NORWEGIAN SCHOOL OF ECONOMICS

Bergen, Fall 2016

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Master Thesis within the main profile of Energy, Natural Resources and the Environment

The effects of commodity price shocks on economic sectors: A comparative study of metal exporters

by
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ABSTRACT

This study investigates the effect of commodity price volatility on sectoral production for three main metal exporters: Australia, Chile, and South Africa. Using quarterly data of the real value added per industry from 1994 to 2015, I perform a SVAR model to analyze the impulse response functions of each industry to a 1% metal commodity price shock. The results show that each country behaves idiosyncratically with the greatest sectoral responses for the construction sector in South Africa, the trade sector in Chile, and the manufacturing sector in Australia. However, some patterns arise across the sample. First, there is no evidence of de-industrialization in the short run given a commodity boom. Second, services and trade sectors seem to benefit from commodity price shocks. Third, the short run impact of the mining sector reflects production capacity constraints and cost structure in the industry. Finally, the overall assessment of the sectoral impact argues against the resource curse hypothesis in the short run as most industries seem to improve their production given an external shock in commodity prices. The increase in each sector after a price shock could came by three channels: the interdependence of other industries with the mining sector, the increase on internal demand due to the increase in private consumption, and the increase of public spending. The results of this study could potentially inform economic policies that allow developing countries that rely on mining activities to shield themselves from price shocks.

CONTENTS

1. INTRODUCTION

Demand for natural resources, in particular metals and energy sources, have grown in great proportions over the last two decades. In the case of metals between 2002 and 2014, consumption grew on average 15% with an evident shift from the West to the East (IMF, 2015). With the increasing demand, international commodity prices grew accordingly and became more volatile; a situation that characterizes a boom cycle in the sector. This boom is a consequence of the growth of emerging economies mostly in Asia, particularly the Chinese economy which has become a main driver for metals (iron ore and copper) and energy sources (coal) demand since the early 2000's (Arezki, Matsumoto, & Zhao, 2015).

The evolution of the metal markets created a situation of economic dependence for some developing countries, which after two decades of increasing commodity exports, currently depend heavily on metal exports as this constitutes an important percentage of their GDP. This situation makes their macroeconomic stability dependent on commodity price fluctuations. According with standard economic theory high endowments of natural resources leads to a comparative advantage for a country; however, many empirical studies have shown that abundant natural resources represents more a threat rather than a blessing for economic growth. This result is known as the natural resource curse.

This thesis is focused on the resource curse literature and its objective is to analyze in a comparative way the effect of price volatility on economic growth for metal exporters. Specially, I focus on two emerging economies (Chile and South Africa) and one developed economy (Australia) using both macroeconomic and industry level data for the period 1994-2015.

In particular, this research will address the following questions:

- *What kind of impact does commodity price volatility have on sectorial economic growth?*
- *Which sectors seem to be more affected by commodity price volatility?*

A Structural VAR methodology will be applied to explore the response of each industry/sector to a positive price shock, as a proxy of price volatility, on the main exporting metal of each country. The analysis of Impulse-response functions will provide empirical

evidence on the subject. A qualitative analysis will also be provided to explain the results using economic theory. This would also allow a comparison of evidence across the sample.

The contribution of this research is to demonstrate the mixed response of each industry to price shocks as well as the heterogeneous results across countries. Providing evidence on which sectors are affected more and under which circumstances do we see an effect could potentially inform economic policies that allow developing countries to shield themselves from price shocks.

One of the most influential papers on the resource curse literature is Sachs and Warner (1995) where they elaborate Barro type growth equations for a cross-country sample between 1970-1989. They found a general negative relationship between economic growth and natural resource abundance (measured as the ratio of commodity exports to GDP). A later work of Arezki and Van der Ploeg (2011) applies a panel cointegration technique and a natural resource stock measure to the Sachs and Warner sample to find that the curse is only present when trade openness is low.

In a study for Nigeria, Sala-I-Martin and Subramanian (2003) found a non-linear negative relationship between economic growth and resource abundance. According to their estimations, institutional quality seems to be the strongest transmission channel. A popular explanation of the resource curse is the lack of institutional quality where insufficient rule of law, weak property rights and rent seeking behavior are proposed as transmission channels (see for example Mehlum, Moene & Torvik [2006], Auty [2006], and Boschini, Pettersson, & Roine [2007]).

However, other studies such as Papyrakis and Gerlagh (2004) and Alichi and Arezki (2012) test different transmission channels and find the investment and income effects as possible channels for the curse. As showed previously, various hypotheses have been proposed to explain the resource curse[1]. However, there is no consensus about the existence of a curse and there are even some examples of resource dependent economies (Australia, Botswana, Canada and Norway) which have experienced high economic growth and development.

[1] For a detailed discussion on the resource curse hypothesis please refer to Frankel (2006).

Among the hypotheses of the resource curse stands the commodity price volatility hypothesis, which according to Van Der Ploeg (2011), appears to be the *"quintessence of resource curse"* as price volatility could induce other economic growth barriers, including the Dutch Disease, crowding out of manufacturing and unstable macroeconomic performance.

Given the behavior of metal prices during the last 20 years, the volatility hypothesis is of relevance to analyze how price shocks on international commodity markets harness or benefit economic growth for commodity exporters. For this reason, the literature of commodity price volatility has focused mainly on time series analysis of price shocks on macroeconomic nominal variables. For example, the studies of Hegerty (2016) and Fornero and Kirchner (2014) focus on the impact of price shocks on interest rates, inflation, and production at the aggregate level. Most of these studies are relevant for monetary policy formulation and inflation targeting analysis.

Other studies such as Collier and Goderis (2008), Arezki and Brückner (2010), and Jacks, Rourke, and Williamson (2011) focus on external market and public debt variables to investigate how these transmission channels attenuate or intensify the effect of price shocks on economic growth.

Few studies have focused on the effect of commodity price volatility on real sector outcomes, particularly at the industry and services sector level. It has been generally assumed that the effect of price volatility is transmitted to the real sector via the nominal macro variables (exchange rate and inflation). Therefore, the study of direct effects of commodity price volatility on industry growth and on economy diversification remains a relatively less explored area. The existing research is mainly concentrated on oil exporting countries like the works of Lee and Ni (2002) and Jiménez-Rodríguez (2008) that analyze the impact of oil price shocks on manufacturing output.

The results of oil shocks studies at the sectorial level cannot be generalized to other point resources given that oil is evidently interconnected through all the sectors both as an energy source and as an input (directly or via their sub-products). In the case of metals, this connection is not so evident across all sectors and should be investigated further.

The analysis at the industry level is of importance to show how price shocks have different effects on different industries. Combining this data with macro variables will help to understand in what degree price shocks are a barrier or an impulse to the diversification of an economy.

The results of this study shows that most industries seem to improve their production given an external, positive shock in commodity prices. The results suggest three possible channels of transmission: the interdependence of other industries within the mining sector, the increase in internal demand due to the increase in private consumption, and the increase of public spending.

This research is organized as follows: Section 2 describes stylized facts of the selected countries and provides background on the extractive industries in each of them. Section 3 provides analysis on the data and selected variables for the empirical methodology. In Section 4, the empirical methodology will be described. Section 5 shows the estimation results. Section 6 lays out the comparative analysis. Finally, section 7 concludes.

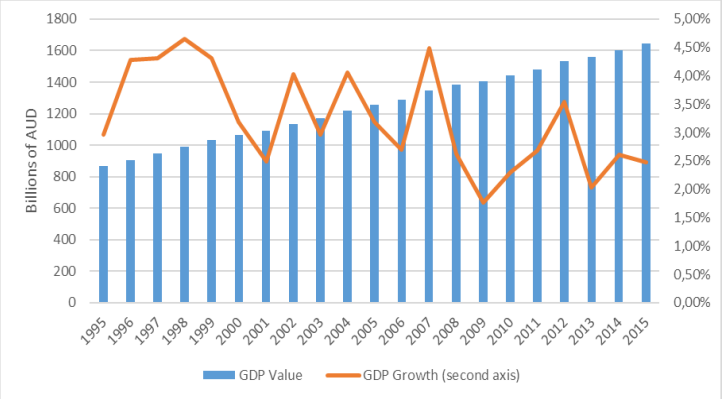
2. STILIZED FACTS

2.1 Australia

The Australian economy have shown continuous economic growth in the last 20 years and currently is the 21st largest export economy in the world[2]. The continuous economic growth is a result of the structural reforms on trade, labor and research performed in the late 1980's and during the 1990's (Gerard & Kearns, 2011). A considerably expansion of household consumption and housing sector growth has stimulated the services, trade and manufacturing sectors in the early 2000's and during the following years the boom in commodity prices contributes to enhancing growth and foreign direct investment in the country.

For the period 1995-2015, the Australian economy has grown on average 3.22% with the highest growth in the year 1998 (4.65%). However, since 2013 economic growth has remained below average due to international conditions, in particular the lower demand from the Chinese economy.

Figure 1. Australia GDP growth



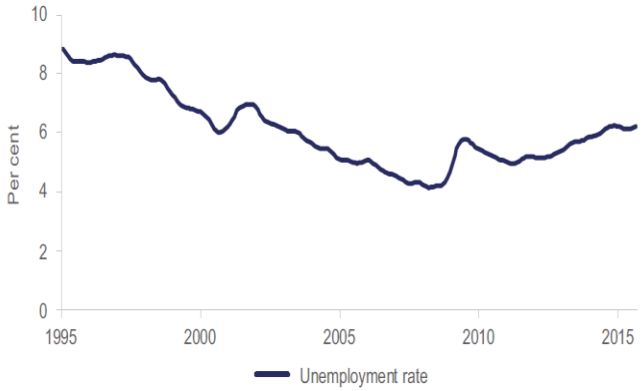
Source: Australian Bureau of Statistics (ABS)

The economic growth has an effect on the unemployment rate that shows a decreasing tendency with an average of 6.3% for the last two decades. According to the Australian Department of Industry, Innovation and Science (2015), the progress on reducing unemployment rate is due to stable wage growth and the increasing relevance of labor

[2] http://atlas.media.mit.edu/en/profile/country/aus/

intensive industries such as: Healthcare & Social Assistance, Accommodation & Food Services, Transport, Postal & Warehousing, and Retail Trade.

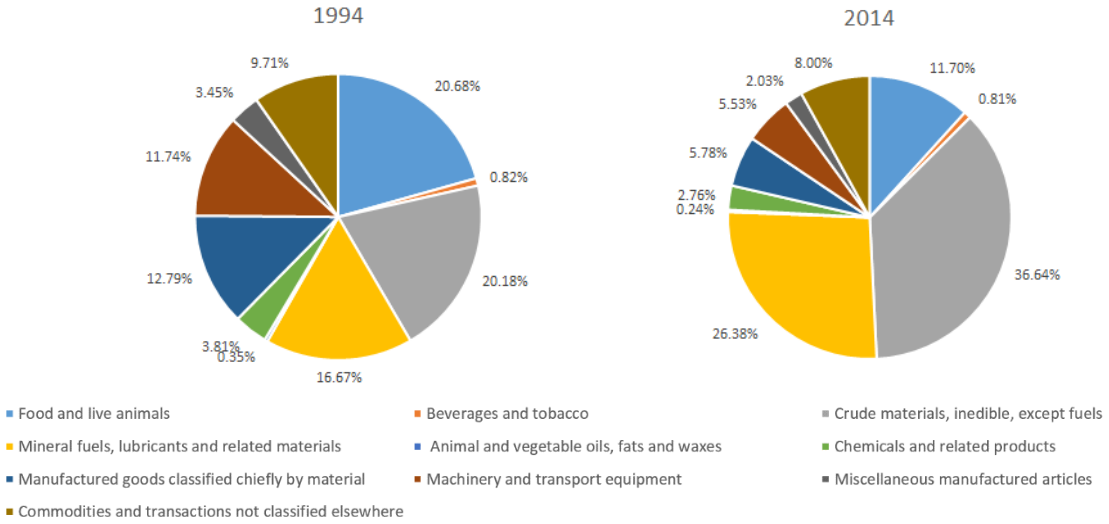
Figure 2. Unemployment rate in Australia



Source: ABS

For the last 20 years, Australian exports share of GDP has remained constant, representing around 20% of total GDP. The change of Australian exports during the period 1994-2015 is completely driven by the commodity boom: in 1994 mining exports were about 19% of the total value of exports while in 2014 the exports of mining products account for 38% of the total value of exports. Petroleum exports also double their share in exports both in value and in volume.

