Exchange Rate, Structural Fiscal Balance, and Copper Price: A Puzzle

Patricio Rojas
Rojas y Asociados

Félix Berríos
Rojas y Asociados

Chile's exchange rate shows a strong volatility to copper price fluctuations. This correlation is essentially because copper is our main export product, therefore increases in the price of copper imply higher returns from copper export volumes, both for private and the state-owned mining company Codelco. However, from the early 2000s, the Chilean state has used a concept of structural balance for its public accounts, defining ex ante a copper price in order to formulate its budget spending. Thus, increases above this price should not have a significant impact on the peso-U.S. dollar parity, since most of the surplus revenue from higher copper prices would be saved overseas. Furthermore, in general, private mining companies do not bring into the country additional surplus revenues obtained from copper prices higher than what had been in their budget forecasting.

In short, the structural balance rule for fiscal accounts should significantly have reduced the volatility of the real and nominal exchange rate, especially since 2003, period where copper prices have been on an upward trend (only temporarily interrupted by the 2008 crisis).

However, evidence shows that nominal parity continues to be affected by changes in copper price, even when agents know that these additional foreign currencies will not enter the country. This could probably be because credibility in the rule is not total and agents consider that the government may not acknowledge their commitment and would enter these revenues to finance a more significant expenditure. Even though this is a feasible explanation, we believe that enforcement of this rule for more than ten years should significantly reduce the importance of this channel to explain the evidence.

Economic Policies in Emerging-Market Economies, Festschrift in Honor of Vittorio Corbo, edited by Ricardo J. Caballero and Klaus Schmidt-Hebbel, Santiago, Chile.

Another alternative explanation could be that an increase in copper prices is an indicator that forecasts a better domestic and global economic outlook; on one hand, this would imply that other goods exported by the country, in terms of prices and demands, would improve and, on the other, that domestic agents would feel wealthier, increasing their future demand and, consequently, domestic spending which would most likely cause a monetary policy reaction by raising interest rates. In this context, a fiscal rule would have eliminated (or significantly reduced) the direct effect caused by higher copper prices on the nominal exchange rate, breaking the direct relationship with a higher currency settlement, but an indirect channel would have been produced (or intensified) that related copper prices to the general expectations for the Chilean economy.

The objective of this paper is to analyze this puzzle that causes the strong relationship between nominal exchange rate movements and copper price movements, when in theoretical terms it should not occur if there is a fiscal rule such as the one implemented by Chile since 2000. In this context, this paper is organized as follows. Section 2 includes a review of the real exchange rate equilibrium level (RER) concept and a review of empirical literature on RER determinants in Chile. In particular, the effect the application of this fiscal rule has on RER empirical estimates. Section 3 includes the empirical analysis of the real exchange rate faced with the implementation of the fiscal rule. Section 4 analyzes the relationship between the nominal exchange rate, the price of copper and the fiscal rule. Finally, Section 5 presents the conclusions.

1. RER Theoretical Aspects and its Equilibrium Level

In a small and open economy such as the Chilean economy, the real exchange rate (RER) is one of the most important relative prices of the economy; therefore its movements cause reallocation of resources and spending between the different sectors. Particularly, RER changes encourage activity to be directed towards the domestic or foreign market and/or towards tradable or non-tradable sectors.

However, it is worth noting that the relative price movement appropriate for the efficient allocation of resources is one that is consistent with its equilibrium level and, therefore, is a clear medium-run sign for production agents. In fact, it is this equilibrium level—that does not necessarily coincide with the short-run level observed —which indicates where the resources of an economy should be moved to; this situation should organize and prioritize the different sector investments. On the contrary, sustain RER deviations from its equilibrium level may result in severe inefficiencies and macroeconomic disequilibria, and its correction tends to be extremely high.[1] Furthermore, history has shown that prolonged or recurrent real exchange rate misalignments have also involved low economic growth rates.

