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THE IMPACT OF COMMODITY PRICE SHOCKS IN A MAJOR PRODUCING ECONOMY. THE CASE OF COPPER AND CHILE*

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Abstract

The present study analyzes how copper price shocks affect macroeconomic variables in Chile, which is the largest producer in the world of this commodity. It is taken into account that shocks with different sources may have different impacts and a separation is made between supply, demand, and specific copper demand shocks. The empirical analysis is based on a structural VAR model, where shocks are identified by sign restrictions, i.e. restrictions are imposed on impulse-response functions. Indeed the results show that the source of the shock is relevant for the economic impact. While a rise in the copper price caused by increased world demand implies higher growth in Chile, impacts of supply and specific copper demand shocks are, at least in the short run, negative for growth. Higher growth in the case of a demand shock implies higher inflation after a couple of quarters and a following more restrictive monetary policy (higher interest rate). A supply shock, on the other hand, does not have significant effects on either inflation or the interest rate. A specific copper demand shock results in a (though not statistically significantly) depreciation of the exchange rate and higher inflation, which, in turn, implies a higher interest rate.

Resumen

El presente estudio analiza cómo afectan los shocks sobre el precio del cobre las variables macroeconómicas en Chile, que es el mayor productor mundial de este metal. Se ha tomado en cuenta que los shocks de distintas fuentes pueden generar diferentes impactos, y por lo tanto se ha separado entre shocks de oferta, demanda y específicos a la demanda de cobre. El análisis empírico está basado en un modelo VAR estructural, donde los shocks son identificados por restricciones de signo, i.e. se imponen restricciones en las funciones de impulso–respuesta. En efecto, los resultados muestran que la fuente del shock es relevante para el impacto económico. Mientras un aumento en el precio del cobre causado por un incremento en la demanda mundial genera un mayor crecimiento en Chile, los efectos de un shock a la oferta y específico a la demanda de cobre es, al menos en el corto plazo, negativo para el crecimiento. En el caso de un shock de demanda, mayor crecimiento implica mayor inflación luego de un par de trimestres y una posterior política monetaria más restrictiva (tasa de interés más alta). Un shock de oferta, por otro lado, no tiene efectos significativos ni en la inflación ni en la tasa de interés. Un shock específico de la demanda de cobre provoca una depreciación (aunque no estadísticamente significativa) del tipo de cambio y mayor inflación, lo que, a su vez, motiva una mayor tasa de interés.

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1. Introduction

While shocks to oil prices have been heavily investigated in the literature, few studies exist on the effects of shocks to prices of other commodities, even though international food prices have attracted more attention since the commodity price boom-bust period in 2007-9. The reason is probably that changes in oil and food prices affect the majority of countries, while the impact of, say, shocks to metal prices affect mainly, but not only, countries that are producers or large importers. The “not only” refers to the fact that shocks to metal prices affect costs of construction, whereas oil and food price shocks are more visible, at least in the short-run, as they affect consumer prices relatively fast.

The focus of the present study is how shocks to commodity prices affect the economy of the country in which the commodity is produced. More precisely, the issue of interest is how fluctuations in the copper price affect the Chilean economy, bearing in mind that Chile produces one third of all the copper used in the world. This objective is met by estimating a structural vector autoregressive (SVAR) model with two blocks of variables; three global variables used to identify the source of the shock and four Chilean variables to measure the effects on the Chilean economy. Shocks are identified by imposing sign restrictions on impulse-response functions.

Evidence suggests that indeed the source of the shock is important for impacts in the Chilean economy. While a demand-pull copper price increase implies more growth in Chile, the growth impact of supply and specific copper demand shocks is, at least in the short run, negative. Negative growth may be caused be an initial appreciation of the exchange rate, which brings difficulties for exporters of other goods to sell their articles at world markets. Higher growth in the case of a demand shock implies higher inflation after a couple of quarters and an accompanying more restrictive monetary policy (higher interest rate). A supply shock, on the other hand, significantly affects neither inflation nor the interest rate. A specific copper demand shock results in a (non-significant) exchange rate depreciation and higher inflation. This, in turn, implies a higher interest rate.

The economics of exhaustible resources has interested researchers for a long time.[1] One direction of research focuses on modeling and forecasting commodity prices (e.g. Labys, 2006), while another more related to the present paper analyzes how fluctuations in commodity prices affect economic variables and policies. While oil price shocks have attracted a lot of attention amongst researchers, investigation of shocks to other commodity prices is less developed. A number of papers, however, have analyzed the general impact of commodity price shocks. Böwer et al. (2007) argue that in Western and Central African countries, the increases in commodity prices between 1999 and 2005 affected growth in oil-exporting countries positively, while non-oil-producing countries experienced lower growth rates, even though they benefitted from the overall increase in commodity prices. On the other hand, inflation rates were not affected much by commodity price changes. Akram (2007) argues that a lower real interest rate and a weaker dollar exchange rate led to higher commodity prices, while Chen et al. (2010) find that real exchange rates in commodity exporting countries are higher in periods where commodity prices are high.

The sign restriction methodology applied in this study was introduced in the late 1990s by Faust (1998), Uhlig (1999) and Canova and De Nicoló (2002), and by now several empirical applications with this approach have been published in academic journals.[2] With respect to commodity prices, applications have mainly, if not exclusively, been concerned with oil price shocks, which is the case of the studies of Peersman and Van Robays (2009, 2011). The method applied in the present paper is similar to that of Peersman and Van Robays.

The remaining of the paper is organized as follows. Section 2 discusses the literature related to the international copper market and the role of copper in the Chilean economy. The third section presents the econometric model and data utilized in the empirical analysis. This section also discusses the results of preliminary testing exercises and presents the sign restriction context in which the empirical analysis is conducted. The fourth section presents results, i.e. effects on the Chilean economy when copper price rises 10% due to a supply,

[1] For an early example, see Hotelling (1931).

[2] Fry and Pagan (2011) present a critical review of the sign restriction method.

demand, or specific copper demand shock, respectively. Finally, the fifth section offers some concluding remarks.

2. The international copper market and the Chilean economy

This section discusses, firstly, some aspects of the international copper market and, secondly, the relation between copper and the Chilean economy.

2.1 The international copper market

When unrefined copper has been extracted from the ore, it is refined in order to increase its electrical conductivity. The main purpose of copper (almost 70% of total use in 2012) is in the manufacturing of electric and electronic products and construction of buildings. In the present analysis, the copper price used is that of refined copper and world demand is measured by the gross domestic product (GDP), which includes the construction sector, rather than industrial production, which is the indicator frequently applied in oil price studies.

