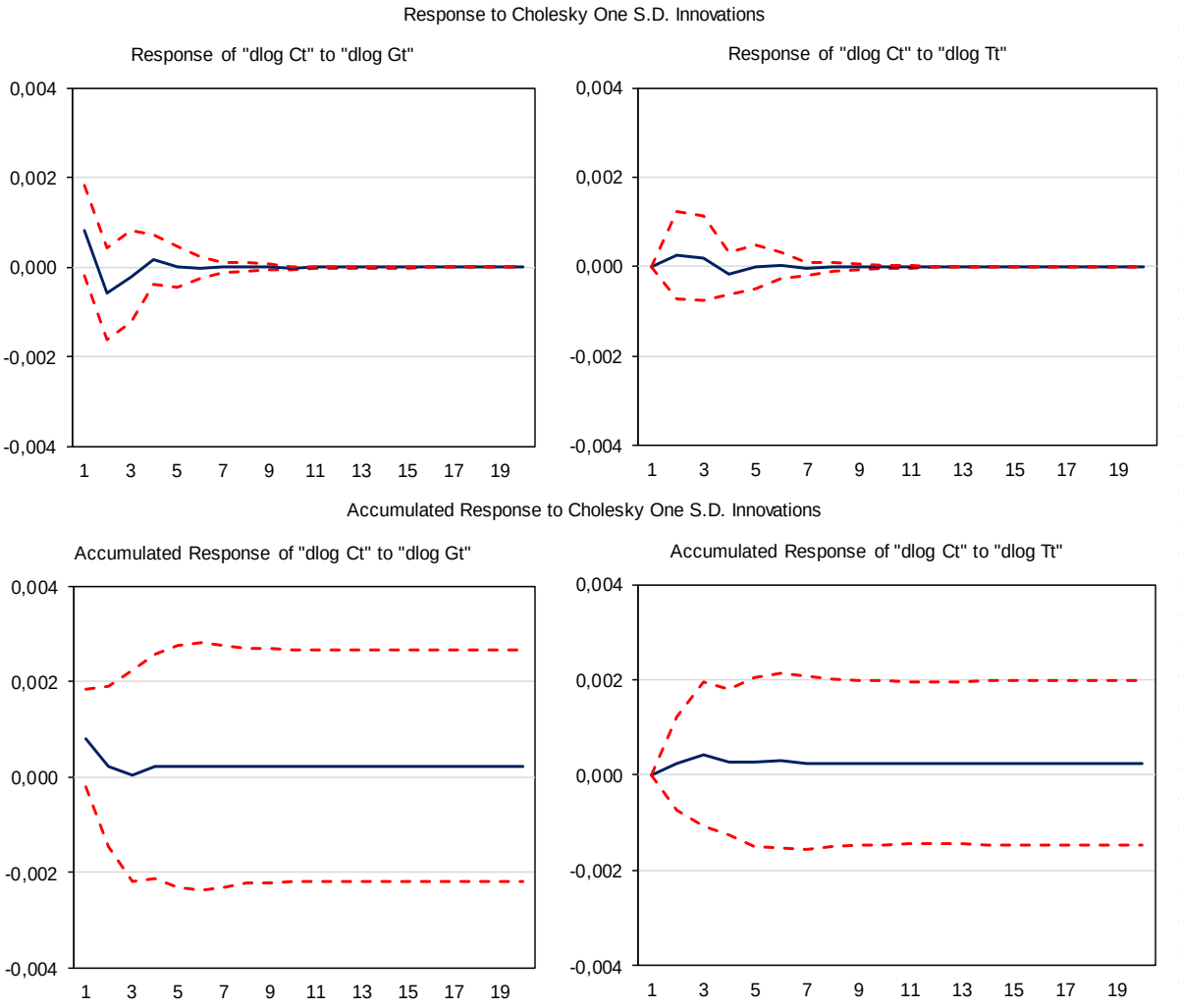


Figure 1.1 displays the response and the accumulated response of private consumption to a one standard deviation Cholesky innovation (shock) to government spending and taxes. Though close to zero, we find a slightly positive though not statistically significant effect of government spending on private consumption at impact, which fades out after four quarters, suggesting that Chile's government spending seems to not crowd-out private consumption. The effect of a shock to taxes on private consumption is slightly positive, also statistically not significant.

Table 1.7. Government Spending and Tax Multipliers
(Bayesian VAR "BP Baseline Model" Including Private Consumption)
Bayesian VAR model with constant and the number of lags suggested by the HQC 1/ 2/

	Impact	1 year	2 years	Long-term
Government Spending				
Univariate AR estimate	0.20	0.36	0.38	0.38
Diagonal VAR estimate	0.20	0.35	0.38	0.38
Full VAR estimate	0.18	0.33	0.35	0.35
Taxes				
Univariate AR estimate	0.00	0.07	0.05	0.05
Diagonal VAR estimate	0.00	0.07	0.04	0.05
Full VAR estimate	0.00	0.10	0.08	0.08

1/ As suggested by the Hannan-Quinn information criterion (HQC) the Bayesian VAR models include 2 lags.

2/ Litterman/Minnesota Prior. Hyper-parameters: $\bar{\theta}_1$ (AR(1) coefficient) = 0; λ0 (tightness on the variance of the first lag) = 0.2; λ1 (relative tightness on other variables) = 0.5; λ3 (harmonic lag decay) = 1.

This section government spending multipliers (Table 1.7) are very similar to those in Table 1.5 ("BP baseline model"), explained in part by the weak relation that exists between government spending and private consumption, and hence with output. Tax multipliers are also about the same in both cases (Table 1.5 and Table 1.7), i.e. null at impact (Cholesky decomposition) and slightly positive but close to zero in the long-term (about 0.05).

Therefore, in this section we found a positive but limited relation between government spending and private consumption, suggesting that government spending seems to not crowd-out private consumption, and that changes in taxes most likely do not affect private consumption. Fiscal multipliers in this section, as in Sections 1.4 and 1.5 Bayesian VAR models, are positive but below 0.5 in the case of government spending, and very close to zero in the case of tax multipliers.

1.7 Fiscal Policy and Unemployment

In a recent paper, Vegh and Vuletin (2014) study the impact of fiscal policy on social indicators in Latin America over the last four decades and in the Eurozone during the aftermath of the global financial crisis. Focusing on the behavior of unemployment, poverty, income inequality and domestic conflict, they find that a counter-cyclical (pro-cyclical) fiscal policy reduces (increases) all four previous social indicators. This section studies the relation between fiscal policy (government spending and taxes) and unemployment, and the effect on the size of fiscal multipliers of including the unemployment rate to the "BP baseline model". Unfortunately, although very interesting, we cannot study the relation between fiscal policy, poverty, income inequality and domestic conflict as these social indicators are not available on a quarterly basis, which is what this chapter Bayesian VAR model needs. Ex-ante we expected to find that Chile's counter-cyclical fiscal policy had led to a reduction (or smaller increase) of the unemployment.

Building on the "BP baseline model" we include the unemployment rate, available during all the period of study, i.e. 1990Q1-2015Q2, and sourced by the Chilean National Bureau of Statistics (INE). All the variables are in real per capita terms, seasonally adjusted, and in logarithms in differences. The exception is the unemployment (in percentage), seasonally adjusted and in differences. Cholesky decomposition is the identification strategy and the ordering of the variables considers the log of real per capita government spending in differences first, followed by the unemployment rate in differences, the log of real per capita GDP in differences, and the log of real per capita taxes in differences. As in previous sections, a Bayesian VAR model with a Litterman/Minnesota prior and constant is estimated. In spite that information criteria suggests using three lags we choose two lags to allow comparability with the fiscal multipliers in Tables 1.5 ("BP baseline model") and 1.6 ("extended model").

Figure 1.2. Impulse-Response Functions (Bayesian VAR "BP Baseline Model" Including Unemployment)

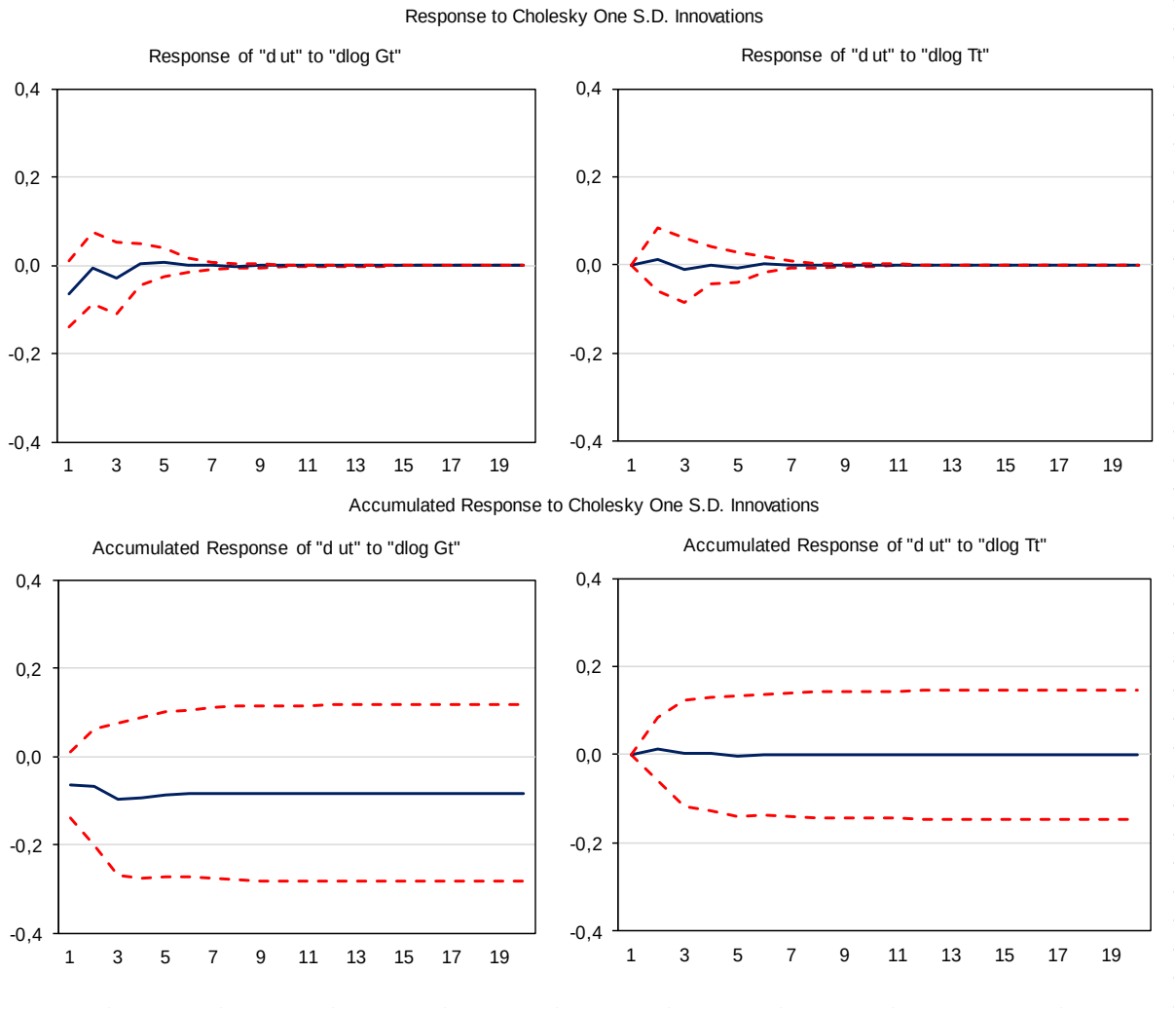


Figure 1.2 displays the response and the accumulated response of unemployment to a one standard deviation Cholesky innovation (shock) to government spending and taxes. We find evidence of a negative relation between government spending and unemployment, meaning that government spending might help to reduce unemployment, in a Keynesian tradition and similar to what Vegh and Vuletin (2014) reports and what we expected to find. During the most recent global crises

(1997 Asian crisis and 2008 global financial crisis) Chile's strong counter-cyclical fiscal policy, focused important efforts on the creation of "emergency public jobs" and public transfers to those most affected by the economic downturn. These efforts might explain the Keynesian relation we found between government spending and unemployment. The relation between taxes and unemployment is about null, meaning that tax changes do not change the unemployment.

Table 1.8. Government Spending and Tax Multipliers
(Bayesian VAR "BP Baseline Model" Including Unemployment)
Bayesian VAR model with constant and 2 lags 1/

	Impact	1 year	2 years	Long-term
Government Spending				
Univariate AR estimate	0.14	-0.06	-0.05	-0.05
Diagonal VAR estimate	0.14	-0.06	-0.05	-0.05
Full VAR estimate	0.14	-0.06	-0.03	-0.03
Taxes				
Univariate AR estimate	0.00	0.16	0.14	0.14
Diagonal VAR estimate	0.00	0.15	0.13	0.14
Full VAR estimate	0.00	0.18	0.17	0.17

1/ Litterman/Minnesota Prior. Hyper-parameters: $\bar{\theta}_1$ (AR(1) coefficient) = 0; λ0 (tightness on the variance of the first lag) = 0.2; λ1 (relative tightness on other variables) = 0.5; λ3 (harmonic lag decay) = 1.

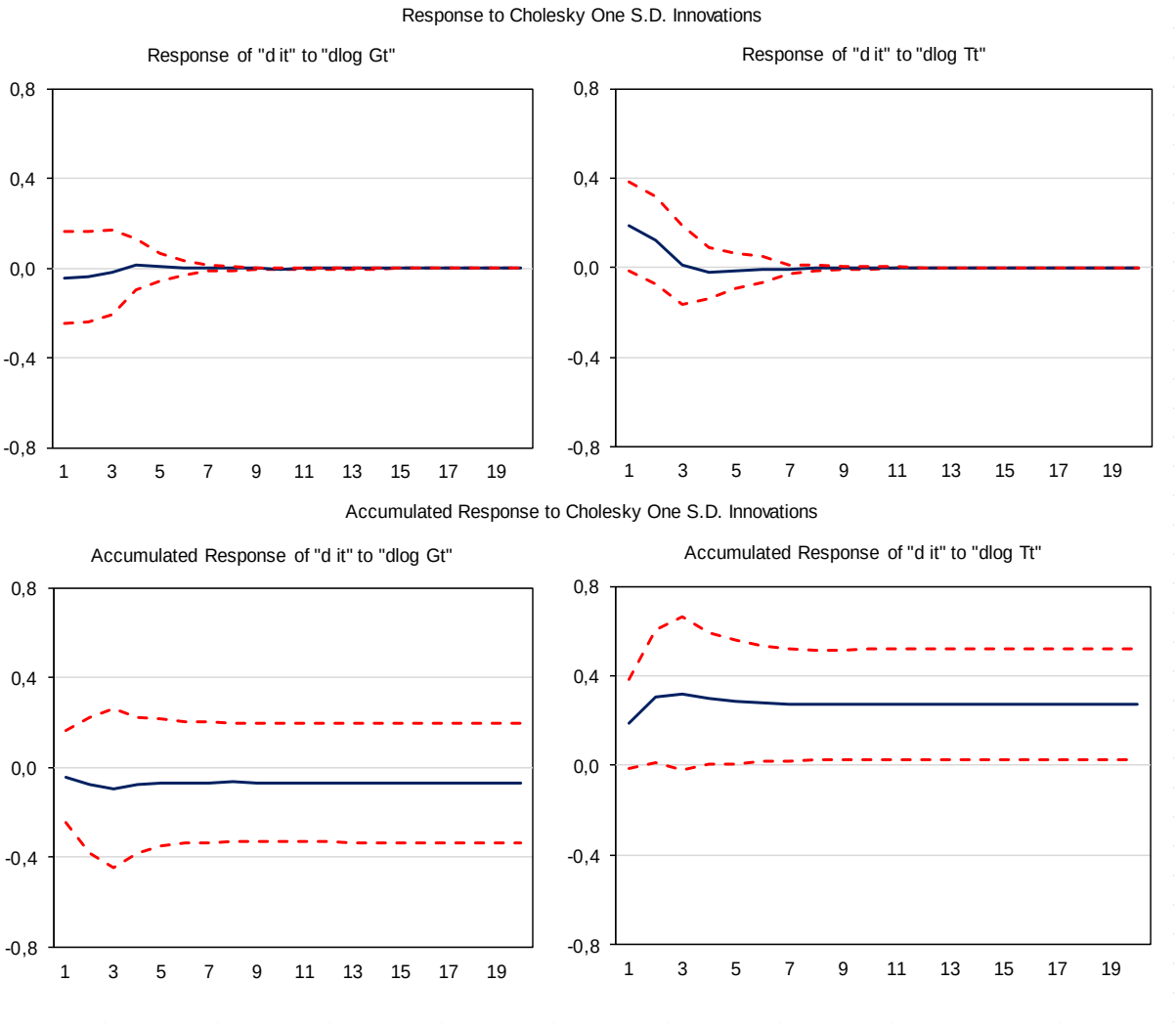
Table 1.8 results show that government spending multipliers are smaller when the unemployment rate is added to the "BP Baseline model", about 0.15 at impact and -0.05 in the long-term. Tax multipliers are positive and about 0.15 in the long-term.

1.8 Inclusion of Monetary Policy

In this section, by including the short-term interest rate to the "BP baseline model", we intend to analyze the relation between monetary and fiscal policies, and to study the effects of including the short-term interest rate on the size of the government spending and tax multipliers. We include the short-term interest rate because the notion that monetary accommodation plays an important role in the expansionary effect of fiscal policy, turns out to be related to those studies showing that fiscal multipliers are larger when central banks' policy interest rate is at the zero lower bound. In this field, a contribution by Ilzetzki *et al.* (2011) presents evidence on the importance of fiscal-monetary interactions as a crucial determinant of the effect of fiscal policy on economic output for developing countries. Additionally, probably the two main pieces of Chile's macroeconomic policy framework are an independent Central Bank, whose main objective is to keep inflation on target, and a fiscal policy, strongly guided by a structural balance fiscal rule.

Building on the "BP baseline model" we include the short-term interest rate available for the period 1990Q1-2015Q2.[25] All variables are in real per capita terms, seasonally adjusted, and in logarithms in differences, with the exception of the interest rate (percentage) which is only seasonally adjusted and in differences. The ordering of the variables considers the log of real per capita government spending in differences, the log of real per capita GDP in differences, the log of real per capita taxes in differences, and the short-term interest rate in differences. The identification strategy is Cholesky decomposition. Two lags, which allow comparability with previous sections results, and Litterman/Minnesota prior are included in the Bayesian VAR model.

Figure 1.3. Impulse-Response Functions (Bayesian VAR "BP Baseline Model" Including Monetary Policy)



In Figure 1.3 we display impulse-response functions that describe the response and the accumulated response of the short-term interest rate to a one standard deviation Cholesky innovation (shock) to government spending and taxes.

[25] The short-term interest rate is sourced by the Central Bank of Chile and corresponds to the Indexed Treasury Bill on 90 days (PRBC the acronym in Spanish) until May 1995, and the Monetary Policy Interest Rate (TPM the acronym in Spanish). When more than one interest rate was available during one quarter we included the average of them, and when the interest rate was not available for one quarter we included the last available.

We find that the short-term interest rate decreases after a shock to government spending, at impact and during the first three quarters, with a slightly negative accumulated response, and that the short-term interest rate response to a tax rise is positive, during the first three quarters and in the long-term. The slightly negative relation between government spending and the short-term interest rate might reflects that Chile's fiscal policy, through government spending, in general has not put pressure on the Central Bank via price increases and hence inflation. The positive relation between government taxes and the short-term interest rate, might be explained by the fact that when government revenues have been negatively affected, mostly by international shocks, the monetary policy, has been expansionary, as it happened in the aftermath of the Asian crisis in the late 90's and especially after the global financial crisis of 2008. These results evidence that the Chilean fiscal authorities, guided by the structural balance fiscal rule, not only have counted with a comfortable fiscal position to execute counter-cyclical fiscal policy, when it has been needed, but also they left enough "space" to the Central Bank to implement expansionary monetary policy too.

Table 1.9. Government Spending and Tax Multipliers
(Bayesian VAR "BP Baseline Model" Including Interest Rate)
Bayesian VAR model with constant and 2 lags 1/

	Impact	1 year	2 years	Long-term
Government Spending				
Univariate AR estimate	0.26	0.66	0.66	0.66
Diagonal VAR estimate	0.26	0.66	0.66	0.66
Full VAR estimate	0.26	0.67	0.68	0.68
Taxes				
Univariate AR estimate	0.00	-0.10	-0.15	-0.14
Diagonal VAR estimate	0.00	-0.10	-0.15	-0.14
Full VAR estimate	0.00	-0.08	-0.13	-0.12

1/ Litterman/Minnesota Prior. Hyper-parameters: $\bar{\theta}_1$ (AR(1) coefficient) = 0; λ0 (tightness on the variance of the first lag) = 0.2; λ1 (relative tightness on other variables) = 0.5; λ3 (harmonic lag decay) = 1.

Table 1.9 displays government spending and tax multipliers obtained from the Bayesian VAR "BP baseline model" including the short-term interest rate. As in previous sections, government spending multipliers are positive both at impact and in the long-term. Though, still below the unit, this section government spending multipliers are slightly bigger than those in Section 1.4 (in this section about 0.25 at impact and 0.65 in the long-term, and about 0.20 at impact and 0.40 in the long-term in Section 1.4). With an average short-term interest rate of about 5 percent, during the period of study, bigger government spending multipliers are in line with the literature that studies the effectiveness of fiscal policy when central banks' policy interest rate is close to the zero lower bound (Ilzetzki *et al.* (2011)). Tax multipliers are again zero at impact and negative but close to zero in the long-term.

Hence, in this section we found that the short-term interest rate has a slightly negative relation with government spending and positive with taxes. Government spending multipliers are positive, below

the unit but bigger than those we obtained from the "BP baseline model" in Section 1.4, and tax multipliers are negative this time but still close to zero.

1.9 Exchange Rate Regime Change Implications

Authors as Céspedes *et al.* (2011) and Ilzetzki *et al.* (2011) have argued that the interaction between fiscal policy, monetary policy and the degree of flexibility of the exchange rate regime, would impact the size of fiscal multipliers. In fact recent evidence suggests that those countries with flexible exchange rate regimes tend to have multipliers close to zero, as the exchange rate flexibility compensate the effect of the fiscal policy. In September 1999 Chile's exchange rate regime moved from a wide band floating during the 90's to a flexible one. Hence, in this section we study the effect of Chile's exchange rate regime change on the size of government spending and tax multipliers. First, we look for possible structural changes using the Chow and Bai-Perron tests, and then building on "BP baseline model" (as in Section 1.4 the model includes a constant, two lags, and same variables order) we estimate impulse-response functions and calculate government spending and tax multipliers for the periods 1990Q1-1999Q4 (Period 1: Before the exchange rate regime change) and 2000Q1-2015Q2 (Period 2: After the exchange rate regime change).

The Chow breakpoint and the multiple breakpoint Bai-Perron tests (Appendix 1.H) suggest statistical evidence of a significant change in the variables in levels (log of real per capita GDP, log of real per capita government spending and the log of real per capita taxes).[26] Nevertheless, this evidence is not necessarily caused by 1999's exchange rate regime change.

[26] The dates we tested with the Chow breakpoint test are 1999Q3, 1999Q4 and 2000Q1.

Table 1.10. Government Spending and Tax Multipliers
(Bayesian VAR "BP Baseline Model" Periods 1 and 2)
Bayesian VAR model with constant and 2 lags 1/

Period 1: 1990Q1-1999Q4	Impact	1 year	2 years	Long-term
Government Spending				
Univariate AR estimate	0.20	-3.11	-4.02	-4.09
Diagonal VAR estimate	0.13	-3.86	-5.15	-5.28
Full VAR estimate	0.12	-3.97	-5.31	-5.44
Taxes				
Univariate AR estimate	0.00	0.55	0.63	0.63
Diagonal VAR estimate	0.00	0.52	0.61	0.62
Full VAR estimate	0.00	0.54	0.63	0.64

Period 2: 2000Q1-2015Q2	Impact	1 year	2 years	Long-term
Government Spending				
Univariate AR estimate	-0.06	0.84	0.83	0.83
Diagonal VAR estimate	-0.06	0.88	0.85	0.86
Full VAR estimate	-0.08	0.79	0.76	0.76
Taxes				
Univariate AR estimate	0.00	0.11	0.10	0.10
Diagonal VAR estimate	0.00	0.12	0.10	0.11
Full VAR estimate	0.00	0.18	0.16	0.16

1/ Litterman/Minnesota Prior. Hyper-parameters: $\bar{\theta}_1$ (AR(1) coefficient) = 0; λ0 (tightness on the variance of the first lag) = 0.2; λ1 (relative tightness on other variables) = 0.5; λ3 (harmonic lag decay) = 1.

