The Dynamic Effects of Chilean Copper Exports and Chinese Market Disturbances

Pardo Piñashca, Eduardo

30 October 2020

The Dynamic Effects of Chilean Copper Exports and Chinese Market Disturbances

By Eduardo Andres Pardo Piñashca[1]
14100139@ue.edu.pe

This research computes the variance decomposition of Chilean copper exports from 2009 to 2019. In order to evaluate fluctuations of Chilean copper exports, we introduce the Secondary Industry of China labeled as the Chinese market (that briefly involves electricity, construction, manufacturing, and mining sectors) along with other macroeconomic variables commonly used among the literature to comprehend commodity markets. Thus following Blanchard & Quah (1985) methodology we use long-run restrictions for the SVAR model. These restrictions focus on describing small open economies such as Chile. Through the variance decomposition, we found out that Chinese market disturbances have a strong linkage describing fluctuations of Chilean copper exports over the studied period. What's more, this contribution is even greater than the international copper price and real exchange rate mainly in the long-run. Therefore, this study finds statistical proof of how relevant is the Chinese market to explain the fluctuations of Chilean copper exports even after the 2000's commodity super cycle.

During the last decades, Chile has superiorly maintained his position as the world's leading copper producer.

Chile and Peru are south American neighbors and this last country is the second-largest copper producer. Both domestic copper markets have been highly differentiated in mining policies and market portions over time. Besides, both indisputable leaders in copper production experienced nationalization in the late '60s with different outcomes. In other words, the Peruvian case suggests a wide liberalization of its market during the twentieth century while Chilean nationalization of copper in 1966 and later efforts allow the government to hold significant participation in the copper market.

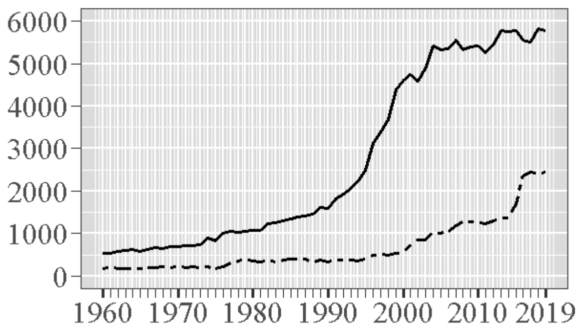

FIGURE 1. COPPER PRODUCTION (TONS),
— = CHILE, - - - = PERU

As we can see in **FIGURE 1,** Chilean copper production shows significant growth rates approximately in the nineties while the

[1] Bachelor of Economics & International Business at ESAN University. October, 2020.

Peruvian case shows relative growth rates yet after a decade.

Reasonably we refer to China as the world's largest manufacturer country. Briefly, the Chinese industry is divided in three major sectors. The Primary Industry includes agriculture, forestry, animal husbandry, and fishery; the Secondary Industry includes production and supply of electricity, gas and water, manufacturing, and mining; the Tertiary Industry involves services.

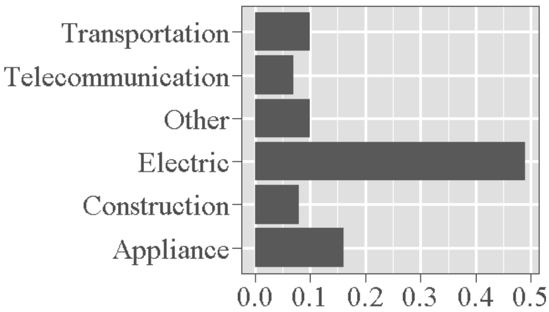

FIGURE 2. COPPER CONSUMPTION STRUCTURE IN CHINA, 2014.

FIGURE 2 suggests a dominance of the electric power industry over the others (in some cases sectors that are part of the Secondary Industry) to describe copper consumption in China so it is feasible to say that the Secondary Industry of China intensively uses copper.

Throughout the study period, the global financial crisis in 2008, caused by the bursting of the United States housing bubble and followed by the subprime mortgage crisis, parked the Great Recession and its impact varied significantly from country to country.