Between 1950 and 2013 world production of copper has grown more than six times and the international market has changed notably during the last fifty years with respect to supply as well as demand. Fisher et al. (1972) report that in 1963 the main copper producer was the US, accounting for 28% of the total production, while Chile, the second largest, produced almost 16% of the world supply.[3] According to numbers published on the webpage of the Chilean Copper Commission,[4] in 2012 Chile provided almost 32% of the world's copper production. Chile, however, exports most of the copper untreated and the share of world production of refined copper is about 14%.[5] Also on the demand side, important changes have occurred. According to Fisher et al., more than 80% of copper demand in 1963 came from the United States and Europe, while now China is responsible for around 40% of global demand.

[3] These numbers exclude eastern-bloc countries.

[4] http://www.cochilco.cl/english/.

[5] These figures are only for primary supply. An important part of the supply is secondary, i.e. recycling of copper.

The question of interest in the present study is to what extent do movements in commodity prices affect economies of producing countries. That indeed there is an effect was shown in a study of commodity price swings published by the International Monetary Fund (2012).[6] It reports that GDP across the group of commodity exporters in general is ½ to 1¼ lower during price downswings than during upswings, and this pro-cyclical behavior is most prominent in oil- and copper-exporting countries. Furthermore, the real effective exchange rate is generally stronger in upswings than in downswings.

To gain further insight into the functioning of the copper market, scholars have tried to model it in order to understand price formation, obtain estimates of elasticities and forecast future prices. An early complete model was presented by Fisher et al. (1972), who estimated supply equations for the four largest producers and one for the rest of the world. In general their estimates for short-run price elasticities are relatively low spanning from 0.07 in Zambia to 0.46 in the US.[7] Long-run elasticities are substantially higher. Supply elasticities reported by Adams and Behrman (1982) are generally in line with or lower than those of Fisher et al., while Lord (1986) reports a short-run elasticity of 0.08, a number that becomes 0.33 in the long-run. Elasticities estimated in a more recent study by Vial (2004) are within a wider range. Short-run elasticities span from -0.06 in Chile to 0.33 in Portugal, while those for the long run span from -1.33 to 3.21.

With respect to demand, Fisher et al. (1972) find short-run price elasticities between -0.22 and -0.09, while they are in the range from -0.92 to -0.19 in the long run, depending on geographic location. Taylor (1979) and Thurman (1988) find short-run elasticities of similar magnitude, while those reported by Adams and Behrman (1982) and Lord (1986) are generally lower (in absolute terms) in the short run as well as the long run. Vial (2004) supplies elasticities for eighteen countries and in the short run they span from -0.54 to 0.07, while those of the long run are in the range of -8.16 to -0.01.

[6] Chapter 4: Commodity Price Swings and Commodity Exporters.

[7] Differences in elasticities may be partly explained by the so-called two price system, where some major producers held their prices below the market-clearing level (see McNicol, 1975).

2.2. Copper and the Chilean economy

Chile's position in the international copper market has increased notably during the last half century, from 13% of the world production in 1960 to 32% in 2011.[8] About one third of the production comes from the state-owned company, Codelco, while the remaining is produced by private companies. More than half of total exportation is copper and the mining sector contributes more than 20% to the total public revenue. More than fifty thousand persons are employed directly in the mining sector, while estimates suggest that about 6.5% of total employment depends directly or indirectly on the mining industry. Thus, obviously the international price of copper has important effects on the Chilean economy, even though the direct effect on public spending is limited by the fiscal rule, which has been operating since 2002 with the current method of estimating the long-run copper price.[9] Possible effects may also be limited by the inflation targeting framework, which was partially implemented in 1990 and fully in 1999; firstly in a context where the target was gradually reduced and since 2001 the target has been fixed at three percent.

The question of relevance is how do swings in the copper price affect the Chilean economy. Calvo and Mendoza (1998) estimate a VAR model with data from 1986 to 1997 and find that the terms of trade, defined as the ratio of copper price to oil price, Granger-causes Chilean activity. Medina and Soto (2007) utilize a dynamic stochastic general equilibrium (DSGE) model to analyze the effect of implementing a fiscal rule. They argue that if fiscal policy turns expansionary when the copper price increases, then a 10% price shock implies that GDP will rise 0.7%, inflation will be 0.03 percentage points higher, and the exchange rate will appreciate by 0.2%. On the other hand, when a structural balance fiscal rule is imposed in the model, GDP increases merely 0.05%, inflation is practically unaltered and the exchange rate appreciates 0.09%. Applying a four dimensional VAR model, where shocks are identified by a Cholesky decomposition, Medina (2010) finds that an international commodity price shock affects Chilean GDP positively, and significantly so. De Gregorio and Labbé (2011) estimate a vector error correction model (VECM) with data

[8] Numbers cited are from Meller (2013).

[9] See e.g. Rodríguez et al. (2007) or Pedersen (2008) for a description of the fiscal rule.

from 1977 to 2010 and argue that the Chilean economy has become more resilient to copper price shocks, partly because the real exchange rate has acted as a shock absorber.

The present study differs from existing copper price studies by analyzing how shocks to the copper price affect the Chilean economy when differences in the sources of the shocks are taken into account. Methodology and data are described in the following section and results are reported in section 4.

3. The econometric model and data

The VAR model utilized in the present analysis includes seven variables, three global and four local. In order to identify the shocks, restrictions are imposed on international variables, while domestic variables remain unrestricted in order to measure the impact on the Chilean economy.

3.1. Description of data

The empirical analysis is made with data spanning the period from 1996Q1 to 2012Q1.

Global data consists of three variables: global copper production, international copper price and world activity. To measure global copper production the series "Refined Copper Production" extracted from Bloomberg (World Bureau of Metal Statistics) is utilized. The measurement is metric tons. Copper price observations are extracted from the database available at the webpage of the Central Bank of Chile.[10] The price is measured as US dollars per pound of refined copper on the London Metal Exchange (LME). World activity is measured by the GDP World series (code: 00199BPIZF…), which is an aggregate of 188 countries, extracted from International Monetary Fund's International Financial Statistics (IFS). Measurement is real US dollars and the series is represented as an index (2005 = 100).

[10] http://si3.bcentral.cl/Siete/secure/cuadros/home.aspx?Idioma=en-US. Results do not change when the real copper price is used. The deflator utilized is the US producer price index extracted from the IMF's IFS database. The correlation between nominal and real prices is 0.99 for the period considered.

Local data of Chilean activity, prices, interest rates and foreign exchange rate are all from the webpage of Central Bank of Chile. The activity series is named "GDP, chained volume at previous year prices" and it is a linked series, reference 2008, measured in millions of chained-pesos. Price observations are included in a series that has been spliced by quarterly inflation rates. The consumer price index (CPI) utilized is named "Headline CPI" and from 1996 to 2009 the base of the index is 2008, and 2009 for the remaining observations. Interest rate is the average nominal lending rate of the financial system, 30 to 89 days (annual percentage), while the exchange rate is the "Observed dollar," which is measured as Chilean pesos (CLP) per US dollar (USD).