Compared to the results in Table 1.5 “BP baseline model”, government spending multipliers presented in Table 1.10 are remarkably different. On one hand, in period 1 the government spending multiplier is about 0.15 at impact and -5 in the long-term, and on the other in period 2 the government spending multiplier is slightly negative at impact (-0.06) and positive but below the unit in the long-term (around 0.80). This finding suggests that government spending multipliers are very sensitive to the sample size (40 quarters in period 1, 62 quarters in period 2, and 102 quarters in the full sample), providing not reliable results. Same occurs with government tax multipliers, zero at impact in all cases (period 1, period 2 and Table 1.5 “BP baseline model”) because Cholesky decomposition, and in the long-term (about 0.6 in period 1, slightly positive and close to 0.1 in period 2, and about zero using the full sample in Table 1.5 “BP baseline model”). To confirm the lack of robustness of these results, we estimated alternative Bayesian VAR models using different number of lags and alternative hyper-parameter values, finding very significant changes in the fiscal multipliers of government spending and taxes.

1.10 Conclusions

In this chapter we estimate impulse-response functions and calculate fiscal multipliers (government spending and taxes) in Chile using quarterly data, alternative definitions of government spending and taxes, and different number of endogenous variables (government spending, taxes, GDP, private consumption, unemployment, and short-term interest rate) and autoregressive models (VAR, Structural VAR and Bayesian VAR).

Our results suggest that in a country with the characteristics of Chile fiscal policy has little influence to boost economic output, and if so government spending seems to have a bigger effect on GDP vis à vis taxes.

The results we obtained from the "BP baseline model" and the "alternative baseline models", which include government spending, taxes and GDP as endogenous variables and different definitions of government spending and taxes, not only vary because of the identification strategy and the vector autoregressive model used (VAR, Structural VAR or Bayesian VAR models), but also because of the definition of government spending and taxes followed. Hence we find that: (i) Government spending multipliers are positive at impact and different in sign and size in the long-term depending on the vector autoregressive model used; (ii) Tax multipliers at impact are null when Cholesky decomposition is the identification strategy (VAR and Bayesian VAR models) and negative when a Structural VAR model is estimated; and (iii) In the long-term, tax multipliers are slightly negative, null or slightly positive, depending on the vector autoregressive model used.

Considering that VAR models might face an over-parameterization problem and that the multipliers coming out of Structural VAR models depend substantially on the elasticities estimated outside the model, building on the "BP baseline model" we estimate an "extended model" that includes private consumption, the unemployment rate, and the short-term interest rate, using a Bayesian VAR model. We find that government spending multipliers, at impact and in the long-term, are slightly positive but below 0.5, and that tax multipliers are close to zero, meaning that fiscal policy has only a limited influence to boost economic output. These results are in line with the international evidence for a small open economy (Spilimbergo *et al.* (2009)) and closer to Cerda *et al.* (2005) and Restrepo and Rincón (2006) than to Céspedes *et al.* (2011).

Then, based on the "BP baseline model" and including alternatively private consumption, the unemployment rate and the short-term interest rate, as endogenous variables, using a Bayesian VAR we find: (i) A positive but weak relation between government spending and private consumption, suggesting that government spending seems to not crowd-out private consumption; (ii) Some evidence of a Keynesian relation between government spending and unemployment; (iii) That the short-term interest rate has a negative relation with government spending and positive with taxes; and (iv) That when the short-term interest rate is taken in consideration, government spending multipliers are positive, below the unit but bigger than those we obtained from the "BP baseline model", and tax multipliers are negative but still close to zero.

Possible avenues for further research might include a better understanding of why Structural VAR models deliver such different results depending on the government spending and taxes to output elasticities and other coefficients assumed for identification; the estimation of a Bayesian VAR model using alternative priors and hyper-parameters for the Chilean economy; and estimation of fiscal multipliers using non-linear models.

Chapter 2

Commodity Price Shocks and Macroeconomic Effects on the Chilean Economy [#]

2.1 Introduction

Commodity prices have shown huge volatility during the past years. In the aftermath of the global financial crisis of 2008 (hereafter global financial crisis), the strong growth and demand for commodities coming from Asia, particularly China, joint with supply constraints, implied a boom in commodity prices and a consequent fiscal resource abundance well received by commodity exporter economies such as Chile. However, since 2011, commodity prices have experimented a sharp decline reaching by the end of 2015 similar levels to those exhibited during the global financial crisis.

Volatility in commodity prices results in a big challenge for commodity exporter economies such as Chile. The country's openness to world markets and the weight of commodity exports in its economy make it quite exposed to global commodity price volatility, which represent a significant challenge in terms of economic growth, fiscal management and effects to the private sector.

In order to reduce uncertainty in fiscal revenues coming from copper price volatility, in 2001 Chile improved its macroeconomic policy framework by including a structural balance fiscal rule (hereafter fiscal rule). Announced in 2000 and launched in 2001, the Chilean fiscal rule was designed as an institutional arrangement aiming to improve the country's policy framework and to reduce the uncertainty in fiscal revenues.

In this chapter we study how commodity price shocks from copper and non-copper commodity prices affect the Chilean GDP, fiscal accounts (government revenues, consumption and investment), and private consumption based on correlation analysis and vector autoregression models, and we explore if the fiscal rule allowed a structural change in the relationship between commodity prices (of copper and non-copper commodities), and the Chilean GDP, fiscal accounts (government revenues, consumption and investment) and private consumption.

The international literature that studies the effects of commodity price shocks on macroeconomic aggregates finds that commodity price shocks do have an impact on the economic activity and fiscal accounts. Meanwhile the effects on the economic activity and fiscal revenues are positive, the effect on fiscal expenditure (government consumption and investment) is ambiguous, with a large divergence among countries that might be explained by their exposure to international shocks and institutional arrangements in place.

[#] A new version of this chapter might include a Threshold-VAR model.

Examining the evidence of cycles in the terms of trade and fiscal policy, in particular government expenditure and revenues, primary balances and inflation, Kaminsky (2010) using correlation analysis and a panel data approach finds for a set of 74 countries, between 1960 and 2008, that terms of trade booms do not necessarily lead to larger government surpluses in developing countries and that fiscal policy is counter-cyclical in developed countries.

In a study including 86 developing commodity export economies, the International Monetary Fund (2012) estimates a dynamic panel model and concludes that commodity exporters' macroeconomic performance tends to move with the commodity price cycle, with fiscal balances deteriorating (improving) during commodity price downswings (upswings), and that such behavior is more prominent for energy and metal exporters than for food exporters, as energy and metal prices are more sensitive to the global business cycle.

Studying a set of developing commodity exporter countries and using a reduced-form cross-country panel regression approach, Spatafora and Samake (2012) builds a data set for up to 116 economies between 1990 and 2010, assessing the impact of commodity export and import price shocks on fiscal revenues and expenditure, social expenditure, and public debt. These authors find that commodity price shocks do have a significant impact on fiscal accounts. Indeed, fiscal expenditure and revenues rise in response to commodity price increases.

Céspedes and Velasco (2014) studies fiscal pro-cyclicality for a set of commodity-rich nations estimating country by country regressions focusing on the behavior of fiscal variables across the commodity cycle. They built a commodity price index for 50 economies between 1900 and 2010 and identify commodity boom episodes (periods of significant increase in commodity prices) before analyzing the behavior of key fiscal variables surrounding these episodes. For almost every country in the sample, these authors identified two boom episodes, the first in the 70's or early 80's and the second in the years immediately prior to the global financial crisis, finding that the fiscal policy of many commodity-rich nations were quite pro-cyclical in the first boom episode and less countries had a pro-cyclical fiscal policy during the second boom episode.

Focusing on Latin America and the Caribbean and using a cross-country panel data, Sinnot (2009) looks at fiscal dependence on commodity production in the region, investigating co-movement between fiscal revenues and expenditure and commodity prices, for a panel of 19 countries between 1964 and 2008. It finds that fiscal revenues have had a positive response to commodity price changes since late 90's and onwards, that fiscal expenditure response is not found, and that at the country level, a large divergence among countries exists between 2000 and 2008.

In the same vein as Sinnot (2009), for a group of eight Latin American commodity exporter countries, Medina (2010) analyzes the dynamic effects of commodity price fluctuations in fiscal revenues and expenditure, covering a period that differs from country to country (as early as the first quarter of 1975, depending on the country, and ending in the last quarter of 2008). It uses aggregate commodity price indices and a vector autoregression approach, finding that their fiscal positions react strongly to shocks to commodity prices. Nevertheless, it also finds that countries included in the sample present a very different behavior, where the highest sensitivity of fiscal expenditure to commodity prices is found in Venezuela and the least in Chile.[27]

[27] In the case of Chile the sample period used by Medina (2010) starts in the first quarter of 1995 and ends in the fourth quarter of 2008.

With copper exports representing about half of the Chilean exports and more than 12 percent of GDP in 2015, most of the literature about Chile focuses on copper price volatility, leaving unexplored the effects of other important commodity export prices on the economy. Moreover, this literature (Medina and Soto (2007), De Gregorio and Labbé (2011), Pedersen (2014), and Eyraud (2015)) has focused on the effects of copper price shocks on GDP and the monetary and exchange rate policies (i.e. inflation, short-term interest rate and exchange rate) without paying much attention to the effects on fiscal accounts (government revenues, consumption and investment) and the private sector (private consumption).

Medina and Soto (2007), using a dynamic stochastic general equilibrium model (DSGE) and different fiscal rule scenario find that a 10 percent shock to copper prices would increase economic output by about 0.05 percent, when a fiscal rule of half percent of GDP is in place, and that the same shock would increase economic output by up to 0.7 percent if the fiscal policy were highly expansive.

De Gregorio and Labbé (2011), based on empirical evidence find that since the adoption of a full flexible exchange rate regime in 1999, the response of GDP to copper price fluctuations has been decreasing, meaning that the Chilean economy has become more resilient to copper price shocks during the last fifteen years.

More recently, using a Structural VAR model, where shocks are identified as sign restrictions imposed to the impulse-response functions, Pedersen (2014) analyzes how copper price shocks affect GDP, inflation, short-term interest rate and the exchange rate, making a distinction between supply, demand, and specific copper demand shocks. It finds that demand shocks imply higher growth in Chile, and that supply and specific copper demand shocks are negative to growth in the short-term.

Last, Eyraud (2015) estimates the effects of copper prices on Chile's growth at various time horizons, using three different methods (statistical approach, event analysis, and vector error correction models (VECM)). It finds that a copper price decline is likely to have a durable, although not permanent effect on GDP growth, where the strongest impact occurs during the first three years.

Thus, the existing literature has left without a clear answer questions such as: What are the effects of copper price shocks on other macroeconomic aggregates, after GDP, such as fiscal accounts (government revenues, consumption and investment) and private consumption? And what are the consequences on economic growth, fiscal accounts (government revenues, consumption and investment) and private consumption of price shocks to other non-copper Chilean commodity exports?

In such a context, this chapter contributes to this literature by extending the estimations and analysis of the impact of copper price shocks on the Chilean GDP (Medina and Soto (2007), De Gregorio and Labbé (2011), Pedersen (2014) and Eyraud (2015)), to other important macroeconomic aggregates, named: government revenues, consumption, investment, and private consumption. It also studies the impact of shocks to other non-copper Chilean commodity exports, as alternative sources of disturbances, on GDP, fiscal accounts (government revenues, consumption and investment) and private consumption. Last, it looks for structural changes in these macroeconomic aggregates (GDP, fiscal accounts and private consumption) as a consequence of the fiscal rule

installment in 2001. To do so, we collected data from January 1990 to September 2015, present stylized facts, set a non-copper commodity price index, do correlation analysis and estimate the dynamic relationship between commodity prices and Chilean macroeconomic aggregates using a vector autoregression approach, assuming that: (i) Commodity price shocks are exogenous i.e. Chile is a price taker in the commodity world markets; and (ii) Chile's fiscal policy (government revenues, consumption and investment) cannot react contemporaneously to changes in the economic activity (using Cholesky decomposition).[28]

The rest of this chapter discusses: stylized facts (Section 2.2); data sources and transformations of variables (Section 2.3); copper prices and the non-copper "IMF type" commodity price index (Section 2.4); correlation analysis between copper prices and non-copper "IMF type" commodity price index cycles, and the GDP, fiscal accounts (government revenues, consumption and investment) and private consumption cycles (Section 2.5); vector autoregression models, their assumptions and results (Section 2.6); the Chilean structural balance fiscal rule and its implications (Section 2.7); and finally the conclusions (Section 2.8).

2.2 Stylized Facts

Chile is a commodity export economy with exports representing in 2015 about 26 percent of its GDP. Most of Chilean exports are related to copper and other commodity products as: wood, fruits, metals and minerals and fish. During 2015, while copper exports represented about 50 percent of total exports and more than 12 percent of GDP, non-copper commodity exports represented about 35 percent of total exports and about 9 percent of GDP.

Table 2.1. Main Chilean Commodity Exports

Commodity 1/ 2/	Millions of US$			As Percent of Total Exports			As Percent of GDP		
	1990	2000	2015	1990	2000	2015	1990	2000	2015
Copper refined/unrefined	3,446.2	4,954.5	16,559.0	40.4	27.2	26.1	10.5	6.4	6.9
Copper ores/concentrates	522.1	2,393.7	13,891.0	6.1	13.1	21.9	1.6	3.1	5.8
Wood pulp	224.8	955.6	2,321.7	2.6	5.2	3.7	0.7	1.2	1.0
Fruit fresh/dried	179.4	386.1	2,138.0	2.1	2.1	3.4	0.5	0.5	0.9
Molybdenum	97.4	170.5	1,847.6	1.1	0.9	2.9	0.3	0.2	0.8
Grapes fresh/dried	378.6	572.2	1,486.1	4.4	3.1	2.3	1.2	0.7	0.6
Fish frozen	158.0	487.3	1,325.3	1.9	2.7	2.1	0.5	0.6	0.6
Fish fillets	33.6	343.7	1,141.2	0.4	1.9	1.8	0.1	0.4	0.5
Softwood	147.4	315.8	818.5	1.7	1.7	1.3	0.4	0.4	0.3
Gold non-monetary	229.9	293.5	800.3	2.7	1.6	1.3	0.7	0.4	0.3
Subtotal	5,417.4	10,872.9	42,328.8	63.6	59.7	66.8	16.5	13.9	17.6
Others	3,104.7	7,341.6	21,031.3	36.4	40.3	33.2	9.5	9.4	8.8
Total	8,522.0	18,214.5	63,360.1	100.0	100.0	100.0	25.9	23.4	26.4

Sources: World Bank (World Integrated Trade Solutions), International Monetary Fund (World Economic Outlook) and author's calculations.

1/ Standard International Trade Classification Rev. 4 (STIC4) 4 digits (Sub-group).

2/ In spite of being the fifth main Chilean export in 2015, "wine of fresh grapes" was excluded from this table as it is considered as a manufactured good.

In Table 2.1 we present figures of the main Chilean commodity exports in millions of US$, as percent of total exports, and as percent of GDP, in 1990, 2000, and 2015. Among the Chilean

[28] The data set starts in January 1990 as quarterly GDP is available for Chile only since the first quarter of 1990.

exports, copper represents more than half of them, with copper refined/unrefined (first) and copper ores/concentrates (second) reaching respectively 26.1 and 21.9 percent of total exports in 2015. On its side, also in 2015, non-copper exports as wood pulp (third), fruit fresh/dried (fourth) and molybdenum (fifth) represent a 3.7, 3.4, and 2.9 percent, respectively.

2.3 Data and Transformations of Variables

In this chapter the data covers the period between January 1990 and September 2015. The variables included in the coming sections are: copper prices and a non-copper commodity price index (we set combining data on international non-copper commodity prices and Chilean commodity exports); the Chilean GDP; government revenues, consumption and investment; and private consumption.[29] [30] [31]

Meanwhile the Chilean GDP and private consumption are sourced directly from its original definitions, we designate government revenues as the total government revenues less social contributions (transfers and pension contributions), the government consumption as government compensation of employees plus government purchases of goods and services, and the government investment as government capital expenditure net of capital transfers.

Commodity price data, sourced from the International Monetary Fund (Primary Commodity Prices Database), has a nominal and monthly frequency and is not seasonally adjusted. Chile's commodity exports data have a yearly basis and comes from the World Bank (World Integrated Trade Solutions). The GDP, sourced from the Central Bank of Chile and the Organization for Economic Co-operation and Development (OECD) and Correa *et al.* (2002), the fiscal variables, from the Chilean Budget Office (Dipres), and the private consumption, also from the Central Bank of Chile and the OECD, are all in nominal terms and have quarterly frequency.

The nominal commodity price data was deflated by the United States consumer price index (of all items), sourced from the United States Bureau of Labor Statistics and the OECD, obtaining the real commodity prices. As the commodity prices have a monthly frequency, we transformed them to a quarterly basis, by averaging the monthly ones to quarterly ones. The reason to set the commodity prices in a quarterly basis is that all the remaining variables (GDP, fiscal accounts (government revenues, consumption and investment) and private consumption) are available quarterly.

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[29] We make a distinction between government consumption and investment because, though we expect that both are affected by lower government revenues due to negative commodity price shocks, the first would tend to be less eroded as it includes more permanent and key activities of the State (as the provision of public goods and services, and the public servants wage bill), than the second which may be affected by lower return to investment, profitability and capital gains.

[30] Though interesting, we do not study private investment because, as far as we understand, Chile does not produce these data at the quarterly level, as this chapter needs.

[31] Private consumption data are available quarterly since the first quarter of 1996. To obtain the private consumption data between the first quarter of 1990 and the fourth quarter of 1995 we extrapolated the annual private consumption, sourced by the Central Bank of Chile and the Organization for Economic Co-operation and Development (OECD), using the quarterly GDP growth rate as a proxy of the quarterly private consumption growth rate. For the period 1996Q1-2015Q3, the quarterly private consumption and quarterly GDP exhibit a quite similar behavior with a high correlation, 0.992. After applying this simple procedure, we calculate the annual sum of the extrapolated quarterly private consumption (estimated values) finding that it deviates from the actual annual private consumption (actual values) by less than one percent.

To obtain the real GDP, real fiscal variables (government revenues, consumption and investment) and real private consumption, the nominal GDP, nominal fiscal variables (government revenues, consumption and investment) and nominal private consumption were deflated by Chile's consumer price index (of all items), sourced from the Chilean National Bureau of Statistics (INE) and the OECD. All the real variables are then expressed in logarithms and seasonally adjusted using the Census X-12 seasonally adjustment method (by the United States Department of Commerce Census Bureau).

The variables we use in Sections 2.5 (Cycle Correlations), 2.6 (Vector Autoregression Model, Assumptions and Results), and 2.7 (The Structural Balance Fiscal Rule and its Implications) are: the logarithm of real copper prices, *copper price*; the logarithm of real non-copper "IMF type" commodity price index, *non-copper "IMF type" index*; the logarithm of real GDP, *GDP*; the logarithm of real government revenues, *government revenues*; the logarithm of real government consumption, *government consumption*; the logarithm of real government investment, *government investment*; and the logarithm of real private consumption, *private consumption*.

2.4 Copper Prices and Non-Copper "IMF type" Commodity Price Index

This section discusses the copper prices and the non-copper commodity price index we use in this chapter. Meanwhile the copper price data is directly sourced from the International Monetary Fund (Primary Commodity Prices Database), we had to build a non-copper commodity price index.

In the literature, commodity price indices often are Laspeyres type, Paasche type and/or indices which use weights based on a certain period (number of years) as the International Monetary Fund does, and that we call here "IMF type".

The Laspeyres type commodity price indices define the weights according to the share of the commodity exports on total exports in a specific year within the period of study, usually the first or the last year, implying that weights remain constant. This type of commodity price index allows for comparison across time because when weights are fix, changes in the commodity price index can be directly associated with movements in commodity prices. The disadvantage of Laspeyres indices is precisely that weights remain constant over time.

The Paasche type commodity price indices use weights updated every year, reflecting the changes in the share of each commodity exported, with the disadvantage that comparability across time is more difficult as the commodity export basket changes over time.

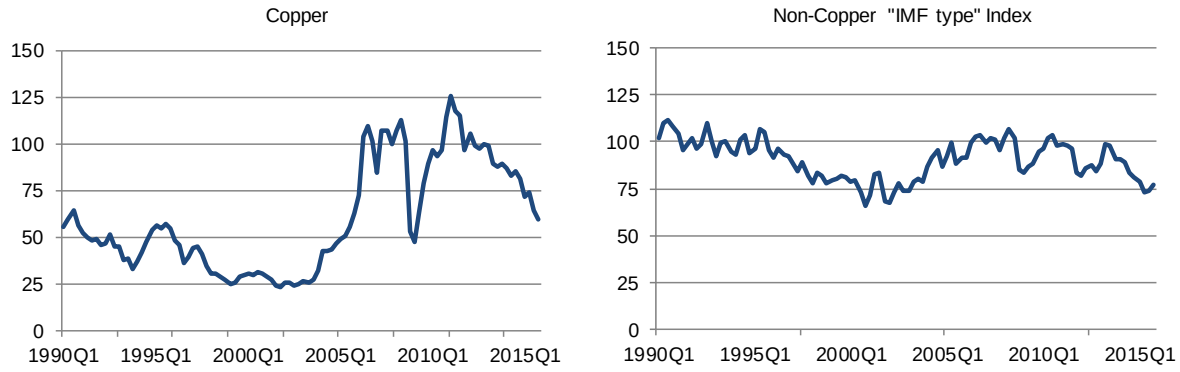
The third type of index is the "IMF type". This type of index uses as weights a certain number of years that reflect the commodity exports structure (three years for instance, as done by the IMF), which is updated every certain time. Then this type of index provides at the same time sufficient data to allow comparability across time and also reflects changes in the share of exported commodities. Because of its characteristics, we setup and use the "IMF type" index. In the setup of such index we use the Chilean trade structure between 2002 and 2004, as the IMF does.[32]

[32] http://www.imf.org/external/np/res/commod/faq/index.htm

Hereafter, for short, we called this non-copper commodity price index non-copper "IMF type" index.

For illustrative purposes in Figure 2.1 we depicted the real copper prices and the non-copper "IMF type" index with a quarterly frequency for the period 1990Q1-2015Q3, and the value in 2010 equivalent to 100.

Figure 2.1. Copper Prices and the Non-Copper "IMF type" Index (2010=100)



Source: International Monetary Fund (Primary Commodity Prices Database).

After about fifteen years where real copper prices remained relatively stable, since 2005 they have experimented a sharp rise reaching their peak during the second quarter of 2008. Afterwards, in parallel with the global financial crisis, the real copper prices started to fall reaching their minimum since late 2004, in the last quarter of 2008 when the global financial crisis spread worldwide. Then the real copper prices again started to rise strongly, triggered by the significant demand coming from China. However since then, the real copper prices have decreased again reaching about the level they had during the early 90's.

Compared to real copper prices, the non-copper "IMF type" index has remained relatively more stable across the full period of study, even during the global financial crisis. After relatively low values between 1998 and 2003, in 2004 (Figure 2.1) it presents an upward trend until mid-2008 with a drop coincident with the global financial crisis, followed by posterior ups and downs since then. Thus, the non-copper "IMF type" index shows that non-copper commodity prices have observed substantially less volatility than copper prices.

Regarding the data in Figure 2.1, meanwhile copper prices (copper refined/unrefined and copper ores/concentrates (US$ per metric ton)) are directly sourced from the International Monetary Fund (Primary Commodity Prices Database), we had to build the non-copper "IMF type" index. To build this index it was necessary to match the non-copper commodity prices with the main non-copper Chilean commodity exports, using as weights the non-copper commodity export shares over the total non-copper exports. As commodity prices and commodity exports data are not available for the same products and with exactly the same detail, the perfect match between both does not exist. To solve this inconvenient, we linked the commodity prices available in the Primary Commodity Prices Database, with the commodity exports at the Standard International Trade Classification

Rev. 4 (STIC4) (by the World Bank, World Integrated Trade Solutions).[33] When the commodity prices and the commodity exports are available in both sources (commodity prices and commodity exports databases) we associate them directly, however when the commodity price does not exist, we associate the commodity export to a similar commodity price, for example: fruit fresh/dried with oranges and bananas, fish frozen excluded fillets with salmon, softwood simply worked with sawn wood, etc.

In a first stage we obtained the copper prices and calculated the non-copper "IMF type" index in a monthly basis, as the commodity prices data, sourced in the Primary Commodity Prices Database, have a monthly frequency to then transform them to a quarterly basis by averaging the months between: January to March, April to June, July to September, and October to December, and relate them to the first, second, third and fourth quarter of each year in our period of study. The reason to set the copper prices and the non-copper "IMF type" index in a quarterly basis is that all the remaining variables we study in this chapter (GDP, fiscal accounts (government revenues, consumption and investment) and private consumption) are available with a quarterly frequency, and that in Sections 2.5 (Cycle Correlations), 2.6 (Vector Autoregression Model, Assumptions and Results) and 2.7 (The Structural Balance Fiscal Rule and its Implications) we need all the data with the same time frequency.