Figure 3. Exports composition as a percentage of total value



Source: ABS

2.1.1 Mining Sector

The mining activity in Australia dates back to the 18th century where coal was exploited in mines near New South Wales. During the 19th century, mining increases mainly in gold exploitation, reaching a point where Australia provided 40% of the world's gold around 1850. During the next 100 years the mining activity declines but important discoveries were made particularly in copper, zinc, tin and other metals. The resource boom begun in 1960 when the production of iron ore, bauxite, nickel and natural gas starts increasing. During the 20th century mining activity in Australia gained relevance and became a motor for regional development, infrastructure investment and intra-sector growth of activities linked with the mining sector (ABS , 2000).

Table 1. Australian main minerals production (2014)

Mineral[3]	World Production ranking	Accessible Economic Demonstrated Resources	Production
Iron Ore (Mt)	1	54412	735
Bauxite (Mt)	1	6195	78.6
Black Coal (Mt)	2	55741	565
Silver (kt)	4	85.21	1.847
Tin (kt)	5	413	6.9

Source: Geoscience Australia

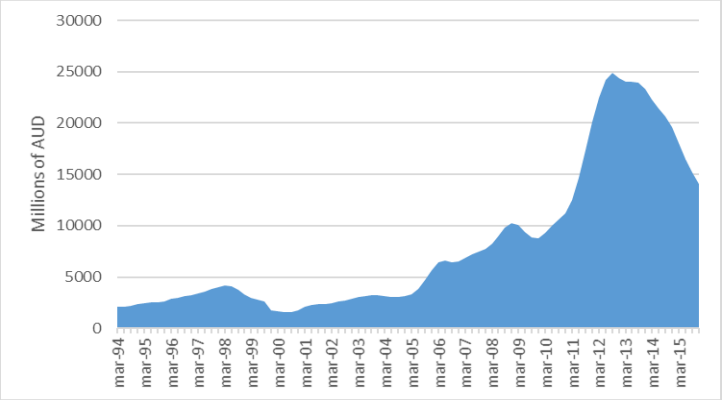
Currently, the mining sector represents around 8% of total GDP, provides around 208,000 direct jobs and constitutes a motor for R&D services in the country. According to the Minerals Council of Australia (2015) the sector is a great provider of specialized technologies, with around 6,539 Australian mining inventions from the period 1994-2011. This technology is exported globally and used in most of the mining production facilities worldwide, including countries such as Canada, Brazil, Mexico and China.

The sector is also an important destination of foreign direct investment; in 2014, 38% of all foreign direct investment in Australia is related to mining activities (around $265 billion). International and local investments on mining sector have been growing since the year 2000 with periods of high investment (2005-2008 and 2011-2013). These investments have

[3] Abbreviations: Mt = million tonnes. Kt = kilotonnes.

increased the installed capacity of the sector allowing the country to satisfy the increasing demand for the same period. According to the Australian Department of Industry, Innovation and Science (2015), the sharp decrease of mining investment in the last two years is a signal of transition in the sector: from an investment phase to a production phase.

Figure 4. Total Private New Capital Expenditure. Mining Sector



Source: ABS

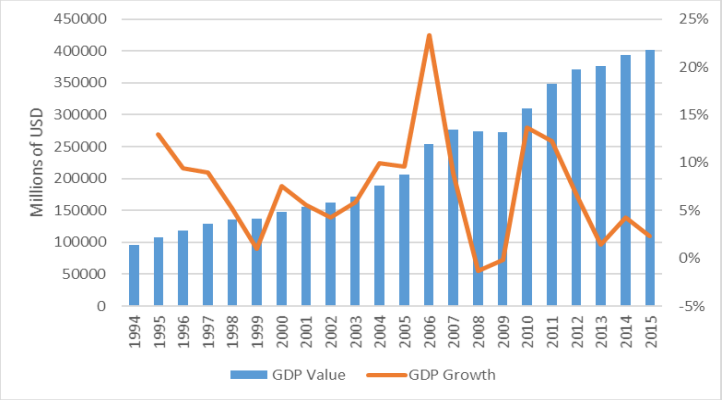
The resource rent extraction of mining activities in Australia is made by two ways: Royalties and Corporate tax. Royalties rates varies among regions and depends on several factors like the type of commodity, location of the mine, extension of the mine among others. Corporate Income tax is around 30% and have some special deductions/amortizations for companies involved in early stages of exploration-production. For the Financial year 2013-2014 taxes and royalties from the mining sector had a value of $25 billion, the government uses this revenue mainly for public infrastructure improvement of mining areas and for supporting R&D activities. Recently, in December 2012 a commodity fund was launched named the Western Australian Future Fund, this fund will receive at least 1% of the royalties in Western Australia and will invest overseas in cash and bonds, it is expected to use the fund in 2032 mainly to infrastructure projects in Western Australia.

2.2 Chile

Economic growth in Chile during the last two decades has been volatile and generally follows international economic cycles; after the crisis in 1980's, the Chilean economy made some structural reforms concentrated in trade, investment liberalization and labor market reforms (OECD, 2015). De Gregorio (2005) calls the period between 1985-1997 the "gold age" as the economy grew in average 7% and income per capita doubled. The Asian crisis of 1997

affected Chile reducing economic growth that remains relatively low until 2003 where the commodity boom begins for the country.

Figure 5. Chilean GDP Growth



Source: OECD

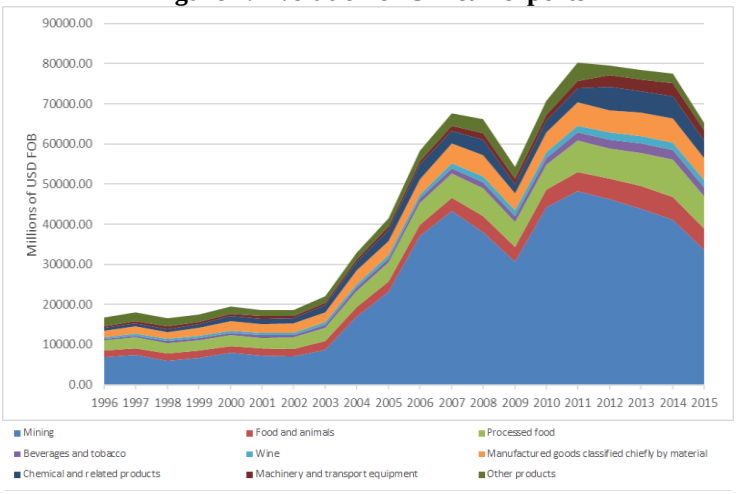
Macro-Prudential policies helped the country to keep robust economic growth allowing the government to apply countercyclical policies during the 2008 crisis and in 2014 to keep aggregate demand high facing the slowdown on international markets. For the period 1994-2015 unemployment was in average 8% and shows a slight decreasing tendency. However, for half of the years considered, unemployment rate remains high, being close to 10%; the last 4 years have shown a slow unemployment rate accompanied with accelerated wage growth, according to the OECD (2015) unemployment rate is expected to remain below 7% for the next 5 years.

Figure 6. Unemployment rate in Chile

Source: OECD

The evolution of Chilean exports shows the effect of commodity boom on Chilean economy, mining exports have more than doubled their value in the period under analysis with an average growth of 12% per year, for the year 2015 mining exports represents approximately 50% of the total value of exports. Signs of exports diversification are present with the chemical industry that presents the higher and most stable average growth (15%). The top destinations of Chilean exports are Japan, the United States and China that currently receives 25% of all exports of Chile.

Figure 7. Evolution of Chilean exports



Source: Central Bank of Chile

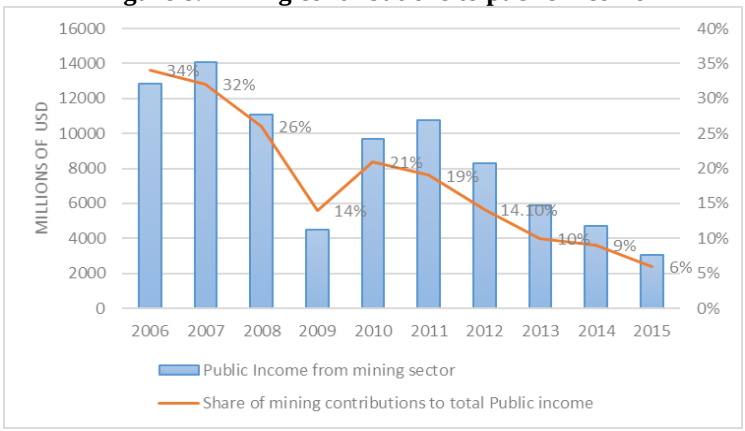
2.2.1 Mining Sector

Mining in the Chilean territory dates back to pre-colonial times, the oldest mine in Chile was found in the northern part of the country and was exploited 12,000 years ago by indigenous communities that extract iron oxide and use it as a pigment. Modern mining exploitation begun on the 19th century with a saltpeter and copper boom, in the middle of the century Chile was a main exporter of both products but the boom ends at the early 1900's when international demand for copper sluggish and saltpeter synthesis was developed. Copper demand increases during the second quarter of the 20th century driven by infrastructure development, power transmission lines, manufacturing and transportation; at the same time mining production in Chile was improved and owned almost completely by foreign capital until the 70's where copper production is nationalized.

Currently, mining industry is no longer nationalized and foreign companies are allowed to exploit mines, but State-owned companies as Codelco still dominate production. Chile's

copper accounts for 34% of global production making it the biggest producer in the world. According to the Chilean copper commission, the country is also rich in other minerals and has the biggest reserves of lithium and iodine in the world. Also Chile is on the top in silver and molybdenum reserves. Chile contributes to more than 50% of lithium global production, a mineral that recently has experienced high demand growth due to its use in modern technology like batteries, computers and electronic devices.

Figure 8. Mining contributions to public income



Source: Chilean mining council

The commodity boom of the 2000's has increased foreign investments flows to the country, Meller (2012) found that between 1990-2011 FDI grew more than nine times being approximately 7% of GDP in 2012. The Chilean government have designed a stable resource rent extraction system, with a general two stage tax procedure where mining companies pay a general income tax of 20% plus a second tax which varies in profit distribution to resident or non-resident shareholders. There is also a tax on mining activities levied on operational income. This tax is adjusted to company size, tonnes sold and value of tonnes sold.