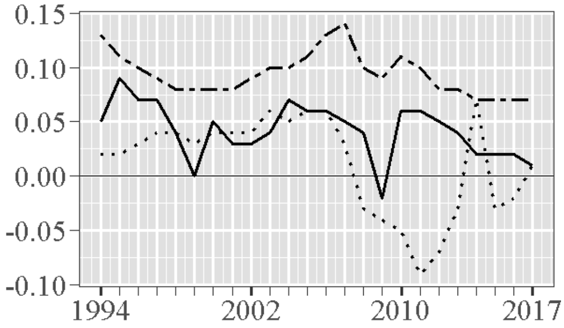

FIGURE 3. GDP ANNUAL GROWTH RATE, --- = CHINA, — = CHILE, · · · = GREECE

As we observed China did not suffer a severe impact from the Great Recession. In the case of Chile, expansionary fiscal policy and a context that greatly favored terms of trade supported a quick recovery as **FIGURE 3** shows how Chilean GDP quickly reverse its track from 2010 to peak up approximately six hundred basis points of GDP annual growth rate for 2011.

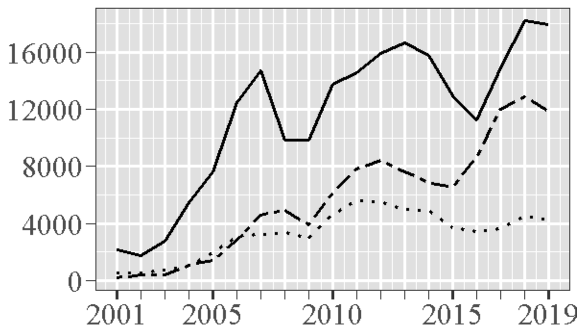

FIGURE 4. COPPER EXPORTS (CONCENTRATE ONLY, BILLIONS USD), — = CHILE, --- = PERU, · · · = AUSTRALIA

Time series in **FIGURE 4** correspond to copper concentrate exports. We observe that the actual gap between Chile & Peru tends to reduce significantly after one and a half-decade. This could be easily explained as the effect of Peruvian authority's efforts to liberalize its market and attract foreign investment while the Chilean series indicates a slower growth.

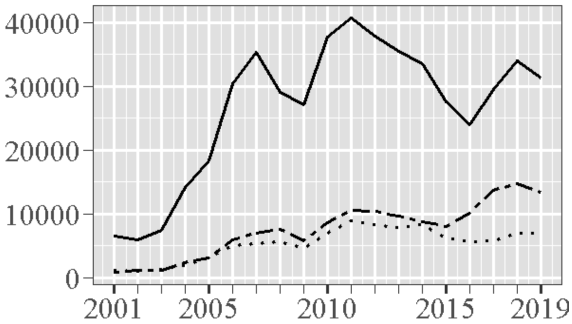

FIGURE 5. TOTAL COPPER EXPORTS (CONCENTRATE & CATHODES, BILLIONS USD), — = CHILE, --- = PERU, · · · = AUSTRALIA

As a counterpart, **FIGURE 5** suggests there's still a considerable gap between Peruvian & Chilean copper exports. The key difference in both figures lays in the added value of concentrate & cathodes. The significant increase in Peruvian copper exports during the 2000's was principally due to the expansion of copper concentrate exports which is the lowest added value product while the Chilean series in **FIGURE 5** indicates there's a persistent gap over time as a possible response of exports diversification strategy. Chilean copper supply has focused on developing its industry since cathode production involves a whole transformation process to obtain a much higher copper concentration.