2.5 Cycle Correlations

In this section we present and discuss contemporaneous correlations, cross correlations and Granger causality between the commodity price cycles (*copper price* and the *non-copper "IMF type" index*) and the *GDP*, fiscal accounts (*government revenues*, *government consumption* and *government investment*), and *private consumption* cycles, to get a preliminary sense of how commodity price shocks are related to these macroeconomic variables, and how pro-cyclical or counter-cyclical are *GDP*, *government revenues*, fiscal policy (*government consumption* and *government investment*) and *private consumption* to changes in the commodity price cycles. To filter the cycle from the trend in the variables we study, we applied the Hodrick-Prescott filter with the standard smoothing parameter recommended for quarterly data, i.e. $\lambda = 1600$.

2.5.1 Contemporaneous Correlations

This sub-section presents the contemporaneous correlations between the commodity price cycles (*copper price* and the *non-copper "IMF type" index*), and the *GDP*, fiscal accounts (*government revenues*, *government consumption* and *government investment*), and *private consumption* cycles after applying the Hodrick-Prescott filter (Table 2.2). Alternatively we applied the Baxter-King filter, with symmetric fixed length, finding similar results (Appendix 2.A).[34]

[33] We chose four digits description for the commodities exported because less detail would imply linking commodity prices with sectors or subsectors (2 or 3 digits levels of description) and hence significant miscalculation.

[34] The frequency length (lead/lags) chosen for the moving average is 12 (lead/lags), and the cycle periods are 6 (low cycle period) and 32 (high cycle period). Beside these options, when applying the Baxter-King filter (with symmetric fixed length) there is no need of stationarity or de-trending method assumptions.

Table 2.2. Contemporaneous Correlations of the Variables' Cycles (Hodrick-Prescott Filter)

	GDP	Government Revenues	Government Consumption	Government Investment	Private Consumption
Copper Price	0.82	0.62	-0.20	-0.33	0.66
Non-Copper "IMF type" Index	0.52	0.40	-0.07	-0.34	0.45

The results in Table 2.2 show that the commodity price cycles (*copper price* and the *non-copper "IMF type" index*) have a positive contemporaneous correlation with respect to the *GDP*, *government revenues* and *private consumption* cycles, presenting preliminary evidence of pro-cyclicality between commodity prices and these macroeconomic variables. The opposite results were found when studying the contemporaneous correlations between the commodity price cycles (*copper price* and the *non-copper "IMF type" index*) and the *government consumption* and *government investment* cycles, suggesting counter-cyclicality of fiscal expenditure with respect to the commodity prices.

Regarding the intensity of the contemporaneous correlations, we find that the *copper price* cycle exhibit a stronger correlation with respect to almost all the macroeconomic variables we study (*GDP*, *government revenues*, *government consumption*, and *private consumption*), compared to the *non-copper "IMF type" index* cycle, suggesting that overall the *copper price* cycle is more related to changes in *GDP*, fiscal accounts but *government investment*, and *private consumption*, compared to the *non-copper "IMF type" index*.

The contemporaneous correlation between the *copper price* and *GDP* cycles is about 0.82, bigger than the 0.52 between the *non-copper "IMF type" index* and *GDP* cycles, implying that the *copper price* are more pro-cyclical with respect to the *GDP* compared to the *non-copper "IMF type" index*. Similar result is found for the contemporaneous correlations between the *copper price* and the *government revenues* cycles (0.62) and the *non-copper "IMF type" index* and the *government revenues* cycles (0.40).

The contemporaneous correlations between the commodity prices and the *government consumption* cycles are small in absolute terms. As before, the correlation between the *copper price* and the *government consumption* cycles (-0.20) seems stronger than between the cycles of the *non-copper "IMF type" index* and this fiscal variable cycle (-0.07). Similar results, though slightly bigger in absolute terms are found for the correlations between the commodity prices and the *government investment* cycles, suggesting that *government investment* is more counter-cyclical to changes in commodity prices, compared to *government consumption*. The contemporaneous correlations between the commodity prices (*copper price* and the *non-copper "IMF type" index*) and the *private consumption* cycles are positive, bigger than 0.45 and suggesting pro-cyclicality.

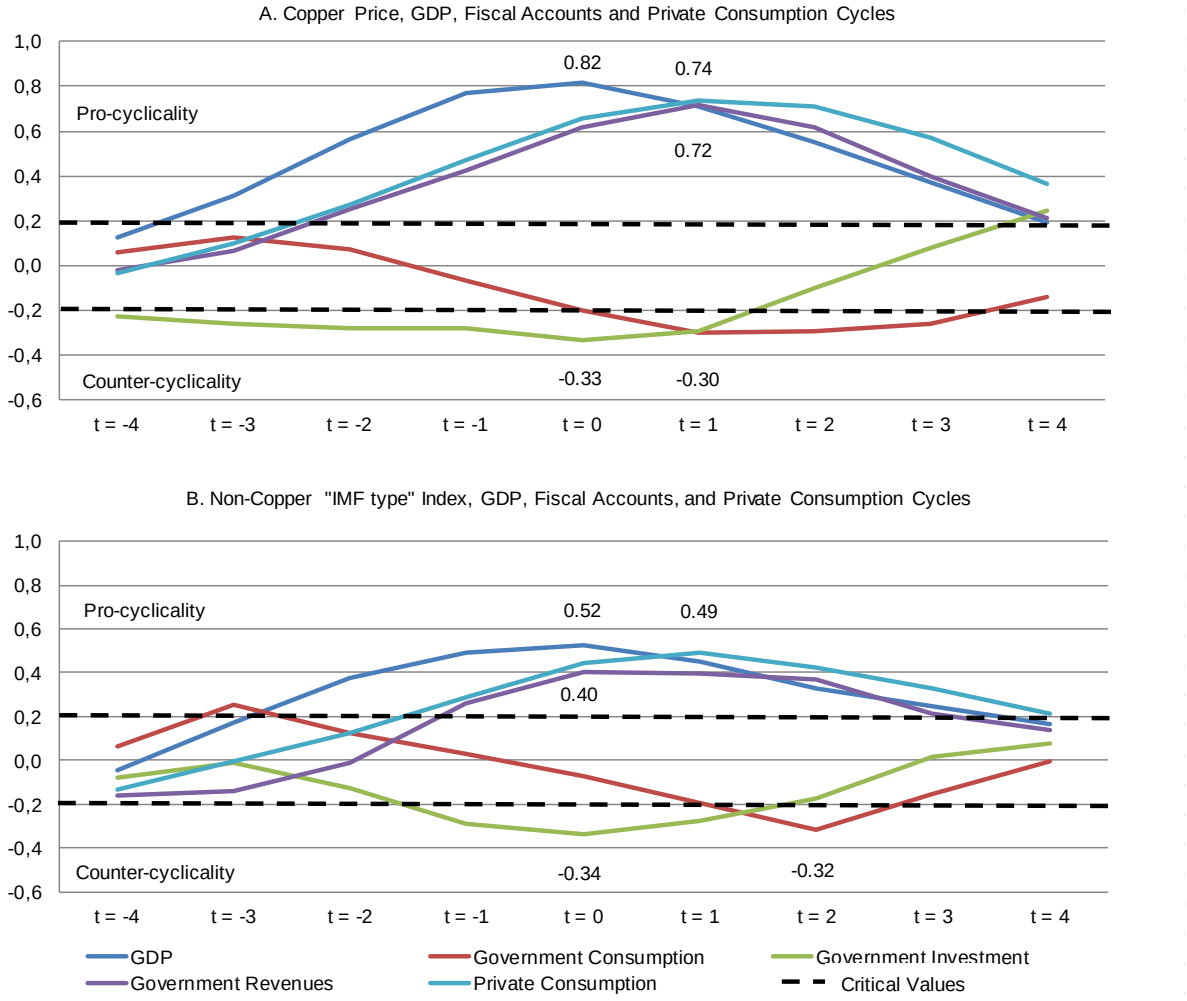
In summary we conclude that: (i) The contemporaneous correlations between the commodity price cycles (*copper price* and *non-copper "IMF type" index*) and the *GDP*, *government revenues* and *private consumption* cycles are positive. The contemporaneous correlations between the commodity price cycles (*copper price* and *non-copper "IMF type" index*) and the *government consumption* and *government investment* cycles are negative; (ii) Almost all the cycles correlations are stronger (bigger in absolute terms) in the case of *copper price* than in the case of the *non-copper*

"IMF type" index; (iii) The *GDP* is pro-cyclical with respect to commodity prices (*copper price* and *non-copper "IMF type" index*); (iv) The *government revenues* cycle is related positively to the commodity price cycles (*copper price* and *non-copper "IMF type" index*); (v) The Chilean fiscal policy on its expenditure side is counter-cyclical with respect to commodity prices, with the *government investment* being slightly more counter-cyclical than *government consumption*; and (vi) The private consumption appears pro-cyclical with respect to commodity prices (*copper price* and *non-copper "IMF type" index*).

2.5.2 Cross Correlations

In the previous sub-section we studied the contemporaneous correlations between commodity price cycles (*copper price* and *non-copper "IMF type" index*), and the *GDP*, fiscal accounts (*government revenues, government consumption* and *government investment*) and *private consumption* cycles. In this sub-section we study the co-movement of these variable cycles following a cross correlation analysis which allows us to infer if changes in the commodity price cycles (*copper price* and *non-copper "IMF type" index*) precede in time or not the changes in the *GDP*, fiscal accounts (*government revenues*, *government consumption* and *government investment*) and *private consumption* cycles. It is important to note that cross correlation analysis does not necessarily demonstrate causality.

Figure 2.2. Cross Correlations Between Copper Price and Non-Copper "IMF type" Index, and GDP, Fiscal Acccounts and Private Consumption Cycles



The cross correlations in Figure 2.2, Panel A, present the inter-temporal relation between *copper price* and the *GDP*, fiscal accounts (*government revenues*, *government consumption* and *government investment*) and *private consumption* cycles, showing that the *copper price* cycle moves contemporaneously with respect to the *GDP* and *government investment* cycles, and precedes in one period the *government consumption*, *government revenues* and *private consumption* cycles.[35] As we assume that Chile is a price taker in the international commodity markets, ex-ante we expected to find that the *copper price* cycle precedes or moves

[35] Commodity price cycles (of *copper price* and *non-copper "IMF type" index*) precede, move contemporaneously or move with lag with respect to the *GDP*, fiscal accounts (*government revenues*, *government consumption* and *government investment*) and *private consumption* cycles, if the cross correlation absolute value has its maximum in a period t>0, t=0 or t<0, respectively (Figure 2.2). The cross-correlation critical values depend on the length of the time series. At the 5 percent level of statistical confidence the critical values correspond approximately to $\left(\pm 2/\sqrt{n}\right)$, where "n" is the length of the time series (Lehmann *et al.* (2007)). In this chapter we include 103 quarters (1990Q1-2015Q3), hence the critical values at a 5 percent level of statistical confidence are: (± 0.197), represented by the dotted black lines in Figure 2.2. As a consequence only cross correlations higher than 0.197 or lower than -0.197 are statistically significant.

contemporaneously with respect to *GDP*, fiscal accounts and *private consumption* cycles. Then Figure 2.2, Panel A, results are consistent with what we expected to find ex-ante, and also consistent with our findings in sub-section 2.5.1 as the *GDP*, *government revenues* and *private consumption* exhibit evidence of pro-cyclicality and the *government consumption* and *government investment* show counter-cyclicality, with respect to *copper price*.

Figure 2.2, Panel B, includes the cross-correlations between *non-copper "IMF type" index* and the *GDP*, fiscal accounts (*government revenues*, *government consumption* and *government investment*) and *private consumption* cycles. The cross correlations between the *non-copper "IMF type" index*, and the *GDP* and *government revenues* cycles suggest contemporaneous movement (the maximums occur when t=0) and pro-cyclicality, as in sub-section 2.5.1. The cross correlation between the *non-copper "IMF type" index* and the *private consumption* cycles also evidences pro-cyclicality, the maximum occurs when t=1 meaning that the *private consumption* cycle is preceded in one period by the *non-copper "IMF type" index* cycle. On its hand, the *government consumption* and *government investment* show counter-cyclicality, with respect to the *non-copper "IMF" index*. Last, the cross correlation between the *non-copper "IMF type" index* and the *government revenues* cycles is slightly different to the one we found for *copper price* and the *government revenues* cycles as the *non-copper "IMF type" index* cycle and the *government revenues* cycle move contemporaneously.

In summary this sub-section finds that: (i) *GDP* and *government investment* cycles move contemporaneously to commodity price cycles (both copper and non-copper); (ii) The *government consumption* and *private consumption* cycles are preceded by the commodity price cycles (both copper and non-copper); (iii) The *government revenues* cycle move with lag with respect to the *copper price* cycle and contemporaneously with respect to the *non-copper "IMF type" index* cycle; and (iv) Overall we found that, as expected, the commodity price cycles do either precede or move contemporaneously with respect to the cycles of the macroeconomic aggregate we study.

2.5.3 Granger Causality

As correlations calculated in the previous sub-sections do not imply causality, in this sub-section we test Granger causality to examine whether the commodity price cycles (*copper price* and *non-copper "IMF type" index*) provide or not statistically significant information about the future values of the *GDP*, fiscal variables (*government revenues*, *government consumption* and *government investment*) and *private consumption* cycles.[36] [37]

[36] Granger causality test hypothesis has been set by its author in negative terms, i.e. variable X does not Granger cause variable Y.
[37] As our data has quarterly frequency, when testing Granger causality we include one to four lags.

Table 2.3. Granger Causality

Null Hypothesis / Number of Lags	1	2	3	4
The copper price cycle does not Granger cause the GDP cycle	0.93	0.54	0.74	0.88
The non-copper "IMF type" index cycle does not Granger cause the GDP cycle	0.97	0.91	0.76	0.87
The GDP cycle does not Granger cause the copper price cycle	0.00	0.00	0.00	0.00
The GDP cycle dos not Granger cause the non-copper "IMF type" index cycle	0.01	0.01	0.00	0.00
The copper price cycle does not Granger cause the government revenues cycle	0.00	0.00	0.00	0.00
The non-copper "IMF type" index cycle does not Granger cause the government revenues cycle	0.04	0.12	0.07	0.26
The government revenues cycle does not Granger cause the copper price cycle	0.10	0.79	0.48	0.51
The government revenues cycle dos not Granger cause the non-copper "IMF type" index cycle	0.91	0.06	0.13	0.33
The copper price cycle does not Granger cause the government consumption cycle	0.02	0.06	0.11	0.10
The non-copper "IMF type" index cycle does not Granger cause the government consumption cycle	0.06	0.02	0.00	0.01
The government consumption cycle does not Granger cause the copper price cycle	0.10	0.44	0.66	0.65
The government consumption cycle dos not Granger cause the non-copper "IMF type" index cycle	0.33	0.56	0.22	0.02
The copper price cycle does not Granger cause the government investment cycle	0.01	0.00	0.00	0.00
The non-copper "IMF type" index cycle does not Granger cause the government investment cycle	0.02	0.09	0.09	0.09
The government investment cycle does not Granger cause the copper price cycle	0.78	0.18	0.17	0.21
The government investment cycle dos not Granger cause the non copper "IMF type" index cycle	0.26	0.31	0.49	0.28
The copper price cycle does not Granger cause the private consumption cycle	0.00	0.00	0.00	0.00
The non-copper "IMF type" index cycle does not Granger cause the private consumption cycle	0.01	0.09	0.11	0.18
The private consumption cycle does not Granger cause the copper price cycle	0.25	0.56	0.55	0.72
The private consumption cycle dos not Granger cause the non-copper "IMF type" index cycle	0.88	0.37	0.51	0.37

Note: The figures included in the table correspond to the p-values. If the p-value is smaller than 0.05 the null hypothesis is rejected.

In Table 2.3 we present the results of Granger causality tests between commodity price cycles (of *copper price* and *non-copper "IMF type" index*) and the *GDP*, fiscal variables (*government revenues*, *government consumption* and *government investment*) and *private consumption* cycles. The null hypothesis test that commodity price cycles (of *copper price* and *non-copper "IMF type" index*) do not Granger cause the *GDP*, fiscal variables (*government revenues*, *government consumption* and *government investment*) and *private consumption* cycles.

In the first panel of Table 2.3 we present the Granger causality test results between the commodity price cycles (of *copper price* and *non-copper "IMF type" index*) and the *GDP*. First we test the null hypothesis that commodity price cycles (of *copper price* and *non-copper "IMF type" index*) do not Granger cause the *GDP* cycle finding that we could not reject this null hypothesis. Then we test the null hypothesis that the *GDP* cycle does not Granger cause the commodity price cycles (of *copper price* and *non-copper "IMF type" index*) rejecting the null hypothesis. Hence we find some evidence implying that changes in the economic output cycle might cause changes in the copper and non-copper price cycles, but not the opposite (commodity price cycles causing changes in the economic output cycle). Such result is counterintuitive as we expected to find the opposite, meaning the international commodity price cycles causing changes in the Chilean economic output cycle, this considering that the Chilean economy is not big enough to drive prices in the international commodity markets. A plausible explanation for this result could be the Granger causality test limitation that rises when two variables are driven by a third common variable. In

this case a suitable third variable causing both the Chilean economic output cycle and the commodity price cycles could be the last decades' strong demand for commodities coming from China.

Next, in the second, third and fourth panels of Table 2.3 we test Granger causality between commodity prices (of *copper price* and *non-copper "IMF type" index*) and fiscal accounts (*government revenues*, *government consumption* and *government investment*) cycles.

In the second panel of Table 2.3 we present the results of testing the relation of causality between the commodity prices (of *copper price* and *non-copper "IMF type" index*) and the *government revenues* cycles, rejecting the null hypothesis suggesting that the copper price cycle (*copper price*) does not Granger cause the *government revenues* cycle. This finding agrees with the related literature's view that focuses on Chile, arguing that copper price volatility leads to government revenues volatility. The evidence regarding the relation between the *non-copper "IMF type" index* and the *government revenues* cycle is not robust as the result depends on the number of lags chosen.

The third panel of Table 2.3 tests Granger causality between the commodity prices (of *copper price* and *non-copper "IMF type" index*) and *government consumption* cycles. The relation is not statistically robust as depending on the number of lags chosen, the null hypothesis of non-causality can be rejected or not. Hence we do not have a clear conclusion regarding the causality among these variables.

The fourth panel of Table 2.3, which studies the relation between the commodity prices (of *copper price* and *non-copper "IMF type" index*) and the *government investment* cycles, concludes that the copper price cycle Granger causes the *government investment* cycle. The alternative hypothesis that *government investment* cycle does not Granger cause the commodity price cycles (*copper price* and *non-copper "IMF type" index*) cannot be rejected. These results imply that copper price cycles cause the government investment cycle but not the other way around, evidencing that government investment is driven by the prices of copper.

From the fifth and last panel of Table 2.3, which studies the relation between the commodity prices (of *copper price* and *non-copper "IMF type" index*) and the *private consumption* cycles, we find that the *copper price* cycles do Granger cause the *private consumption*. This finding suggests that private consumption is driven by copper prices. The evidence regarding the relation between the *non-copper "IMF type" index* and the *private consumption* cycles is not robust as the result depends on the number of lags chosen.

In summary, the Granger causality tests provide: (i) Unexpected results for the relation between the economic output and commodity price cycles, where a plausible explanation might be the Granger causality test limitation already mentioned in this sub-section; (ii) Expected results for the relation between copper prices and government revenues cycles, meaning that government revenues cycles are driven by the copper price cycle. Similar result is find for the relation between commodity prices and government investment cycles, which means that government investment cycle is driven by changes in commodity price cycles; (iii) No clear evidence regarding the relation between commodity prices and government consumption cycles; and (iv) Evidence suggesting that the private consumption cycle is driven by the copper price cycle.

2.6 Vector Autoregression Models, Assumptions and Results

Vector autoregression models (VAR) are dynamic systems of equations that examine the inter-relations between economic variables of interest, based on the past interactions between them. Compared to correlation analysis, the VAR, as econometric models, have the advantage of reporting more formal results and compared to alternative econometric models, they need only few assumptions about the structure of the economic relationship studied. VAR estimations require choosing which variables to include, their order, and to decide on the number of lags. The variables selection and their order are based on economic theory and assumptions.

In this section we estimate the dynamic effects of shocks to commodity price cycles (*copper price* and the *non-copper "IMF type" index*) on *GDP*, fiscal accounts (*government revenues*, *government consumption* and *government investment*), and *private consumption* cycles.

2.6.1 VAR Model

Let's assume the following VAR model:

$$F(L)X_t = \mu_t \qquad (2.1)$$

Where $F(L)$ is an N*N polynomial lags matrix and L is a lag operator, X_t is a vector in real terms and logarithms of commodity prices (*copper price* or the *non-copper "IMF type" index*, depending on the model); *GDP*; *government revenues*, *government consumption* and *government investment*; and *private consumption*; and μ_t is a matrix of vector residuals, which represent the unexplained movements in the variables influenced by exogenous shocks.

To answer if the time series included are stationary or not, we use the Augmented Dickey-Fuller, Phillip-Perron, Kwiatkowski-Phillips-Schmidt-Shin (KPSS) and Elliot-Rothenberg-Stock (ERS) tests, finding that all the variables in levels (*copper price*, *non-copper "IMF type" index*; *GDP*; *government revenues*, *government consumption* and *government investment*; and *private consumption*) are non-stationary (at the 95 percent statistical confidence). This is not the case when we study the cycles of our variables (also at the 95 percent statistical confidence), hence in our VAR estimations we use the cycles of *copper price*, the *non-copper "IMF type" index*; *GDP*; *government revenues*, *government consumption*, and *government investment*; and *private consumption*.[38]

2.6.2 Assumptions

To set the ordering of the variables within the VAR we make two assumptions: (i) Commodity price shocks are exogenous implying that Chile is a price taker in the international commodity markets; and (ii) Fiscal policy cannot react contemporaneously to changes in economic output.

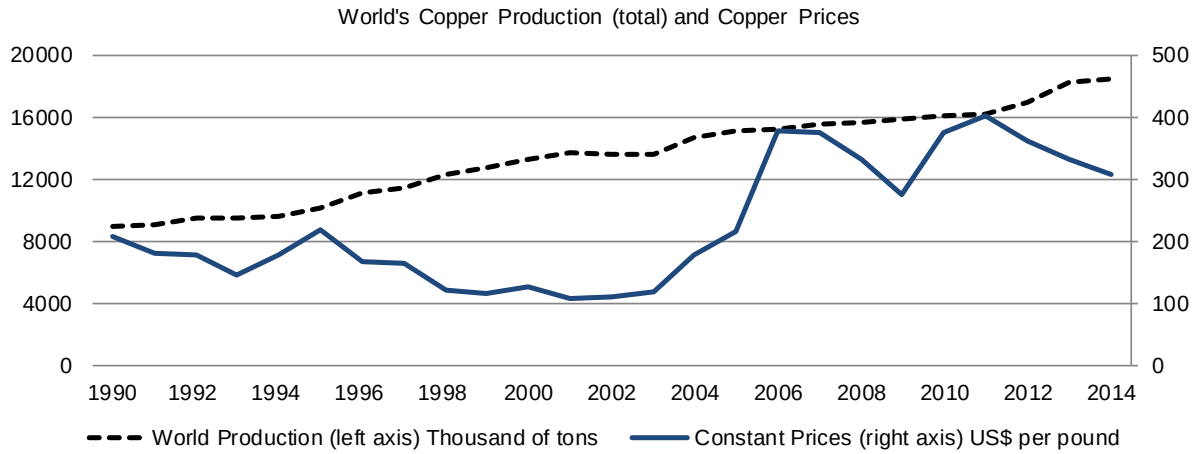
The first assumption, that commodity price shocks are exogenous, meaning that Chile is a price taker, has been validated in the literature. Indeed, this assumption was part of an interesting debate in Chile during the early 2000's, before the rise of China as a big consumer in the copper market.

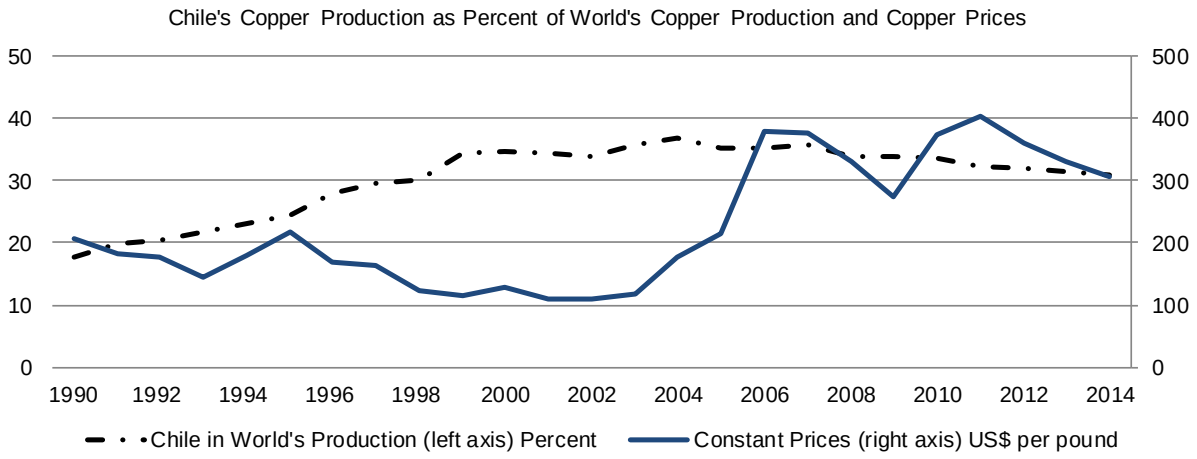
[38] The estimations using the variables in differences present almost the same results as those presented in this section and were estimated as a robustness exercise. These results are available upon request.