3.2. Model and preliminary tests

As often happens when analyzing macroeconomic time series, univariate unit-root tests are inconclusive for some of the series included in the analysis. Based on economic intuition, all global variables and three Chilean (CPI, GDP and the exchange rate) are assumed to be non-stationary. The nominal interest rate, on the other hand, is assumed to be stationary as it is unlikely that copper price shocks would have permanent effects on the interest rate.[11]

Allowing for a maximum of five lags, information criteria suggest that one (Schwarz) or five (Akaike and Hannah-Quinn) lags should be included in the VAR model formulated in levels. The final model includes two lags,[12] i.e. one lag in differences, which appears to be sufficient to obtain errors which are not affected by autocorrelation or are skewed[13] when including seasonal dummies and dummies to deal with outliers.[14] The Johansen Trace test indicates that no cointegration exists amongst variables.

[11] Furthermore, if the real interest rate and the inflation rate are stationary, the nominal interest rate must be stationary as well. A similar specification is applied by Peersman and Van Robays (2009) for studying the impact of oil price shocks.

[12] Killian (2001) argues that more precise impulse-response functions may be estimated if including more lags than what is suggested by the conservative Schwarz criterion.

[13] Juselius (2006) notes that estimated VAR models are more sensitive to non-normal residuals caused by skewness than by excess kurtosis.

[14] Dummies included are for the following observations: 1998Q3, 2001Q1, 2005Q4, and 2010Q1.

The SVAR can be written as

$$\begin{bmatrix} Y_t \\ X_t \end{bmatrix} = C + A \begin{bmatrix} Y_{t-1} \\ X_{t-1} \end{bmatrix} + B \begin{bmatrix} \varepsilon_t^Y \\ \varepsilon_t^X \end{bmatrix}, \tag{1}$$

where Y_t includes three global variables: growth in world production of refined copper (Δq_t), change in international copper price (Δcp_t) and world activity growth (Δw_t), while X_t contains four local variables: national production growth (Δy_t), inflation rate (Δp_t), short-term nominal interest rate (R_t), and exchange rate appreciation (Δs_t). Small letters indicate that variables are measured in logarithms. The term C includes the deterministic components of the model (constant,[15] centered seasonal dummies and centered outlier-dummies), A is the coefficient matrix for lagged variables, while B is a contemporaneous effects matrix.

As Chile is a relatively small economy, it is very unlikely that the Chilean variables included in the model would affect global variables. To deal with this, zero-restrictions are imposed on the A matrix such that there is no feedback from local to global variables. The inclusion of the zero-restrictions was supported by a Wald test with a p-value of 0.10.

3.3. Identification with sign restrictions

Structural innovations, represented by the εs in (1), are uncorrelated such that the variance-covariance matrix of reduced form estimated VAR can be written as $\Omega = BB'$. As is well-known, for a fixed Ω several possibilities exist for B and, hence, it is necessary to place restrictions on this matrix to obtain an identification of the shocks. In the present context restrictions are placed merely in the part of the B matrix corresponding to the global shocks.

Briefly speaking, the methodology consists in Bayesian estimation where prior and posterior distributions belong to the normal-Wishart family.[16] For each estimated model the impulse-response (IR) function is calculated and restrictions are imposed on responses in

[15] The null hypothesis for exclusion of the deterministic trend could not be rejected when applying a Wald test (p-value = 0.29).

[16] For more details, see Peersman and Van Robays (2009, 2011) and Peersman (2011). The methodology has also been applied by Canova and De Nicoló (2002, 2003).

order to identify the shocks. Only results that comply with these restrictions are kept, while the remaining are deleted. When 1000 successful draws are obtained, they are ordered according to size and the distribution is shown graphically with median and percentiles 16 and 84, which has become standard in the literature using this method.

Three kinds of shocks are identified. A supply shock occurs in a situation where the copper price rises in a context where both global copper production and world activity fall. One example of this kind of shock could be the paralyzation of a big copper mine (maybe because of a natural disaster) in a major producing country. The demand shock is defined as a situation where the copper price rises in circumstances where world activity and global copper production increase. An example could be higher growth in a major economy such as the US or China. The final shock has to be orthogonal to supply and demand shocks, hence, a possibility is a situation where the copper price rises, copper production increases and world activity falls. As this is neither a supply nor a demand shock, it is interpreted as a specific copper demand shock, i.e. a shock where the copper price rises; even though fundamentals imply that it should fall. An example of a specific copper demand shock is a speculative shock, where investors buy (sell) copper, expecting the price to rise (fall).[17] Another example is a demand for copper as collateral to obtain financing, which is most notable in China.[18] Table 1 summarizes the restrictions, which are placed on the accumulated impulse-response functions. They apply for four periods, i.e. the first year after the shock.

Table 1. Sign restrictions

	q_t	cp_t	w_t
Supply shock	-	+	-
Demand shock	+	+	+
Specific copper demand shock	+	+	-

[17] Examples of recent studies that account for possible speculative effects in commodity prices are Killian and Murphy (2013) and Knittel and Pindyck (2013).

[18] Yuan et al. (2014) estimate that almost one third of China’s short-term foreign exchange loans are backed by commodities as collateral. See Tang and Zhu (2014) for a description of the process of commodity-based financing.

4. The impact of copper price shocks in Chile

This section presents the results of the empirical exercise aimed at analyzing how a permanent 10% copper price shock affects the Chilean economy when the origin of the shock is taken into account. Subsection 4.1 presents the results of the supply shock analysis; subsection 4.2 that of a demand shock, while subsection 4.3 reports the results for when the shock occurs because of specific copper demand. Finally, subsection 4.4 explores further the effect of copper price shocks on Chilean activity, firstly be considering investment[19] instead of GDP and, secondly, by separating activity between production of the mining and non-mining sector, respectively. This last exercise is also performed with data of employment.

4.1. Copper supply shocks

Figures 1 and 2 present the results from a negative supply shock.[20] As can be appreciated in the graphs, the effects on the Chilean economy are relatively small, and in most cases not statistically significant. Chilean activity falls initially due to the fall in world activity, and the currency appreciates a bit the same period the shock occurs. Both of these effects are statistically significant and the appreciation of the CLP can be explained by a higher inflow of USD due to the higher copper price. In the long run the effect on activity is still negative and the CLP price measured in USD is a bit higher, but none of these effects is statistically significant. The interest rate falls initially as monetary policy turns more expansionary to accommodate the fall in activity even though inflation rises in the beginning. Neither of these effects is, however, statistically significant.

[Figure 1]

[19] Fornero and Kirchner (2014) examine a DSGE model for Chile where agents learn about the persistence of commodity price shocks. They find that investment increases in a gradual way driven by investment in the commodity sector. In the same line, Fornero et al. (2014) consider six major commodity exporting countries and argue that in most of them the expansionary effects of positive commodity price shocks are driven by investment in the commodity sector and there is spill over to the other sectors.

[20] Short-run effects are differences of the responses, while long-run effects refer to levels.