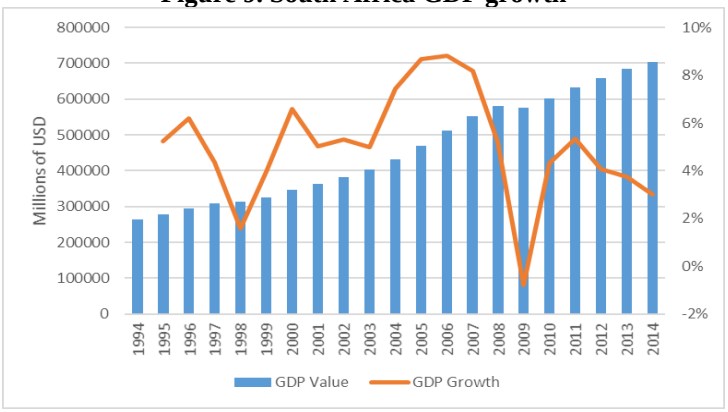
Mining activities contributes about 20% of the fiscal income in Chile that have presented fiscal surplus for almost all the twenty years under consideration, mining taxes and macro-prudential policy have contributed to the reduction of public external debt, which decreased from about 19% of GDP in the 90's to 2-3% of GDP for the last 3 years. Chile has two wealth funds (the economic and stabilization fund and the pension reserve fund) to manage the extra-income of the commodity boom and preserve the resource wealth for future generations.

2.3 South Africa

Since 1994 South African economy has shown continuous growth, the democratic transition and the creation of stable institutions have contributed to the growth and development of the country. Laubscher (2013) attributes the growth performance of South Africa mainly to the lifting of trade and financial sanctions that boost exports and private investment on businesses that have doubled since 1994.

However, real GDP growth (3.1%) is relative low compared with other emerging markets and the benefits of economic growth have not contributed to reducing inequality due to the lack of proper infrastructure and rigidities in the labor market (OECD, 2015b). Fiscal deficits are persistent in South Africa for the last 20 years, government spending has increased in line with the commodity boom but since 2012 some spending limits have been introduced (government deficit cannot be greater as 4% of GDP) as a countercyclical measure against commodity price shocks.

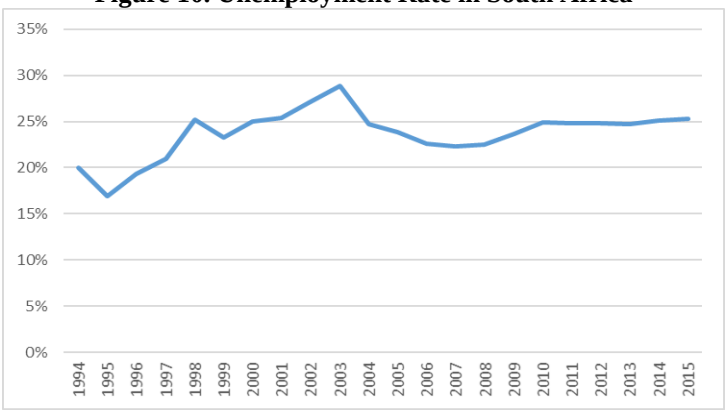
Figure 9. South Africa GDP growth



Source: OECD

The unemployment in the country remains high being in average 25% between 1994-2015 and concentrated among unskilled South Africans (OECD, 2015). Due to the lack of proper public infrastructure and a rigid labor market, unemployment shows high variations across regions in the country, a situation that contributes to the increase on income inequality despite the positive economic growth. According to the OECD (2015) on the last years *"many unemployed people have given up job search, meaning that the share of the labor force that would like to work is nearly 50% higher than reflected in the standard unemployment rate"*.

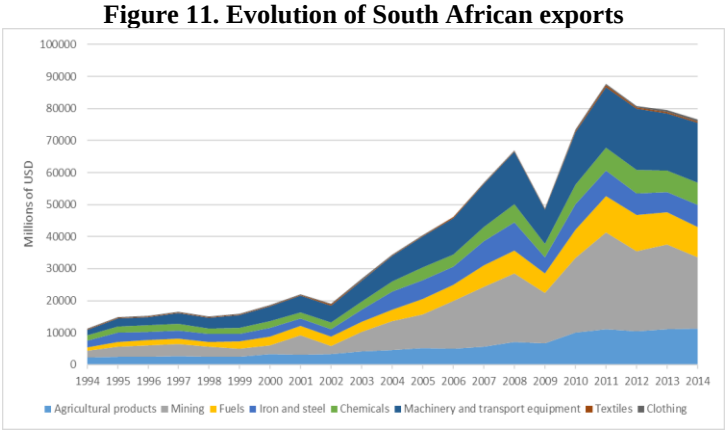
Figure 10. Unemployment Rate in South Africa



Source: OECD

The South African exports are quite diverse and show an interesting tendency, unlike other commodity exporters, during the period 1994-2014 the share of mining products in the total value of exports have remained quite constant (20% in average) while for the same period some manufactures have doubled or tripled their share such machinery exports that passed from 6.1% of exports share in 1994 to 18% in 2014. Precious metals as diamonds and non-monetary gold still have a good share of exports of about 29% for 2014.

Figure 11. Evolution of South African exports



Source: WTO

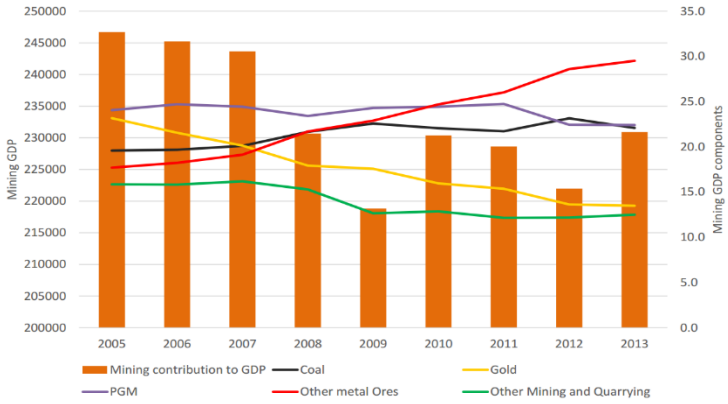
2.3.1 Mining Sector

Modern mining in South Africa begins in the middle of the 19th century when the first commercial exploited copper mine opened in 1852. However, the mining boom came ten years later with the several discoveries of diamond mines around Northern Cape. Diamond exploitation was the main mining activity during the last decades of the 19th century and first years of the 20th century. At the same time gold discoveries were realized on the farm Eersterling, on Pilgrim's village and in Barbeton.

During the 20th century gold gained importance and gold exploitation became the main mining activity in the country until the 1970's when gold activity starts to slip. Exploitation of other minerals as coal and iron ore was relative important from 1950's onwards, the iron and steel industry was controlled by the State and their purpose were to supply the internal demand and allow a self-sufficient industrialization process. Exports of iron ore and coal were banned until the 1970's where a reform in the sector was conducted allowing more private companies participation and by privatizing on the 1980s the State Owned companies.

Currently, South Africa has vast resources in a range of minerals, with 11% of world gold reserves and 96% of world Platinum reserves. The country will continue to be an important producer of these products in the next 30 years[4].

Figure 12. Mining Value Added to Mining GDP



Source: Chamber of mines of South Africa

The mining activity in South Africa have diversified on the last two decades with increasing production of uranium, vanadium and manganese. However, the total mining contribution to GDP have decreased and currently represents about 8% of South Africa GDP. Inside the sector, gold contribution drives the decreasing tendency but production of ores has increased around 10% on the last decade. According to the Chamber of Mines of South Africa (2015), during the 2000's mining activity has in average contributed with 6-8% of public finances, around 15-25% of higher foreign direct investment and with aproximately 600.000 direct jobs on the sector.

[4] Estimations of the Chamber of mines of South Africa.

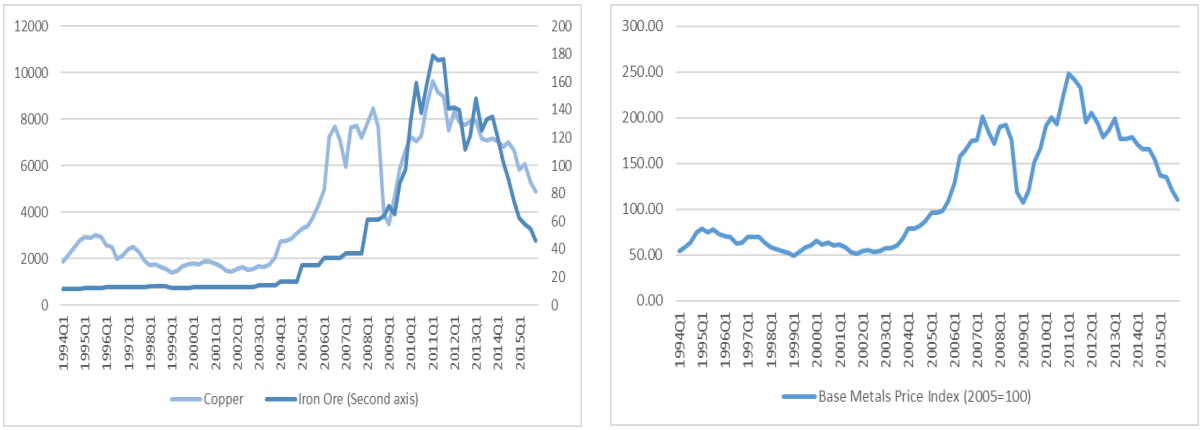
3. DATA

Quarterly data is collected from 1994 to 2015[5] for macroeconomic variables which include interest rates, real exchange rate, inflation and industrial output measured as the real value added of each sector. To facilitate comparison between countries the data is consolidated to form 5 big sectors: Mining, construction, manufacturing, trade and services. Data on the agricultural sector is excluded because this sector experiences periods of high volatility as a consequence of weather conditions. A detailed description of data sources is provided in Appendix A.

3.1 Metal commodities

The selected metals (Iron Ore and Copper) exhibit similar behavior on their international prices for the period 1994-2015. A substantial increase in price and volatility is present in both series since 2003 where a positive trend can be observed.

Figure 13. Selected Metals (USD per metric Ton)



Source: IMF

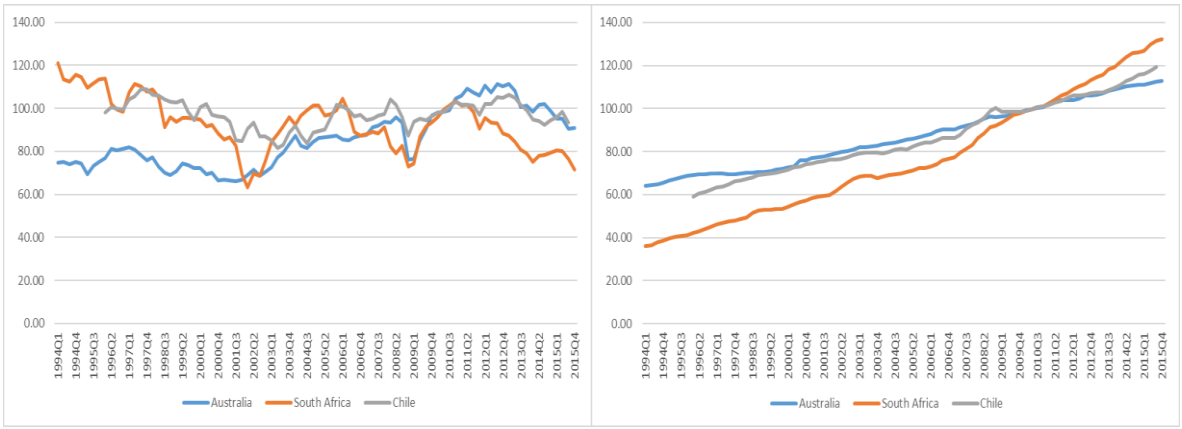
The metal price index shows the same pattern, meaning that not only Copper and Iron Ore but other main metals (Aluminum, Tin, Nickel and Zinc) experienced a boom during the last 15 years until 2012 when a change in trend starts with decreasing prices, a tendency mainly driven by lower international demand and excess capacity in producing countries that have been investing in the sector since the early 2000's (Arezki et al., 2015).