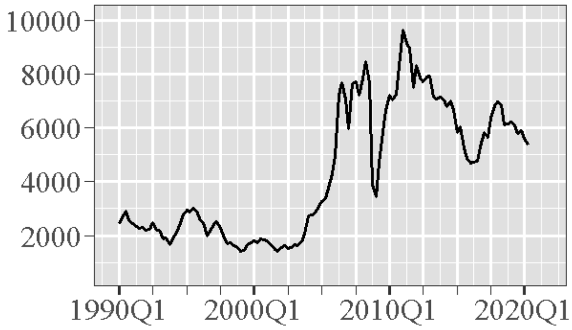

FIGURE 6. COPPER PRICE (USD PER METRIC TONE)

During 2000's commodity super cycle prices of many physical commodities (i.e. copper price according to **FIGURE 6**) increase due to the rising demand from emerging countries in addition to the concern about the long-term availability of these goods. Chilean copper exports quickly jumped during the 2000's commodity super cycle. Furthermore, during this period between 2000 and 2010, the vast majority of countries in South American (highly dependent on commodity exports) experimented a significant economic growth. What's more, this period was also characterized by the high number of free trade agreements (FTAs) signed. Chile & China rapidly negotiated and signed it in 2006 which made Chile the first non-ASEAN country to negotiate an agreement with the largest economy in Asia. As a consequence, the Chinese market is vital for the Chilean economy since China has yearly absorbed more than 20% of total Chilean exports since 2015.

Empirical evidence suggests an important linkage between Chilean exports and the Chinese market. In the following sections, we present the statistical assessment along with the assumptions based on economic theory to study this phenomenon.

1. Methodology

In order to understand the relationship among studied variables, we use Blanchard & Quah (1989) methodology which is a structural vector autoregressive model with a particular identification process that consists of setting restrictions over the long-run multipliers matrix. Briefly, they studied fluctuations in GNP and unemployment. They labeled structural shocks coming from unemployment and GNP as supply and demand shocks respectively. Working straightforward with the long-run multipliers matrix, they assumed that only supply shocks could have a permanent effect in the economy. They found out that demand disturbances make an important contribution to output fluctuations in short and medium-term periods.

Data are sampled monthly. The production of the Secondary Industry in China is sourced from the National Bureau of Statistics of China, seasonally adjusted. Copper prices are U.S dollar spot prices as reported by the Reserve Bank of St. Louis. Exchange rate (CLP/USD) is taken from the International Monetary Fund (IMF) and Chilean copper exports are sourced from CODELCO (both PPP adjusted based on its national report indexes). Series are logged, first differentiated, and deflated by the U.S. consumer price index.

Without ambiguity, we can easily transform a VAR structure into its Moving-average representation

$$\Psi_t = \sum_{s=0}^{\infty} A_1^s u_{t-s}. \qquad (1)$$

In this case, Ψ_t is a vector containing four endogenous variables described above, A_1^s is a coefficient matrix and u_t a vector of possibly correlated innovations. Additionally, by linear transformation we know that $u_t = Se_t$. Following this path, it is possible to express (1) as

$$\Psi_t = \sum_{s=0}^{\infty} \phi(s)\, e_{t-s}, \qquad (2)$$

where $\phi(s) = A_1^s S$ and we label it as long-run multipliers matrix.

Computing impulse response functions of a specific endogenous variable $\Psi_t^{(1)}$ to structural shocks is straightforward

$$\frac{\partial \Psi_t^{(1)}}{\partial \vec{e}_{t-s}} = \sum_{i=1}^{s} \vec{\phi}(s)^{(1)},$$

$$\rightarrow \sum_{i=1}^{\infty} \vec{\phi}(s)^{(1)}.$$

To recover structural shocks, we need to estimate the covariance matrix of the residual from the VAR system then Cholesky decomposition allows us to represent it as the product of a lower triangular matrix and its transpose ($\Omega = S'S$). At this point, we only have $\left(\frac{k(k+1)}{2}\right)$ restrictions so we need to impose $\left(\frac{k(k-1)}{2}\right)$ more, reasonably distributed in matrix $\phi(s)$. Additional restrictions need to be supported by economic theory. For example, setting $\phi(s)_{12} = 0$ we are assuming that there is no permanent effect from a structural shock $e_{t-s}^{(2)}$ over $\Psi_t^{(1)}$. Similarly, restrictions over the diagonal elements of $\phi(s)$ are also allowed, see Blanchard & Quah (1989).