More specifically, the most important reasons to avoid real exchange rate deviations from its equilibrium value are based on microeconomics and macroeconomics costs that cause significant misalignments. From a microeconomic perspective, when the exchange rate is misaligned, it does not provide an appropriate guide to allocate productive resources and spending on foreign and domestic goods. From a macro perspective, when economic agents perceive a severe deviation, the expectations generated are that its value will be adjusted in the future to reach equilibrium through important variations in the nominal exchange rate. For example, an overvaluation of the local currency discourages local agents from holding domestic currency assets, which is a potential source of reversal of capital flows and exchange crisis.

In brief, it is crucial for both an efficient use of resources and making private decisions to analyze real exchange rate performance, basically because it is, in terms of an equilibrium level, a key price of the economy and it affects the profitability of the tradable sector. Furthermore, by establishing the fundamental variables that explain real exchange rate movements, future economic policy actions directed at modifying such fundamentals can be established as well as the real exchange rate level.

1.1 Determination of the Equilibrium Real Exchange Rate

It is not easy to determine the real exchange rate considered to be in equilibrium (ERER) because ERER represents an endogenous

1. In general, currency would be overvalued (or undervalued) in real terms if the current real exchange rate is below (above) the equilibrium real exchange rate. A significant undervaluation of the real exchange rate (overvaluation of the domestic currency) it is usually considered an indicator of a potential future balance-of-payments crisis, while an overvaluation is usually a sign of higher future inflation.

variable that is not observable. However, its calculation is fundamental because it represents the rule against which RER fluctuations are calculated.

Economic literature has for several decades addressed this subject. Cassel (1922) put forward that the exchange rate should fluctuate so that it counteracts inflation rate movements related to the different currencies. This would convert purchasing power parity (PPP) into the first ERER measure, but, as will be described below, it would not be exempt from criticism.

Subsequently, Nurkse (1945) defined the exchange rate around an ideal condition of the economy. According to him, the equilibrium real exchange rate must be defined as: "the value of the real exchange rate compatible with the external and internal equilibrium objectives, given determined values of "other variables" that may influence these objectives." External equilibrium refers to a sustainable external capital inflow in order to finance the current account deficit of the balance of payments; while internal equilibrium refers to a non-tradable goods market in a sustainable equilibrium. This definition would originate what would later be known as the macroeconomic approach of the real exchange rate (made popular by Williamson, 1983 and 1994), that specifically defines ERER as the real exchange rate consistent with the simultaneous attainment of internal and external equilibrium of the economy.

Edwards (1989) defined equilibrium of the real exchange rate as: the relative price of tradable goods to non-tradable goods, for given sustainable values (of equilibrium) of other relevant variables—such as taxes, international prices and technology—simultaneously produces internal and external equilibrium. Internal equilibrium means that the non-tradable goods market is cleared during the current period, and it is expected to continue balanced in the future. It is implicit in this definition of equilibrium real exchange rate that equilibrium occurs when unemployment is at its natural rate. External equilibrium is attained when the intertemporal budget constraint is met, whereby the sum discounted from a country's current account balances must equal zero. In other words, external equilibrium means that current account balances (current and future) are consistent with the capital flows sustainable in the long run.

In turn, Edwards states that certain implications that arise from these concepts: (i) the equilibrium real exchange rate is not immutable. When there are changes in any of the variables that affect the internal and external equilibrium, the real exchange rate must also vary. Hence, the real exchange rate required to attain equilibrium will vary, for instance, with global price movements of a country's main export product; with import tariffs; export taxes; real interest rate and capital controls. He calls these immediate determinants "real exchange rate fundamentals." (ii) There is not just "one" equilibrium real exchange rate, but a path of real equilibrium exchange rates through time. (iii) The temporal path will be affected not only by current values of the fundamentals, but also by "its expected future evolution," i.e., the economic agent's expectations.

In brief, equilibrium real exchange rate (ERER) definitions include, explicitly or implicitly, their conception of relative price of internationally tradable and non-tradable goods and make reference to *sustainability* as a necessary condition for real exchange rate equilibrium, therefore, the concept has, in general, a long-run nature. This in turn implies the existence of what is known in economic literature as *gap* or *misalignments of the* real exchange rate, i.e., the difference between current or observed real exchange rate and long-run sustainable or equilibrium real exchange rate.