[5] For Chile data sample starts in 1996.

3.2 Macroeconomic variables

The exchange rates for the three countries under analysis shows relative stationary fluctuation with a positive trend for Australia and a negative trend for South Africa. Inflation behaves similarly for the countries with positive trend, with South Africa having the highest increase on inflation since 2007-2008.

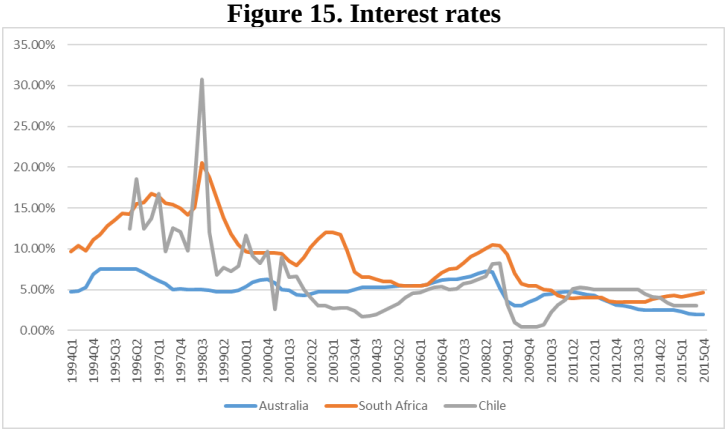
Figure 14. Real Effective Interest Rates and Consumer Price indexes (2010=100)



Source: IMF

The cash interest rates, which shows the short-run response of monetary policy against external shocks, shows a downward tendency for all the countries. Australia's cash rate is the most stable among them, fluctuating at around 5% while the Chilean cash rate shows high volatility.

Figure 15. Interest rates



Source: DataStream

Table 2. Descriptive statistics (1994-2015)[6]

		Mean	Min	P25	P50	P75	Max	Standard Deviation
Base Metals Price Index		115.49	49.61	61.15	91.44	175.51	248.64	59.32
Real Exchange Rate Index	**Australia**	85.26	66.10	74.14	83.94	95.76	111.36	13.21
	Chile	96.96	81.44	93.61	97.13	101.75	108.66	6.48
	South Africa	92.80	63.36	84.31	93.04	101.19	120.96	12.46
Consumer Price Index	**Australia**	86.80	63.96	71.02	85.17	100.23	112.80	15.05
	Chile	87.15	59.11	74.04	84.19	100.94	119.36	16.56
	South Africa	76.77	35.96	53.02	70.20	100.34	132.22	27.94
Interest Rates[7]	**Australia**	4.93%	2.00%	4.35%	4.96%	5.90%	7.55%	1.45%
	Chile	6.14%	0.43%	3.00%	5.02%	7.92%	30.79%	4.83%
	South Africa	8.71%	3.50%	4.91%	8.36%	11.58%	20.52%	4.24%

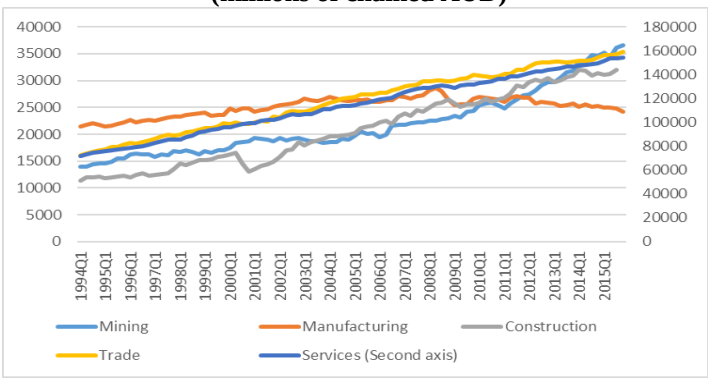
Source: IMF and OECD

3.3 Sector data

3.3.1 Australia

Comparing the evolution of Australian sectors, the construction sector presents the higher average growth (5.12%) with the highest growth rate (21%) in the year 2002. The construction sector evolution is linked with the mining sector that presents similar growth patterns as both sectors have almost doubled their value added on GDP over the last 10 years.

Figure 16. Value added by Industry Seasonally Adjusted (millions of chained AUD)



Source: Australian Bureau of Statistics

[6] For Chile the time series goes from 1996 to 2015.

[7] All Interest rates considered corresponds to the Overnight Interest rate as a proxy measure of each country Central bank short run response to external shocks.

The manufacturing sector presents the lowest average growth (0.8%) of all industries, a result mainly driven by the negative growth reported since 2012. Retail & wholesale trade sector shows an average growth of 3.8% and is almost constant in all the periods analyzed. The services sector has the highest value added of all sectors and presents an average growth of 3.7%, being positive in all periods but trending downwards since 2008.

Table 3. Descriptive statistics (1994-2015)[8]

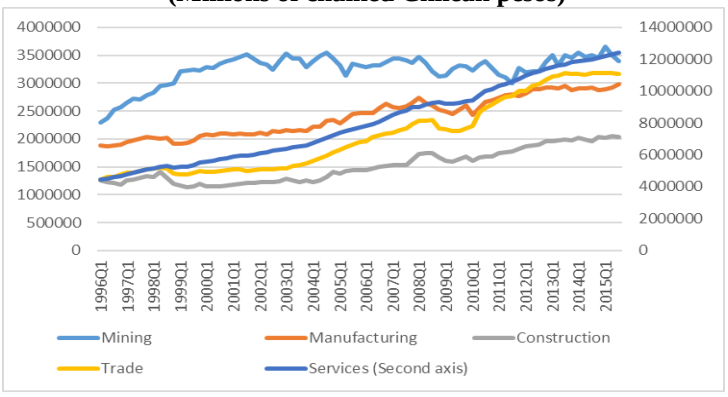
	Mining	Manufacturing	Construction	Trade	Services
Mean	21,804.02	25,127.72	20,945.26	26,210.11	114,089.83
Min	13,956.00	21,499.00	11,415.00	16,053.00	71,500.00
P25	16,998.00	23,738.75	14,578.75	21,238.50	94,012.25
P50	19,415.00	25,541.00	20,110.00	26,888.50	114,100.00
P75	25,378.25	26,479.75	26,473.00	30,849.25	134,369.50
Max	36,544.00	28,604.00	32,037.00	35,339.00	154,331.00
Standard Deviation	5,969.82	1,741.24	6,801.79	5,663.15	24,455.76

Source: Australian Bureau of Statistics

3.3.2 Chile

Among Chilean industries, services sector has the higher average growth (5.44%) closely followed by the retail & wholesale trade sector (5.00%). The mining sector increases their value added in the late 90's and remains stationary since the year 2000. The manufacturing sector shows an average growth of 2.44% with no growth during the last two years, the construction sector has an almost constant growth of 3.9% over the period under analysis.

Figure 17. Value added by Industry Seasonally Adjusted (Millions of chained Chilean pesos)



Source: Central Bank of Chile

[8] The values are seasonally adjusted millions of chained AUD. The average quarterly GDP for the same period was 208,176.94 AUD (excluding taxes, government GDP and Agriculture GDP for comparative purposes).

Table 4. Descriptive Statistics (1996-2015)[9]

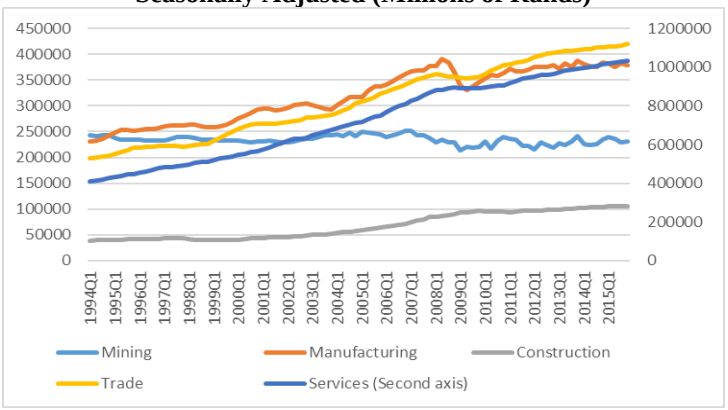
	Mining	Manufacturing	Construction	Trade	Services
Mean	3,249,714.24	2,401,518.21	1,507,204.16	2,052,285.10	8,029,741.17
Min	2,298,074.86	1,873,066.50	1,138,577.76	1,266,821.44	4,460,885.84
P25	3,207,808.95	2,082,063.43	1,224,234.01	1,451,534.29	5,790,529.70
P50	3,316,889.78	2,442,935.31	1,438,135.38	1,938,107.03	7,711,342.94
P75	3,439,785.61	2,733,120.14	1,747,914.31	2,621,764.23	1,010,9841.03
Max	3,649,455.85	2,981,042.08	2,050,809.12	3,188,319.84	12,411,544.45
Standard Deviation	276,382.64	353,070.65	297,113.73	656,678.04	2,472,415.27

Source: Central Bank of Chile

3.3.3 South Africa

Mining sector in South Africa presents an average negative growth of -0.10%. The value added of this sector starts with a relatively high value and stays almost constant until it starts fluctuating and slowly decreasing since 2007. Construction sector shows the highest growth of all sectors (4.86%) with an increasing trend since 2003. Manufacturing and retail & wholesale trade sectors show similar growth (2.58% and 3.57% respectively); both sectors doubled their value added to the South African economy over the last 20 years. The services sector's value added has more than doubled and presents an average growth of 4.39%. It is the only sector in South Africa that reports positive growth in all quarters during the whole period under study.

Figure 18. Real Value added by Industry Seasonally Adjusted (Millions of Rands)



Source: South African Reserve Bank

[9] The values are seasonally adjusted millions of chained Chilean pesos. The average quarterly GDP for the same period was 17,240,462.88 million of Chilean pesos (excluding taxes, government GDP and Agriculture GDP for comparative purposes).

Table 5. Descriptive statistics (1994-2015)[10]

	Mining	Manufacturing	Construction	Trade	Services
Mean	234,274.95	319,283.32	67,275.42	309,039.80	724,659.38
Min	214,554.00	231,204.00	39,217.00	198,417.00	408,467.00
P25	229,814.75	263,387.25	42,480.50	240,024.00	529,077.00
P50	233,980.00	317,402.50	58,766.00	306,048.00	714,587.50
P75	240,137.75	369,820.25	95,489.50	372,108.00	903,033.75
Max	251,117.00	391,090.00	105,620.00	420,075.00	1,031,916.00
Standard Deviation	8,060.84	50,169.49	25,115.18	71,467.35	201,640.84

Source: Reserve Bank of South Africa

4. METHODOLOGY

A vector autoregressive (VAR) model is the generalization of ARIMA processes for multivariate time series analysis. This kind of models have been used as valuable tools for macroeconomic analysis, in particular, to study the effects of exogenous shocks (monetary, inflationary, etc.) on economic performance.

VAR models were first introduced in the seminal work of Sims (1980) where the author criticizes the strong assumptions and identification restrictions needed for estimating multiple equation regression models. Sims proposed the VAR approach as a "theory free" methodology that captures the dynamics of the data without imposing strong assumptions on it.

A general VAR(p) model can be described as[11]:

$$Y_t = A_1 Y_{t-1} + \cdots + A_p Y_{t-p} + C D_t + u_t \qquad (1)$$

Where Y_t consist of a set of K endogenous variables, A_i are (K x K) coefficient matrices for $i = 1, \ldots, p$, C is a (K x M) coefficient matrix for the deterministic regressors, D_t is a vector with dimension M of deterministic regressors. Finally, u_t is a K dimensional vector containing the error terms, u_t is assumed to be a white noise time invariant process.