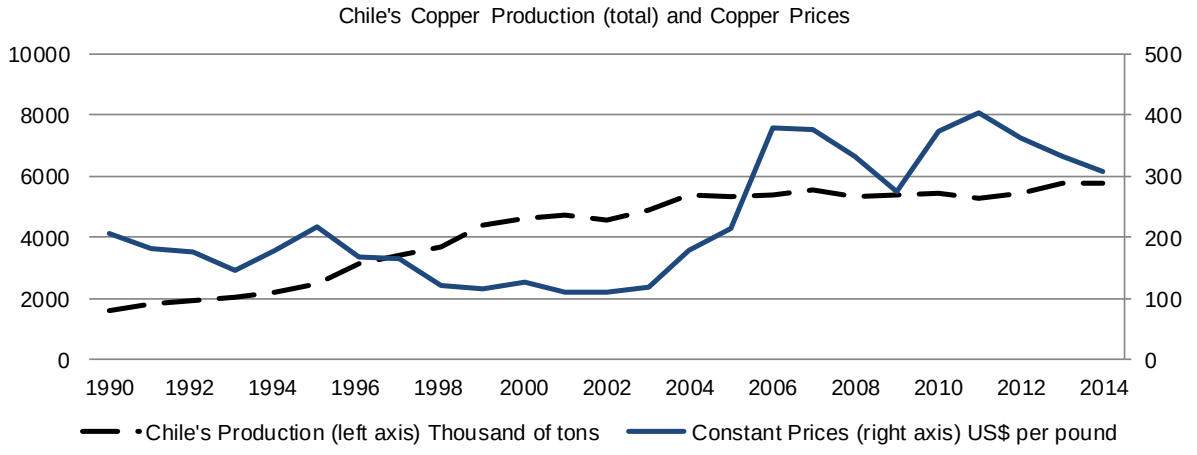
At that time, some Chilean politicians and economists were convinced that the existing large private (local and foreign) and public investment in the Chilean copper industry, with the consequent increase in the world copper supply, was reducing copper prices. As a response to this, Meller (2003) discussed Chile's capacity to control copper prices arguing that: (i) Constraining Chile's copper production and thus inducing a rise of copper prices would be very difficult to implement in the country as besides the large state owned enterprise (CODELCO) multiple and important private competitors also exist, complicating any bargaining process; (ii) Controlling the Chilean copper supply would imply constraining the arrival of foreign direct investment to the copper industry, going against Chile's cornerstone commitment to welcome and incentive the arrival of foreign direct investment; (iii) Chile does not have a monopoly in copper production, then if foreign investors are constrained to invest, they would simply invest in another country, increasing the World's copper supply anyway.

Figure 2.3 presents data of copper prices and Chile's and the World's copper production, for the period 1990-2014. In the first chart of Figure 2.3 we observe that while the World's copper production has been increasing steadily during the full period, the same is not observed for copper prices, with increases and decreases that have no relation with the changes in the World's copper supply. Then Figure 2.3, second chart, shows that Chile's contribution to the World's copper production has never exceeded 40 percent, reaching around 20 percent during the early 90's and more than 30 percent since 1997, suggesting that Chile might not have enough market power to affect copper prices by itself. Last, the third chart of Figure 2.3 presents the relationship between copper prices and Chile's copper production which is not the expected when a supplier has enough market power, as copper price rises do not necessarily coincide with decreases in Chile's copper production.

Figure 2.3: Copper Prices and Chile's and World's Copper Production 1/ 2/







Source: Copper Chilean Commission (Cochilco)

1/ Data on Chile's and World's copper production correspond to the total copper production.

2/ Copper prices correspond to the refined copper.

Additionally, authors like Bloodgood (2006), Lehmann *et al.* (2007), Yu (2011), and Roache (2012) argue that changes in commodity prices, especially metals, are driven by the demand with a high contribution to the global demand of commodities by the Asian economies, with China counting for about 40 percent. In this line, Lehmann *et al.* (2007) measures the impact of China's expansion on commodity prices illustrating how the Latin American economies are affected, finding a positive and significant relationship between China's industrial production and the evolution of metal prices. In particular it finds that between 15 to 30 percent of copper price rise could be related to a higher demand from China. On its hand, Roache (2012) finds that a shock to the Chinese real activity has a large and statistically significant impact on copper prices, where a one-time one percent point shock to the real growth rate of China's industrial production leads to an increase in the real copper prices by about two percent after four quarters.

Regarding the second assumption of no contemporaneous reaction of fiscal accounts (government revenues, consumption and investment) to unexpected changes on GDP, it is justified by Blanchard and Perotti (2002), whose research study assumes that when using high frequency data, quarterly or higher, fiscal policy reacts with at least one period lag (quarter in this chapter) when unexpected changes affect the economic activity. Then GDP could contemporaneously affect fiscal accounts but fiscal policy cannot react contemporaneously to changes in GDP. Hence the basic VAR variables ordering includes the *copper price* or the *non-copper "IMF type" index* (first), the *GDP* (second), and the fiscal variables (*government revenues*, *government consumption* and *government investment*) or the *private consumption* (third).

Finally, regarding the number of lags included, in this chapter we follow the criterion by Ivanov and Killian (2005) using the number of lags suggested by the Schwarz Information Criterion (SIC) if the sample size is smaller than 120 periods (our data includes 103 periods (quarters)).[39]

2.6.3 Results

In this sub-section we present the results of the VAR models estimated (Table 2.4). The first three models are those that include either the *copper price* or the *non-copper "IMF type" index* cycles, the *GDP* cycle and a fiscal variable cycle (*government revenues* (Model A), *government consumption* (Model B) or *government investment* (Model C)). Model D studies the relation between commodity price cycles (*copper price* or the *non-copper "IMF type" index*), and the *GDP* and *private consumption* cycles.

Table 2.4. VAR Models with Variables in Cycles

Model	Copper Price or the Non-Copper "IMF type" Index	GDP	Government Revenues	Government Consumption	Government Investment	Private Consumption
A	√	√	√	-	-	-
B	√	√	-	√	-	-
C	√	√	-	-	√	-
B	√	√	-	-	-	√

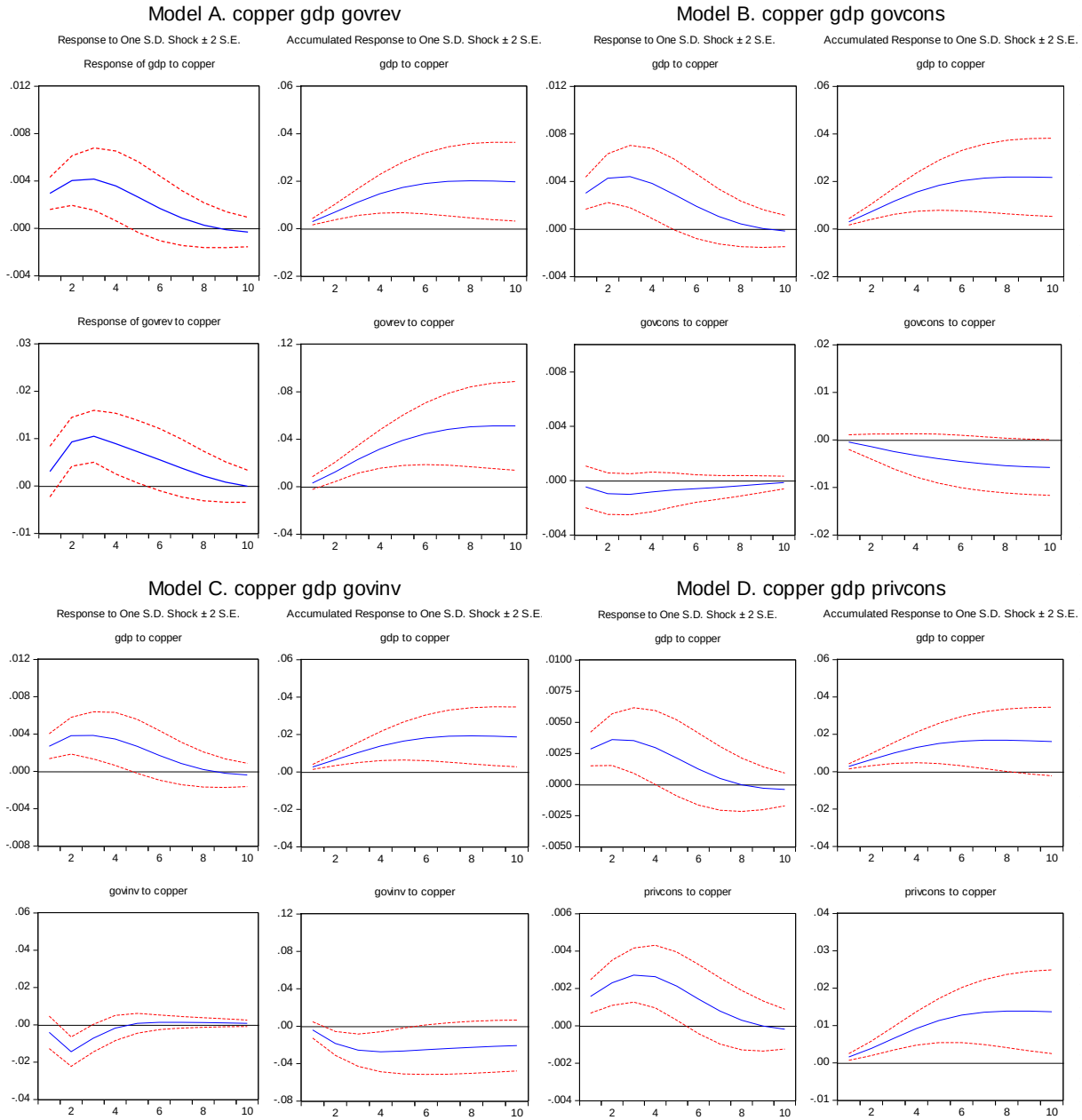
As a standard procedure, before estimating models in Table 2.4 we chose the number of lags included in each model. To do so, we checked the SIC which suggests that all models including

[39] This information is available upon request.

the *copper price* cycle as an exogenous variable have to be estimated using two lags. According to the SIC, models that include the *non-copper "IMF type" index* cycle as an exogenous variable suggest the estimation using one lag in models A and D, and two lags in models B and C.

The solid lines in blue in Figures 2.4 and 2.5 reflect the response and the accumulated response to a one standard deviation Cholesky innovation (shock) to the *copper price* cycle (Figure 2.4) and the *non-copper "IMF type" index* cycle (Figure 2.5), and the red dashed lines represent the two standard deviation bands.

Figure 2.4. Impulse-Response Functions with Copper Price as Exogenous Variable (Cycles)



Note: copper (*copper price*), gdp (*GDP*), govcons (*government consumption*), govinv (*government investment*), govrev (*government revenues*), and privcons (*private consumption*).

Figure 2.4 results' suggest that the response of the *GDP* cycle to a one standard deviation shock to the *copper price* cycle is positive and statistically significant during the first four quarters in all models.[40] In the first quarter, the *GDP* cycle rises about 0.3 percent after the one standard deviation shock to the *copper price* cycle. Then the positive effect continues until the eighth quarter when it reaches zero increase. In all models after ten quarters, the accumulated response of the *GDP* cycle to a one standard deviation shock to the *copper price* cycle is about a 2 percent increase, meaning that the accumulated effect of a positive one percent shock to *copper price* implies about a 0.3 percent *GDP* increase.

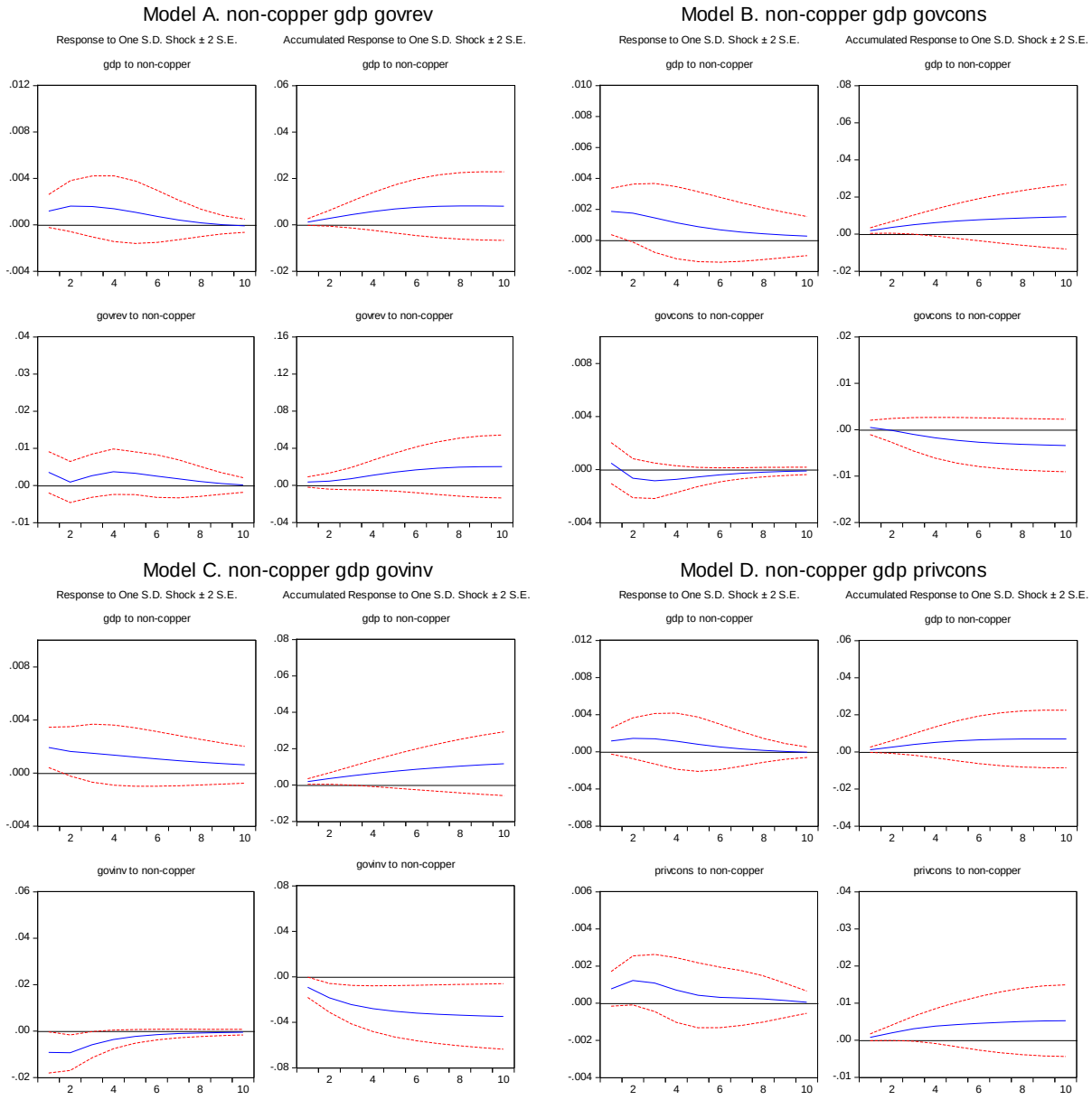
As expected, the *government revenues* cycle reacts positively to a one standard deviation shock to *copper price* cycle (first quarter response of about 0.3 percent). The accumulated response on the *government revenues* cycle is about 5 percent after ten quarters. Hence, we expect that a one percent *copper price* shock implies an accumulated 0.7 percent increase in government revenues. On their hand, *government consumption* and *government investment* cycles responses to a one standard deviation shock to *copper price* cycle are negative but statistically not significant.

The model including the *private consumption* cycle shows a rise of about 0.2 percent in this variable during the first quarter after a one standard deviation shock to the *copper price* cycle. The response during the third quarter is the highest and lasts positive and statistically significant until the fifth quarter. The accumulated response of the *private consumption* cycle to a one standard deviation shock to the *copper price* cycle is about 1.4 percent and statistically significant. Then a one percent increase in copper prices would imply about a 0.2 percent increase of private consumption.

In summary, we found a positive reaction of the GDP and government revenues cycles to a positive one standard deviation shock to copper price cycle. This evidences that the Chilean economy and its fiscal revenues are benefited when they face a positive international commodity price shock. The slightly negative reaction of government consumption and investment cycles, though statistically not significant, to a positive shock to copper price cycle was already found in Section 2.5 evidencing a counter-cyclical behavior in the government expenditure. Last, the private consumption cycle results suggest that the private sector consumption is pro-cyclical with respect to shocks to copper prices, meaning that increases in the copper price cycle do motivate increases in the private consumption cycle.

[40] A one standard deviation shock to the copper price cycle represents about 7.5 percent increase in the copper price with respect to its trend.

Figure 2.5. Impulse-Response Functions with the Non-Copper "IMF type" Index as Exogenous Variable (Cycles)



Note: non-copper (*non-copper "IMF type" index*), gdp (*GDP*), govcons (*government consumption*), govinv (*government investment*), govrev (*government revenues*), and privcons (*private consumption*).

Figure 2.5 presents the results from replacing the *copper price* cycle, as an exogenous variable, by the *non-copper "IMF type" index* cycle. It allows us to distinguish between the effects of shocks to copper prices and non-copper commodity prices on the Chilean GDP, fiscal accounts (government revenues, consumption and investment) and private consumption. In this case we found that:

The reaction of the *GDP* cycle to a positive one standard deviation shock to the *non-copper "IMF type" index* cycle is slightly positive and statistically significant only during the first quarter.[41] As

[41] A one standard deviation shock to the *non-copper "IMF type" index* cycle represents about a 2.5 percent increase in the *non-copper "IMF type" index* cycle.

the GDP cycle response is statistically significant only during the first quarter we found that a shock to non-copper commodities cycle almost does not affect the GDP cycle.

On its hand, the *government revenues* cycle response to a one standard deviation shock to the *non-copper "IMF type" index* is positive but not-significant. The accumulated response is about 2 percent at the tenth quarter. Thus, the evidence suggests that shocks to non-copper commodities almost do not have a statistically significant effect on government revenues.

On the government expenditure side we have that the *government consumption* cycle reports a slightly negative but statistically not significant response to a one standard deviation shock to the *non-copper "IMF type" index* cycle. The accumulative response is also negative and statistically not significant. The response of the *government investment* cycle to a one standard deviation shock to the *non-copper "IMF type" index* cycle is about a -1 percent at impact, while the accumulative response is also negative but reaches about an -4 percent. Hence while the *government consumption* cycle responses (at impact and cumulative) are statistically not significant, the *government investment* cycle responses are negative and significant, meaning that shocks to the non-copper commodity cycle are related negatively to the government investment cycle but not to the government consumption cycle.

The response of the *private consumption* cycle to a one standard deviation shock to the *non-copper "IMF type" index* is positive and significant during the first three quarters after the shock, with an accumulative response of about 0.5 percent at the tenth quarter. It means that a one percent increase in the non-copper commodity prices is related to about a 0.2 percent increase in private consumption.

Overall a stronger effect was found for shocks to the *copper price* cycle in comparison to shocks to the *non-copper "IMF type" index* cycle, that might be explained by the higher volatility exhibited by the copper price cycle compared to non-copper commodity price cycle.

2.7 The Structural Balance Fiscal Rule and its Implications

During the period of study, 1990Q1-2015Q3, fiscal discipline has been an important feature of the Chilean fiscal policy. Thus since 1990 the Chilean economy reduced its general government gross debt from more than 40 percent to less than 20 percent in 2015, and reached consecutive overall balance fiscal superavits only interrupted by the periods that followed the Asian financial crisis (1997) and the global financial crisis (2008), the reconstruction efforts after the 2010 earthquake, and a number of recent social demands faced by the current government in office (Appendix 2.B).

In this context, in May 2000 former President Lagos announced the launch of the Structural Balance Fiscal Rule in force since 2001, with the objective to count with a tool for macroeconomic management and fiscal policy predictability. At its conception, the fiscal rule was designed as an institutional arrangement aiming to reduce the uncertainty induced by the fiscal revenues fluctuations, mostly driven by copper price changes.

This section first presents some of the key characteristics of the fiscal rule and second studies if our variables of study exhibit or not structural changes as a consequence of the fiscal rule installment.

2.7.1 The Structural Balance Fiscal Rule

In force since 2001, the fiscal rule is the result of the adjustment to the public sector balance, caused mainly by cycle movements of GDP and copper prices, and is based on the central government's structural balance evaluated at the potential output and the estimates medium-term copper prices.[42]

The fiscal rule considers the fiscal revenues and expenditures obtained if the economy were at its potential and the copper prices were the ones of medium-term, excluding the cyclical and random effects from the Chilean GDP and the copper prices. This implies that all the revenues that come from the difference between the actual and the medium-term copper prices have to be saved or expended depending if the actual copper prices are higher or lower than the medium-term prices.

At the time of its creation, the fiscal rule set that the central government would follow a structural balance equivalent to one percent of GDP, to provide a credible medium-term fiscal policy and enough savings to cover Chile's long-term contingent liabilities as: (i) pension liabilities (recognition bonds introduced in the early 80's after the privatization of the pension system); (ii) fund deficits in different areas of the public sector; (iii) fund government guarantees; and (iv) copper wealth intergenerational equity. Later in the 90's and 2000's other reasons were added as the fiscal buffers which allow facing external shocks and the minimum pension guaranteed.

The public character of the fiscal rule provides credibility to fiscal policy, making the economic agents fully informed about changes on fiscal policy when the macroeconomic environment changes. By construction the fiscal rule allows fiscal policy to be counter-cyclical as when revenues increase or decrease with the cycle, fiscal expenditure does it smoother.

To strengthen the fiscal rule, since 2002 two different committees of independent experts have provided their technical advice and estimates of the Chilean potential GDP and the medium-term copper prices.[43] [44] During the recent years, the fiscal rule's target has been relaxed to a 0.5 percent surplus in 2007, zero percent in 2008, and -1 percent in 2009 (due to the strong counter-cyclical fiscal policy applied after the global financial crisis). More recently, as a consequence of 2010's

[42] The public sector balance considers the central government, including ministries, autonomous public institutions as the National Congress, the Judiciary Power, the General Comptroller's Office, and other decentralized public services, and excluding the state owned enterprises, municipalities, public universities and the Central Bank of Chile (Marcel *et al.* 2001).

[43] The committee of independent experts that estimate the Chilean potential GDP in 2017 included 17 experts. The methodology to calculate the medium-term output follows the IMF methodology to estimate the structural balance of a Cobb-Douglass production function. Each of the experts, members of the committee, provided to the Ministry of Finance their estimations of capital, labor and productivity to be included in a Cobb-Douglass production function. Once calculated each expert medium-term output, the maximum and the minimum estimations of each year are dropped, and then the remaining estimations are averaged. Last, the growth rate and the gap with the actual output are calculated (Chilean Ministry of Finance website).

[44] In 2016 the committee of independent experts that estimates the medium-term copper prices included 16 members. As part of the process each of these experts provided to the Ministry of Finance their annual estimation of the copper prices for the period 2017-2026. Then the average of these annual estimations is calculated excluding the minimum and maximum estimations of each year, to have a more robust indicator. This exercise is done once a year as it is a main input for the public sector annual budget law (Chilean Ministry of Finance website).

earthquake and reconstruction efforts, President Piñera's administration committed itself to a deficit of -1 percent by 2014.

2.7.2 Potential Structural Changes

In this sub-section we look for structural changes in our variables of study. First we do a set of Chow breakpoint and multiple breakpoint Bai-Perron tests.[45] Then, having in mind the launch of the fiscal rule in 2001, we estimate the VAR models we estimated in Section 2.6 (with the variables in cycles) dividing the sample in two periods: 1990Q1-2000Q4 (before the fiscal rule) and 2001Q1-2015Q3 (period with the fiscal rule in force), to explore if the fiscal rule produced or not a structural change in the relation between the commodity price cycles (of *copper price* and *non-copper "IMF type" index*), and the *GDP*, fiscal accounts (*government revenues*, *government consumption* and *government investment*) and *private consumption* cycles.