Now let us express (2) for a specific future value m

$$\Psi_{t+m} = \sum_{s=0}^{\infty} \phi(s) e_{t-s+m},$$

Evaluating the forecast error ξ_{t+m} we obtain

$\xi_{t+m} = \Psi_{t+m} - E_t(\Psi_{t+m}),$

$$\xi_{t+m} = \sum_{s=0}^{m-1} \phi(s) e_{t+m-s}. \qquad (3)$$

Our next step is to compute the variance decomposition which is a sophisticated statistical tool that allows us to estimate the proportion of information from each variable to explain the fluctuations of a specific one. Finally, the following expression constitutes the covariance matrix of the forecast error

$$Var(\xi_{t+m}) = \begin{bmatrix} \sigma_{e1}^2 \sum_{s=0}^{m-1} \phi_{11}(s)^2 + \sigma_{e2}^2 \sum_{s=0}^{m-1} \phi_{12}(s)^2 \\ \sigma_{e1}^2 \sum_{s=0}^{m-1} \phi_{21}(s)^2 + \sigma_{e2}^2 \sum_{s=0}^{m-1} \phi_{22}(s)^2 \end{bmatrix}.$$

In this case, the variance of forecast error consists of the squared of the multipliers matrix plus a vector of structural variances. In other words, the contribution of each disturbance to explain fluctuations of a specific variable is possible to find by computing the variance of the forecast error for a specific period m as described above.

2. Identification

In this section, we discuss the identification process and the assumptions behind restrictions over the long-run multipliers matrix. For instance, let us represent the matrix form of (2)

$$\Psi_t = \sum_{s=0}^{\infty} \begin{bmatrix} \phi(s)_{11} & 0 & 0 & 0 \\ \phi(s)_{21} & \phi(s)_{22} & 0 & 0 \\ \phi(s)_{31} & \phi(s)_{32} & \phi(s)_{33} & 0 \\ \phi(s)_{41} & \phi(s)_{42} & \phi(s)_{43} & \phi(s)_{44} \end{bmatrix} \begin{bmatrix} e_{1,t} \\ e_{2,t} \\ e_{3,t} \\ e_{4,t} \end{bmatrix}.$$

We discussed in the previous section that we need to impose six restrictions on the long-run multipliers matrix. These restrictions are the elements above the diagonal equal to zero.

We are studying two foreign origin disturbances that could mainly affect Chilean copper exports: international cooper price and production of the Secondary Industry of China, which we label as Chinese market disturbance. Neither of the variables describing the Chilean economy (i.e. exchange rate and exports) affects these two foreign origin disturbances principally because Chile is an emerging economy that does not significantly affect the long-run course of international commerce in contrast to developed economies.

Based on suggestive empirical evidence by Roache (2012) shocks to aggregate activity in China have a significant impact on copper price and it is a one-sided effect only.

Even though Chile has a floating exchange rate regime, monetary authorities have intervened smoothing exchange rate fluctuations during periods of high economic uncertainty, see Morandé & Tapia (2002). The impact of these interventions in the market is not clear yet as Claro & Soto (2013) suggest, nevertheless, positive results were achieved. In other words, the impact from exchange rate shocks is vanished periods ahead possibly due to interventions (during high uncertainty) or the market itself so we assume no long-run effect of exchange rate shocks in the economy.

3. Estimation output

First, some statements about the model need to be taken into consideration as the econometric procedure requires.

Augmented Dickey-Fuller results accept the null hypothesis for all series. Neither autocorrelation nor heteroscedasticity in forecast errors were detected using the Breusch-Godfrey Test and White Test respectively. As a trade-off between serial autocorrelation and loss of degrees of freedom, we chose four lags supported primarily by Akaike Information Criterion. Finally, the eigenvalues laid inside the unit circle characteristic from a stable VAR system, key assumption behind the moving average representation that we use in the previous section.