[10] The values are 2010 constant, seasonally adjusted million of Rands. The average quarterly GDP for the same period was 1,654,532.87 million of Rands (excluding taxes, government GDP and Agriculture GDP for comparative purposes).

[11] For a detailed textbook description of VAR models please refer to Amisano & Giannini (1997)

If the conditions mentioned above hold, each equation of the VAR(p) model can be estimated consistently by OLS. Equation 1 is a reduced form VAR(p) model that can be expressed in its structural (SVAR) form as:

$$A_0 Y_t = A_1 Y_{t-1} + \cdots + A_p Y_{t-p} + C D_t + B\varepsilon_t \qquad (2)$$

On its structural form, contemporaneous interaction between endogenous variables are considered and contained on the A_0 matrix with dimension (K x K). The structural error vector ε_t is assumed to be white noise. Any structural model can be represented as a reduced VAR(p) model just by pre-multiplying A_0^{-1} to both sides of equation 2.

The coefficients of the structural form will be the same for the reduced form only if A_0 is an identity matrix. The SVAR model form is overdetermined as they are more unknown coefficients than equations on the model. Therefore, to estimate a SVAR model, some restrictions are needed either on A_0 or B matrices.

An SVAR model is estimated by minimizing the negative of the log-likelihood function defined as:

$$lnL_c(A,B) = const + \frac{T}{2} ln|A^2| - \frac{T}{2} ln|B^2| - \frac{T}{2} tr\left(A' B'^{-1} B'^{-1} A \hat{\Sigma}_u\right) \qquad (3)$$

Where T is the sample size and $\hat{\Sigma}_u$ is the estimated residual covariance matrix of the reduced form model.

4.1 A SVAR model for a small open commodity exporter economy

To construct a SVAR model to analyze commodity price shocks effects on sectoral data, I follow closely the methodology adopted by Knop and Vespignani (2014) and Fornero and Kirchner (2014). In line with these studies exogenous variables describing the global economic conditions are included in the SVAR model.

Exogenous variables included in each model are:

- **WORLD GDP($GDPW_t$):** Constructed as an aggregation of the quarterly GDP in US dollars, seasonally adjusted by the ARIMAX13 procedure of the four largest trading partners for each country in the last 20 years[12].
- **WORLD INTEREST RATE ($RATEW_t$):** Aggregation of government policy rates of the four largest trading partners for each country and weighting by their share of trade with the country under analysis.
- **WORLD INFLATION ($CPIW_t$):** Constructed as an aggregation of the CPI (rebased to a common year 2010=100) for each of the four largest partners and weighting by their share of trade with the country under analysis.

The endogenous variables include: Base metal Index (BIN_t), Non Agricultural GDP (GDP_t)[13], Industry Value Added (IND_t), Inflation (CPI_t), government policy rate (RATE_t) and Real Effective Exchange Rate (REER_t). In order to have similar scales and comparable results among variables and countries, the following variables are transformed by applying the natural logarithm: Base metal index, Non Agricultural GDP, Industry Value Added and World GDP.

The proposed SVAR model is the following:

$$A_0 Y_t = C + A_1 Y_{t-1} + \cdots + A_p Y_{t-p} + D X_t + B \varepsilon_t \qquad (4)$$

Where:

$Y_t = (\mathrm{BIN}_t, \mathrm{GDP}_t, \mathrm{IND}_t, \mathrm{CPI}_t, \mathrm{RATE}_t, \mathrm{REER}_t)$

$X_t = (\mathrm{GDPW}_t, \mathrm{RATEW}_t, \mathrm{CPIW}_t)$

$\varepsilon_t = Vector\ of\ structural\ errors$

[12] Australia: Japan, USA, UK, China.
Chile: Japan, USA, China and Germany.
South Africa: Japan, USA, UK, China.

[13] Constructed as GDP minus Agricultural value added minus Industry value added.

Restrictions are imposed on the A_0 matrix which describes the contemporaneous interactions between variables. I assume B=I. A summary of the identification restrictions is shown in equation 5:

$$A_0 Y_t = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 & 0 \\ a_{31} & a_{32} & 1 & 0 & 0 & 0 \\ a_{41} & a_{42} & a_{43} & 1 & 0 & 0 \\ a_{51} & a_{52} & 0 & a_{54} & 1 & 0 \\ a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & 1 \end{bmatrix} \begin{bmatrix} \log(\mathrm{BIN}_t) \\ \log(\mathrm{GDP}_t) \\ \log(\mathrm{IND}_t) \\ \mathrm{CPI}_t \\ \mathrm{RATE}_t \\ \mathrm{REER}_t \end{bmatrix} \qquad (5)$$

As SVAR models are sensitive to the order of the variables, the ordering of variables should lie on economic reasoning. The commodity price index is ordered on the first place because is the less endogenous variable and therefore is not contemporary affected by the other endogenous variables of the model. GDP_t comes in second place as this variable shows the flow of the whole national economy (excluding the sector under analysis), IND_t is ordered in third place as the industry behavior is considered to be affected contemporaneously by commodity prices and the whole national economy.

Commodity prices and national output affect inflation in the same quarter as producers adjust prices quickly in response to a change in input prices (like commodities) and to changes in the economic environment. In line with a simple Taylor rule for economic policy, government monetary policy responds instantaneously to changes in economic conditions and to inflation while the effect of monetary policy on inflation takes time to occur. Finally, the exchange rate is the most endogenous of all variables and is affected by all of them within the same quarter.

The proposed model is estimated in two ways: First, it is estimated in levels regardless of the stationarity of the variables. Second, the model is estimated with all the variables being stationary (differences model). The debate about which model is a "better" fit for the data is long and dates back to the initial Sims proposal of the VAR model. The standard textbook recommendation is to work with stationary data since inference can be done and normality assumptions are fulfilled. However, Sims, Stock, & Watson (1990) found that estimation in levels for non-stationary time series produces consistent estimators which are asymptotically normally distributed.

Given that the main interest of the proposed model is to analyze the dynamic interactions between variables via Impulse-Response Functions (IRF's) and that according to Gospodinov, Herrera & Pesavento (2013), Impulse response estimators are more robust in levels specification as long as the estimated VAR has no serial autocorrelation, I choose to use SVAR in levels as the main model for analysis. IRF's obtained from SVAR model in differences will be provided as a complementary tool to analyze the sectors that present "unusual" behavior in their IRF and are provided in Appendix B.

For the lag selection for each model, I consider first the information criteria of Akaike, Schwartz Bayesian and Hannan-Quinn, the model for each industry is estimated with the lowest lag provided by the information criteria methods. Then, a serial autocorrelation test is considered for the estimated model. If the model presents serial correlation, then it is estimated again with additional lags until serial correlation disappears. Information criteria and serial correlation test results for each model are provided in Appendix C.

5. RESULTS

This section analyses the impulse response functions of each industry to commodity prices shocks. Generally, the IRF measures the dynamic response of a particular variable to external or unpredicted shocks keeping all the other variables of the system constant. The impulse response function can be expressed as:

$$IRF = \frac{\partial Y_{t+S}}{\partial \varepsilon_t} = \varphi_s \qquad (6)$$

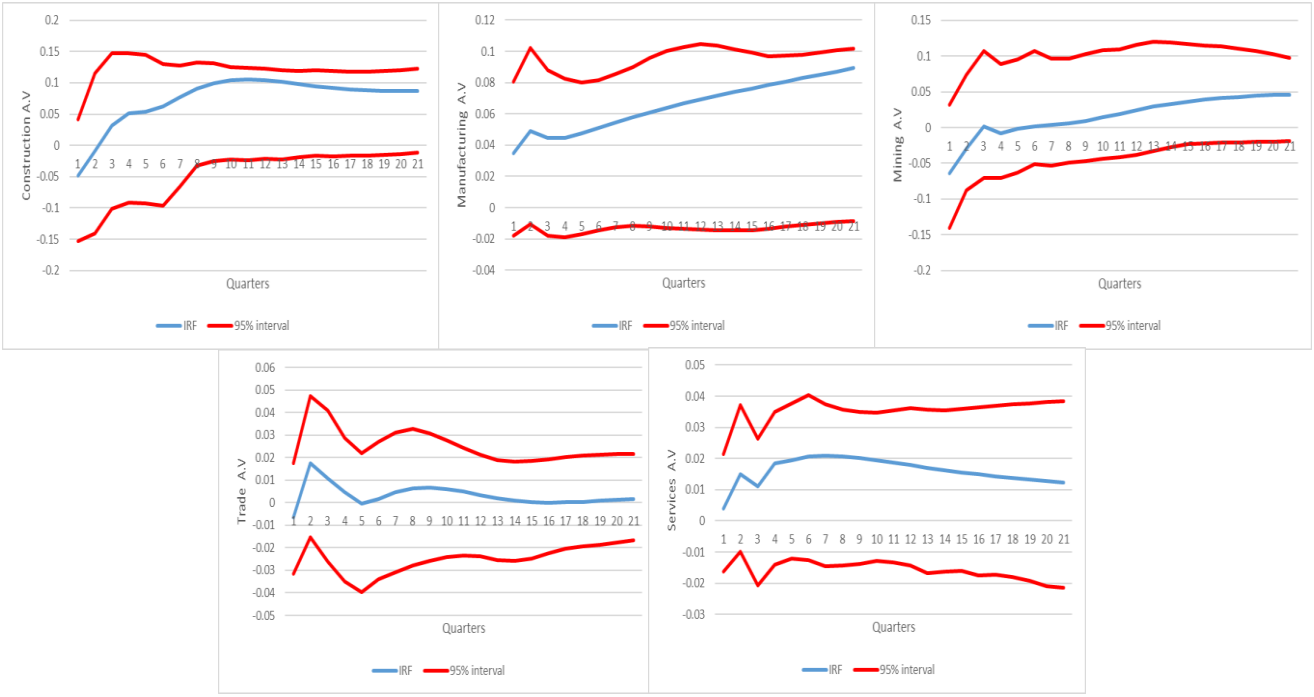
Where φ_s can be obtained from the vector moving average VMA(∞) representation of the model presented in equation 4. For the purpose of this study, the IRF's are estimated as the particular industry response to a 1% structural shock to the base metal commodity index. Stability and sensitivity tests for each model are provided in Appendix C.

5.1 Australia

For a positive 1% shock on metal commodity prices, almost all Australian industries responses are positive, except for the trade sector that shows a small positive response only for the first quarter and then diminishes to zero. The services sector growth increases around

2% but its effect diminishes over time; there is no evidence of a Dutch disease spending effect on trade and services sectors due to a shock in commodity prices.