According to the Chow breakpoint and the multiple breakpoint Bai-Perron tests, none of our variables present a structural change in the period of study, with no statistical evidence to argue that the fiscal rule led to a significant change in *GDP*, the fiscal variables (*government revenues*, *government consumption* and *government investment*) or its *private consumption* cycles.[46]

Before estimating the VAR models, as we did in Section 2.6, we identified the number of lags to be included in each model by testing the SIC in both periods: 1990Q1-2000Q4 and 2001Q1-2015Q3. As a result, we proceed to estimate the VAR models using one lag for the period 1990Q1-2000Q4 and either one or two lags, depending on the specific model, for the period 2001Q1-2015Q3.

As this sub-section's aim is to explore if the fiscal rule produced or not a structural change in the relation between the commodity price cycles (of *copper price* and the *non-copper "IMF type" index*), and the *GDP*, fiscal accounts (*government revenues*, *government consumption* and *government investment*) and *private consumption* cycles, we compare the results for the period 1990Q1-2000Q4 and the period 2001Q1-2015Q3.[47]

In the case of *GDP*, we found that during the period before the fiscal rule, the response of the *GDP* cycle to a one standard deviation shock of both *copper price* and the *non-copper "IMF type" index* cycles is positive and statistically significant, while for the period after the fiscal rule it is also positive but statistically not significant. This result suggests that before the existence of the fiscal rule the exposure of the Chilean GDP to commodity price shocks (copper and non-copper) used to be stronger and consistent with the finding by Larraín and Parro (2008) which shows that the fiscal rule allowed reducing GDP growth volatility.

The *government revenues* cycle response to a one standard deviation shock to commodity price cycles (*copper price* and the *non-copper "IMF type" index* cycles) is found positive but statistically not significant both before and after the fiscal rule.

[45] The Chow breakpoint tests looks for structural breaks in 2000Q4 and 2001Q1.
[46] These results are available upon request.
[47] These results are available upon request.

The response of the *government consumption cycle* to a one standard deviation shock to commodity price cycles (*copper price* and the *non-copper "IMF type" index* cycles) results negative but not significant both before and after the fiscal rule. A quite similar result was found for the response of the *government investment* cycle.

Finally, regarding the *private consumption's* response to a one standard deviation shock to commodity price cycles (*copper price* and the *non-copper "IMF type" index* cycles) we found that before the fiscal rule the response and the accumulated response are positive and significant, but once installed the fiscal rule, the response of both *copper price* and the *non-copper "IMF type" index* cycles is not significant. A possible explanation for the results we found for *private consumption* could be Chile's transition from a floating band to a free exchange rate regime change in September 1999. Before the exchange rate regime change, only part of the external shocks were absorbed by the exchange rate as the interest rate was also used to "defend" the exchange rate, and thus directly affect the *private consumption*. Once the exchange rate regime had changed, the interest rate has not been used to "defend" the exchange rate, and then most of the effects of external shocks, such as those coming from commodity prices, have been absorbed by the exchange rate.

2.8 Conclusions

In this chapter we studied how commodity price shocks (of copper and non-copper) affect the Chilean economic output, fiscal accounts (government revenues, consumption and investment) and private consumption, based on correlation analysis and VAR models in cycles.

Correlation analysis and Granger causality testing suggests that: (i) GDP, fiscal revenues and private consumption are pro-cyclical with respect to commodity prices (contemporaneous correlations); (ii) Fiscal expenditure (government consumption and investment) is counter-cyclical with respect to commodity prices (contemporaneous correlations); (iii) Commodity price cycles (of copper and non-copper) are contemporaneous to the Chilean economic output and government investment cycles, and preceed the government and private consumption cycles (cross correlations); and (iv) A causality relation from commodity price cycles to government revenues and investment cycles, a counterintuitive result for GDP, and no robust results for government and private consumption (Granger causality).

When studying the period between 1990Q1 and 2015Q3 VAR models find that the Chilean GDP cycle reacts positively to shocks to commodity price cycles, though the effect is stronger (statistically significant) when the shocks affect the copper price cycle compared to the non-copper commodity price cycle. The response of government revenues cycles to shocks to copper price cycle is positive and statistically significant. The government expenditure cycles (both consumption and investment) responses to shocks to commodity price cycles are slightly negative but mild (statistically not significant). Last, we found evidence to argue that the private consumption cycles response to shocks to commodity price cycles is positive. These findings evidence that with respect to shocks to international commodity prices, the Chilean economy, its fiscal revenues and private consumption are pro-cyclical, and that the fiscal expenditure is counter-cyclical. Overall the effect of shocks to copper prices is "stronger" compared to non-copper commodities.

The evidence found suggests that before the creation of the Chilean fiscal rule, the country's GDP cycle used to respond more to shocks to commodity price cycles than during the period after the fiscal rule's installment. Similar results, in terms of GDP's volatility, were found by Larraín and Parro (2008) and De Gregorio and Labbé (2011). We also found that the *government consumption* and *government investment* cycle responses to shocks to commodity prices (both copper and non-copper commodity prices cycles) are negative before and after the fiscal rule. These findings confirm that the fiscal rule by itself is a quite important institutional arrangement that helps reduce volatility, but that Chilean fiscal authorities' discipline comes even before the fiscal rule installment.

As our analysis pretty much focuses on the role and effects of the fiscal policy, other avenues of research could include the effects of the exchange rate regime and the inflation targeting policy. Both instruments have been presented in the literature (Medina and Soto (2007), Larraín and Parro (2008) and De Gregorio and Labbé (2011)), as alternative shock mitigation tools, but using alternative methodologies to VAR models.

Chapter 3

Foreign Financial Shocks, Credit and the Real Economy: A VAR Model for Chile [ξ]

3.1 Introduction

Due to the country's condition of being a small and open economy, Chile's business cycle and its main macroeconomic fundamentals have been historically affected by foreign shocks, notably terms of trade (copper prices) and financial shocks. This fact has been documented in the literature based on Vector Autoregression (VAR) and Dynamic Stochastic General Equilibrium (DSGE) models with focus on Chile, though such literature has paid much more attention to the consequences of copper price shocks (Franken *et al*. (2006), Medina and Soto (2007), Kumhof and Laxton (2009), De Gregorio and Labbé (2011), Engel *et al.* (2011), Pedersen (2014), Eyraud (2015), among others) than to the effects of foreign financial shocks on the Chilean real economy.[48] In this chapter, we study this second branch.

In the aftermath of the Asian financial crisis, Caballero (2002), using an empirical analysis, argued that Chile's business cycle was mainly driven by foreign shocks with the country's vulnerability lying essentially in a financial problem, i.e. a lack of financing when it was most needed.[49] More recently, the International Monetary Fund (2015) suggests that the Chilean economy, in spite of having a deep local capital market, sound macroeconomic fundamentals, and a credible policy framework, is exposed to lack and cost increases of financing due to changes in the credit interest rate spreads and sharp assets price adjustments.

The channels through which foreign financial shocks might affect the Chilean real economy are: banks, pension funds, foreign direct investment inflows, portfolio investment and risk premium (International Monetary Fund (2015)). With the Chilean financial system having assets for more than twice the economy's GDP, and banks accounting for more than half the total assets in the system (International Monetary Fund (2014)), banks represent a concrete link between foreign financial shocks and the Chilean real economy.

As far of our knowledge, the literature that has studied the impact of foreign financial shocks on the Chilean real economy includes contributions by Franken *et al.* (2006), Carrière-Swallow and

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[ξ] This chapter will be submitted for review as *EconomiX Working Paper*.

[48] VAR models are dynamic systems of equations that examine the relation between economic variables, in which each variable is explained by its own lags, plus the current and past values of the remaining variables in the system.

DSGE models are a standard tool in modern macroeconomics allowing a quantitative analysis of policies that characterize co-movements of economic variables over time, normally based on micro-foundations and the hypothesis of market clearing.

[49] On Caballero's (2002) view, foreign shocks affect the Chilean economy decreasing the terms of trade, rising the need of foreign resources at the same time that the economy observes a decrease in the net capital inflows, generating a gap between the supply and demand for credit not addressed neither by the international markets nor the domestic financial intermediaries.

Medel (2011), Sosa (2012) and Cabezón (2012), using VAR models, and by Caputo *et al.* (2011) and García-Cicco *et al.* (2014), using DSGE models.

The literature using VAR models (Franken *et al.* (2006), Carrière-Swallow and Medel (2011), Sosa (2012) and Cabezón (2012)) and focusing on the effects of foreign financial shocks – measured by the spread between the foreign and domestic interest rates, the global markets uncertainty, the foreign interest rate, and the net capital inflows – on the Chilean business cycle has paid less attention to the effects of these shocks on private consumption and private investment. Neither has it studied the role that locally based banks play through credit, relating to foreign financial markets and the Chilean real economy.[50] Carrière-Swallow and Medel (2011)'s research work is the closest to this chapter by studying the effects of foreign financial shocks on the most likely affected sectors of the Chilean economy, though not considering the role of banks. This gap is addressed in this chapter by studying the effects of foreign financial shocks, measured by the interest rates spread between the United States and Chile's Treasury Bills (a measure intending to reflect country risk), on the domestic credit interest rates spread (a measure intending to reflect the risk in the Chilean domestic market of credit), private consumption, investment (unfortunately Chilean national accounts data does not include private investment on a quarterly basis as this chapter needs, so we use investment data as second best option) and GDP, and by assessing the role of the credit (total, to households, and to firms) supply from banks, using quarterly data for the period 2000Q1-2016Q1 and a standard VAR approach, and assuming Cholesky decomposition.[51]

Thus, in this chapter we study the impact that foreign financial shocks, measured by the interest rates spread between the United States and Chile's Treasury Bills (sovereign spread), have on the country's domestic credit interest rates spread, Chile's supply for credit (total, to households, and to firms) provided by the locally installed banks, and the private consumption, investment, and business cycle. More concretely we respond to three questions: (i) What are the effects of foreign financial shocks, measured by the interest rates spread between the United States and Chile's Treasury Bills, on the Chilean economic output, the total credit supply and the domestic credit interest rates spread, and the role that the total credit supply has affecting the Chilean economic output after such foreign financial shock?; (ii) Does the credit to households explain the changes in the domestic credit interest rates spread for small credits, private consumption, and GDP, after a shock to the interest rates spread between the United States and Chile's Treasury Bills?; and (iii) Does a foreign financial shock, measured by the interest rates spread between the United States and Chile's Treasury Bills, affect the credit to firms, and hence the domestic credit interest rates spread for big credits, investment and GDP?

Ex-ante we expected to find that less international capital would be available in Chile as a consequence of an increase in the interest rates spread between the United States and Chile's Treasury Bills, implying a decrease in the credit supply. Such credit constraint would decrease total credit, credit to households and credit to firms. Then these changes, joint by an increase in the

[50] Banks are key players in the economy as they bring resources from individuals with superavits of income to those in need to finance either consumption and/or investment.

[51] The interest rates spread between the United States and developing economies Treasury Bills is usually used as a proxy of the country risk of developing economies. A widening of this spread is usually associated to higher costs and less availability of funds for credit. The interest rates spread between the United States and Chile's Treasury Bills intends to reflect this effect.

domestic credit spread, would be followed by a decrease in private consumption, investment and GDP. Nevertheless, what we found is that after such a shock to the interest rates spread between the United States and Chile's Treasury Bills, the Chilean economy observes a statistically significant economic output loss and a reduction in the credit to households and private consumption, statistically significant as well. We did not find statistically significant effects of such a shock on the domestic spread (to average, small and big size credits), total credit and credit to firms, and on investment.[52]

The rest of this chapter is organized into six sections including this introduction. Section 3.2 discusses the literature that has studied the effects of foreign financial shocks on the Chilean economy, both using VAR and DSGE models. Section 3.3 describes the Chilean financial system, with special focus on the banking sector. Section 3.4 presents the empirical strategy including the data, the variables of interest and their arrangements, the statistical tests applied, the VAR models estimated and the assumptions considered, notably Cholesky decomposition. Section 3.5 presents and discusses the results, and Section 3.6 concludes.

3.2 Related Literature

In the case of Chile, the literature that has studied the effects of foreign financial shocks on the economy using analytical models includes contributions by Franken *et al.* (2006), Carrière-Swallow and Medel (2011), Sosa (2012) and Cabezón (2012), using VAR models, and by Caputo *et al.* (2011) and García-Cicco *et al.* (2014), using DSGE models. The literature based on VAR models has used alternative measures of foreign financial shocks, such as the spread between foreign and domestic interest rates, the global markets uncertainty, the foreign interest rate, and the net capital inflows, finding that foreign financial shocks do have a negative effect on the Chilean economic output. Table 3.1 presents a summary of this literature including the period of study, the data frequency, type of VAR models estimated and the number of lags included, the variables used, the variables representing the foreign financial shocks, the proxies of the foreign financial shocks studied, their units and/or the arrangements applied, and the effects on the Chilean economic output.

[52] Alternatively we used the S&P500 Chicago Board Options Exchange Market Volatility Index (VIX) as measure of foreign financial shock, including a dummy variable for the period where the Zivot-Andrews unit root and structural change test found evidence of a structural break. Results are qualitatively similar, but statistically non-significant suggesting weak quantitative effects. Such finding rests on the low external vulnerability of Chile.

Table 3.1. Summary Related Literature Using VAR Models

	Franken *et al.* (2006)	Carrière-Swallow and Medel (2011) 1/	Sosa (2012)	Cabezón (2012)
Period of study	1950-2003	1990Q1-2010Q4	1990Q1-2011Q4	1997Q3-2010Q4
Frequency	Annual	Quarterly	Quarterly	Quarterly
Approach	VAR model with block exogeneity and Cholesky decomposition	VAR model and Cholesky decomposition	VAR model and Cholesky decomposition	VAR model and Cholesky decomposition
Number of lags included in the VAR model	1 lag	2 lags	2 lags (based on the Akaike Information Criterion)	3 lags (based on the Akaike Information Criterion)
Variables included	External demand, terms of trade, foreign interest rate, foreign equity, terms of trade, net capital flows, openness, real exchange rate, money, fiscal revenue, fiscal expenditure, domestic equity and output. 2/	Uncertainty index developed by the authors, S&P500 and inflation in cycles, and the real demand and supply national accounts data in cycles. 3/	VIX in log levels, real global output, real copper prices, Chile's real domestic output, all in first differences.	External demand for Chilean exports, foreign interest rate, foreign stock markets, international price of copper, international price of oil, growth rate of the Chilean economy, domestic prices, domestic interest rate, exchange rate and domestic stock market. 4/
Variables representing the foreign financial shocks	Foreign equity volatility	Global market uncertainty	Global market uncertainty	Foreign stock markets performance
	Foreign interest rate			Foreign interest rates spread
	Net capital inflows			
Proxy variables of the foreign financial shocks, their units and/or arrangements.	Annual standard deviation of daily real returns from the Dow Jones Index. Deviation of the standard deviation of real returns from Hodrick-Prescott trend.	VIX index (S&P 500 Chicago Board Options Exchange Market Volatility Index). Annualized standard deviation of daily returns over a calendar month.	VIX index (S&P 500 Chicago Board Options Exchange Market Volatility Index). VIX index in levels (logarithms).	MSCI (Morgan Stanley Capital International) World Index. Coefficient of variation of the MSCI World Index computed as the standard deviation over the mean within each period.
	Average secondary market rate of the three-months United States Treasury Bill minus the annual consumer price index of the United States economy, based on data from the IMF. Deviation of the real rate from Hodrick-Prescott trend.			Average weight of the three months interbank offer rate or the rate associated with the Treasury Bills of the five largest world economies for the studied period, in percent. Chile's equivalent Treasury Bill.
	Current account deficit net of international reserves accumulated to GDP. Deviation of the ratio to GDP from Hodrick-Prescott trend.			
Effect on the Chilean economic output (GDP)	A rise in the volatility of world markets lowers the Chilean GDP	A global market uncertainty shock reduces the Chilean GDP	A positive shock to the VIX index has a negative impact on output	An increase in the foreign stock markets volatility results in a negative effect on the Chilean GDP
	A rise in the foreign interest rate lowers domestic output			An increase in the spread between foreign and domestic interest rates lowers the Chilean GDP
	An increase in the net capital flows expands the Chilean business cycle at impact			

1/ These authors found that global markets uncertainty shocks drop significantly the sectors of construction, durable consumption goods, and investment in plants and equipments.

2/ These variables were transformed depending on their specific characteristics. See Franken *et al.* (2006) Table 2 for further detail.

3/ Demand national accounts components: aggregate demand, private consumption, current consumption, durable consumption, investment, machineries and equipments, and construction and works. Supply national accounts components: GDP, fisheries, mining, commerce, industry, and construction.

4/ These variables were transformed depending on their specific characteristics. See Cabezón (2012) Appendix for further detail.

To respond to what extent the pronounced economic output fluctuations in the Chilean economy were associated with ups and downs in the foreign conditions, and if real or financial shocks, either foreign or domestic, were the most important sources of such fluctuations, Franken *et al.* (2006) adopts a VAR model with block exogeneity and Cholesky decomposition, that covers the period 1950-2003 using annual data. The variables these authors use to measure the foreign financial shocks are: (i) The real foreign interest rate (obtained from the average secondary market rate of

the three months United States Treasury Bill minus the annual United States consumer price index); (ii) The foreign equity volatility (which proxies the global markets uncertainty, and is represented by the annual standard deviation of daily real returns from the Dow Jones index); and (iii) The net capital inflows (corresponding to the current account deficit net of the international reserves over GDP). These authors find that both foreign real and financial shocks have been dominant sources of Chile's economic output fluctuations, and that meanwhile a rise in the real foreign interest rate and the foreign equity volatility have a negative effect on the economic output, an increase in the net capital inflows expands the Chilean business cycle.

Later, Carrière-Swallow and Medel (2011) estimates the impact of global markets uncertainty shocks (identified as sudden jumps in the United States stock market volatility, proxy by the S&P500 Chicago Board Options Exchange Market Volatility Index (VIX)) on the sectors of the Chilean economy most likely to be affected by these types of shocks. Using a VAR model, Cholesky decomposition and quarterly data for the period 1990Q1-2010Q4, they estimate that global markets uncertainty shocks generate a fall in the Chilean GDP of 1.7 percent with respect to the trend, after three quarters, and at the sector level significant drops are found in construction (-4 percent after three quarters), durable consumption goods (-7 percent after one quarter), and investment in plants and equipment (-10 percent after two quarters).

With the aim of quantifying the impact of foreign real and financial shocks on Chile's economic activity, Sosa (2012) using a VAR model, Cholesky decomposition and quarterly data between 1990Q1 and 2011Q4, finds that both foreign real and financial shocks have an impact on Chile's economic output. To measure foreign financial shocks, Sosa (2012) considers the global markets uncertainty, proxied by the VIX index. This author finds that a positive shock to the VIX, has a negative impact on the Chilean economic output (in particular, a one positive standard deviation shock to the VIX (4.1 units) leads to an economic output loss of 0.7 percent after 8 quarters).

Aiming at assessing the effects of foreign financial shocks on the Chilean economy, Cabezón (2012) estimates a VAR model based on Cholesky decomposition using data at quarterly frequency that covers the period 1997Q3-2010Q4. The variables used to measure the foreign financial shocks are the foreign stock markets performance and the foreign interest rates spread. The foreign stock markets performance variable is computed using the Morgan Stanley Capital International World Index (MSCI). The foreign interest rate is calculated as the average weight of the three months interbank offer rate or the rate associated with the Treasury Bills of the five largest world economies for the period. This variable along with the domestic interest rate attempts to capture the effect of shocks produced by the interest rates spreads. The main findings of this paper are that shocks increasing the foreign stock markets volatility and the spread between foreign and domestic interest rates, lower the Chilean economic output.

On its side, as far as we know, the literature that has studied the effects of foreign financial shocks using DSGE models and focusing on Chile includes contributions by Caputo *et al.* (2011) and García-Cicco *et al.* (2014). These authors find that financial frictions and/or financial intermediaries (banks) play a central role in explaining the relationship between foreign financial shocks and the Chilean real economy. The role of credit from financial intermediaries (banks) relating to foreign financial shocks and the Chilean real economy is missed in the literature using VAR models. We address this gap in this chapter.

Caputo *et al.* (2011) analyses empirically the consequences of the global financial crisis of 2008 on the Chilean economy, for the period from 2001Q2 to 2010Q4, estimating a DSGE model for a small open economy that includes financial frictions (domestic spread and country risk premium), finding that financial shocks, both foreign and domestic, played a major role in explaining the downturn in Chile's economic activity in 2009. Their model incorporates a foreign financial shock that affects the cost at which domestic agents borrow in the international financial markets and a domestic financial shock that affects the lending rate at which households are able to borrow domestically.

With the objective of assessing the importance of domestic frictions in propagating foreign shocks (international relative price of commodities, world inflation, world interest rate and the world economic output), García-Cicco *et al.* (2014) using Chilean quarterly data for the period between 2001 and 2012, estimate a DSGE model for a small open economy introducing two types of frictions: one in the relationship between depositors and financial intermediaries (banks) and the other one between financial intermediaries (banks) and borrowers. These authors find that among foreign shocks, the international relative price of commodities seems to be the most relevant, followed by the world inflation and the world interest rate, while world economic output plays a negligible role.

3.3 The Chilean Financial System

Chile is an economy where the financial system plays an important role intermediating resources between individuals having superavits (savings) and those having deficits, to mainly finance consumption and investment which then determine the economic output.

Reports from the Organization for Economic Co-operation and Development (2011), OECD, and the International Monetary Fund (2011, 2014 and 2015), IMF, describe the Chilean financial system as large, well-diversified, highly integrated to Latin-American and world markets (both at emerging markets and OECD standards) in terms of number of participants, variety of products supplied, and market depth, with financial conglomerates being a special characteristic.

Orozco (2014) comparing the Chilean financial system with those in Colombia and Peru suggests that the higher economic development and the earlier financial reforms (leave the import substitution strategy, privatization of many public enterprises, loosening restrictions on mandatory credits and price liberalization in the mid-70's, reform of the pension system in the early 80's, and major banking reforms in 1986 and 1997) made in Chile, allowed the country to have a more developed and efficient financial system compared to these other two Latin-American countries. Despite the advance state of Chile's financial system compared to other countries in the region, some vestiges of a controlled financial environment remain. One are the Central Bank of Chile surveillance mechanisms over the foreign exchange market, and other is the role that indexation plays in its financial system (Organization for Economic Co-operation and Development (2011)).

In the 2011 Financial Sector Assessment Program report, the IMF concludes that in spite the overall Chilean financial system looks resilient, remaining challenges exist. For example in the banking sector, meanwhile banks in general are well capitalized, profitable, and have enough core deposits to limit the risk of funding, stress tests done by the Central Bank of Chile found some vulnerability among small banks.

Table 3.2. Financial System Structure (2012)
(Assets as a share of total and GDP, in percent)

	Share of total	Share of GDP
Banks	52.4	107.7
Pension funds	28.9	59.4
Insurance companies	10.0	20.5
Other funds	8.7	17.8
Total	100.0	205.4

Source: International Monetary Fund (2014).

Regarding its size and diversification, by the end of 2012, the Chilean financial system had assets for more than two times the GDP, with banks, pension funds, and insurance companies accounting for about 52.4, 28.9 and 10.0 percent of total assets in the system, respectively (Table 3.2).

About its integration to Latin-American and world markets, in its "2014 Article IV consultation" (International Monetary Fund (2014)), the IMF argues that Chile's financial system is the most open in Latin-America when measured by the total international assets and liabilities as percentage of GDP (a standard financial openness indicator), with an index equal to 227 percent compared to the 131 percent regional average index (which includes Argentina, Brazil, Chile, Colombia, Mexico and Venezuela country indices), evidencing Chile's exposure to regional and international financial risks.

Financial conglomerates are a special feature of the Chilean financial system.[53] Their relevance comes from the Chilean law which impedes banks to directly engage in financial activities, such as insurances and securities or investment banking. It implies that banking, pension funds, insurances and securities, and other type of financial activities are somehow separated but at the same time can be under the control of the same financial conglomerate. As most financial institutions in Chile are part of financial conglomerates, which tend to be large, complex, and prone to regulatory arbitrage and intra-group contagion, financial conglomerates pose a significant challenge for supervision (International Monetary Fund (2014)).