The response of exports to foreign shocks plus exchange rate shock and variance decomposition are reported in this section. The horizontal axes denote time in months after a structural shock. In case of the vertical axes these can be interpreted as approximations of percentage change from Chilean copper exports.

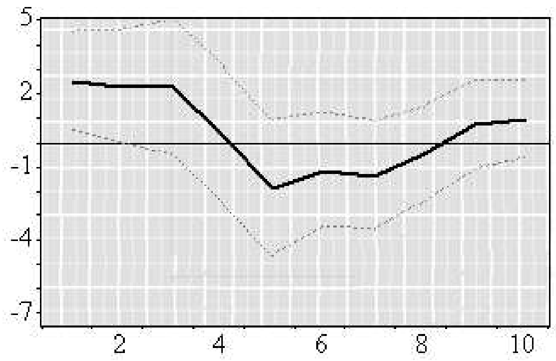

FIGURE 7. RESPONSE OF EXPORTS TO SECONDARY INDUSTRY

Figure 7. denotes how Chilean copper exports respond to a Chinese market shock reaching its peak during the first month and having a considerable positive effect up to the third month when it starts to vanish over time. In other words, the positive effect is reversed after three months so the instant effect of Chinese market disturbance over Chilean copper exports is the highest positive value from all periods ahead.

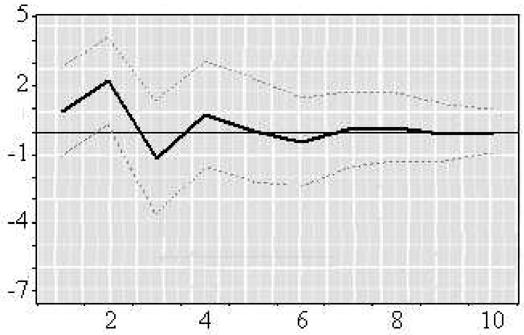

FIGURE 8. RESPONSE OF EXPORTS TO COPPER PRICE

The effect of a copper price shock significantly vanishes after reaching its peak during the second month. This peak slightly passes a positive two percent during the second month. This result is consistent with the traditional view of how commodity prices affect small and open economies that depend mostly on these markets.

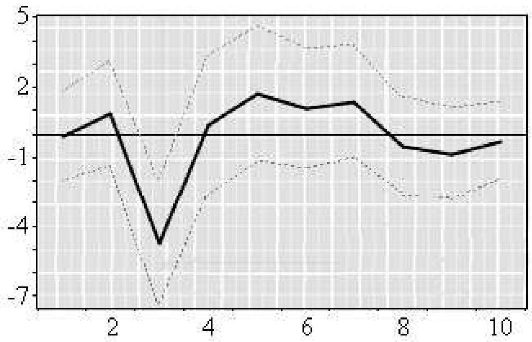

FIGURE 9. RESPONSE OF EXPORTS TO EXCHANGE RATE

Exchange rate shock leads to a decrease in Chilean copper exports. Its highest negative effect peak during the third month then the effect reverse for five months and finally, it vanishes over time.

TABLE 1 – VARIANCE DECOMPOSITION OF CHILEAN COPPER EXPORTS

Percentage of Variance Due to:			
Periods (Months)	Secondary Industry of China	Copper price	Exchange rate
1	12.01	1.02	2.34
	(10.44, 13.02)	(0.70, 1.93)	(1.66, 2.73)
3	12.62	2.65	2.26
	(10.82, 14.21)	(2.01, 3.77)	(1.52, 2.88)
10	13.81	2.22	2.95
	(11.22, 15.81)	(1.93, 3.43)	(1.62, 3.12)
20	16.04	9.09	4.24
	(12.93, 17.09)	(7.21, 11.43)	(3.43, 4.88)
40	19.35	10.03	5.55
	(17.22, 24.92)	(8.31, 12.02)	(4.82, 6.21)
60	23.14	12.54	5.82
	(18.21, 27.12)	(10.21, 12.92)	(4.93, 6.70)
85	28.53	13.86	6.45
	(21.72, 31.88)	(11.18, 14.55)	(5.26, 7.03)
110	30.92	15.03	6.93
	(24.22, 36.51)	(13.26, 16.31)	(5.66, 7.05)