Figure 19. Response of Australian industry sectors to a 1% price commodity shock



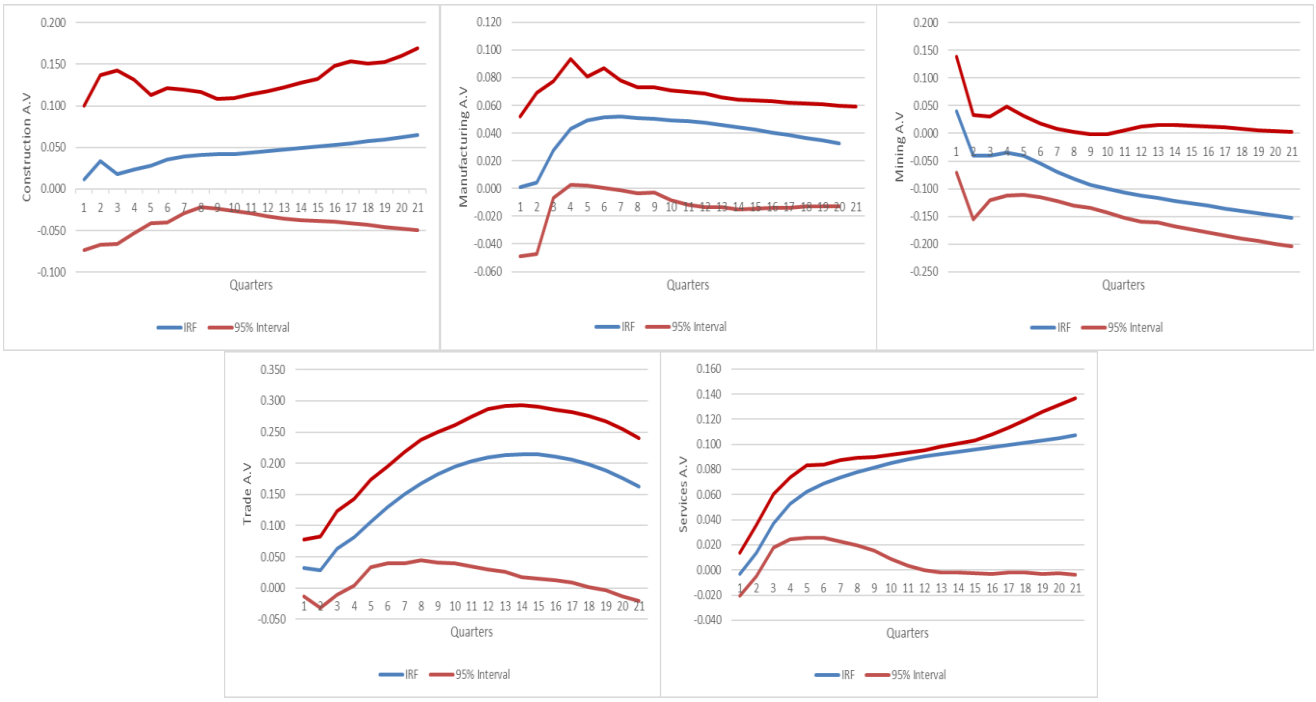
Construction and mining sectors response is similar being initially negative and then positive, these responses can be an effect of production constraints on the mining sector where the increase in production takes some time. Manufacturing sector shows a positive response with an average growth of 6% on all quarters, this sector response shows no evidence of a crowding out effect due to a positive shock on commodity prices.

5.2 Chile

For Chile, a 1% positive shock in commodity prices generates a negative response on real value added of the mining industry with everything else being constant; the output of mining sector shows a reduction of about 5% every quarter according with the IRF's; this result can be explained as an effect of capacity constraints on the mining industry where production cannot be increased quickly. The services and trade sectors respond positively to a commodity price shock with increases of around 1.6% and 11% for services and trade growth respectively.

These results can be explained by a "spending effect" in the short-run where the increase of revenue, as a consequence of the shock, raises demand of these "non-internationally tradable" sectors, similar to the effect expected in the short run by the Dutch disease model of Corden (1984).

Figure 20. Response of Chilean industry sectors to a 1% price commodity shock

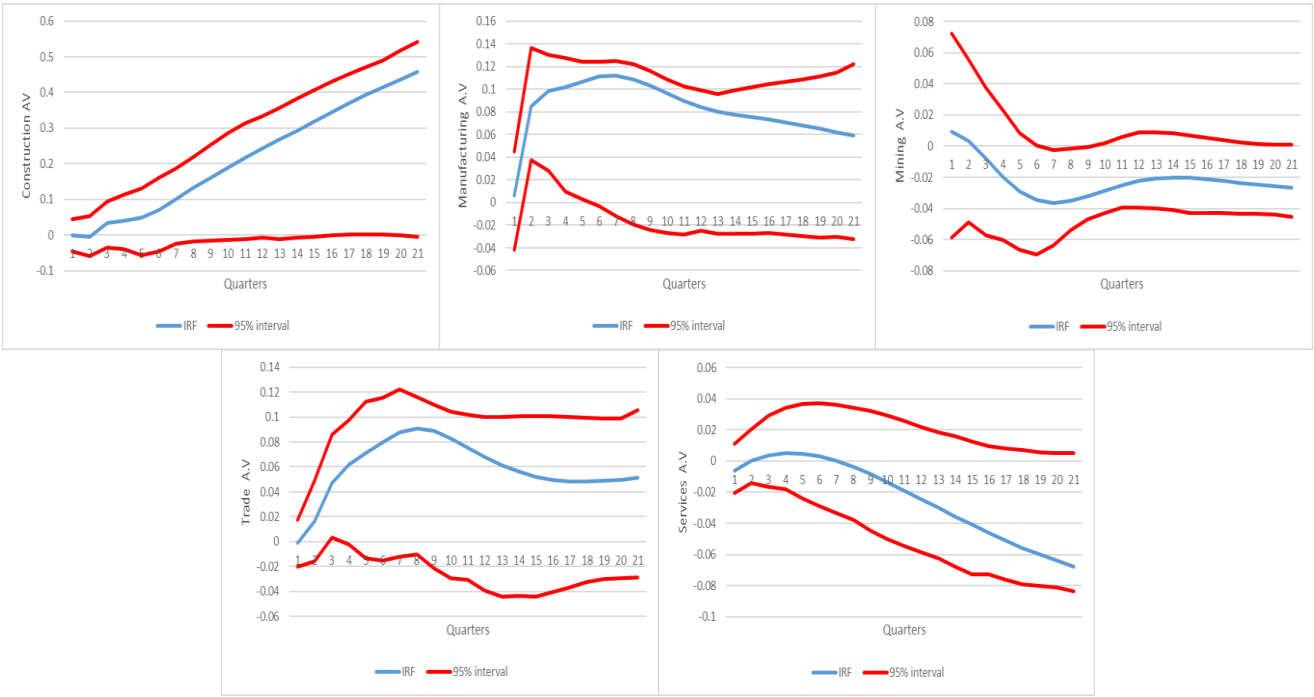


The construction sector response is positive and the shock induces around 5% higher growth in this sector. This behavior supports a possible link between the mining and construction sectors. The shock in commodity price could induce an increase in investment on new mines or in increasing existing capacity which involves the construction sector. Finally, the manufacturing sector has a positive response that diminishes over time meaning that the shock contributes to the sector growth only in the very short run. From this sector point of view, there is no evidence of a Dutch disease in the short run since there is no contraction of the output of the manufacturing sector as a response to a boom in the mining sector.

5.3 South Africa

The construction sector in South Africa shows an almost linear positive response to a 1% commodity price shock, the output of this sector increases in average 10% each quarter. Manufacturing sector has a high initial response on the first 2 quarters, the effect diminishes over time but remains positive, again there is no evidence of a crowding out effect on the manufacturing sector due to a shock on commodity prices.

Figure 21. Response of South African industry sectors to a 1% price commodity shock



The mining sector response is slightly negative for all periods and remain close to zero, for South Africa the mining industry is quite unresponsive to a commodity price shock in the short run. Trade sector shows a positive response with an average growth of 1.3% in output each quarter which, as on the Chilean case, can be explained as a spending effect created by the commodity price shock. The services sector shows an odd response being slightly positive for half of the quarters and then becoming negative.

6. COMPARATIVE ANALYSIS

In this section, a comparative analysis of the impulse response functions for each sector across the sample countries is presented. The results are contrasted with similar works in the literature, with data from each industry and with economic theory to identify patterns and possible explanations of the estimated model.

6.1 Mining

The response of the mining sector for a 1% positive shock on metal commodity prices is heterogeneous among the three sampled countries. First, the greatest response is seen in the Chilean mining industry where the shock generates a continuous contraction in output. For Australia, the response is negative during the initial periods and becomes positive thereafter. The response of the South African mining industry is negative for most of the quarters but approaching to zero from quarter six.

These results suggest that expanding the capacity of the mining industry takes time. Therefore, mining producers react in the short run by increasing extraction on depleted stressed mines that require greater input per unit extracted. In other words, the benefits of higher commodity prices are offset in the short run by the greater increase in extraction costs. As the real value added is a proxy measure of volume, and given the costs implied, it is rational to expect, in the short run, a contraction of the value added in the mining industry. It should be noted that the results obtained in the model do not imply a reduction in profits in the industry, as pointed out by Knop & Vespignani (2014). Profits and nominal value added increase even with contractions in the output of the mining industry.

Thus, the main point of mining response to commodity price shocks lies in the cost structure of the sector, making possible to use the impulse response functions as a comparative measure of cost structures among the sampled countries. Following this reasoning, the impulse response function for the Australian mining sector provides evidence that cost structure in Australia is more flexible and can adapt faster to commodity price shocks than the Chilean or South African mining industries. Indeed, the Australian mining sector has created over the past twenty years a good environment for innovation. According with the

Department of Industry, Innovation and Science (2015) during the last decade the share of R&D over the total business expenditures for the sector was about 20-25%, making the mining sector the leader of innovation in the country. This business environment could explain why the mining industry in Australia does not suffer a continuous contraction in their output when facing a commodity price shock.

The case of the Chilean mining industry is quite the opposite of the Australian one. The impulse response function shows that the cost structure in Chile is strictly rigid. Chilean mining sector suffers from higher costs and extreme production constraints mainly concentrated in two necessary inputs: electricity costs and water use. Electricity costs in Chile are approximately 25% higher than the world average, and more than 30% higher when compared with other mining nations like Australia, Canada and Peru (Simpson , Aravena, & Deverell, 2014). Regarding water consumption, the majority of the mining activity in Chile is located in the dessert, where water is scarce. Desalination plants of fresh water is an alternative to the freshwater constraints but the costs are more than threefolds (Nielsen, 2013).

The impulse response function for the South African mining sector also indicates a rigid cost structure but not as constrained as the Chilean case. During the last decade, production costs in South Africa have been rising in some inputs such as electricity, water and labor. According to the Chamber of Mines of South Africa (2015), between 2007-2013 electricity costs grew about 238%, labor costs have been growing on average 5% per annum in real terms which is above the average of other industries in the country.

In summary, production costs and capacity constraints are a possible explanation of the observed patterns on the estimated impulse response functions of the mining industry to a price shock in metal commodities for the countries analyzed. Australia seems to adapt more easily due to the high R&D in the industry, which could explain why the response of the sector became positive after four quarters. South Africa starts facing strong constraints by the rising costs in inputs, reason why the industry is almost unresponsive to the price shock. Finally, Chile faces the highest cost and input constraints. Since mining requires a significative upfront investment to increase production, the constraints imply that a considerably increase in production is impossible in the short run for Chile.

6.2 Construction

The construction response is similar for the three countries under the current analysis. A shock in commodity prices generates an increase in the construction sector output in the short run, suggesting the existence of a good degree of interdependence between mining and construction sectors. This finding may be explained by the investment channel as price shocks induce investment on improving the productive capacity of the mining sector that involves the construction sector.

A second interpretation of the shapes of the impulse response functions in the construction sector is the public spending channel, which implies that commodity booms generally increase public income which may boost public infrastructural investments. As mentioned before, the mining sector in the three countries represents an important source of public income, thus making it viable that public infrastructural investments increase as a result of growth in the mining sector.

The greatest effect is present in the South African construction sector, where the output is increased on average 10% each quarter. This response to positive price commodity shocks is mainly driven by public spending. The South African government's focus for the last decade has been on improving public infrastructure in the country to reduce costs of public services and increase coverage in power, water, education and roads (National Treasury of South Africa, 2015). Thus, for South Africa the construction sector benefits directly from the growth in the mining sector and from the increase in public spending.

For Chile, construction sector growth is 5% greater after a commodity price shock, for this country the link between price shocks and the construction sector lies both in the private and public investments on infrastructure. According to Fornero & Kirchner (2014), for the Chilean economy, a positive shock in commodity prices boosts private commodity investment by about 2%. This increase in turn generates positives spillovers in other sectors and in the aggregate real GDP. The Australian construction sector has the smallest effect in the sample, with only a 3% higher growth each quarter after a commodity price shock.