The Chilean financial system is regulated and supervised, depending on the type of financial service provided, by the Central Bank of Chile, the Superintendence of Banks and Financial Institutions (SBIF), the Superintendence of Securities and Insurance (SVS), and the Superintendence of Pensions (SP). The Central Bank of Chile and the SBIF regulate and supervise the banking system, the SVS is in charge of securities and insurance, and the SP is responsible for following the activities in the pension system and the unemployment insurance. The Chilean financial system regulatory framework also includes a Financial Stability Council, chaired by the Ministry of Finance, which facilitates coordination and data sharing among regulators/supervisors, and the Superintendents' Committee, composed by the heads of the SBIF, SVS and SP, aiming to coordinate capital market matters requiring participation and coordination among these

[53] A financial conglomerate is a corporation that runs different seemingly unrelated business, as banking, pension funds, securities, insurances, investment banking, mutual funds, etc.

regulators/supervisors. Although these multiple agencies provide close and active financial oversight, the framework and governance could be strengthened. Remove data sharing constraints among regulators/supervisors of the system, clear allocation of powers and responsibilities for continuous supervision, prudential regulation at the financial conglomerate level would improve the existing framework (International Monetary Fund (2014)). Strengthening the regulatory and supervisory framework for financial conglomerates would improve Chile's financial sector resilience (International Monetary Fund (2015)).

3.3.1 Banking Sector

By the end of 2012, the Chilean banking sector had assets for more than a hundred percent of GDP (Table 3.2). Meanwhile domestic owned banks represent about 60 percent of the total market (total credit), foreign owned banks represent the remaining 40 percent. The Chilean banking sector is mainly owned by private actors, including 23 banks by the end of 2014. Banks total credit equals about 80 percent of GDP in 2014 (Table 3.4), so links between banks and the real economy exist.

Table 3.3. Banks Market Share and Ownership (2014)

	Share of total	Main shareholder	Ownership share
Banco Santander	17.9	Santander Chile Holding S.A.	35.5% (majority)
Banco de Chile	17.6	Soc. Administist. de la Obligacion	30.2%
Banco Estado	13.3	State of Chile	100.0%
Banco de Crédito e Inversiones	12.6	Emp. Juan Yarur S.A.C.	55.0%
Corpbanca	11.3	Corp Group Banking S.A.	43.7% (majority)
Banco Bilbao Vizcaya Argentaria	6.6	BBVA Pensiones Chile S.A.	68.2%
Scotiabank	5.0	Nova Scotia Inv Ltda	99.5%
Itaú	4.9	BKB Chile Holding Inc	100.0%
Bice	2.9	Bicecorp S.A.	99.9%
Security	2.9	Grupo Security S.A.	99.9%
Others	5.0		

Source: Superintendence of Banks and Financial Institutions.

The top ten players of the banking system represent about 95 percent of the market, with five corresponding to private owned domestic banks (Banco de Chile, Banco de Crédito e Inversiones, Corpbanca, Bice and Security), four to subsidiaries of foreign banks (Banco Santander (Spanish), Banco Bilbao Vizcaya Argentaria (Spanish), Scotiabank (Canadian) and Itaú (Brasilian)), and one State owned bank (Banco Estado), (Table 3.3). Market concentration seems high, with the five main banks having a market share of about 70 percent, however their market distribution appears relatively similar with around 14 percent of the market share each. According to the International Monetary Fund (2014), foreign banks market share represents a concrete link between Chile's banking sector and foreign markets, with exposure to foreign markets increasing in recent years as domestic banks have expanded their operations abroad.

Compared to the other banks in the system, Banco Estado is much focused on the small scale and SMEs lending. Banco Estado is subject to the same regulation and supervision as the other banks

in the system, though it is governed by its own law. Nevertheless it is not allowed to provide loans to state-owned institutions (Organization for Economic Co-operation and Development (2011)).

Table 3.4. Credit Composition by Economic Activity (2014)

Economic activity	Share of total	Share of GDP
Commercial (firms)	59.9	48.8
Housing (households)	25.2	20.5
Consumption (households)	13.4	11.0
Others	1.5	1.3

Source: Superintendence of Banks and Financial Institutions and International Monetary Fund.

In Chile, banks represent an important source for credit (financing) to firms with about 60 percent of the banking system total credit going to commercial financing (Table 3.4). On its side, credit to households is around 38 percent, with 25 percent for housing and 13 percent for consumption. Under the supervision of the SBIF, large retailers (others in Table 3.4) have become competitors to banks, as these firms have taken over the credit to the low-income segment, though by the end of 2014 they account for about 1.5 percent of total credit in the Chilean financial system.

During 2016, Chilean authorities and Congress have been discussing a new general banking law, which intends to improve the banking sector resilience, adapting the Basel III capital standards to the Chilean banks, and introducing a capital surcharge for those banks domestically more important.

3.3.2 Non-Banking Sector

Pension funds and insurance companies are key players of the financial system in the non-banking sector. Other minor players include mutual funds, investment funds and investment funds for foreign capital. Meanwhile the pension funds, privately administrated, account assets for 59.4 percent of GDP by 2012, the insurance companies assets represent about 20.5 percent of GDP (Table 3.2).

Chilean pension funds are the main institutional investors in the financial system. Six players exist in the privately managed Chilean pension funds system. Their assets distribution, by the end of 2014, is concentrated in the four main players, i.e.: Provida (27.8 percent), Habitat (25.9 percent), Cuprum (21.2 percent) and Capital (20.6 percent) (Superintendence of Pensions, 2015). The two remaining players are Planvital and Modelo with limited assets, as percent of total, reaching 2.8 and 1.7 percent, respectively. According to the International Monetary Fund (2011) the Chilean pension funds risk diversification has improved during the 2000's as the investment portfolios are better diversified, thanks to changes in the investment limits allowed to the pension funds, which are now more consistent with the long-term objectives of the system.

On its hand, the insurance sector is relatively large and is expected to grow in the coming years, driven by life insurance companies, as Chile's number of retirees will increase (International Monetary Fund (2014)). In 2015, insurance sector companies totalized sells by US$ 10.4 billion, of which a 69 percent corresponded to life insurance and 31 percent to general insurance. Insurance

companies involved in the life insurance business are 36, and those in the general insurance market are 30.

3.3.3 Foreign Direct Investment

In Chile, foreign direct investment (FDI) is an important source of investment representing an average of 8.4 percent of GDP in recent years (International Monetary Fund (2015)).

Table 3.5. Foreign Direct Investment by Country of Origin and by Recipient Sector (2009-13)

Country	Share of total	Share of GDP
United States	16.7	1.3
Netherlands	14.8	1.2
Spain	10.4	0.9
Canada	5.1	0.4
United Kingdom	4.3	0.3
Others	48.7	4.3

Sector	Share of total	Share of GDP
Mining	44.9	3.9
Financial services	13.4	1.1
Electricity, gas and water	10.2	0.9
Industry	4.7	0.4
Telecommunications	2.6	0.2
Others	24.2	1.9

Source: Central Bank of Chile.

Although FDI is well diversified in terms of country of origin, it is not the case in terms of sectors, since it mostly focuses on the sectors of mining (44.9 percent of total), financial services (13.4 percent of total) and utilities (10.2 percent of total), (Table 3.5). The FDI by country of origin, as share of total, is dominated by the United States (16.7 percent), Netherlands (14.8 percent) and Spain (10.4 percent).

3.4 Empirical Strategy

In this section we present the data, our variables of interest and their transformations, the statistical tests applied, the assumptions considered, and the VAR models estimated.

This chapter uses foreign and domestic financial, banking credit and macroeconomic data, with quarterly frequency covering the period 2000Q1-2016Q1.

Foreign financial data includes the spread between the United States and Chile's Treasury Bills interest rates (hereafter we called "sovereign spread" for short), sourced by the United States Federal Reserve Board and the Central Bank of Chile, with a quarterly frequency.[54]

Domestic financial data corresponds to the domestic credit interest rates spread (hereafter "domestic spread" for short). It is measured as the spread between commercial banks interest rates and the yield on 90 days Chilean Treasury Bills, using data sourced by the Central Bank of Chile and the SBIF. We set three different domestic spreads: (i) The spread between the commercial banks average size credit and the Central Bank of Chile Treasury Bills interest rates; (ii) The spread between commercial banks interest rate for small size credits (below 200UF), which mainly corresponds to credits to households for consumption, and the Central Bank of Chile Treasury Bills interest rate; and (iii) The spread between commercial banks' big size credits interest rate (above 5,000UF), mainly commercial credits to firms, and the Central Bank of Chile Treasury Bills interest rate.[55] [56]

Banking credit data (total, to households, and to firms), in nominal terms, sourced by the Central Bank of Chile and the SBIF, were deflated by Chile's consumer price index of all items, sourced by the Chilean National Bureau of Statistics (INE) and the OECD, obtaining the banking credit data in real terms.

Private consumption, investment (Chile does not report private investment data on a quarterly frequency as this chapter requires, then we use investment as second best option), and GDP data, all in nominal terms, are sourced by the Central Bank of Chile and the OECD. Private consumption, investment, and GDP data were also deflated by Chile's consumer price index of all items, sourced by the INE and the OECD, obtaining the real private consumption, the real investment and the real GDP.[57]

To make the interpretation of the impulse-response functions reported in Section 3.5 easier, we proceeded with the following transformations: (i) From the nominal sovereign spread expressed in deviations with respect to its trend, using the Hodrick-Prescott filter (HP filter) with the λ multiplier for quarterly data, i.e. 1600, we obtained the variable we called "*s-spread*"; (ii) From the nominal domestic spreads, for "average", "small" and "big" credits, expressed in deviations with respect to its trend, using the HP filter, we have the variables we called "*d-spread-a*", "*d-spread-s*" and "*d-spread-b*"; (iii) Last, from the real total credit, real credit to households, real credit to firms, real private consumption, real investment and real GDP, expressed in deviations of their log levels from their trend, using the HP filter, we obtained the variables we called "*credit*", "*households*", "*firms*", "*cons*", "*inv*", and "*gdp*", respectively. To prevent the HP filter "tail problem" we excluded from our estimations in Section 3.5 the data for the periods: 2000Q1-2000Q4 and 2015Q2-2016Q1,

[54] An increase (widening) of the sovereign spread is usually associated to more expensive and less available international funds.

[55] The UF ("Unidades de Fomento", in Spanish) is a Chilean unit of account indexed to inflation. In 2016, 200UF and 5000UF represent about US$ 8,000 and US$ 200,000 (these numbers are a very raw estimation).

[56] When the yield on 90 days Chilean Treasury Bills data was not available, we used the existing information in the previous quarter to fill the gap. This occurs in the following quarters: 2008Q3, 2010Q2, 2012Q4, 2013Q1, 2013Q4, 2014Q3, 2014Q4, and 2015Q4.

[57] Further detail in Appendix 3.A.

studying the period 2001Q1-2015Q1. However, alternatively and for robustness purposes we also used the full period, i.e.: 2000Q1-2016Q1.[58]

Following the standard statistical procedure when using time series, we checked for seasonal patterns, stationarity and cointegration among our variables. First we looked for seasonal patterns by studying the correlograms of our variables of study, second we checked for stationarity by applying unit root tests, and last we searched for cointegration using statistical tests as well.

In order to avoid the effects of seasonality in our estimations we analyzed the correlograms of our data, before the transformations explained above, and we seasonally adjusted the total credit, the credit to households, the credit to firms, the private consumption, the investment and the GDP, using the Census X-12 quarterly seasonal adjustment method (by the United States Department of Commerce Census Bureau). Then we applied the Augmented Dickey-Fuller and the Phillips-Perron unit root tests, and the Zivot-Andrews unit root and structural change test to our variables of study, finding no evidence of unit root though some evidence of structural breaks.[59] Cointegration was studied by applying the standard Johansen cointegration, finding that in most cases both the "Trace" and the "Maximum eigenvalue" Johansen cointegration tests could not reject the null hypothesis of none cointegration, meaning the absence of cointegration, allowing VAR models estimation.[60]

Finally we estimated alternative VAR models (Models A, B, and C) assuming Cholesky decomposition as identification strategy. The ordering of the variables considers: First the sovereign spread, i.e. "*s-spread*", representing the foreign financial shock and therefore the most exogenous variable to the Chilean economy; Second the domestic spreads ("*d-spread-a*", "*d-spread-s*", and "*d-spread-b*") considering that these are expressed in nominal terms as the sovereign spread, and hence are more directly affected among the remaining variables of study; Third those reflecting the domestic credit ("*credit*", "*households*", "*firms*"), as we assume that changes in sovereign and domestic spreads would directly affect credit in the Chilean financial markets due to changes in the cost and availability of funds for credit. Last, private consumption, investment and GDP, ("*cons*", "*inv*", and "*gdp*", respectively) as these variables represent the real Chilean economy, and therefore are the most endogenous.

Regarding the number of lags included in Section 3.5 models, the international literature estimating vector autoregression models using quarterly data usually chooses four lags, however the literature related to this chapter (Franken *et al.* (2006), Carrière-Swallow and Medel (2011), Sosa (2012) and Cabezón (2012)), uses one, two or three lags (Table 3.1). In this chapter we follow the criterion by Ivanov and Killian (2005) and use the number of lags suggested by the Schwarz Information Criterion (SIC) if the sample size is smaller than 120 periods. Our data includes 65 periods (quarters) then according to SIC the number of lags in the next section models is one.[61]

[58] These estimations are available upon request.
[59] Further detail in Appendix 3.B.
[60] These tests results are available upon request.
[61] This information is available upon request.

3.5 Results

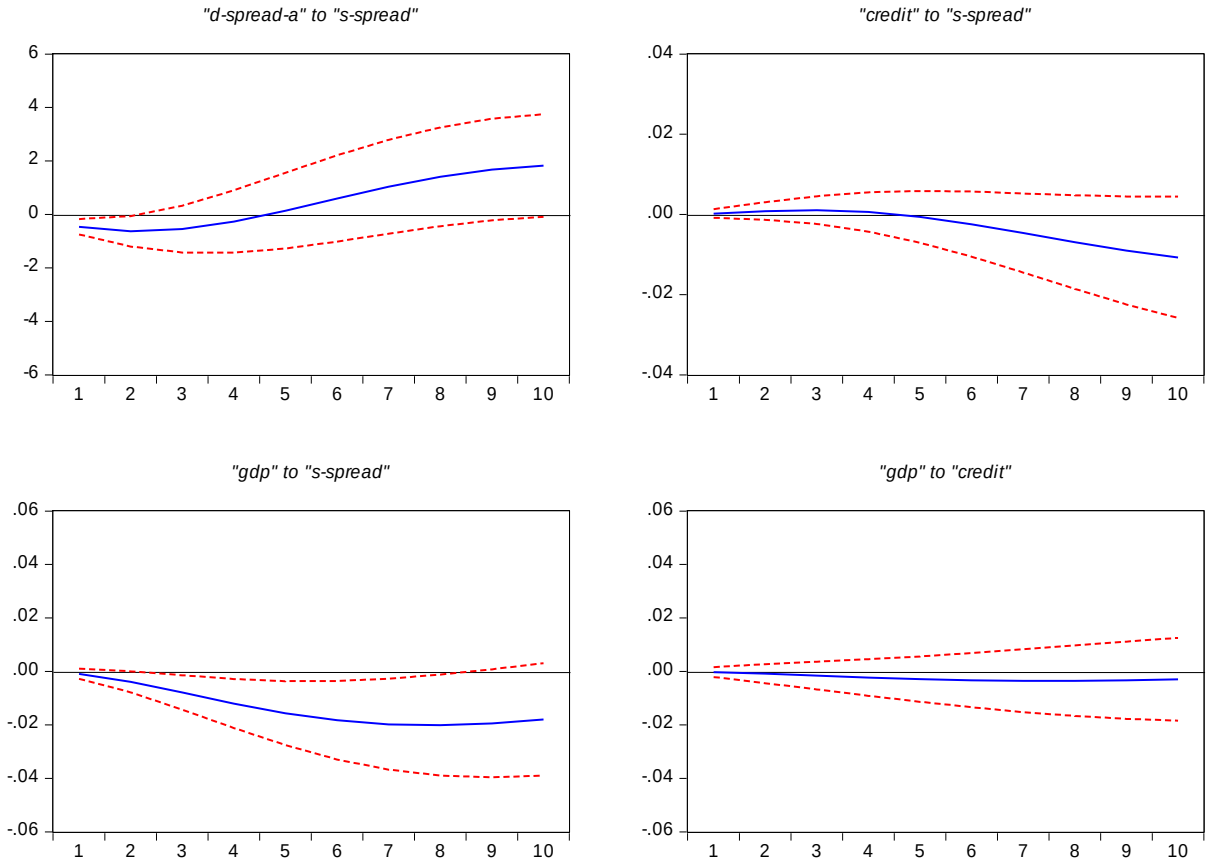
In this section we present the accumulated impulse-response functions coming from the VAR models we estimate and we address the following questions: First, what are the effects of foreign financial shocks, measured by the sovereign spread, on the Chilean GDP, the total credit supply and the domestic spread "for average size credits", and what is the role that the total credit supply has affecting the Chilean GDP after such a shock?; Second, does the credit to households explains the changes in the domestic spread "for small credits", private consumption, and GDP, after a sovereign spread shock?; And third, does a sovereign spread shock affects the credit to firms, the domestic spread "for big credits", investment and GDP?

The accumulated impulse-response functions we present in this section represent a shock of one standard deviation to the sovereign spread from its long-term trend (i.e. a shock of one standard deviation to the variable "*s-spread*"), and the figures presented include ten quarters (the number of periods that we define as the medium-term).

First, to find the effects that a foreign financial shock, measured by the sovereign spread, have on the Chilean economic output, the total credit and the domestic spread "for average size credits", and the role that total credit has in Chile's economic output, we estimate a VAR model (Model A) with one lag (as suggested by SIC) and the variables following the ordering: first *"s-spread"*, followed by "*d-spread-a*", third *"credit"*, and last *"gdp"*, for the period 2001Q1-2015Q1 (by excluding the first and last four quarters of our original sample, 2000Q1-2016Q1, to avoid the HP filter "tails critique").[62]

[62] The results we found using the full sample period, i.e.: 2000Q1-2016Q1, are similar to those we report in this section. They are available upon request.

Figure 3.1. Accumulated Response to One S.D. Shock to Sovereign Spread *"s-spread"*
Model A. Sovereign Spread, Domestic Spread (Average Size Credits), Total Credit and GDP



In Figure 3.1 we observe the accumulated response of "*d-spread-a*", "*credit*" and "*gdp*" to a one standard deviation shock to "*s-spread*" (sovereign spread deviation from its long-term trend) and the effect that total credit has on Chile's economic output ("*gdp*" to "*credit*"). Thus, an increase of a one standard deviation shock to "*s-spread*" (equivalent to 1.18 percent) leads to an output loss of -2.1 percent after ten quarters (statistically significant during the first two years), a reduction in the total credit supply of about -1.3 percent in the medium-term (statistically non-significant), an initially negative effect in the domestic spread for average size credits "*d-spread-a*" that later becomes positive (statistically significant only during the first quarter), and an about null effect of the total credit supply on "*gdp*" (statistically non-significant).

Then, if the Chilean economy is affected by a foreign financial shock, represented by a shock to the interest rates spread between the United States and Chile's Treasury Bills, in a 1.18 percent, Chile's economic output observes a loss of -2.1 percent, and the total credit observes a reduction of -1.3 percent, statistically non-significant. Such a result is in line with Cabezón (2012) finding about the relation between the sovereign spread and GDP. These findings, presented in Figure 3.1, are robust to the number of lags used in Model A, one to four, the sample period (2000Q1-2016Q1 instead of 2001Q1-2015Q1) and the inclusion of a constant or not in the model.

Second, to check the effects that a shock to the sovereign spread, "*s-spread*", has on the domestic spread for small size credits cycle, "*d-spread-s*", credit to households cycle, "*households*", private

consumption cycle, "*cons*", and the economic output cycle "*gdp*", we estimate a VAR model (Model B) including one lag, as suggested by SIC, for the period 2001Q1-2015Q1. Thus Model B includes the variables: "*s-spread*", "*d-spread-s*", "*households*", "*cons*", and "*gdp*", following this ordering.

Figure 3.2. Accumulated Response to One S.D. Shock to Sovereign Spread "s-*spread*"
Model B. Sovereign Spread, Domestic Spread (Small Size Credits), Households Credit, Private Consumption and GDP

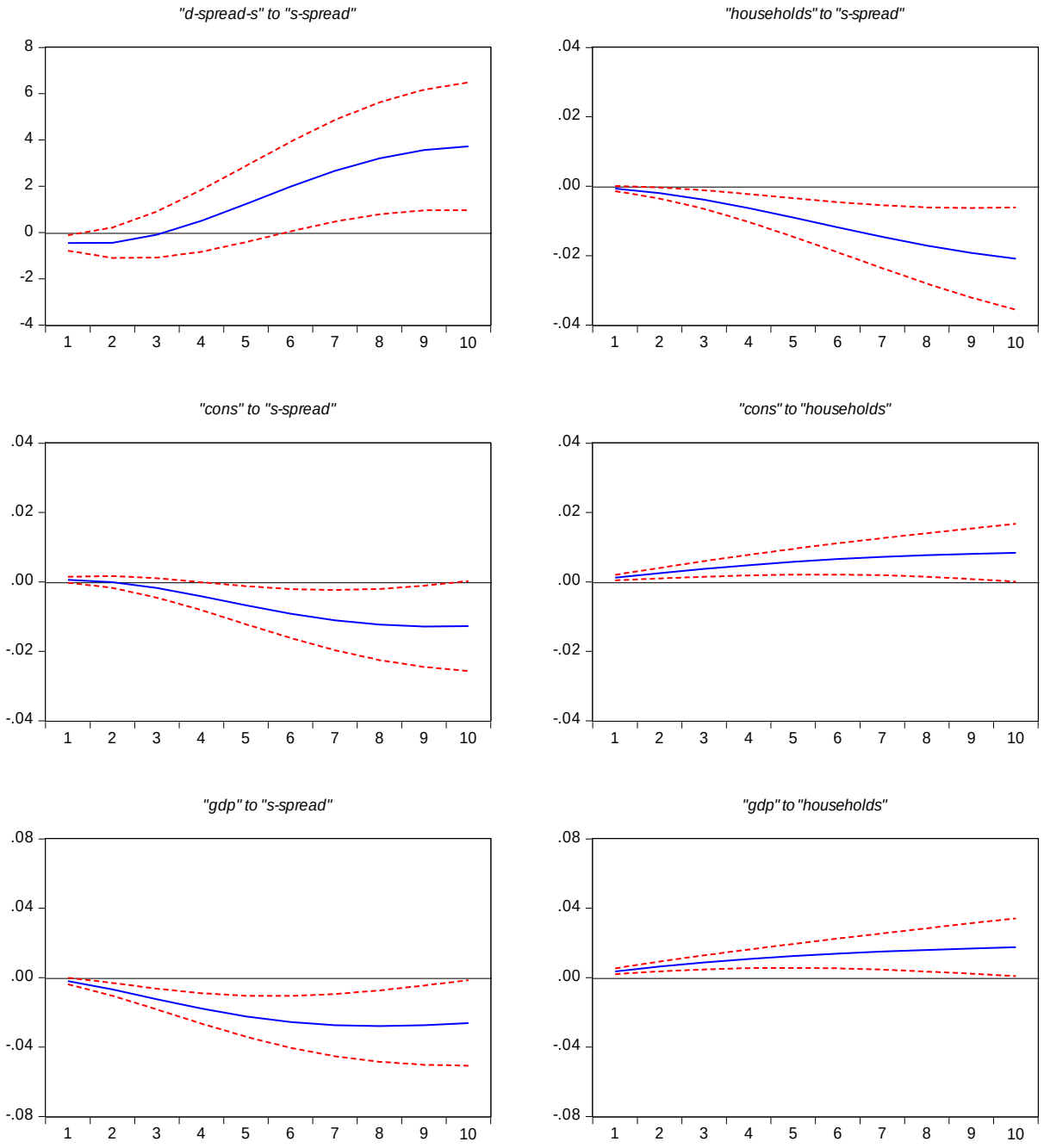


Figure 3.2 presents the accumulated response to a one standard deviation shock to the sovereign spread cycle, "*s-spread*", by the domestic spread for small size credits cycle, "*d-spread-s*", credit

to household's cycle, "*households*", private consumption cycle, "*cons*", and the Chilean economic output cycle, "*gdp*". It also presents the relation between the credit to household's cycle, and the private consumption and GDP cycles.

