The impact of commodity price shocks in a major producing economy. The case of copper and Chile

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Abstract

Volatile commodity prices have more or less become a stylized fact in the world economy today. Countries where commodities are produced are naturally affected by these price swings and in some of them the production and exportation of these basic goods are of great importance for the local economies. In this context, a fundamental question is how commodity price shocks affect the economy of mayor producing countries.

The present study analyzes how copper price shocks impact the economic 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 impact, and a separation is made between supply, demand, and speculative shocks. The empirical analysis is based on a structural VAR model, where the shocks are identified by sign restrictions, where the restrictions are imposed on the 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, the impacts of supply and speculative shocks are, at least in the short-run, negative for the growth. The reason may be an initial appreciation of the exchange rate making it harder for producer of other goods to compete at the world market. The 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 impact on neither the inflation rate nor the interest rate. A speculative shock results in (though no significantly) a depreciation of the exchange rate and higher inflation, which, 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 policy options in response to copper price shocks.

1. Introduction

While shocks to oil prices have been heavily investigated in the literature, fewer 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 in 2007-8. The reason is probably that changes in oil and food prices affect the majority of the countries, while the impact of, say, shocks to metal prices mainly, but not only, affect the countries that are producers or large importers. The “not only” refers to the fact that shocks to metal prices affect the costs of construction, whereas oil and food price shocks are more visible, at least in the short-run, as they impact 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 the copper used in the world. This objective is met by estimating a structural vector autoregressive (SVAR) model with two blocks of variable; three global variables used to identify the source of the shock and four Chilean variables to measure the effect in the Chilean economy. The shocks are identified by imposing sign restrictions on the impulse-response functions.

The evidence suggests that indeed the source of the shock is important for the impact at the Chilean economy. While a copper price increase caused by higher demand implies more growth in Chile, the growth impact of supply and speculative shocks is, at least in the short-run, negative. The negative growth may be caused be the initial appreciation of the exchange rate, which implies difficulties for exporters of other goods to sell their articles on the world market. The 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, does not have significant impact on neither inflation nor the interest rate. A speculative shock results in a (non-significantly) depreciation of the exchange rate 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, the investigation of the effects of shocks to other commodity prices is less developed. A number of papers, however, analyze the general impact of commodity price shocks. Böwer et al. (2007) argue that in Western and Central African countries, the rising of the commodity prices between 1999 and 2005 affected the growth in oil-exporting countries positively, while the 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 the commodity price changes. Akram (2007) argues that lower real interest rate and a weaker dollar exchange rate led to higher commodity prices, while Chen et al. (2010) find that the real exchange rates in commodity exporting countries are higher in periods where commodity prices are high.

The sign restriction methodology applied in this paper was introduced in the late 1990s by Faust (1998), Uhlig (1999) and Canova and Nicoló (2002), and by now several empirical applications with this approach have been published in academic journals.[2] With respect to commodity prices, the 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, though the interpretation of one of the global shock is different due to differences in the international markets for oil and copper.

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 for the Chilean economy. The third section presents the econometric model and the 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

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

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

presents the results, i.e. the effect on the Chilean economy when the copper price rises 10% due to a supply, demand, or speculative shock, respectively. Finally, the fifth section offers the conclusions of the analysis.

2. The international copper market and the Chilean economy

This section discusses, firstly, some aspect of the international copper market and, secondly, the relation between the copper price 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 the total use in 2012) is in the manufacturing of electric and electronic products and in the construction of buildings. In the present analysis, the copper price used is that of the refined copper and the world demand is measured by the gross domestic product (GDP), which includes the construction sector, rather than industrial production, which is often the indicator used in oil price studies.

Between 1950 and 2013 the 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) reports that in 1963, the main copper producer was USA, accounting for 28% of the total production, while Chile, the second largest producers, produced almost 16% of the world production.[4] According to numbers published at the webpage of the Chilean Copper Commission[5], in 2012 Chile provided almost 32% of the world's copper production. Chile, however, exports most of the copper untreated and the share of the world production of refined copper is about 14%.[6] Also on the demand side, important changes have occurred. According to Fisher et al., more than

[4] These numbers exclude eastern-bloc countries.

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

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

80% of the copper demand in 1963 was from the United States and Europe, while China is currently responsible for around 40% of the global demand.