Downes, Hanslow, & Tulip (2014) estimate that without the commodity boom, the growth of the construction sector between 2000 and 2013 would be on average 5% lower.[14]

6.3 Manufacturing

A positive commodity price shock generates an increase in manufacturing output in the three countries, with similar shapes for Chile and South Africa. For all three countries, the impulse response function shows that there is no crowding out of the manufacturing sector in the short run. One of the main problems identified in the growth literature is the effect of natural resource sector in enhancing or constraining the manufacturing industry. According to the Dutch disease hypothesis, a commodity boom reduces growth in the manufacturing sector by moving resources away from this industry, and by the appreciation of the national currency.

In this paper, I find that the estimated impulse response functions of the manufacturing sector show the opposite effect to the Dutch disease hypothesis. This result implies either that central banks are efficient in stabilizing exchange rates in the short run or that the negative effect caused by the appreciation of the national currency is offset by other factors like a greater internal demand or a spending effect. The greatest response is observed in the Australian manufacturing sector, where a 1% positive shock in commodity prices generates a continuous growth in manufacturing of about 6% each quarter. The responses for the manufacturing sector in Chile and South Africa show an initial higher response that diminishes over time. For Chile, the peak is reached in the fifth quarter while for South Africa the peak of the response is reached in the seventh quarter.

The estimated results of this study are consistent with Hegerty (2016), Fornero & Kirchner (2014), Downes, Hanslow, & Tulip (2014), as well as Bean (1987), supporting the idea that price shocks generates a general appreciation of national currencies in the short run for commodity exporters. Therefore, the positive response observed for all the countries may be a consequence of the spending effect.

[14] In their own words *"these industries (construction) sell a disproportionate share of their output to the mining industry"* and thus benefit with commodity price shocks.

6.4 Services & Trade

The trade sector seems to benefit from a positive commodity price shock in Chile and South Africa. For Australia, the trade sector is unresponsive overall, showing an initial positive response and then falling to zero. The services sector shows mixed responses for all sampled countries. The responses for Chile and Australia are positive while for South Africa the response is negative for almost all the quarters. Chile and Australia have impulse response functions in the services and trade sectors that behave in a consistent manner with the Dutch disease hypothesis, which states that a commodity boom increases the income in individuals that boosts the non-tradable sector. This spending effect may come from two different sources: higher income in individuals and higher demand of services related to the mining sector.

For the Australian services sector, a commodity price shock increases growth by 1.6% on average each quarter. Bhattacharyya & Williamson (2013) find that a mineral commodity price shock increases inequality by increasing the income share of the top 1 percent, increasing demand on the non-tradable sector that becomes relative more expensive due to the real exchange rate appreciation that follows a commodity boom. This distributive impact could be an explanation for the responses observed both in trade and services in Australia. However, the increase in the services industry can also be a result of the connection of the services industry within the mining sector. According to Rayner & Bishop (2013), the services sector have benefited from the boom by the increasing participation of a sub-industry of mining related services[15].

The Chilean services sector has a positive response with an average increase of 2% each quarter, while the trade sector in the country increases on average 11% with a decreasing tendency. The higher growth in trade may be a result of the distributive impact of the mining industry in the Chilean economy. According to Álvarez , García, & Ilabaca (2015), commodity price shocks have a positive effect on reducing poverty in the mining regions in Chile, a shock that generates a significant increase in salaries and employment in such areas,

[15] Business services, Transport & Warehousing, Utilities and Waste services. These services contributed, in the last decade, around 31% of the gross value added of the resource economy in the country.

particularly among unskilled workers. This regional impact boosts the local economy that involves the retail and wholesale trade sectors.

For South Africa, the trade sector response to a commodity price shock could be explained by the spending effect mentioned before that diminishes over time. Regarding the services sector, the response is negative for almost all quarters, a result that contradicts the spending effect. Instead, the negative response of the services sector could be explained by structural factors of the South African economy. Since the country has high unemployment rates (above 25% in average) and high income inequality, the effect of a 1% price shock may not be strong enough to generate a spending effect among individuals (those with employment) and in companies that are directed towards the services sector.

7. CONCLUSIONS

This study examines the relationship between metal commodity price shocks and the performance of different industrial sectors in three countries: Australia, Chile and South Africa. The results show that each country behaves idiosyncratically with the greatest sectoral responses for the construction sector in South Africa, the services sector in Chile, and the manufacturing sector in Australia. However, some consistent patterns arise across the sampled countries. First, there is no evidence of de-industrialization in the short run given a commodity boom. Second, services and trade sectors seem to benefit from commodity price shocks. Third, the short run impact of the mining sector reflects production capacity constraints and cost structure in the industry.

The overall assessment of the sectoral impact argues against the resource curse hypothesis in the short run as most industries seem to improve their production given an external, positive shock in commodity prices. The results suggest three possible channels of transmission: the interdependence of other industries within the mining sector, the increase in internal demand due to the increase in private consumption, and the increase of public spending.

Australia seems to have the strongest inter-sectoral links as construction, manufacturing and services are boosted by the activity of the mining sector. The Chilean economy also shows strong inter-sectoral links but mainly in manufacturing and construction. For South Africa,

some structural conditions like high unemployment and high public spending may explain the odd responses in each industry, particularly in the construction and services sectors.

It is important to note that the selected methodology, a SVAR model for simulating the responses of each industry to a commodity price shock, presents some limitations that only allow us to see a small frame in the picture of the effect of commodity price shocks in the industries. Specifically, the estimated impulse response functions represent a short run analysis and thus the implications of the shock for the long-term economic development of the countries analyzed is not captured. Also, the methodology only allows us to observe the complete dynamic response of each sector. In other words, with this analysis, it is impossible to map exactly which transmission channels have higher relevance for each sector. Finally, some bias on the results are expected as the proposed model is sensible to the ordering of the variables, a different ordering may show different results.

Overall, this study shows that metal commodity price shocks have a positive effect on most industries' output in the short-run. These results have implications for policy formulation, in particular for stabilizing policies in the short-run, although the issue of long-run impact on industrial growth remain an open and relevant topic for further research. Some possible extensions are to include sectoral employment data to the model presented in order to analyze how employment responds to commodity price shocks. Also, this study can constitute the basis for an industrial organization research of the mining sector, where the cost structure and profits in the industry can be analyzed in a long run perspective, similar to the Keay (2015) study of the Canadian wood industry. Finally, the current analysis could be extended to include sub-sectors in the services and manufacturing industries to better identify the sources of response within sectors.

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APPENDIX A. Data Sources

Endogenous Variables

Series	Country	Proxy	Source
Commodity Metal Price	**ALL**	Metal Price Index	International Financial Statistics
Added value by industry	**AUSTRALIA**	Gross Added value by industry (quarterly, seasonally adjusted)	Australian Bureau of Statistics. "time series 5206.0, table 6"
Exchange Rate		REER	International Financial Statistics
Interest rate		Australian Cash rate	DataStream. Code AUCASH11F
Inflation		CPI	International Financial Statistics
Added value by industry	**CHILE**	Gross Added value by industry (quarterly, seasonally adjusted)	Central Bank of Chile. "PIB por clase de actividad económica a valores encadenados del año anterior"
Exchange Rate		REER	International Financial Statistics
Interest rate		Overnight Index Average	DataStream. Code CLQIR060R
Inflation		CPI	OECD
Added value by industry	**SOUTH AFRICA**	Gross Added value by industry (quarterly, seasonally adjusted)	South African Reserve Bank. "GDP at constant 2010 prices, by production approach (seasonally adjusted annualized rates)"
Exchange Rate		REER	International Financial Statistics
Interest rate		SOUTH AFRICA IBK. CALL - MIDDLE RATE	DataStream. Code Y70234
Inflation		CPI	International Financial Statistics

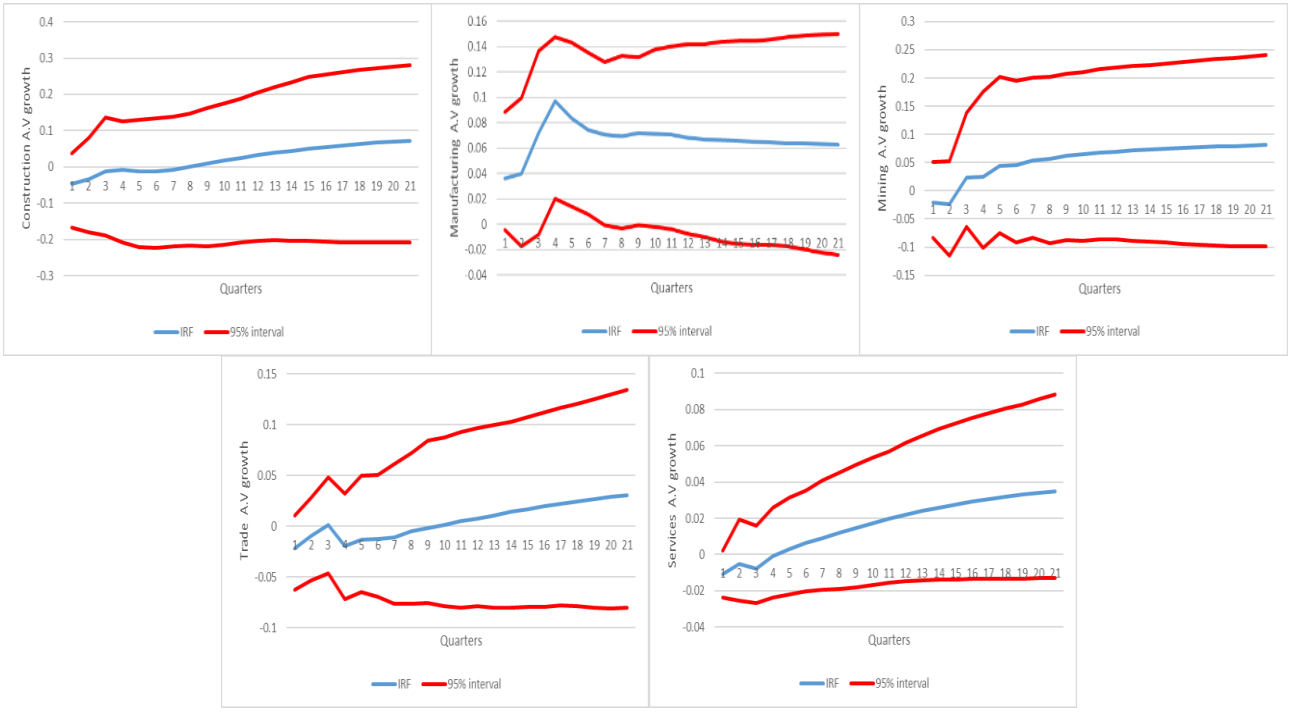
Exogenous Variables

Series	Country	Proxy	Source
GDP	**CHINA**	Quarterly GDP in USD	DataStream. Code CHXGDP$.C
Inflation		Consumer Price Index	DataStream. Code CHXCPI..F
Interest rate		Short Term Central Bank Policy	DataStream. Code CHXRCB..R
GDP	**GERMANY**	Quarterly GDP in USD	DataStream. Code BDXGDP$.C
Inflation		Consumer Price Index	DataStream. Code BDXCPI..E
Interest rate		Short Term Central Bank Policy	DataStream. Code BDXRCB..R
GDP	**JAPAN**	Quarterly GDP in USD	DataStream. Code JPXGDP$.C
Inflation		Consumer Price Index	DataStream. Code JPXCPI..F