[Figure 2]

4.2. World demand shocks

The positive shock to world activity affects Chilean activity positively as shown in figures 3 and 4. The growth rate increases initially and stabilizes after a year, while activity remains more stable with a small decline at the end of the period shown in the graphs. Higher activity, in turn, affects inflation that rises as well, and the price level remains significantly higher. The interest rate falls initially to compensate the effect of appreciated currency, but in the longer run monetary policy tightens, due to higher growth and inflation, even though the effect on the interest rate is not statistically significant after the second quarter. As mentioned, the exchange rate falls, i.e. the CLP appreciates, due to a higher inflow of USD and the effect is statistically significant the first two years.

[Figure 3]

[Figure 4]

4.3. Specific copper demand shock

When the copper price rises because of a specific copper demand shock, the negative impact on world activity affects Chilean activity and this effect seems to be permanent, as shown in figures 5 and 6. Inflation increases leading to a more contractionary monetary policy reaction such that the interest rate increases as well, but it returns to its original level when the inflationary period ends. Initially the currency appreciates a bit because of higher dollar inflows, but in the longer term it is more likely to depreciate, even though this effect is not statistically significant. This depreciation, however, may partly explain the combination of lower growth and higher inflation.

[Figure 5]

[Figure 6]

4.4. Exploring the effect on domestic activity

The baseline analysis presented in the previous three subsections included Chilean GDP to measure the effect on domestic activity. In the present subsection, the impact on domestic activity is explored in further detail. First, GDP is replaced with investment as the impact may be different because a higher copper price may stimulate investment, particularly in the mining sector. Presently no quarterly disaggregated data exists for Chile, which makes it possible to distinguish investment between different sectors and, thus, two additional exercises are supplied to evaluate differences between mining and non-mining activity. The first separates GDP between the mining and the non-mining sector and the second does the same for employment.

4.4.1. Effects on investment

Data for investment is extracted from the Central Bank of Chile and the series is named "Gross fixed capital formation, GDP expenditure chained volume at previous-year prices" and it is a linked series, reference 2008, measured in millions of chained-pesos. Figure 7 shows short- and long-run effects on investment in Chile from a 10 percentage point increase in the copper price due to supply, demand, and specific demand shock, respectively.

[Figure 7]

For supply and demand shocks the effects on investment are similar to those of the GDP. In the case of a supply shock, the effect on investment initially is less negative than for the entire GDP, but it becomes more negative in the short-to-medium term and again less so in the long run. Hence, in this case the effect of lower demand dominates the effect of a higher copper price, which probably happens because the negative shock to copper production with some probability happens in Chile even though this cannot be directly inferred with the available data. A demand shock, on the other hand, affects Chilean investment more strongly than the rest of the GDP, as the increasing copper price stimulates investment in the mining sector. This effect is also visible with a specific copper demand shock, where investment increases the first year and a half, but in the longer run the effect of lower world activity dominates, and in the long-run the negative effect on investment is greater than for the rest of the GDP.

4.4.2. Effect on mining and non-mining sectors

Activity of the Chilean mining sector is measured by the series "Gross domestic product contribution of mining", which is also extracted from the webpage of Central Bank of Chile and is comparable with the GDP series utilized for overall Chilean activity. The GDP excluding the mining sector is calculated as the difference between the two series. The model (1) is altered such that X_t includes five series, i.e. growth rates of GDP mining and GDP non-mining replace the national growth series. A similar exercise is made for employment, where the data is available from the webpage of the National Statistical Institute in Chile.[21] Results of the two exercises are shown in figure 8.

[Figure 8]

A supply shock has negative effects on the mining as well as the non-mining sector, and the effect is largest in the mining sector, which may, as discussed earlier, be explained by the fact that Chile is the largest producer of copper in the world, and a supply shock large enough to affect prices may occur in Chile. The same effects are present in employment. A demand shock affects both the mining sector and the rest of the economy positively; in the long run the effect is largest in the mining sector. Employment in the non-mining sector, however, is practically unchanged, while that of mining increases in the short run, but the long-run impact is negative. In any case, impacts on employment are relatively small and, in fact, they are not statistically significant.

A specific copper demand shock has a negative impact on the mining as well as the non-mining sector, but in the long run the effect of the higher copper price dominates in the mining sector, and the effect becomes positive, though not statistically significantly so.

[21] From 2010 the series used are "Ocupados total" and "Ocupados por rama de actividad económica. Explotación de minas y canteras" and before 2010 the same series are extracted from "Cuadro No. 3 – Serie empalmada". In the case of the mining sector, series are spliced backwards with monthly changes. The series cover the whole country and are measured in thousands of persons.

Somewhat puzzling, the effect on employment seems to be positive in the short run for the non-mining sector and negative in mining, but none of the initial effects is statistically significant. The negative long-run effect in mining is statistically significant probably because of the initial negative impact on production.

5. Concluding remarks

As a major producer of copper and copper being the main exportation article of the economy, swings in the copper price naturally affect Chilean macroeconomic variables. This in a context where the Chilean governments have conducted fiscal policy according to an arguably counter-cyclical fiscal rule, where the current copper price has little impact on the budget, and the anchor of monetary policy is inflation targeting with a fully flexible exchange rate.

As demonstrated in the empirical analysis, however, the source of the price shock is important for the impact on economic variables. A rise in the copper price caused by increased demand implies higher growth in Chile, while the effects of supply and specific copper demand shocks are, at least in the short run, negative for growth. Higher growth in the case of a demand shock implies higher inflation rates after a couple of quarters and a more restrictive monetary policy (higher interest rate). A supply shock, on the other hand, does not have a significant impact on either inflation or the interest rate. A specific copper demand shock results in a depreciated exchange rate, though not statistically significant, and higher inflation rates. This, in turn, implies a higher interest rate. These results suggest that policy makers have to take into account the source of the shock when evaluating possible policy options in response to copper price shocks.

References

Adams, F.G. and J.R. Behrman (1982), *Commodity Export and Economic Development*, Lexingtonbooks.

Akram, Q.F. (2009), ‘Commodity prices, interest rates and the dollar′, *Energy Economics*, 31, 838-851.

Böwer, U., A. Geis and A. Winkler (2007), ‘Commodity price fluctuations and their impact on monetary and fiscal policies in Western and Central Africa’, *Occasional Paper No. 60,* European Central Bank.

Calvo, G.A. and E.G. Mendoza (1998), ‘Empirical puzzles of Chilean stabilization policy’, *Document prepared for the seminar on Chile Development Lessons and Challenges organized by the Economic Development Institute of the World Bank, held in Washington D.C., December 17-18, 1997,* March 6.

Canova, F. and G. De Nicoló (2002), ‘Monetary disturbances matter for business fluctuations in the G-7’, *Journal of Monetary Economics,* 49(6), 1131-1159.

Canova, F. and G. De Nicoló (2003), ‘On the sources of business cycles in the G-7’, *Journal of International Economics,* 59(1), 77-100.