1.2 ERER Modeling Strategies

According to Clark and MacDonald (1999), the real exchange rate (q_t) is determined by a series of economic variables and random shocks. Certain economic variables may have permanent effects on the RER level and other only a temporary effect. Hence, RER may be defined as follows:

$$q_t = \beta Z_t + \theta T + \xi_t, \tag{1}$$

where Z_t is a vector of economic variables or fundamentals that explain medium- and long-run RER behavior and T_t represents a temporary variable vector that have a short-run effect on RER. On the other hand, ε_t is random shocks, while β and θ represent coefficient vectors.

In the medium run, the equilibrium real exchange rate will be defined as consistent with the economy's internal and external balance. Hence, ERER does not include random shocks or temporary variables; then, using the hat symbol denotes medium-run variables, ERER would be:

$$\hat{q}_t = \beta \hat{Z}_t. \tag{2}$$

To calculate the different equilibrium RER, a formal structure is required, for which different theoretical models have been developed. The three most used paradigms to analyze long-run RER are: purchasing power parity (PPP), RER level consistent with a sustainable current account deficit and a full employment rate (internal and external equilibrium, known as FEER) and the empirical relationship between the exchange rate and its theoretical fundamentals (BEER).

It is important to note that despite all the approaches being susceptible to criticism, each one delivers a diagnosis on RER evolution and its eventual misalignment from its medium- and long-run equilibrium level. In line with the latest research undertaken in this area, concerning the Chilean economy, in our empirical analysis we will use an approach based on a reduced form of a model that explains the effective real exchange rate model over a specific sampling period. In this reduced form, the RER depends on the medium- and long-run macroeconomic fundamentals, as well as on short-run temporary factors.

This approach includes natural ERER (NATREX) and trend RER (BEER), providing a stock and flow dynamic analysis where key real exchange rate determinants are identified. Both models contrast the co-integration relationship between RER and its fundamentals to provide an ERER that moves in time.

Models based on time series (BEER) aim to capture how different variables determine RER dynamics. According to Faruqee (1995) a convenient form of analyzing RER is to divide its determinants into two categories: determinants that act through the current account (trade flow) and determinants that act through the capital account (country's net asset position), thus isolating RER determinants that affect the flow position of the *stock* position. Therefore, the relationship between RER (q_t) and its fundamentals is expressed in the following equation:

$$q_t = \beta_0 + \beta_1 TNT_t + \beta_2 TOT_t + \beta_3 \left(\frac{G}{Y}\right)_t + \beta_4 \left(\frac{NFA}{Y}\right)_t + \beta_5 TARIFF_t, \qquad (3)$$

where TNT is the tradable-to-non-tradable productivity ratio; G/Y is the governmental spending as a percentage of GDP, TOT are the terms of trade, NFA/Y refers to a country's net foreign assets as a percentage of GDP and TARIFF represents an average import tariff of the country. This specification corresponds to the reduced form of a general theoretical model.

It is evident that in the above models the variables considered —referred to as fundamentals—are the most important to determine the equilibrium of the economy and, therefore, of the real exchange rate. Even more so, it is feasible to describe the expected relationship of these fundamentals with the real exchange rate, which in the models is reflected in the sign and the significance of the β coefficients.

Key forecasts for the RER equation in (3) are:

Productivity (TNT): the most known theoretical relationship concerning the effect of productivity on determining the long-run equilibrium real exchange rate is the Balassa[2]-Samuelson[3] effect; it establishes that, given certain assumptions, countries that have a faster growing in total factor productivity related to its trading partners will tend to appreciate in real terms. In particular, while greater the difference in productivity of tradable goods production between two countries, greater will be the difference in salaries and non-tradable good prices and, therefore, greater will be the gap between purchasing powers of both currencies and the equilibrium exchange rate. Similarly, the faster the country in question grows compared to another country, greater will be the real currency appreciation that such a country must accept. The natural consequence of this greater growth of productivity is that international competitiveness of the domestic economy increases, which, all in all, results in an expansion of exports and a fall in RER, which is an equilibrium. In brief, greater productivity allows the economy to accommodate a lower equilibrium real exchange rate.