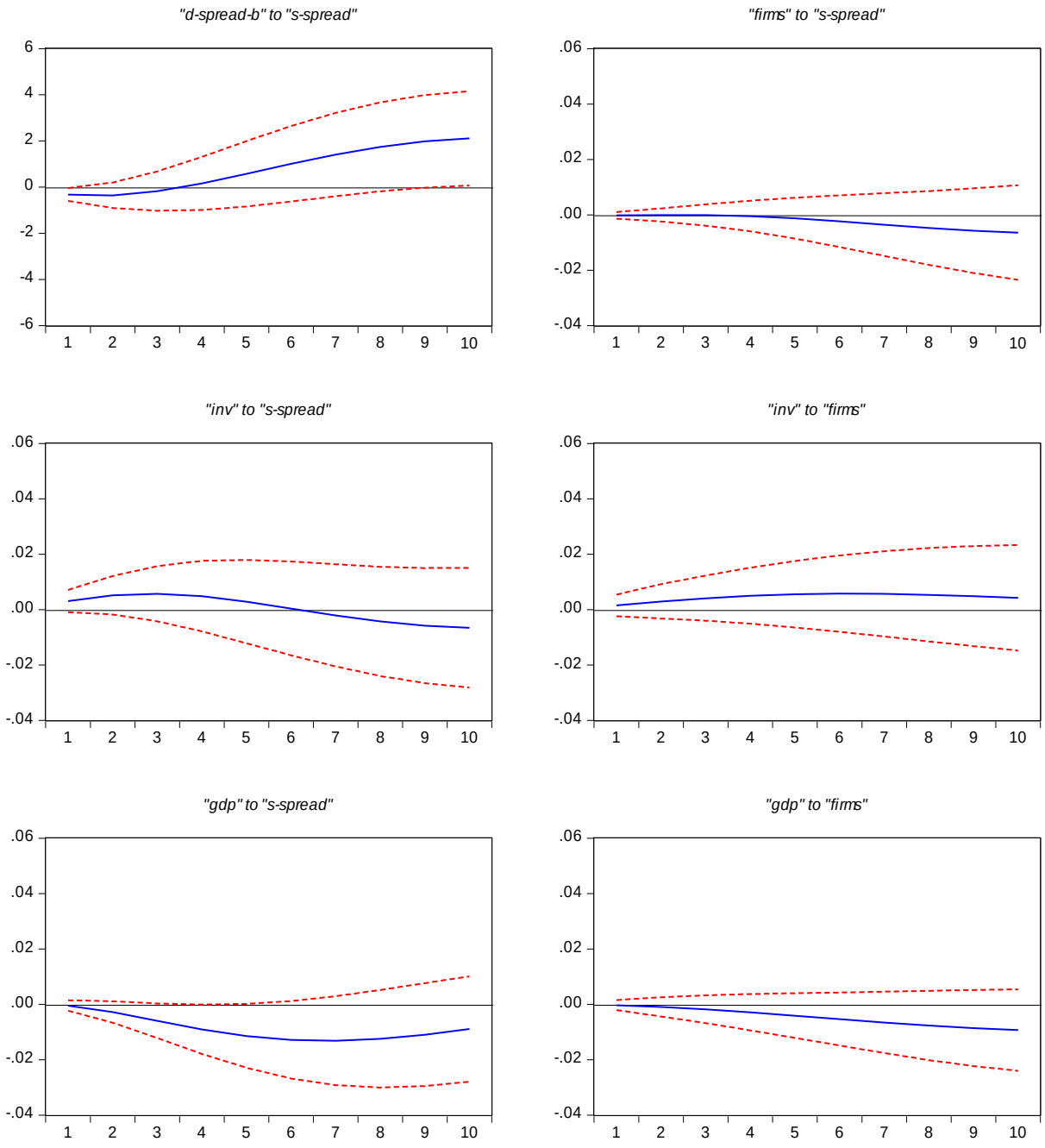
We find that a one standard deviation shock to the "*s-spread*" (equivalent to 1.18 percent) leads, after ten quarters, to a reduction of -2.5 percent in the credit to households, a decrease in private consumption of -1.5 percent, and an output loss of -3.1 percent, all statistically significant. At the same time, a one standard deviation shock to the "*s-spread*" leads to an increase of 4.4 percent in the domestic spread for small size credits, "*d-spread-s*", after ten quarters, though statistically significant only after the sixth quarter.

Finally, in Figure 3.2 we also observe that private consumption cycle response to changes in the credit to household's cycle (in one percent) is positive and statistically significant in a number of 0.08 percent, in the medium-term. Similar relation is found between GDP and credit to household's cycles, meaning that when credit to household's increases in one percent with respect to its trend, the GDP observes also a statistically significant increase in 0.2 percent with respect to its trend.

Compared to the results in Figure 3.1, in Figure 3.2 we observe that credit to households seems to be more affected than the total credit by a shock to the sovereign spread, meaning that when the difference between the United States and Treasury-Bills interest rates cycle becomes bigger, the credit to households supply cycle seems more reactive than the total credit supply cycle. Also we observe that the GDP seems to be more responsive to changes in the credit to households supply than the total credit supply.

In Figure 3.3 we present the accumulated response to a one standard deviation shock to the "*s-spread*" (equivalent to 1.18 percent) by the domestic spread for big size credits, "*d-spread-b*", credit to firms, "*firms*", investment, "*inv*", and the economic output, "*gdp*". It also describes the relation between the credit to firms and investment, after such a shock. Thus, Figure 3.3 observes that the domestic spread for big size credits rises in 2.5 percent with respect to its trend when the Chilean banking sector faces an exogenous sovereign spread shock of a one standard deviation (equivalent to 1.18 percent). Such a relation is statistically significant only after eight quarters.

Figure 3.3. Accumulated Response to One S.D. Shock to Sovereign Spread "*s-spread*"
Model C. Sovereign Spread, Domestic Spread (Big Size Credits), Firms Credit, Investment and GDP



The responses of credit to firms and investment to a sovereign spread shock are statistically non-significant, and the response of GDP to this shock is negative (about -1.1 percent) and statistically significant during the first six quarters, but then turns non-significant until the medium-term (ten quarters). On its hand, the relation between credit to firms and investment is positive, as expected, though statistically non-significant.

After comparing the results in Figures 3.2 and 3.3, we conclude that while the relation between credit to households and private consumption appears positive and significant, it is not the case for

the relation between credit to firms and investment. In other words we find that foreign financial shocks, measured by the sovereign spread between the United States and Chile's Treasury Bills interest rates, generate fluctuations in the Chilean economy through the credit to households supply and then private consumption, and not through the credit to firms supply and then investment.[63] This finding is in line with Caballero's (2002) argument that foreign shocks generate a gap between the supply and demand for credit not addressed by locally installed banks, affecting more credit to households and SMEs than credit to big size firms.

In summary, this section finds that foreign financial shocks, measured by the spread between the United States and Chile's Treasury Bills interest rates, do affect the Chilean economy. In particular, a widening in the sovereign spread reduces the credit to households, private consumption, and leads to an output loss. Finally we did not find statistically significant effects of such a shock on the domestic spread (to average, small and big credits), total credit, credit to firms, and investment.

3.6 Conclusions

In this chapter we studied the effects that foreign financial shocks, measured by the sovereign spread between the United States and Chile's Treasury Bills interest rates, on Chile's business cycle, private consumption, and investment, and the role that alternative domestic credit interest rate spreads (to average, small and big size credits) and the country's credit (total, to households, and to firms) supply have relating the sovereign spread shocks and these macroeconomic variables. We used a standard vector autoregressive (VAR) approach assuming Cholesky decomposition for the period 2000Q1-2016Q1.

Our findings suggest that a sovereign spread shock (a widening in this spread) does affect the Chilean economy, by reducing credit to households, negatively affecting private consumption, and leading to an output loss in the medium-term (ten quarters). In addition, after such a shock we did not find statistically significant effects on the domestic credit interest rates spreads we set, total credit, credit to firms, and investment. These findings are robust to different models specifications and time period, and are in line with those presented by Caballero (2002) and Cabezón (2012). Possible avenues for future research include using other measures of foreign financial shocks, use the Chilean private investment data with a quarterly frequency, when it becomes available, and other vector autoregressive models different than the standard VAR approach in this chapter.

[63] These findings are robust to the number of lags chosen, the use of a constant or not in the VAR models estimated (Models B and C), and the time period considered, either 2001Q1-2015Q1 (to avoid the "tails critique" to the HP filter use) or 2000Q1-2016Q1 (the full period of study).

Conclusions

The economic integration and interdependence among world economies have become increasingly important, in particular for commodity and financial markets. In fact, recent years ups and downs in the commodity markets and the global financial crisis, put into evidence the importance that strong institutions and economic policy frameworks have for open, small, developing and resource-rich economies such as Chile.

In this Ph.D. dissertation we study the effectiveness of the Chilean fiscal policy as an instrument helping to guarantee macroeconomic stability, and the effects that commodity price and foreign financial shocks have on the Chilean economic output, fiscal accounts, private consumption, investment, and other important macroeconomic fundamentals. We do so using quarterly data and alternative vector autoregressive models.

Thus, Chapter 1 starts estimating impulse-response functions and calculating fiscal multipliers (government spending and taxes) in Chile using alternative definitions of government spending and taxes, and different number of endogenous variables and autoregressive models (VAR, Structural VAR and Bayesian VAR). It finds that in a country with Chile's characteristics fiscal policy has little influence to boost the economic output, and if so, government spending seems to have a bigger effect on GDP compared to taxes. In particular it finds: that government spending multipliers are slightly positive but below 0.5 and that tax multipliers are close to zero, that government spending seems to not crowd-out private consumption, some evidence of a Keynesian relation between government spending and unemployment, and that the short-term interest rate has a negative relation with government spending and positive with taxes.

Then, Chapter 2 studies how commodity price shocks (of copper and non-copper) affect the Chilean economic output, fiscal accounts (government revenues, consumption and investment) and private consumption, based on correlation analysis and VAR models in cycles, finding that the Chilean economy, its fiscal revenues and private consumption are pro-cyclical, and that the fiscal expenditure is counter-cyclical. Overall the effect of shocks to copper prices is "stronger" compared to non-copper commodities. This chapter also finds that even if the Chilean fiscal rule by itself is a quite important institutional arrangement that helps reduce volatility, the countries fiscal authorities' discipline comes before the fiscal rule installment.

Finally, Chapter 3 considers the effects that a foreign financial shock, measured by the sovereign spread between the United States and Chile's Treasury Bills interest rates (sovereign spread), has on Chile's business cycle, private consumption, and investment. It also analyzes the role that alternative domestic credit interest rate spreads and the country's credit supply have relating the shocks to the sovereign spread and the macroeconomic variables subject to study. It does so using VAR models in cycles, finding that a widening in the sovereign spread reduces credit to households, negatively affects private consumption, and leads to an output loss in the medium-term.

Possible avenues for further research might include: A better understanding of why Structural VAR models for Chile deliver such different fiscal multipliers depending on the government spending and taxes to output elasticities and other coefficients assumed for identification; The estimation of fiscal multipliers using Bayesian VAR models, with alternative priors and hyper-parameters for the Chilean economy, or the use of non-linear models; Studying the effects of commodity price shocks, copper prices in particular, using a Threshold-VAR approach; Using other measures different from the sovereign spread in the study of foreign financial shocks; And estimating other vector autoregressive models different from the standard VAR approach used in Chapter 3.

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Appendices

1.A. Lag Order Selection Criteria
(VAR Model with constant)
Endogenous variables: *"dlog Gt" "dlog Yt" "dlog Tt"*
Maximum number of lags: 6

Blanchard and Perotti (2002) 1/	AIC	SIC	HQC
0	-16.27575	-16.19510	-16.24316
1	-16.77040	-16.44780*	-16.64005
2	-16.93557*	-16.37103	-16.70746*
3	-16.88827	-16.08179	-16.56239
4	-16.86543	-15.81700	-16.44179
5	-16.84584	-15.55546	-16.32443
6	-16.84167	-15.30935	-16.22250

Cerda *et al.* (2005) 1/	AIC	SIC	HQC
0	-16.35131	-16.27066	-16.31872
1	-16.87660	-16.55400*	-16.74624
2	-17.08615	-16.52161	-16.85803*
3	-17.12111*	-16.31462	-16.79523
4	-17.12109	-16.07265	-16.69744
5	-17.07424	-15.78386	-16.55283
6	-16.99185	-15.45952	-16.37267

Céspedes *et al.* (2011) 1/	AIC	SIC	HQC
0	-10.25374	-10.19998	-10.23202
1	-10.56832	-10.40702*	-10.50314*
2	-10.57031*	-10.30148	-10.46169
3	-10.52878	-10.15242	-10.37670
4	-10.51914	-10.03525	-10.32361
5	-10.50085	-9.909426	-10.26187
6	-10.46255	-9.763594	-10.18012

Restrepo and Rincón (2006) 1/	AIC	SIC	HQC
0	-15.63509	-15.55444	-15.60250
1	-16.00070	-15.67810*	-15.87035
2	-16.20243	-15.63789	-15.97432*
3	-16.20885	-15.40236	-15.88296
4	-16.21455*	-15.16612	-15.79090
5	-16.18703	-14.89665	-15.66562
6	-16.14680	-14.61448	-15.52763

1/ Number of lags.
* Indicates lag order selected by the criterion.
AIC: Akaike information criterion.
SIC: Schwarz information criterion.
HQC: Hannan-Quinn information criterion.

1.A. Lag Order Selection Criteria - Continuation
(VAR Model with constant)
Endogenous variables: "*dlog Gt" "dlog Yt" "dlog Tt"*
Maximum number of lags: 7

Blanchard and Perotti (2002) 1/	AIC	SIC	HQC
0	-16.31146	-16.23029	-16.27867
1	-16.80934	-16.48466*	-16.67819
2	-16.99879	-16.43061	-16.76929*
3	-17.02580*	-16.21411	-16.69794
4	-16.95992	-15.90472	-16.53370
5	-16.93624	-15.63753	-16.41166
6	-16.97821	-15.43600	-16.35527
7	-16.98660	-15.20088	-16.26530

Cerda *et al.* (2005) 1/	AIC	SIC	HQC
0	-16.38731	-16.30614	-16.35452
1	-16.91596	-16.59129*	-16.78482
2	-17.15348	-16.58529	-16.92397*
3	-17.22786*	-16.41617	-16.90000
4	-17.19398	-16.13878	-16.76776
5	-17.11989	-15.82118	-16.59530
6	-17.07752	-15.53531	-16.45458
7	-17.14885	-15.36313	-16.42755

Céspedes *et al.* (2011) 1/	AIC	SIC	HQC
0	-10.26812	-10.21400	-10.24626
1	-10.60356	-10.44122*	-10.53799*
2	-10.61178*	-10.34122	-10.50250
3	-10.58041	-10.20162	-10.42741
4	-10.57221	-10.08519	-10.37549
5	-10.57226	-9.977021	-10.33183
6	-10.53115	-9.827686	-10.24700
7	-10.58304	-9.771346	-10.25517

Restrepo and Rincón (2006) 1/	AIC	SIC	HQC
0	-15.63965	-15.55848	-15.60686
1	-16.02405	-15.69938*	-15.89291
2	-16.24613	-15.67795	-16.01662*
3	-16.27458*	-15.46289	-15.94671
4	-16.25505	-15.19985	-15.82882
5	-16.22781	-14.92911	-15.70323
6	-16.22894	-14.68673	-15.60600
7	-16.21506	-14.42934	-15.49376

1/ Number of lags.

* Indicates lag order selected by the criterion.

AIC: Akaike information criterion.

SIC: Schwarz information criterion.

HQC: Hannan-Quinn information criterion.

1.A. Lag Order Selection Criteria - Continuation
(VAR Model with constant)
Endogenous variables: "*dlog Gt" "dlog Yt" "dlog Tt"*
Maximum number of lags: 8

Blanchard and Perotti (2002) 1/	AIC	SIC	HQC
0	-16.28535	-16.20366	-16.25237
1	-16.77918	-16.45239*	-16.64723
2	-16.96664	-16.39476	-16.73573*
3	-16.99418	-16.17721	-16.66431
4	-16.92592	-15.86386	-16.49709
5	-16.91865	-15.61150	-16.39086
6	-16.97937	-15.42713	-16.35262
7	-17.00721*	-15.20988	-16.28150
8	-16.97042	-14.92800	-16.14575

Cerda *et al.* (2005) 1/	AIC	SIC	HQC
0	-16.36058	-16.27888	-16.32759
1	-16.88451	-16.55773*	-16.75257
2	-17.12793	-16.55605	-16.89702*
3	-17.18995*	-16.37298	-16.86008
4	-17.16051	-16.09845	-16.73168
5	-17.10166	-15.79451	-16.57387
6	-17.07871	-15.52647	-16.45196
7	-17.16807	-15.37074	-16.44236
8	-17.15031	-15.10789	-16.32564

Céspedes *et al.* (2011) 1/	AIC	SIC	HQC
0	-10.25188	-10.19742	-10.22989
1	-10.58675	-10.42336*	-10.52078*
2	-10.58971	-10.31739	-10.47976
3	-10.55760	-10.17635	-10.40366
4	-10.54733	-10.05715	-10.34941
5	-10.54754	-9.948435	-10.30564
6	-10.50645	-9.798415	-10.22057
7	-10.56430	-9.747336	-10.23444
8	-10.59892*	-9.673025	-10.22507

Restrepo and Rincón (2006) 1/	AIC	SIC	HQC
0	-15.61418	-15.53248	-15.58119
1	-15.99701	-15.67022*	-15.86506
2	-16.21838	-15.64650	-15.98747*
3	-16.23729	-15.42033	-15.90743
4	-16.21924	-15.15718	-15.79041
5	-16.21103	-14.90388	-15.68324
6	-16.24006*	-14.68782	-15.61331
7	-16.23361	-14.43628	-15.50790
8	-16.19503	-14.15262	-15.37036

1/ Number of lags.
* Indicates lag order selected by the criterion.
AIC: Akaike information criterion.
SIC: Schwarz information criterion.
HQC: Hannan-Quinn information criterion.

1.B. VAR Residual Serial Correlation LM Test (VAR Model with constant)
Null Hypothesis: No serial correlation at lag order h

Blanchard and Perotti (2002)	Lag order h	LM-Stat	Prob	
VAR(1) SIC	1	33.84691	0.0001	Rejects Null Hypothesis at 1%
VAR(2) HQC *	1	15.66393	0.0742	Cannot reject Null Hypothesis at 1%
	2	18.98248	0.0253	Cannot reject Null Hypothesis at 1%

Cerda *et al.* (2005)	Lag order h	LM-Stat	Prob	
VAR(1) SIC	1	36.95308	0.0000	Rejects Null Hypothesis at 1%
VAR(2) HQC *	1	21.59254	0.0103	Cannot reject Null Hypothesis at 1%
	2	16.34376	0.0600	Cannot reject Null Hypothesis at 1%

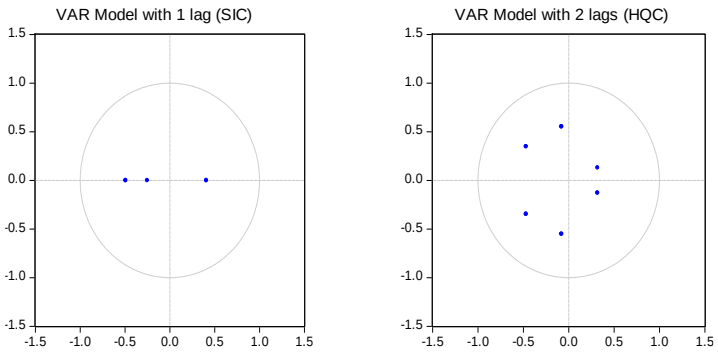
Céspedes *et al.* (2011)	Lag order h	LM-Stat	Prob	
VAR(1) SIC and HQC *	1	10.10340	0.0387	Cannot reject Null Hypothesis at 1%

Restrepo and Rincón (2006)	Lag order h	LM-Stat	Prob	
VAR(1) SIC	1	27.10466	0.0013	Rejects Null Hypothesis at 1%
VAR(2) HQC *	1	17.59892	0.0401	Cannot reject Null Hypothesis at 1%
	2	9.528180	0.3900	Cannot reject Null Hypothesis at 1%

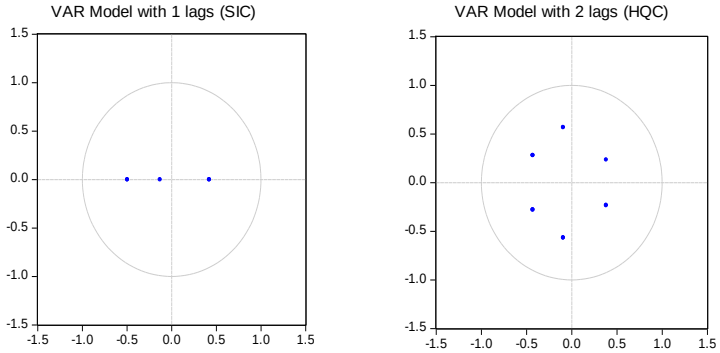
* Indicates the model chosen.
SIC: Schwarz information criterion.
HQC: Hannan-Quinn information criterion.

1.C. Inverse Roots of AR Charactheristic Polinomial

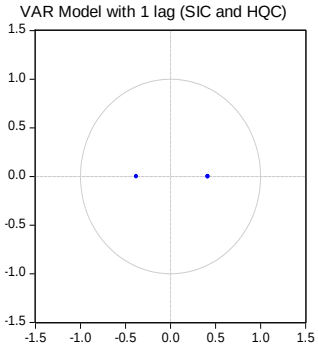
Blanchard and Perotti (2002)



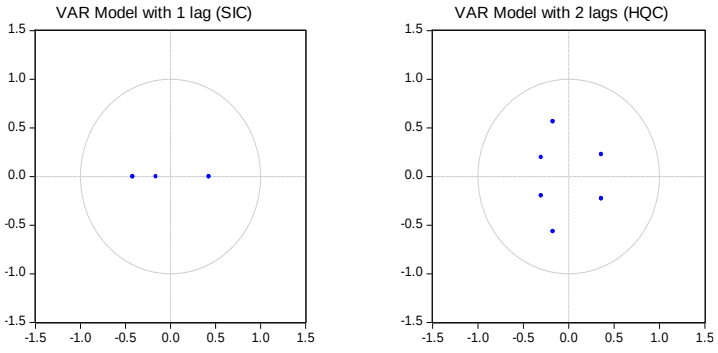
Cerda *et al.* (2005)



Céspedes *et al.* (2011)



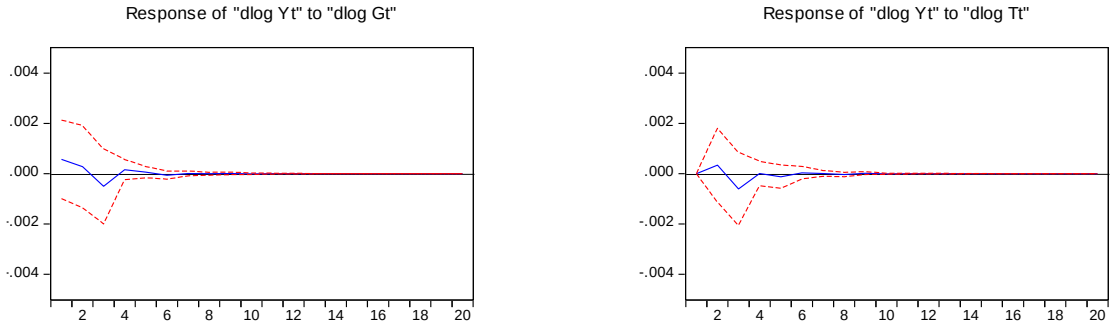
Restrepo and Rincón (2006)



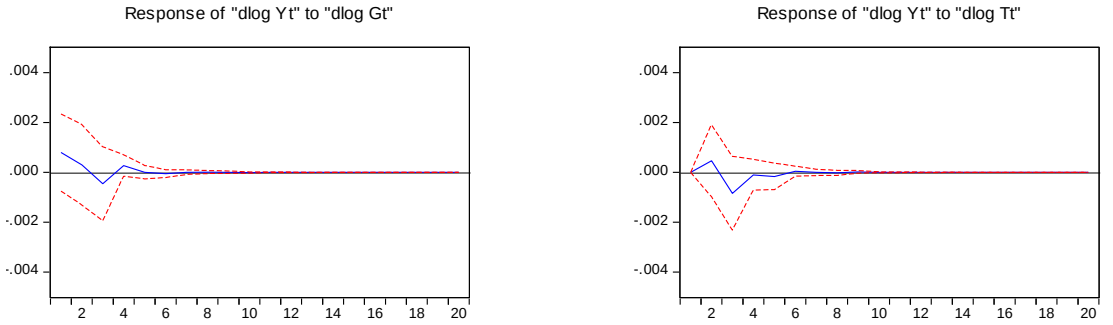
1/ No root lies outside the unit circle. The models satisfy the stability condition.

1.D. Impulse-Response Functions (VAR Model)

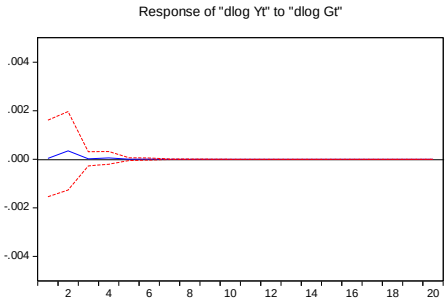
Blanchard and Perotti (2002) Definitions (HQC: 2 lags)
Response to Cholesky One S.D. Innovations ± 2 S.E.