Chen, Y.-C., K. Rogoff and B. Rossi (2010), ‘Can exchange rates forecast commodity prices?’, *Quarterly Journal of Economics,* 125(3), 1145-94.

De Gregorio, J. and F. Labbé (2011), ‘Copper, the real exchange rate and macroeconomic fluctuations in Chile’, *Working Paper No. 640,* Central Bank of Chile.

Faust, J. (1998), ‘The robustness of identified VAR conclusions about money’, *Carnigie-Rochester Conference on Public Policy,* 49, 207-244.

Fisher, F.M., P.H. Cootner and M.N. Baily (1972), ‘An econometric model of the world copper industry’, *The Bell Journal of Economics and Management Science,* 3(2), 568-609.

Fornero, J. and M. Kirchner (2014), ‘Learning about commodity cycles and saving-investment dynamics in a commodity-exporting economy’, *Working Paper No. 727,* Central Bank of Chile.

Fornero, J., M. Kirchner and A. Yany (2014), ‘Terms of trade shocks and investment in commodity-exporting economies’, *Paper prepared for the 18th Annual Conference of the Central Bank of Chile “Commodity Prices and Macroeconomic Policy” on October 23rd 2014.*

Fry, R. and A. Pagan (2011), 'Sign restrictions in structural vector autoregressions: A critical review', *Journal of Economic Literature*, 49(4), 938-960.

Hotelling, H. (1931), 'The economics of exhaustible resources', *Journal of Political Economy,* 39(2), 137-175.

International Monetary Fund (2012), *World Economic Outlook*, April.

Juselius. K. (2006), *The Cointegrated VAR model: Methodology and Applications*, Oxford University Press.

Killian. L. (2001), 'Impulse response analysis in vector autoregressions with unknown lag order', *Journal of Forecasting*, 20(3), 161-179.

Killian, L. and D.P. Murphy (2013), 'The role of inventories and speculative trading in the global market for crude oil', *Journal of Applied Econometrics*, 29(3), 454-478.

Knittel, C.R. and R.S. Pindyck (2013), 'The simple economics of commodity price speculation', *Working Paper No. 2013-006*, MIT Center for Energy and Environmental Policy Research.

Labys, W.C. (2006), *Modeling and Forecasting Primary Commodity Prices*. Ashgate Publishing Company.

Lord, M.J. (1986), 'Market price models for Latin America´s major commodity exports', *Working Paper 86/1*, Economic and Social Development Department, International Economics Section, Inter-American Development Bank.

McNicol, D.L. (1975), 'The two prices systems in the copper industry', *The Bell Journal of Economics*, 6(1), 50-73.

Medina, J.P. and C. Soto (2007), 'Copper price, fiscal policy and business cycle in Chile', *Working Paper No. 458*, Central Bank of Chile.

Medina, L. (2010), 'The dynamic effects of commodity prices on fiscal performance in Latin America', *Working Paper WP/10/192*, International Monetary Fund.

Meller, P. (2013), *La Viga Maestra y el Sueldo de Chile. Mirando el Futuro con los Ojos del Cobre*, Ugbar Editores.

Pedersen, M. (2008), 'The Chilean fiscal rule', *Danmark Nationalbank: Monetary Review,* 3rd quarter, 131-140.

Peersman, G. (2011), 'The relative importance of symmetric and asymmetric shocks: The case of United Kingdom and the euro area', *Oxford Bulletin of Economics and Statistics,* 73(1), 104-118.

Peersman, G. and I. Van Robays (2009), 'Oil and the euro area economy', *Economic Policy*, 24(60), 603-651.

Peersman, G. and I. Van Robays (2011), 'Cross-country differences in the effects of oil shocks', *Energy Economics*, 34(5), 1532-1547.

Rodríguez, J., C. Tokman and A. Vega (2007), 'Structural balance policy in Chile', OECD, *Journal of Budgeting*, 7(2), 59-92.

Taylor, C.A. (1979), 'A quarterly domestic copper industry model', *The Review of Economics and Statistics*, 61(3), 410-422.

Tang, K. and H. Zhu (2014), 'Commodities as collateral', *Manuscript*, 22 August.

Thurman, W.N. (1988), 'Speculative carryover: An empirical examination of the U.S. refined copper market', *The Rand Journal of Economics*, 19(3), 420-437.

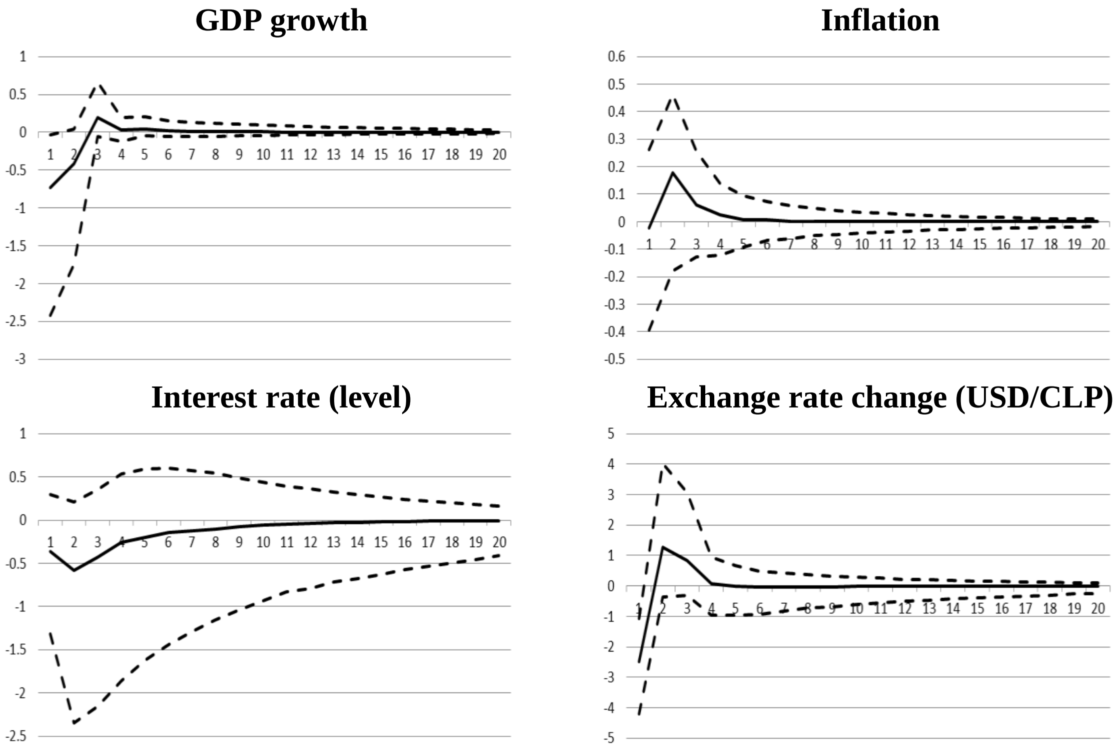
Uhlig, H. (1999), 'What are the effects of monetary policy: Results from an agnostic approach', *Working Paper No. 9928,* Tilburg University.