The question on interest in the present study is to what extent movements in commodity prices affect the economies of the producing countries. That there indeed is an effect was shown in a study of price swings in commodity prices published by the International Monetary Fund (2012).[7] It reports that GDP across the group of commodity exporters in general is ½ to 1¼ lower during 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 upswing than in downswings.

To gain further insight into the functioning of the copper market, scholars have tried to model it in order to understand the price formation, obtain estimates of elasticities and forecast the future price. An early complete model was presented by Fisher et al. (1972), who estimate 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.[8] Long-run elasticities are substantial higher. The 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 which is 0.33 in the long-run.

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 the 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 as well as the long-run.

More recent studies account for possibly speculative effects in the commodity prices. An example is the studies of Killian and Murphy (2013), who apply a sign restriction approach to investigate the role of inventories and speculative trading in the oil market. Another is

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

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

Knittel and Pindyck (2013) that present a framework, which takes into account speculation in commodity prices by modeling supply and demand in cash and storage markets for the commodity. The present study also takes into account possible speculative impact on the copper price by identifying a particular shock as speculative, as it, by definition, is not due to neither supply nor demand effects.

2.2. Copper and the Chilean economy

Chile's position in the international copper market has increased notably during the last half a century, from 13% of the world production in 1960 to 32% in 2011.[9] About one third of the production comes from the state own company, Codelco, while the remaining is produced by private companies. More than half of the total exportation is copper and the mining sector contributes by 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 the total employment depends directly or indirectly on the mining industry. Thus, obviously the international price of copper has important effect on the Chilean economy, even though the direct effect on the public spending is limited because of the fiscal rule, which has been operating since 2000.[10]

The question of relevance is how swings in the copper price affect the Chilean economy. Calvo and Mendoza (1999) estimate a VAR model with data from 1986 to 1997 and find that the terms of trade, defined at the ratio of the copper price and the oil price, Granger-causes the 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 the fiscal policy turns expansive when the copper price increases, then a 10% price shock implies that the GDP rises 0.7%, the inflation will be 0.03 percentage points higher, while the exchange rate appreciates with 0.2%. On the other hand, when a structural balance fiscal rule is imposed in the model, the GDP increases merely 0.05%, the 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,

[9] The numbers cited are from Meller (2013).

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

Medina (2010) finds that an international commodity price shock affects the Chilean GDP positively, and significantly so. De Gregorio and Labbe (2011) estimate a vector error correction model (VECM) with data from 1977 to 2010 and argue that the Chilean economy has become more resilient to copper prices shocks, partly because the real exchange rate has acted as a shock absorber.

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

3. The structural VAR 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 the international variables, while the 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. The series that define the endpoints are Chilean and World GDP, respectively.

Global data consist of three variables, global copper production, international copper price and world activity. To measure the 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.[11] The price is measured in US dollars per pound of refined copper (BML). World activity is measured by the series GDP World (code: 00199BPIZF…), which is an aggregate of 188 countries, extracted from

[11] http://si3.bcentral.cl/Siete/secure/cuadros/home.aspx?Idioma=en-US.

International Monetary Funds (IMFs) International Financial Statistics (IFS).[12] The measurement is real US dollars and the series is represented as an index (2005 = 100).

Local data of Chilean activity, prices, interest rate and foreign exchange rate are all from the webpage of the Central Bank of Chile.[13] 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, which has been spliced by quarterly inflation rates. The consumer prices indices utilized are named "Headline CPI" and from 1996 to 2009 the base of the index is 2008, while it is 2009 for the remaining of the observations. The interest rate is the average nominal lending rate of the financial system, 30 to 89 days (annual percentage), while the exchange rate is "Observed dollar" and it is measured as Chilean pesos per U.S. dollar.

3.2. 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 the global variables and three Chilean (CPI, GDP and 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 effect on the interest rate.[14]

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[15], i.e. one lag in differences, which appears to be sufficient to obtain errors which are not affected by autocorrelation or are skewed[16] when

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[12] The June 2013 issue.

[13] Data were extracted October 10, 2013.

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

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

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

including seasonal dummies and dummies to deal with outliers.[17] The Johansen Trace test indicates the no cointegration exists amongst the variables.