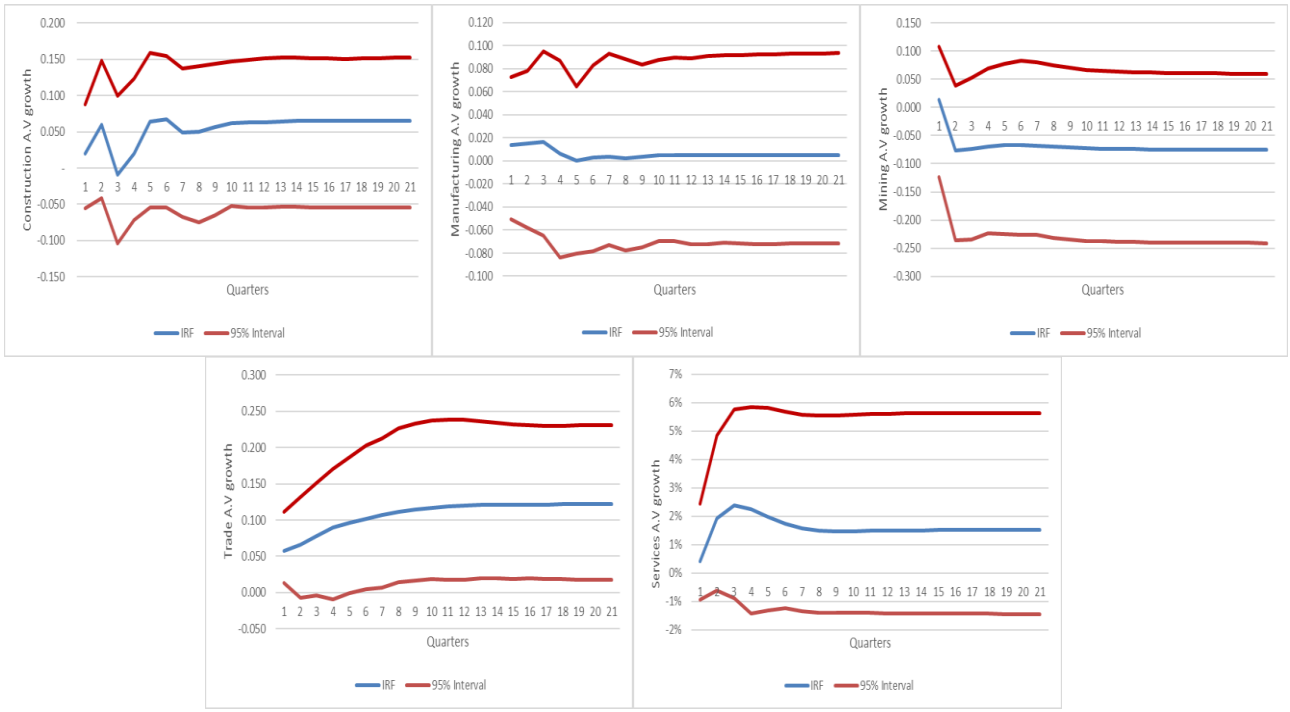
Series	Country	Proxy	Source
Interest rate		Short Term Central Bank Policy	DataStream. Code JPXRCB..R
GDP	**UNITED STATES**	Quarterly GDP in USD	DataStream. Code USXGDP$.C
Inflation		Consumer Price Index	DataStream. Code USXCPI..E
Interest rate		Short Term Central Bank Policy	DataStream. Code USXRCB..R
GDP	**UNITED KINGDOM**	Quarterly GDP in USD	DataStream. Code UKXGDP$.D
Inflation		Consumer Price Index	DataStream. Code UKXCPI..F
Interest rate		Short Term Central Bank Policy	DataStream. Code UKXRCB..R

APPENDIX B. SVAR in Difference Impulse Response Functions

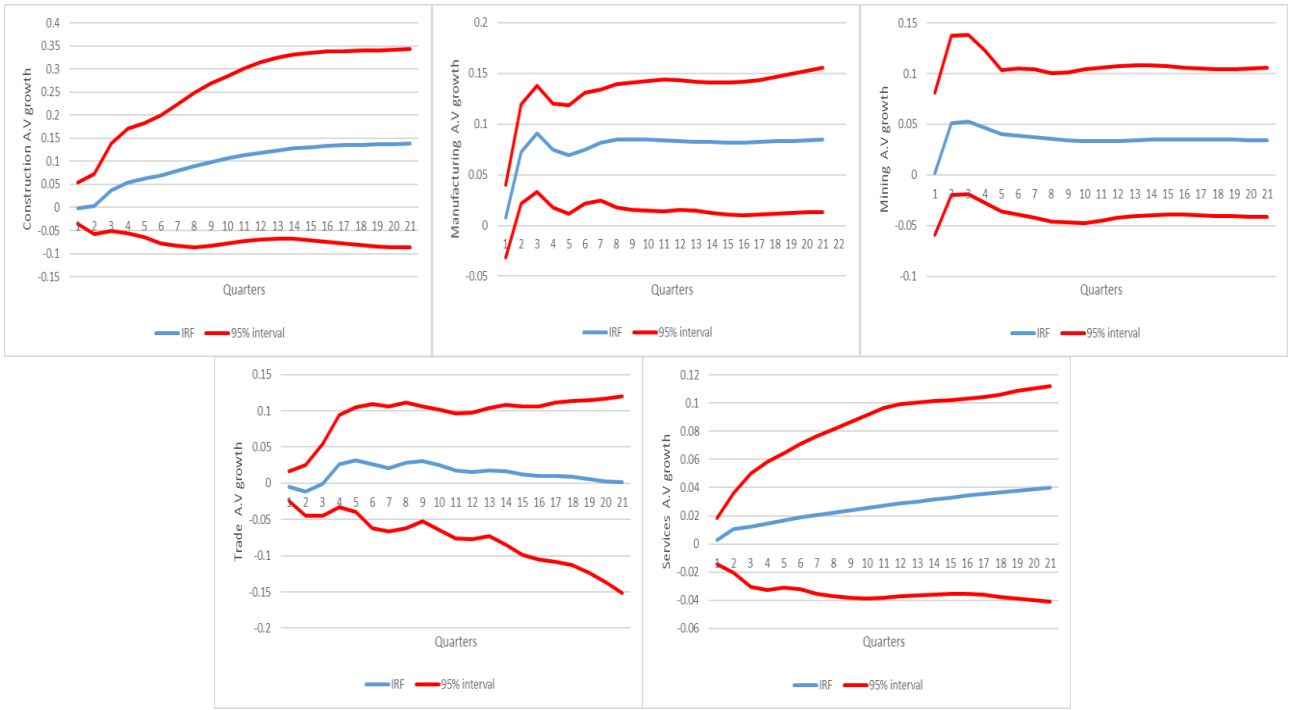
AUSTRALIA



CHILE



SOUTH AFRICA



APPENDIX C. SVAR MODEL TESTS

INFORMATION CRITERIA

	SVAR in Levels			Model
Australia	**AIC**	**HQ**	**SC**	**Estimated**
Construction	2	1	1	2
Manufacturing	2	1	1	1
Mining	2	1	1	2
Trade	2	2	1	2
Services	2	1	1	1

	SVAR in Levels			Model
Chile	**AIC**	**HQ**	**SC**	**Estimated**
Construction	2	1	1	2
Manufacturing	4	1	1	2
Mining	4	1	1	2
Trade	4	2	1	2
Services	4	1	1	2

	SVAR in Levels			Model
South Africa	**AIC**	**HQ**	**SC**	**Estimated**
Construction	3	1	1	3
Manufacturing	2	1	1	2
Mining	1	1	1	1
Trade	3	1	1	3
Services	2	1	1	1

SERIAL CORRELATION TEST

Edgerton-Shukur F test modification of the Breusch-Godfrey LM-statistic for small samples[16], where:

$$H_0 = No\ serial\ autocorrelation\ on\ the\ first\ two\ lags$$

$$H_1 = Serial\ Autocorrelation\ in\ at\ least\ one\ of\ the\ \ first\ two\ lags$$

[16] For a detailed description of the test please refer to Pfaff, Bernhard. (2008). Analysis of integrated and Cointegrated Time Series with R. *Springer Books. (1st Edition).*

	P-value		
	Australia	**Chile**	**South Africa**
Construction	0.4228	0.0972	0.2228
Manufacturing	0.0992	0.3574	0.08135
Mining	0.2222	0.1782	0.4032
Trade	0.1701	0.383	0.3217
Services	0.1325	0.2	0.4773

Characteristic Roots of the Estimated Models

Australia	BIN_{t-1}	GDP_{t-1}	IND_{t-1}	CPI_{t-1}	$RATE_{t-1}$	$REER_{t-1}$	BIN_{t-2}	GDP_{t-2}	IND_{t-2}	CPI_{t-2}	$RATE_{t-2}$	$REER_{t-2}$
Construction	0.994	0.794	0.787	0.787	0.745	0.469	0.397	0.397	0.382	0.382	0.362	0.362
Manufacturing	0.998	0.913	0.755	0.290	0.290	0.024						
Mining	0.976	0.976	0.810	0.810	0.543	0.461	0.447	0.447	0.441	0.441	0.182	0.115
Trade	0.966	0.909	0.822	0.822	0.573	0.523	0.448	0.448	0.405	0.405	0.062	0.062
Services	0.996	0.924	0.774	0.423	0.195	0.011						

Chile	BIN_{t-1}	GDP_{t-1}	IND_{t-1}	CPI_{t-1}	$RATE_{t-1}$	$REER_{t-1}$	BIN_{t-2}	GDP_{t-2}	IND_{t-2}	CPI_{t-2}	$RATE_{t-2}$	$REER_{t-2}$
Construction	0.9995	0.877	0.662	0.662	0.605	0.605	0.493	0.413	0.402	0.371	0.371	0.081
Manufacturing	0.914	0.914	0.680	0.680	0.649	0.649	0.450	0.450	0.432	0.432	0.195	0.195
Mining	0.926	0.817	0.747	0.747	0.624	0.624	0.469	0.469	0.133	0.133	0.122	0.122
Trade	0.993	0.993	0.725	0.725	0.557	0.557	0.502	0.502	0.360	0.336	0.223	0.004
Services	0.919	0.662	0.662	0.615	0.615	0.556	0.556	0.443	0.443	0.333	0.214	0.214

SOUTH AFRICA	**Construction**	**Manufacturing**	**Mining**	**Trade**	**Services**
BIN_{t-1}	0.9344	0.9574	0.9265	0.9159	0.9947
GDP_{t-1}	0.8873	0.8742	0.8220	0.8862	0.9947
IND_{t-1}	0.8873	0.8742	0.7986	0.8862	0.8487
CPI_{t-1}	0.8439	0.8004	0.7986	0.8655	0.8033
$RATE_{t-1}$	0.8439	0.8004	0.7122	0.8655	0.8033
$REER_{t-1}$	0.7475	0.5227	0.5494	0.8606	0.5941
BIN_{t-2}	0.7475	0.5227		0.7106	
GDP_{t-2}	0.6263	0.1654		0.6913	
IND_{t-2}	0.6263	0.1315		0.6913	
CPI_{t-2}	0.6247	0.1315		0.5897	
$RATE_{t-2}$	0.6247	0.1235		0.5694	
$REER_{t-2}$	0.5641	0.0890		0.5694	
BIN_{t-3}	0.5641			0.5593	
GDP_{t-3}	0.5306			0.4897	
IND_{t-3}	0.5306			0.4897	

SOUTH AFRICA	Construction	Manufacturing	Mining	Trade	Services
CPI_{t-3}	0.4441			0.2926	
$RATE_{t-3}$	0.3231			0.2926	
$REER_{t-3}$	0.0337			0.2795	