Vial, J. (2004), 'Modeling commodity markets in the global economy: Familiar finding and new strategies', *Working Paper No. 18,* Center on Globalization and Sustainable Development, The Earth Institute at Columbia Institute.

Yuan, R., M. Layton, J. Currie and D. Courvalin (2014), 'Days numbered for Chinese commodity financing deals', *Goldman Sachs Commodities Research*, March.

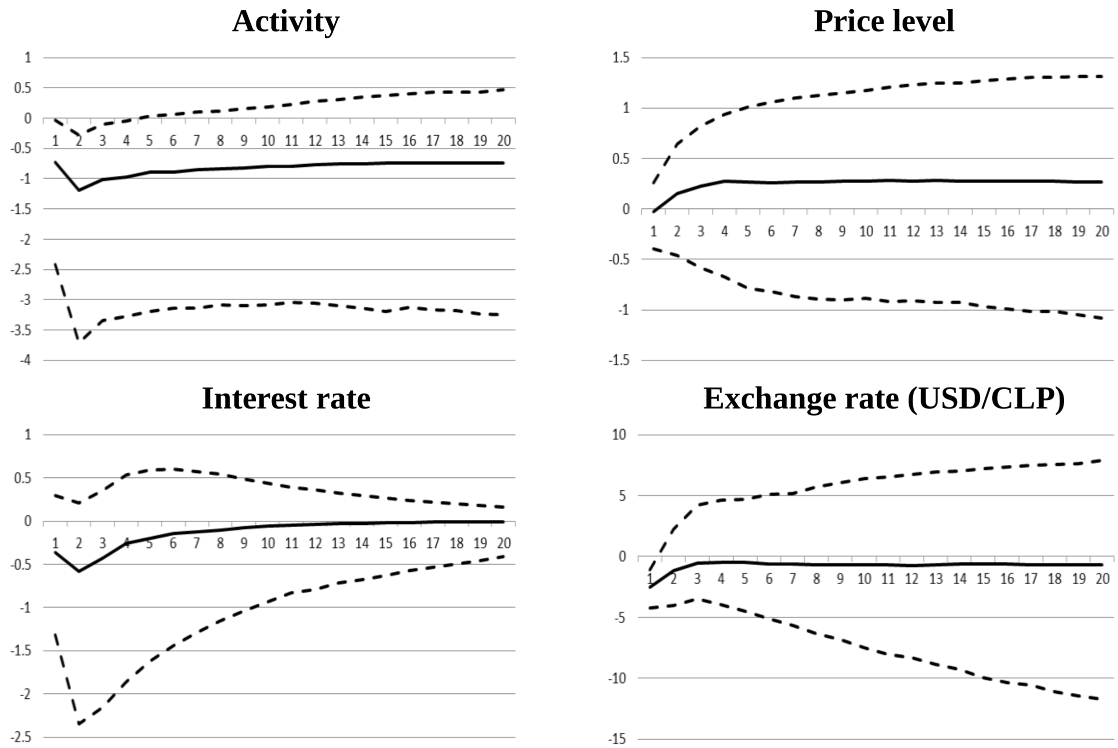
Figures

Figure 1. Supply shock: Short-run effect of a 10% copper price shock



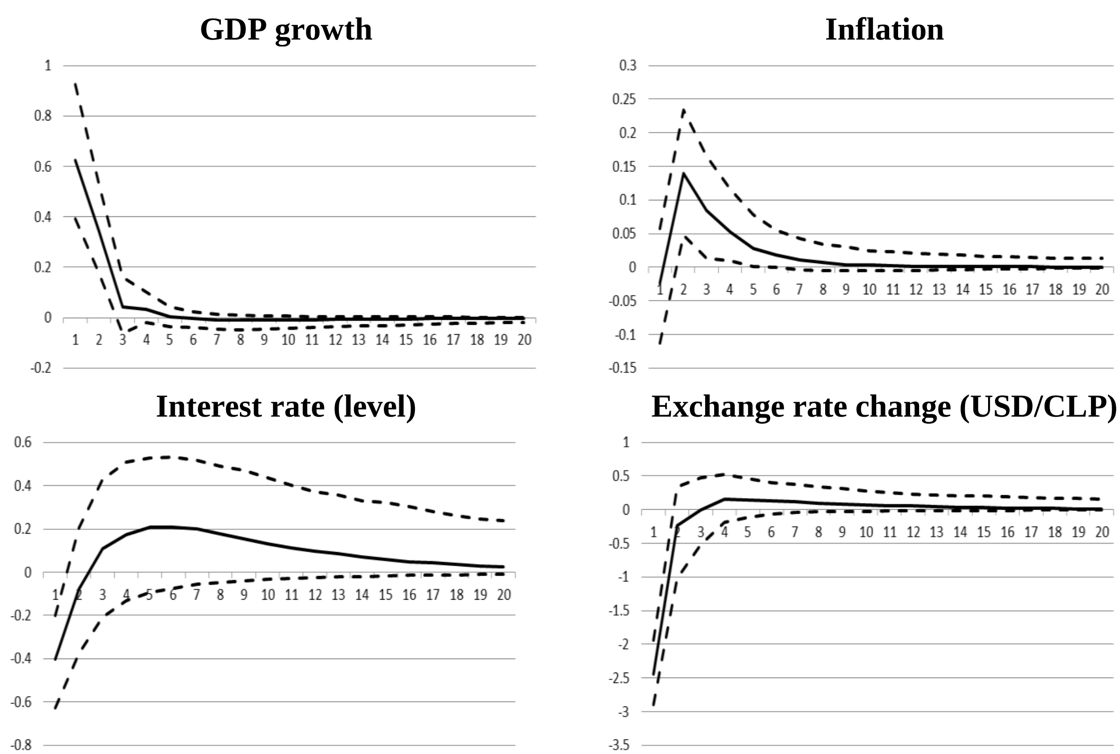
Note: Solid lines are the median, while dotted lines are percentiles 16 and 84.