The SVAR can be written as

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

where Y_t includes the three global variables; the world production of refined copper (Δq_t), the international copper price (Δcp_t) and the world activity (Δw_t), while X_t contains the four local variables; national production (Δy_t), the price level (Δp_t), a short-term nominal interest rate (R_t), and the exchange rate (Δs_t). Small letters indicate that the variables are measured in logarithm. The term C includes the deterministic components of the model (constant[18], centered seasonal dummies and centered outlier-dummies), A is the coefficient matrix for the lagged variables, while B is a contemporaneous effects matrix.

As Chile is a relatively small economy, it is highly unlikely that the Chilean variables included in the model affect the global variables. To deal with this, zero-restrictions are imposed on the A matrix such that there are 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

The structural innovations, represented by the εs in (1), are uncorrelated such that the variance-covariance matrix of the 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, the restrictions are placed merely in the part of the B matrix which corresponds to the global shocks.

[17] The dummies included are for the following observations: 1998Q3, 2001Q1, 2005Q4, and 2010Q1.

[18] The Wald test for exclusion of the deterministic trend was accepted with a p-value of 0.29.

Briefly speaking the methodology consists in Bayesian estimation where prior and posterior distributions belong to the normal-Wishart family.[19] For each estimated model the impulse-response (IR) function is calculated and restrictions are imposed on the responses in order to identify the shocks. Only the results that comply with these restrictions are kept, while the remaining is deleted. When 1000 successful draws are obtained, they are ordered according to size and the distribution is shown graphically with the median and the percentiles 16 and 84, which has become standard in literature using this method.

Three kinds of shocks are identified. A supply shock, which is a situation where the copper price rises in a context where the global copper production falls and the world activity falls as well. An example of this kind of shock could be paralyzation of the copper production (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 also increase. An example could be higher growth in a mayor economy such as the US or China. The final shock has to be orthogonal to the supply shock and the demand shock, hence, a possibility is a situation where the copper price rises, the copper production increases and the world activity falls. As this is neither a supply nor a demand shock, it is interpreted as a speculative shock, i.e. a shock where the copper price rises, even though the fundamentals imply that it should fall.[20] Table 1 summarizes the restrictions placed on the impulse-response functions in the present analysis. The restrictions apply for four periods, i.e. the first year after the shock.

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

[20] In oil price applications this shock is related to specific oil demand, e.g. because of an extraordinary cold winter in, say, the U.S. A similar interpretation is not plausible for the copper market. Kilian and Murphy (2013) use oil inventories to identify the speculative component of the real oil price. Frankel and Rose (2010) find that inventories do statistically significantly affect the real copper price negatively when the econometric model is formulated in levels, but the effect is not significant when the model is formulated in first differences.