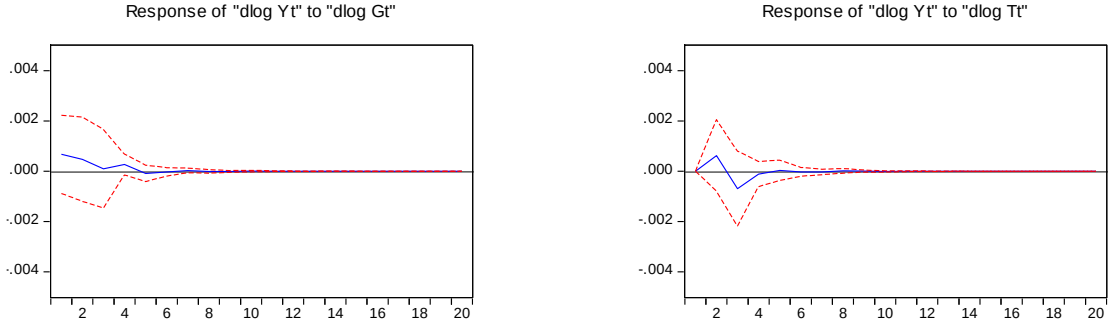
Cerda *et al.* (2005) Definitions (HQC: 2 lags)
Response to Cholesky One S.D. Innovations ± 2 S.E.



Céspedes *at al.* (2011) Definitions (HQC: 1 lag)
Response to Cholesky One S.D. Innovations ± 2 S.E.

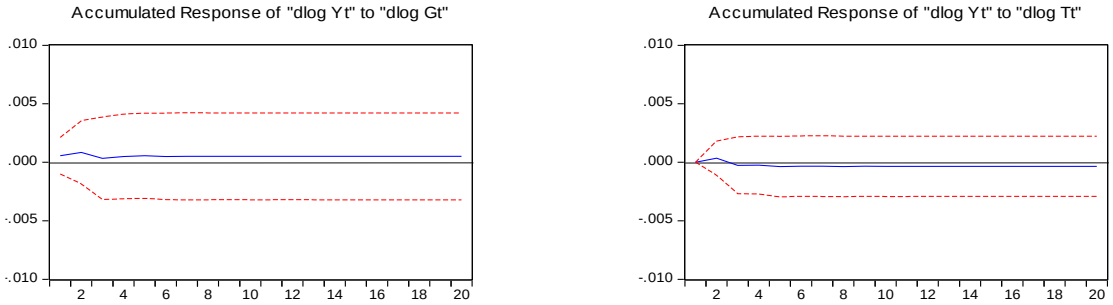


Restrepo and Rincón (2006) Definitions (HQC: 2 lags)
Response to Cholesky One S.D. Innovations ± 2 S.E.

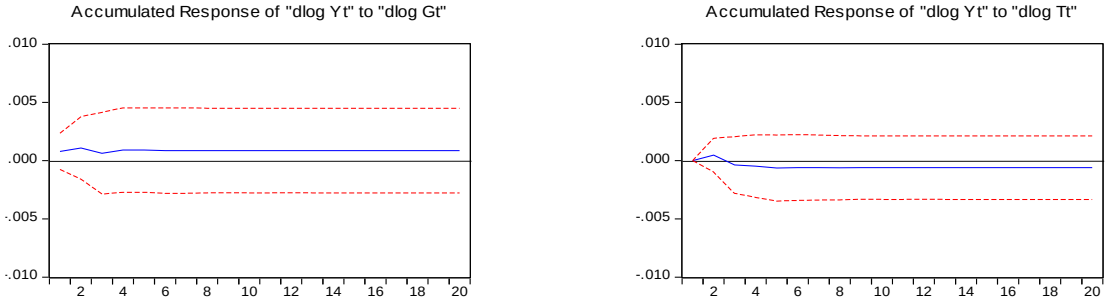


1.D. Impulse-Response Functions (VAR Model) - Continuation

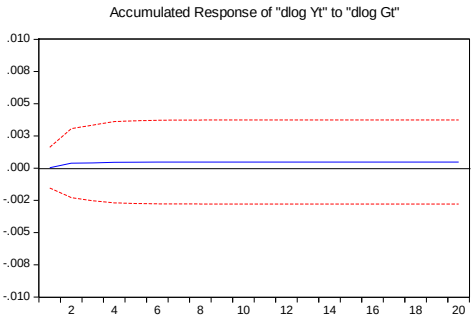
Blanchard and Perotti (2002) Definitions (HQC: 2 lags)
Accumulated Response to Cholesky One S.D. Innovations ± 2 S.E.



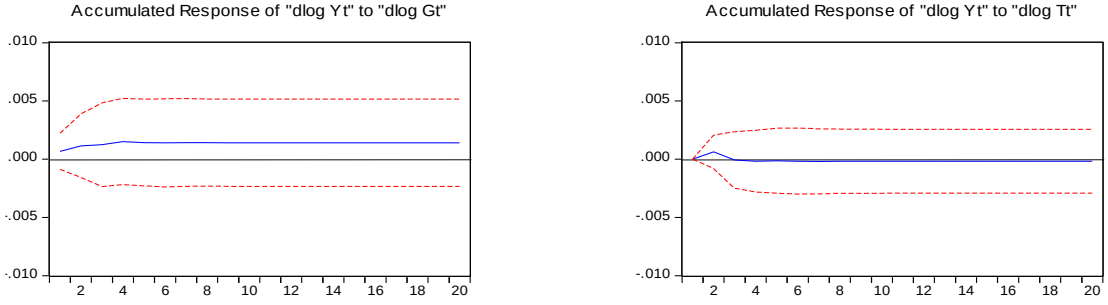
Cerda *et al.* (2005) Definitions (HQC: 2 lags)
Accumulated Response to Cholesky One S.D. Innovations ± 2 S.E.



Céspedes *at al.* (2011) Definitions (HQC: 1 lag)
Accumulated Response to Cholesky One S.D. Innovations ± 2 S.E.



Restrepo and Rincón (2006) Definitions (HQC: 2 lags)
Accumulated Response to Cholesky One S.D. Innovations ± 2 S.E.



1.E. Government Spending and Tax Multipliers (Alternative VAR Models)

VAR model with constant, time trend and the number of lags suggested by the HQC 1/

Government Spending Definition	Impact	1 year	2 years	Long-term
Blanchard and Perotti (2002)	0.21	0.36	0.35	0.35
Cerda *et al.* (2005)	0.30	0.65	0.58	0.59
Céspedes *et al.* (2011) 2/	0.02	0.42	0.42	0.42
Restrepo and Rincón (2006)	0.42	1.57	1.43	1.44

Taxes Definition	Impact	1 year	2 years	Long-term
Blanchard and Perotti (2002)	0.00	-0.08	-0.12	-0.12
Cerda *et al.* (2005)	0.00	-0.17	-0.23	-0.22
Restrepo and Rincón (2006)	0.00	-0.07	-0.07	-0.07

VAR model with constant and the number of lags suggested by the SIC 3/

Government Spending Definition	Impact	1 year	2 years	Long-term
Blanchard and Perotti (2002)	0.23	0.73	0.73	0.72
Cerda *et al.* (2005)	0.27	0.74	0.73	0.72
Céspedes *et al.* (2011) 2/	0.02	0.42	0.42	0.42
Restrepo and Rincón (2006)	0.30	0.94	0.94	0.94

Taxes Definition	Impact	1 year	2 years	Long-term
Blanchard and Perotti (2002)	0.00	0.15	0.14	0.14
Cerda *et al.* (2005)	0.00	0.27	0.28	0.28
Restrepo and Rincón (2006)	0.00	0.27	0.29	0.29

1/ As suggested by the Hannan-Quinn information criterion (HQC) the VAR model includes 2 lags for all the "Baseline models" but Céspedes *et al.* (2011) which includes 1 lag.

2/ The VAR model that follows Céspedes *et al.* (2011) definition does not include taxes.

3/ As suggested by the Schwarz information criterion (SIC) the VAR models include 1 lag for all the "Baseline models".

1.F. Government Spending and Tax Multipliers (Structural VAR Model)
Structural VAR model with constant and the number of lags suggested by the SIC 1/

Government Spending Definition	Coefficients	Impact	1 year	2 years	Long-term
Blanchard and Perotti (2002)	2/	0.75	2.33	2.30	2.30
	3/	0.84	2.41	2.39	2.39
Cerda *et al.* (2005)	2/	0.75	2.36	2.32	2.31
	3/	0.81	2.34	2.31	2.31
Restrepo and Rincón (2006)	2/	1.87	5.07	5.10	5.10
	3/	1.98	5.07	5.11	5.12

Taxes Definition	Coefficients	Impact	1 year	2 years	Long-term
Blanchard and Perotti (2002)	2/	-0.29	-0.55	-0.56	-0.56
	3/	-0.16	-0.21	-0.22	-0.22
Cerda *et al.* (2005)	2/	-0.33	-0.40	-0.40	-0.40
	3/	-0.21	-0.14	-0.14	-0.14
Restrepo and Rincón (2006)	2/	-0.34	-0.42	-0.42	-0.42
	3/	-0.21	-0.14	-0.14	-0.14

1/ The Structural VAR model includes a constant and the number of lags suggested by the Schwarz information criterion, i.e. all definitions with 1 lag.

2/ Restrepo and Rincón (2006) coefficients: $a_1 = 3.03$; $b_1 = 0$; $c_1 = -0.034$; $c_2 = 0.165$; $a_2 = 0$ (Taxes decisions come before government spending decisions).

3/ Restrepo and Rincón (2006) coefficients: $a_1 = 3.03$; $b_1 = 0$; $c_1 = -0.034$; $c_2 = 0.165$; $b_2 = 0$ (Government spending decisions come before taxes decisions).

1.F. Government Spending and Tax Multipliers (Structural VAR Model) - Continuation
Structural VAR model with constant and the number of lags suggested by the HQC 1/

Government Spending Definition	Coefficients	Impact	1 year	2 years	Long-term
Blanchard and Perotti (2002)	2/	-1.20	-3.14	-3.15	-3.17
	3/	-1.17	-3.08	-3.12	-3.14
Cerda *et al.* (2005)	2/	-1.20	-3.12	-3.18	-3.19
	3/	-1.22	-3.18	-3.22	-3.24
Restrepo and Rincón (2006)	2/	-3.01	-7.26	-7.77	-7.82
	3/	-3.05	-7.35	-7.84	-7.89

Taxes Definition	Coefficients	Impact	1 year	2 years	Long-term
Blanchard and Perotti (2002)	2/	-0.05	-0.19	-0.24	-0.24
	3/	-0.10	-0.38	-0.47	-0.46
Cerda *et al.* (2005)	2/	-0.19	-0.76	-0.85	-0.84
	3/	-0.13	-0.53	-0.60	-0.59
Restrepo and Rincón (2006)	2/	-0.19	-0.59	-0.60	-0.60
	3/	-0.13	-0.40	-0.40	-0.41

1/ The Structural VAR model includes a constant and the number of lags suggested by the Hannan-Quinn information criterion (HQC), i.e. all definitions with 2 lags.

2/ Cerda *et al.* (2005) coefficients: $a_1 = 1.31$; $b_1 = 1.92$; $c_1 = -0.03$; $c_2 = -0.25$; $a_2 = 0$ (Taxes decisions come before government spending decisions).

3/ Cerda *et al.* (2005) coefficients: $a_1 = 1.31$; $b_1 = 1.92$; $c_1 = -0.03$; $c_2 = -0.25$; $b_2 = 0$ (Government spending decisions come before taxes decisions).

1.G. Government Spending and Tax Multipliers (Bayesian VAR Model)
Bayesian VAR model with constant and the number of lags suggested by the SIC 1/ 2/

Government Spending Definition	Initial Residual Covariance	Impact	1 year	2 years	Long-term
Blanchard and Perotti (2002)	Univariate AR estimate	0.23	0.67	0.66	0.66
	Diagonal VAR estimate	0.23	0.67	0.66	0.66
	Full VAR estimate	0.23	0.68	0.67	0.67
Cerda *et al.* (2005)	Univariate AR estimate	0.26	0.69	0.68	0.68
	Diagonal VAR estimate	0.26	0.69	0.68	0.68
	Full VAR estimate	0.26	0.70	0.69	0.69
Restrepo and Rincón (2006)	Univariate AR estimate	0.29	0.87	0.87	0.87
	Diagonal VAR estimate	0.29	0.87	0.87	0.87
	Full VAR estimate	0.30	0.88	0.88	0.88

Taxes Definition	Initial Residual Covariance	Impact	1 year	2 years	Long-term
Blanchard and Perotti (2002)	Univariate AR estimate	0.00	0.13	0.13	0.13
	Diagonal VAR estimate	0.00	0.13	0.13	0.13
	Full VAR estimate	0.00	0.14	0.14	0.14
Cerda *et al.* (2005)	Univariate AR estimate	0.00	0.24	0.25	0.25
	Diagonal VAR estimate	0.00	0.24	0.25	0.25
	Full VAR estimate	0.00	0.25	0.25	0.25
Restrepo and Rincón (2006)	Univariate AR estimate	0.00	0.24	0.25	0.25
	Diagonal VAR estimate	0.00	0.24	0.25	0.25
	Full VAR estimate	0.00	0.25	0.26	0.26

1/ As suggested by the Schwarz information criterion (SIC) the Bayesian VAR models include 1 lag for all the "Baseline models".

2/ Litterman/Minnesota Prior. Hyper-parameters: $\bar{\theta}_1$(AR(1) coefficient) = 0; $\lambda 0$ (tightness on the variance of the first lag) = 0.2; $\lambda 1$ (relative tightness on other variables) = 0.5; $\lambda 3$ (harmonic lag decay) = 1.

1.H. Chow Breakpoint and Multiple Breakpoint Bai-Perron Tests (Series in Logarithms)

GDP

Chow Breakpoint Test: 1999Q3 1999Q4 2000Q1
Null Hypothesis: No breaks at specified breakpoints
Varying regressors: All equation variables
Equation Sample: 1990Q1 2015Q2

F-statistic	58.02604	Prob. F(3,98)	0.0000
Log likelihood ratio	104.1544	Prob. Chi-Square(3)	0.0000
Wald Statistic	174.0781	Prob. Chi-Square(3)	0.0000

Multiple breakpoint tests
Bai-Perron tests of L+1 vs. L sequentially determined breaks
Date: 01/18/16 Time: 16:34
Sample: 1990Q1 2015Q2
Included observations: 102
Breakpoint variables: log Yt
Break test options: Trimming 0.15, Max. breaks 5, Sig. level 0.05

Sequential F-statistic determined breaks:	4

Break Test	F-statistic	Scaled F-statistic	Critical Value**
0 vs. 1 *	433.5830	433.5830	8.58
1 vs. 2 *	114.0853	114.0853	10.13
2 vs. 3 *	95.39886	95.39886	11.14
3 vs. 4 *	28.91608	28.91608	11.83
4 vs. 5	0.000000	0.000000	12.25

* Significant at the 0.05 level.
** Bai-Perron (Econometric Journal, 2003) critical values.

Break dates:

	Sequential	Repartition
1	2004Q3	1994Q3
2	1994Q4	2000Q4
3	2010Q2	2004Q4
4	2000Q4	2010Q2

Government Spending

Chow Breakpoint Test: 1999Q3 1999Q4 2000Q1
Null Hypothesis: No breaks at specified breakpoints
Varying regressors: All equation variables
Equation Sample: 1990Q1 2015Q2

F-statistic	56.78911	Prob. F(3,98)	0.0000
Log likelihood ratio	102.7537	Prob. Chi-Square(3)	0.0000
Wald Statistic	170.3673	Prob. Chi-Square(3)	0.0000

Multiple breakpoint tests
Bai-Perron tests of L+1 vs. L sequentially determined breaks
Date: 01/18/16 Time: 16:40
Sample: 1990Q1 2015Q2
Included observations: 102
Breakpoint variables: log Gt
Break test options: Trimming 0.15, Max. breaks 5, Sig. level 0.05

Sequential F-statistic determined breaks:			4
Break Test	F-statistic	Scaled F-statistic	Critical Value**
0 vs. 1 *	263.8820	263.8820	8.58
1 vs. 2 *	145.5341	145.5341	10.13
2 vs. 3 *	55.08220	55.08220	11.14
3 vs. 4 *	19.56088	19.56088	11.83
4 vs. 5	0.000000	0.000000	12.25

* Significant at the 0.05 level.
** Bai-Perron (Econometric Journal, 2003) critical values.

Break dates:

	Sequential	Repartition
1	2006Q4	1995Q4
2	1997Q2	2001Q1
3	2010Q3	2006Q4
4	2001Q1	2010Q3

Taxes

Chow Breakpoint Test: 1999Q3 1999Q4 2000Q1
Null Hypothesis: No breaks at specified breakpoints
Varying regressors: All equation variables
Equation Sample: 1990Q1 2015Q2

F-statistic	55.11596	Prob. F(3,98)	0.0000
Log likelihood ratio	100.8279	Prob. Chi-Square(3)	0.0000
Wald Statistic	165.3479	Prob. Chi-Square(3)	0.0000

Multiple breakpoint tests
Bai-Perron tests of L+1 vs. L sequentially determined breaks
Date: 01/18/16 Time: 16:49
Sample: 1990Q1 2015Q2
Included observations: 102
Breakpoint variables: log Tt
Break test options: Trimming 0.15, Max. breaks 5, Sig. level 0.05

Sequential F-statistic determined breaks:	3

Break Test	F-statistic	Scaled F-statistic	Critical Value**
0 vs. 1 *	414.1599	414.1599	8.58
1 vs. 2 *	71.86074	71.86074	10.13
2 vs. 3 *	24.10365	24.10365	11.14
3 vs. 4	7.221720	7.221720	11.83

* Significant at the 0.05 level.
** Bai-Perron (Econometric Journal, 2003) critical values.

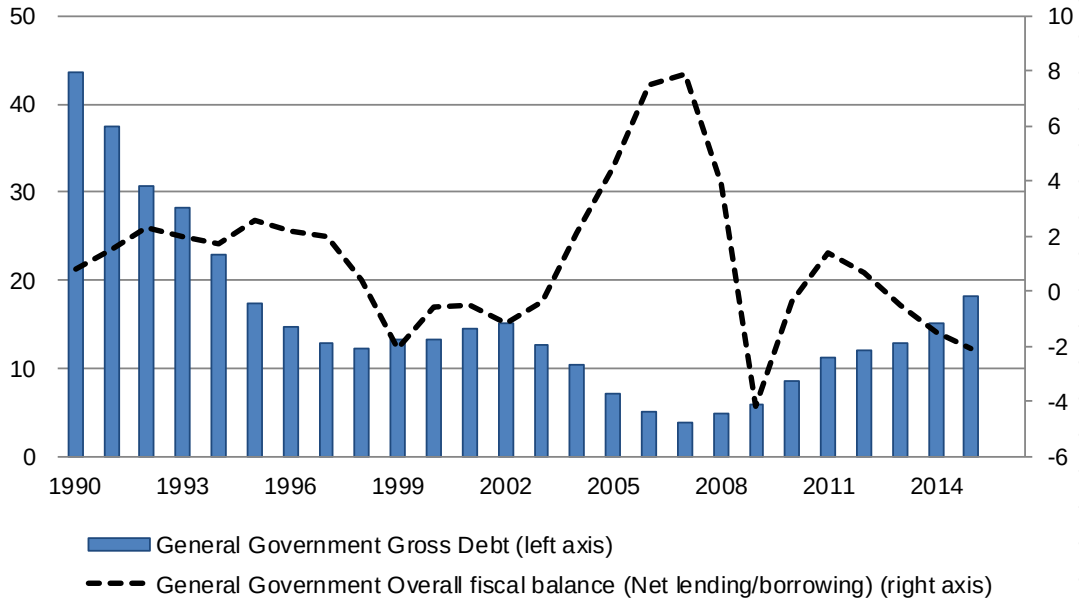
Break dates:

	Sequential	Repartition
1	2004Q2	1995Q2
2	1995Q2	2004Q4
3	2010Q2	2010Q2

2.A. Contemporaneous Correlations of the Variables' Cycles (Baxter-King Filter)

	GDP	Government Revenues	Government Consumption	Government Investment	Private Consumption
Copper Price	0.87	0.78	-0.23	-0.51	0.70
Non-Copper "IMF type" Index	0.64	0.55	-0.11	-0.52	0.45

2.B. General Government Gross Debt and Overall Fiscal Balance



Source: Chilean Budget Office (Dipres) and International Monetary Fund (World Economic Outlook).

3.A. Data Summary (2000Q1-2016Q1)

	Variable	Description	Source	Units
1. Foreign Financial Data (Foreign Financial Shock)	Sovereign spread	Difference between the United States nominal short-term interest rate (percent per annum) (3 months or 90 days yields on certificates of deposit) and Chile's nominal short-term interest rate (percent per annum) (yield on 90 days Treasury Bills (PDBC90)).	United States Federal Reserve Board, Central Bank of Chile, OECD	Deviation of nominal interest rates spread from Hodrick-Prescott filter trend
2. Domestic Financial Data	Domestic spread	The domestic interest rates spread corresponds to the difference between the commercial banks credit interest rates (in national currency and nominal terms for operations of more than 90 days), and Chile's nominal short-term interest rate (percent per annum) (yield on 90-day Treasury Bills (PDBC90)).	Central Bank of Chile, Superintendence of Banks and Financial Institutions	Deviation of nominal interest rates from Hodrick-Prescott filter trend
3. Banking Credit Data	Total credit	Nominal total credit data deflated by the consumer price index of all items	Central Bank of Chile, Chilean National Bureau of Statistics, and OECD	Deviation of log (millions of pesos in constant prices 2010) from Hodrick-Prescott filter trend
	Households credit	Nominal households credit data deflated by the consumer price index of all items	Central Bank of Chile, Chilean National Bureau of Statistics, and OECD	Deviation of log (millions of pesos in constant prices 2010) from Hodrick-Prescott filter trend
	Firms credit	Nominal firms credit data deflated by the consumer price index of all items	Central Bank of Chile, Chilean National Bureau of Statistics, and OECD	Deviation of log (millions of pesos in constant prices 2010) from Hodrick-Prescott filter trend

3.A. Data Summary (2000Q1-2016Q1) (Continuation)

	Variable	Description	Source	Units
4. Macroeconomic Variables	Private consumption	The private consumption results from the nominal private consumption deflated by the consumer price index of all items. The nominal private consumption corresponds to the private final consumption expenditure (in millions of national currency, current prices, quarterly levels).	Central Bank of Chile, Chilean National Bureau of Statistics, and OECD	Deviation of log (millions of pesos in constant prices 2010) from Hodrick-Prescott filter trend
	Investment	The investment results from the nominal gross fixed capital formation deflated by the consumer price index of all items. The Chilean national accounts do not provide data on private investment, hence we use total investment data as a second best option.	Central Bank of Chile, Chilean National Bureau of Statistics, and OECD	Deviation of log (millions of pesos in constant prices 2010) from Hodrick-Prescott filter trend
	GDP	The GDP was obtained by deflating the nominal GDP by the consumer price index of all items	Central Bank of Chile, Chilean National Bureau of Statistics, and OECD	Deviation of log (millions of pesos in constant prices 2010) from Hodrick-Prescott filter trend

3.B. Summary Unit Root Tests Variables in Cycles 1/

	Augmented Dickey-Fuller 2/	Phillips-Perron 3/	Zivot-Andrews 4/		
			Intercept 5/	Trend 6/	Intercept and trend 7/
Foreign Financial Shocks					
s-spread	No	No	No (2007Q4)	No (2005Q3)	No (2007Q4)
Domestic Spread					
d-spread-a	No	No	No (2009Q1)	No (2008Q1)	No (2009Q1)
d-spread-s	No	No	No (2009Q1)	No (2013Q4)	No (2009Q1)
d-spread-b	No	No	No (2009Q1)	No (2008Q2)	No (2009Q1)
Credit					
households	No	No	Yes (2004Q2)	Yes (2006Q2)	No (2008Q3)
firms	No	No	Yes (2006Q4)	NSME	Yes (2006Q4)
credit	No	No	Yes (2005Q4)	Yes (2008Q1)	Yes (2009Q1)
Macroeconomic Variables					
cons	No	No	Yes (2008Q3)	Yes (2013Q4)	Yes (2008Q3)
inv	No	No	Yes (2009Q1)	Yes (2013Q4)	Yes (2012Q2)
gdp	No	No	Yes (2008Q2)	Yes (2006Q3)	Yes (2008Q2)

1/ "No" indicates absence of evidence of unit root, "Yes" indicates evidence of unit root, and "NSME" means a Near Singular Matrix Error suggesting that the regressors might be perfectly collinear.

2/ The null hypothesis indicates that the selected variable has a unit root.

3/ The null hypothesis indicates that the selected variable has a unit root.

4/ The Zivot-Andrews test statistic has been compared to the 5% critical value, and the break points chosen by the test are in parenthesis.

5/ The null hypothesis indicates that the selected variable has a unit root with a structural break in the intercept.

6/ The null hypothesis indicates that the selected variable has a unit root with a structural break in the trend.

7/ The null hypothesis indicates that the selected variable has a unit root with a structural break in both intercept and trend.