Figure 2. Supply shock: Long-run effect of a 10% copper price shock



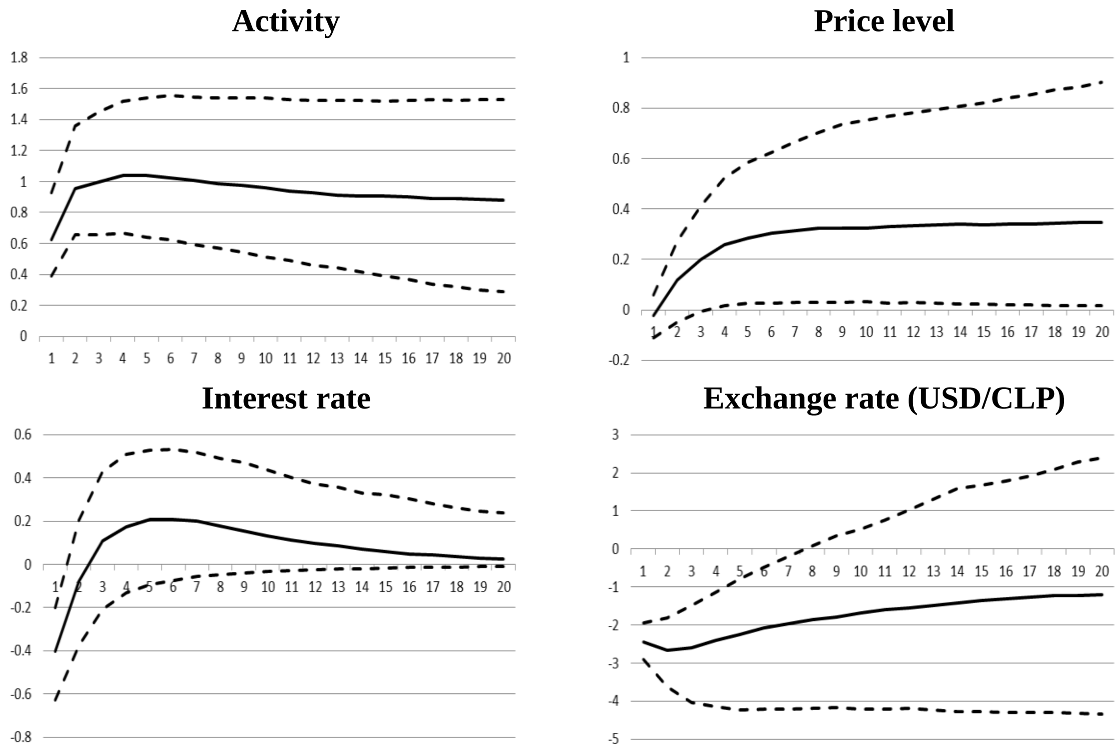
Note: Solid lines are the median, while dotted lines are percentiles 16 and 84.

Figure 3. Demand shock: Short-run effect of a 10% copper price shock



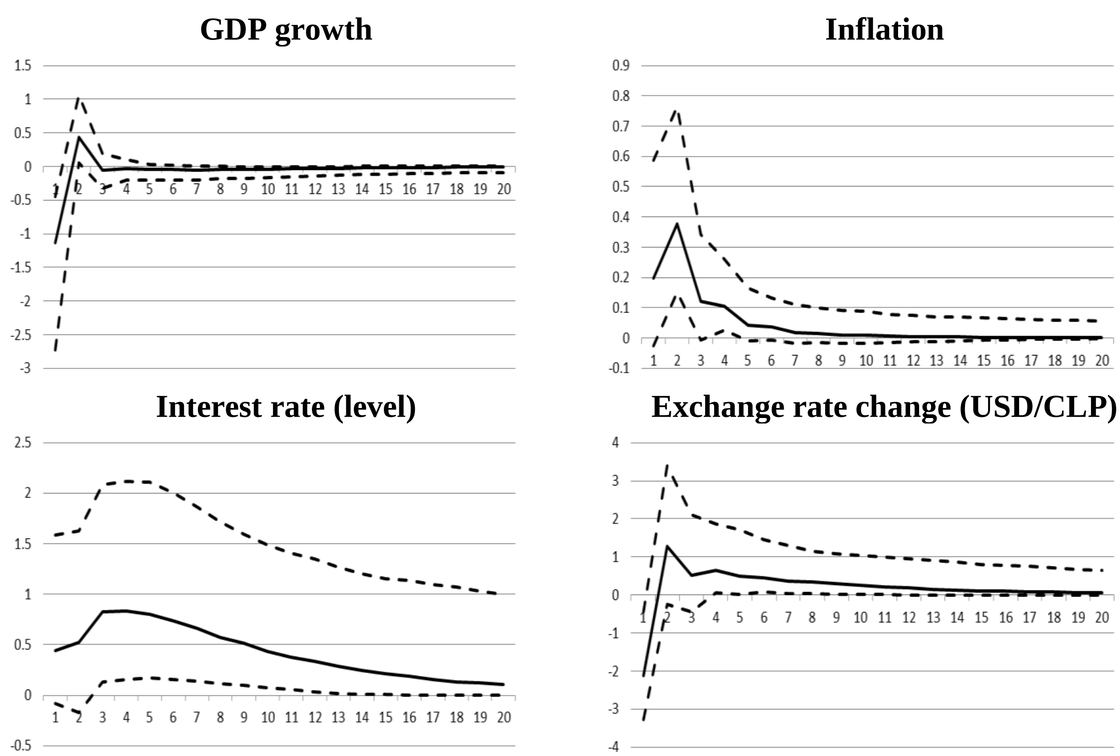
Note: Solid lines are the median, while dotted lines are percentiles 16 and 84.

Figure 4. Demand shock: Long-run effect of a 10% copper price shock



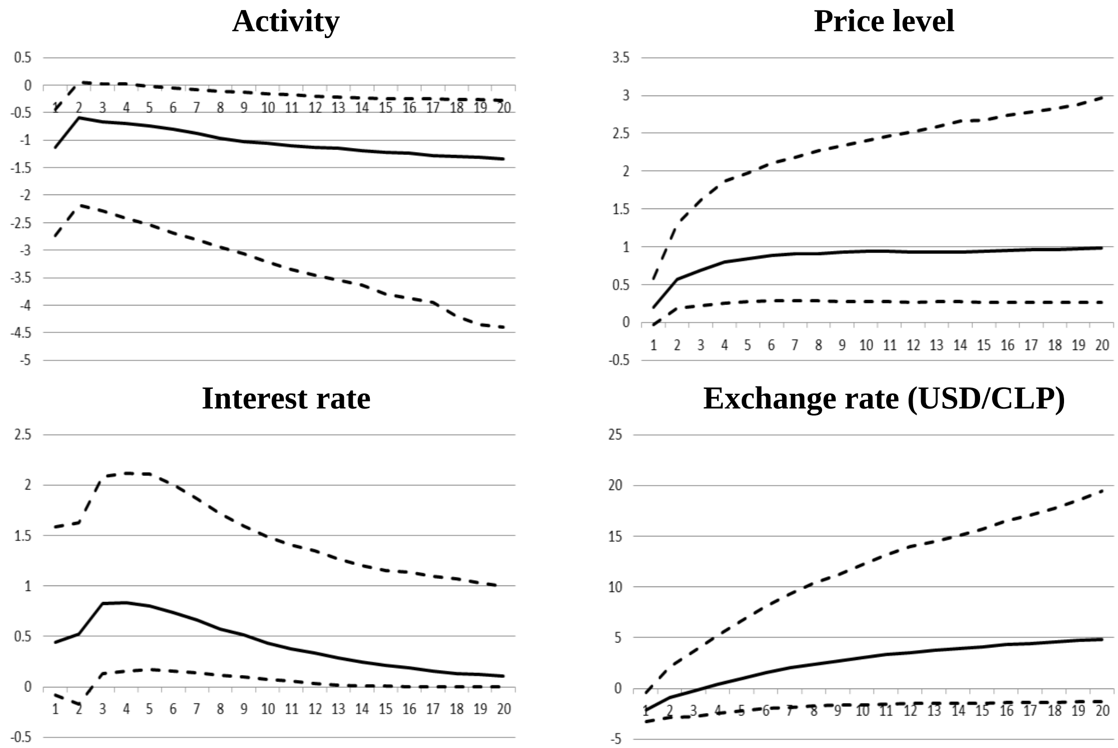
Note: Solid lines are the median, while dotted lines are percentiles 16 and 84.