Table 1. Sign restrictions

	q_t	cp_t	w_t
Supply shock	-	+	-
Demand shock	+	+	+
Speculative shock	+	+	-

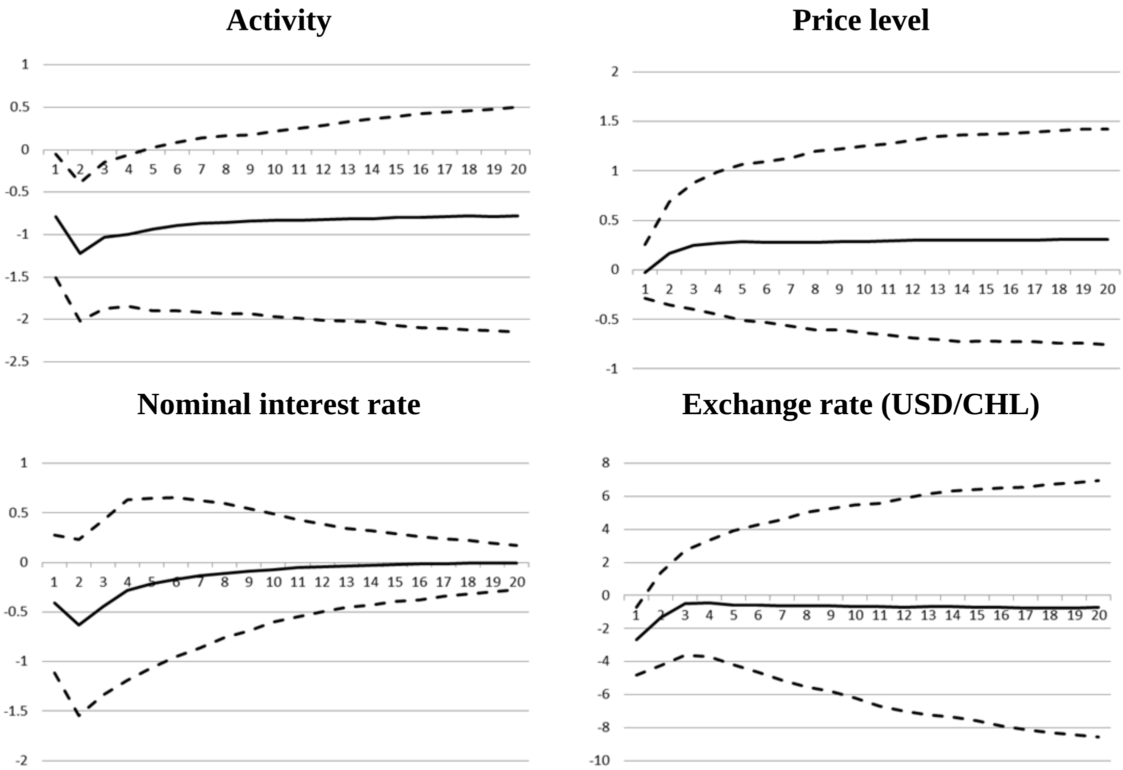
4. The impact of copper price shocks in Chile

This section presents the results of the empirical exercise aimed at analyzing how a permanent 10% copper price shock affects the Chilean economy, when taking into account the origin of the shock. 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 when the shock is speculative. Finally, subsection 4.4 briefly summarizes the results and to give an impression of the size of the effects, the responses are compared to the effects of a shock to the price of oil, of which Chile is net importer. The oil price results are obtained from Pedersen and Ricaurte (2014).

4.1. Copper supply shocks

Figure 2 presents the result when the price of copper rises because of a negative supply shock. As can be appreciated from the graphs, the effects on the Chilean economy are relatively small, and in most cases not statistically significant. It should be noted, however, that the 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 Chilean peso can be explained by higher inflow of U.S. dollars due to the higher copper price. In the long-run the effect on the activity is still negative and the price of the Chilean peso measured in U.S. dollars is a bit higher, but none of these effects are statistically significant. The interest rate falls initially as monetary policy turns more expansive to accommodate the fall in the activity even though the inflation rises to begin with. Neither of these effects are, however, statistically significant.