So **FIGURE 9** shows that a positive shock to exchange rate (currency depreciation) decrease Chilean copper exports with a peak that slightly passes minus four percent. Instinctively, one may argue about this finding principally because traditional consensus suggests that currency depreciation should increase exports; however, empirical evidence such as Huchet-Bourdon & Korinek (2012) suggest that the impact of exchange rate on exports in small and open economies depends significantly on the sector and trading partner. They also found out that a ten percent depreciation in the peso results in a 9-12% decrease in exports to China and indicates this could be possibly due to Chinese inelastic demand over Chilean copper exports. In other words, in case of a CLP/USD depreciation that only last one period and considering Chinese inelastic demand, Figure suggest that the real values of Chilean copper exports will decrease significantly but only transitory. While impulse response functions are suggestive, computing the variance decomposition will give us a more formal statistical assessment.

Following notation (3) variance decomposition of the forecast errors allow us to identify and measure the contribution of each disturbance to explain fluctuations of a specific variable for a specific period; therefore, we take a step forward and compute it for Chilean copper exports. Table 1 report these results. Periods reported by Table 1 are equal to m in equation (3). This forecast error for a specific period is due to disturbances from each variable for the last m months as explained above. The contribution of Chilean copper exports is not reported but is easy to obtain by operating a hundred minus the sum of the last three columns for each period separately. Numbers in parenthesis are one standard deviation bands. Not asymmetric and over 1000 repetitions following Monte Carlo methods.

Table 1 gives evidence about the positive evolution of the Secondary Industry of China to explain Chilean copper exports fluctuations. This contribution turns relevant at medium to (principally) high frequencies. Additionally, results suggest that contribution of Chinese market disturbances is twice greater than copper price to explain Chilean copper exports for long periods while the exchange rate contribution is relatively low for all periods.

4. Conclusions

China, a key partner for the Chilean economy, intensively uses copper through the Secondary Industry. Therefore, we study the linkage between this variable and Chilean copper exports. Based on empirical suggestions and among other assumptions discussed at length in this study, we follow Blanchard & Quah (1989) methodology and impose restrictions over the long-run multipliers matrix to recover structural shocks. The estimation output suggests the following: (1) Chilean copper exports reaction to a Chinese market shock is slightly faster (for one month approximately) than a copper price shock; (2) Chinese market shock over Chilean copper exports reach a negative effect that lasts about three months; (3) copper price and exchange rate shock vanish overtime after reaching its peaks; (4) exports reaction to exchange rate shock suggest a different position from the traditional point of view of a positive reaction possibly due to Chinese inelastic demand; (5) variance decomposition of the forecast errors exhibit a significant contribution from Chinese market disturbances in comparison to copper price and exchange rate disturbances especially for long periods.

5. References

Blanchard, O., & Quah, D. (1989). The Dynamic Effects of Aggregate Demand and Supply disturbances. *American Economic Association*, 655-673.

Claro, S., & Soto, C. (2013). Exchange rate policy and exchange rate interventions: the Chilean experience . *BIS Papers chapters* , 81-93.

Huchet-Bourdon, M., & Korinek, J. (2012). Trade Effects of Exchange Rates and their Volatility: Chile and New Zealand. *OECD Trade Policy Working Papers*.

Mikusheva, A. (2007). Structural VARs. *14.384 Time Series Analysis Massachusetts Institute of Technology*.

Morandé, F., & Tapia, M. (2002). Exchange Rate Policy in Chile: From the Band to Floating and Beyond. *Institute for Economic Policy Research*.

Roache, S. (2012). China's Impact on World Commodity Markets. *IMF Working Papers*.

Ye, Z.-h., Yan, Q., & Guo, J.-h. (2016). Study on Copper Consumption in China and Abroad. *Atlantis Press*.