Figure 5. Spec. copper demand shock: Short-run effect of a 10% copper price shock



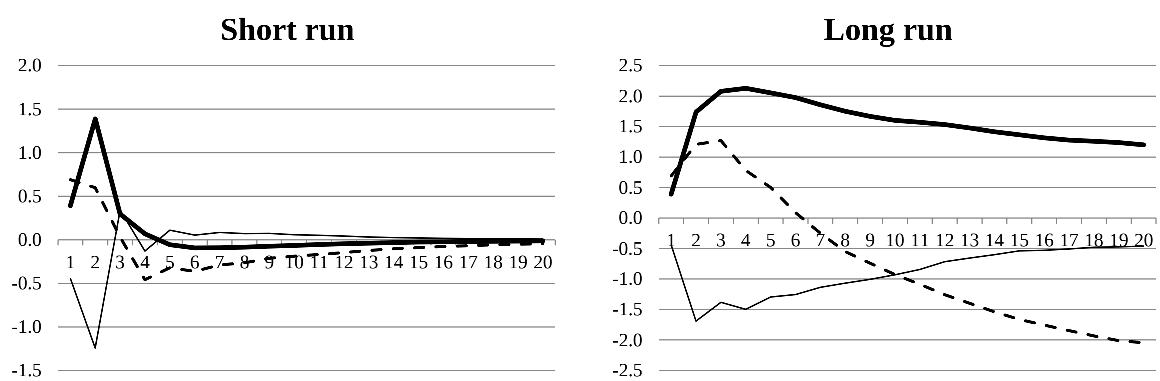
Note: Solid lines are the median, while dotted lines are percentiles 16 and 84.

Figure 6. Spec. copper demand shock: Long-run effect of a 10% copper price shock



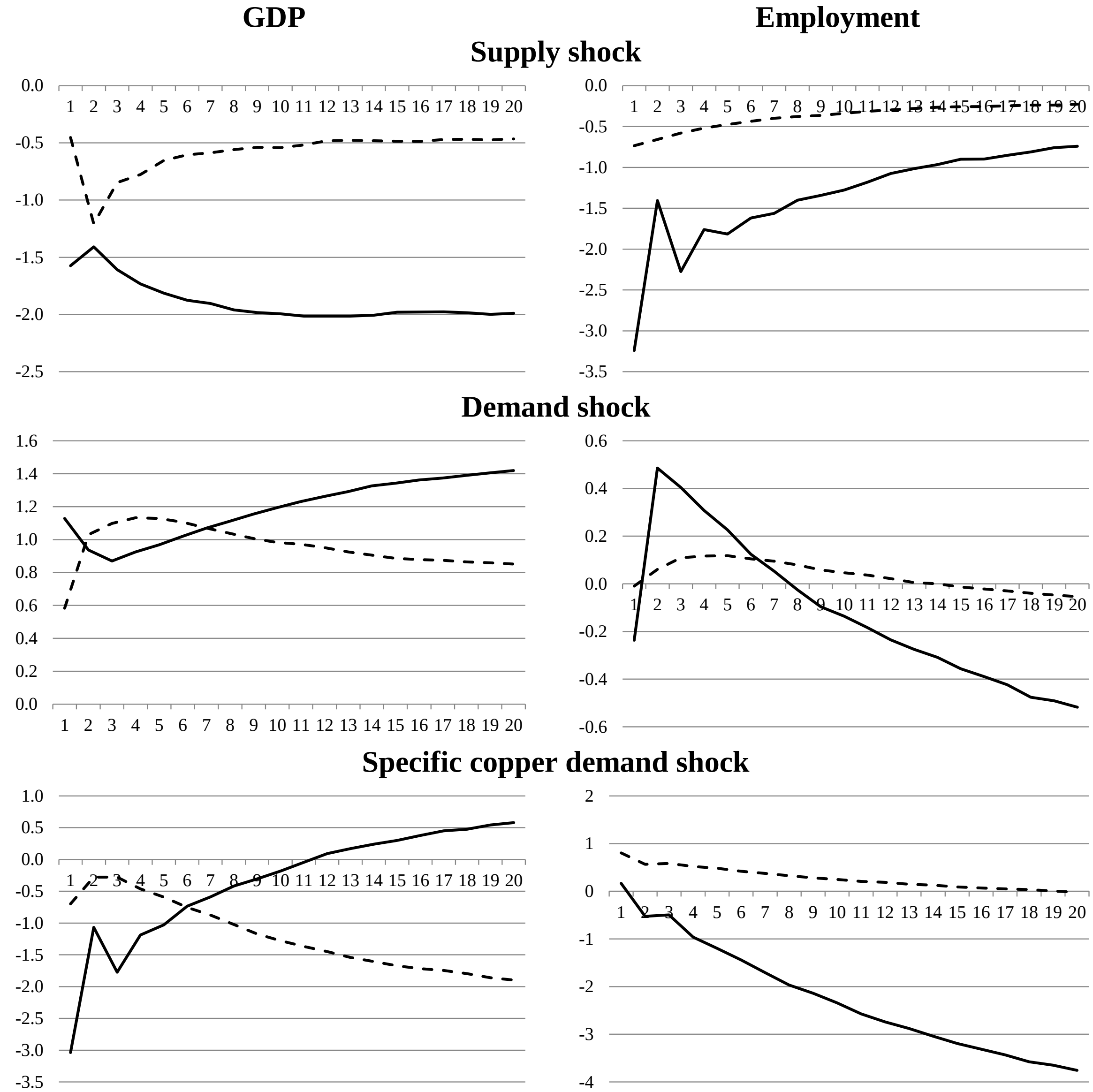
Note: Solid lines are the median, while dotted lines are percentiles 16 and 84.

Figure 7. Effect on investment of a 10% copper price shock (median)



Note: Solid thin line is supply shock, thick line demand shock and dotted line specific demand shock.

Figure 8. Long-run effects of a 10% copper price shock (median)



Note: Solid lines are for the mining sector, while dotted lines are non-mining.

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