Figure 2. Supply shock: Effect of a 10% copper price shock

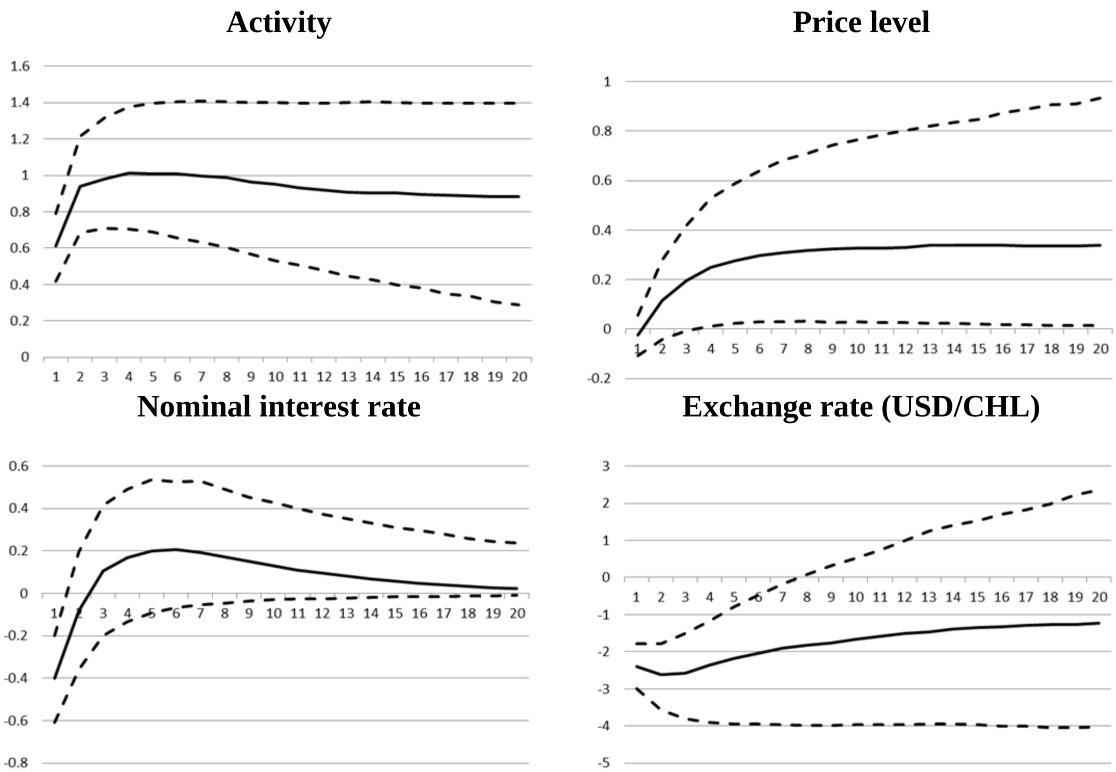


Note: Solid lines are the median, while dotted lines are percentiles 16 and 84.

4.2. World demand shocks

The positive shock to world activity affects the Chilean activity positively as shown in figure 3. The growth rate increases initially and stabilizes after a year, where the activity remains more stable with small decline at the end of the period shown in the graph. The higher activity, in turn, affects the price level that rises as well, and after a year it is significantly higher. The interest rate falls initially to compensate the effect of the appreciated currency, but in the longer run the monetary policy becomes more restrictive, due to the higher levels of activity 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 peso appreciates, due to higher inflow of U.S. dollars and the effect is statistically significant the first two years.

Figure 3. Demand shock: Effect of a 10% copper price shock

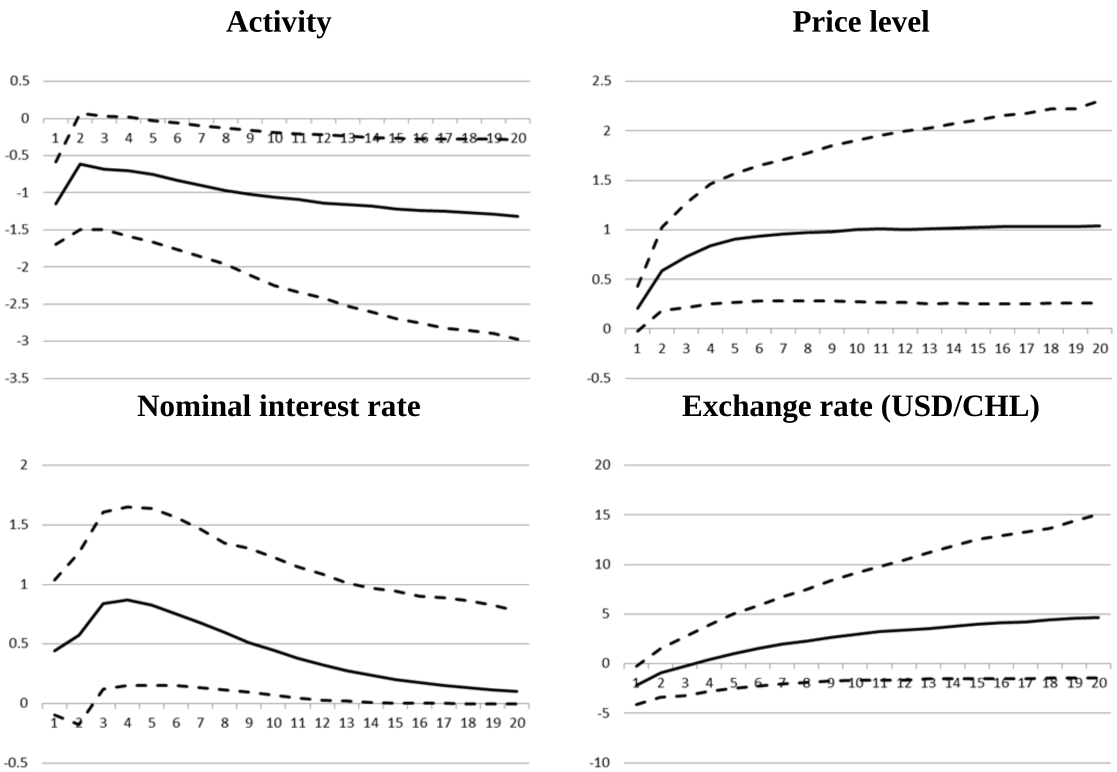


Note: Solid lines are the median, while dotted lines are percentiles 16 and 84.

4.3. Speculative price shocks

When the copper price rises because of speculation, the negative impact on world activity affects the Chilean activity and this effect seems to be permanent. The domestic prices, on the other hand, rises which leads to a restrictive monetary policy reaction such that the interest rate increases. Initially the currency appreciates a bit because of the higher dollar inflow, but in the longer term it is more likely to depreciate, even though this effect is not statistically significant.

Figure 4. Speculative shock: Effect of a 10% copper price shock



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

4.4. Copper price shock vs. oil price shock

The results reported in the three previous subsections show that the Chilean economy reacts very differently to copper price shocks depending on the source of the shock. Prices and the exchange rate, however, seem to react in similar manners when the copper price is affected by a positive shock, namely with an initial appreciation of the Chilean peso, due to more dollar inflow, and higher inflation rates. The sizes of the responses of these two variables are, however, different for different types of shocks. The impact on the Chilean activity is closely connected to the impact on world activity, i.e. it falls when shocks is caused by supply and speculation and rises when it is related to demand. The monetary policy reactions are broadly in line with what is expected from an inflation targeting central bank: the inflation rate increases in the three cases and the interest rates rises, except in the case of the supply shocks where neither the effect on inflation nor the interest rate is statistically significant.

Since this is, to the knowledge of the author, the first study to analyze the impact of a copper price shock in Chile taking into account the source of the shock, it may be useful to compare the responses with those of oil price shocks where more research is available. In a recent article Pedersen and Ricaurte (2014) analyze how a 10% oil price shock affects the Chilean economy utilizing the same methodology applied in the present study.

Generally speaking, the impact is higher in Chile from a 10% copper price shock than a 10% oil price shock. With supply and speculative copper price shocks, the Chilean activity falls more than with an oil price shock and it increases more when faced with a demand shock. With respect to the impact on the price level, it is a similar picture, the reactions are larger with copper price shocks, but in the case of a supply shock the responses are not statistically significant in any of the cases. The reactions of the interest rate are somewhat different. For a supply shock, the reaction in the oil case is initially positive, while it is negative in the copper case. Both responses are, however, not statistically significant. For the demand shock the reactions are similar but the response is significant in the first quarter only in the case of a copper price shocks. For the speculative / specific demand shock, there are important differences. In the oil case, while statistically insignificant, the response is positive the first two quarters after the shock and negative afterwards. Faced with a copper price shock, the interest rate reaction is positive and significantly so from the third quarter. Hence, it seems that the monetary response in Chile is different when faced by copper price and oil price shocks. Also with respect to exchange rate reactions there are some important differences. A supply shock results in an initial appreciation in both cases, significantly so in the case of copper, but in the long-run the peso depreciates when it is an oil price shock. The demand shock results in appreciations in both cases, but in the copper case the response is only statistically significant the first seven quarters. When the shock is speculative / specific demand related, there is an initial significant appreciation with a copper price shock and an initial significant depreciation with an oil price shock. In the long-run, however, there is an insignificant depreciation in both cases.

5. Conclusions

As a major producer of copper and copper being the main exportation article of the economy, swings in the copper price naturally affects Chilean economic variables. This in a context where 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 the monetary policy is inflation targeting and a fully flexible exchange rate.

As demonstrated in the empirical analysis, however, the source of the price shock is important for the impact on the economic variables. A rise in the copper price caused by increased demand implies higher growth in Chile, while the impacts of supply and speculative shocks are, at least in the short-run, negative for the growth. The reason may be an initial appreciation of the exchange rate, which implies difficulties for exporters of other goods to compete at the world market. The higher growth in the case of a demand shocks, 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 significant impact on neither the inflation rate nor the interest rate. A speculative shock results in a depreciated exchange rate, though not statistical significantly, 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 policy options in response to copper prices shocks.

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