Fiscal Policy (G/Y): The effect of an increase in government spending on the real exchange rate depends on two factors: (i) composition of government spending on tradable and non-tradable goods; and (ii) financing government spending (through taxes or higher foreign debt), which change the availability of resources and spending of the private sector.

An increase in public spending would increase spending on tradable and non-tradable goods by the government. This would have two effects on the equilibrium real exchange rate; a direct effect of a higher demand for domestic goods that originates a real appreciation; and an indirect effect—if financed through higher taxes—of reducing

2. Balassa, Bela, 1964, "The Purchasing Power Parity Doctrine: A Reappraisal", *Journal of Political Economy,* vol. 72; 584 - 596.

3. Samuelson, Paul A. "Theoretical Notes on Trade Problems," *The Review of Economics and Statistics*, vol. XLVI, May 1964: 145 - 154.

private wealth and consumption of non-tradable goods, resulting in a real depreciation. Hence, the final effect on the non-tradable goods market and, therefore, on RER, is ambiguous and will depend on the marginal propensities to consume non-tradable goods by the private sector and the government. If the government's marginal propensity to consume non-tradable goods is higher (lower) than the private sector's marginal propensity, an increase in public spending would produce an increase (reduction) in the demand for non-tradable goods, and a fall (rise) in the real exchange rate. The empirical evidence has tended to support the hypothesis that the marginal propensity to consume non-tradable goods is higher in the public sector than in the private sector.

However, if an increase in public spending is financed with a net transfer of resources from overseas, then there will not be a shift in private spending (it is assumed that the private sector will not react faced with eventual tax increases in the future to service a higher public debt). In this case, the effect on ERER is not ambiguous; the demand for non-tradable goods increases and RER falls.

In short, the general argument is that lower public spending enables the economy to accommodate a lower ERER, and hence the competitiveness of the external sector increases.

Terms of Trade (TOT): a negative shock in the terms of trade generates a series of effects on the real exchange rate. These are: (a) income effect: a fall in the *TOT* originates a fall in the country's disposable income, resulting in lower consumption of all goods, including non-tradable goods. It is important to note that this effect is greater when a TOT fall is perceived as permanent, therefore faced with temporary shocks, the agents will not significantly adjust their consumption patterns, since their permanent income has changed very little. (b) Intertemporal substitution effect: a temporary TOT fall transfer future consumption to the present, generating a real appreciation in the present in exchange for real depreciation in the future. (c) Intratemporal substitution effect: a TOT fall causes imported goods to be relatively more expensive. The effect that this has on the demand for non-tradable goods will depend on the substitution level between these goods and imported goods; a real equilibrium appreciation is generated if the imported and the non-tradable goods are substitutes in consumption, and it is depreciated if they are only complementary.

Therefore, the final effect of a fall or an increase in the terms of trade on the real exchange rate is ambiguous. However, empirically, it has been observed that, in general, TOT falls cause increases in RER, since the income effect tends to dominate the substitution effect, causing a decrease in demand for goods and a subsequent fall in prices of non-tradable goods. Likewise, it can be said that an improvement in the terms of trade allows the economy to adopt a lower equilibrium real exchange rate, incrementing the competitiveness of the external sector.

Net Foreign Assets (NFA/Y): A higher volume of net foreign assets, as a GDP percentage, reflects more net payments to factors from overseas, and therefore, it implies a higher sustainable deficit of the balance of trade. This higher deficit is consistent with a more appreciated real exchange rate.

In short, an increase in the net foreign asset stock can sustain a higher trade deficit and, therefore, accommodate a lower real exchange rate.

Trade Policy: Changes in the level of open trade, by modifying tariff levels (TARIFF), have an important effect on a country's wealth and, therefore, on the real exchange rate. In fact, a permanent increase in import tariff rates will have two effects: income and substitution. The final effect on RER will depend on the direction and magnitude of each effect. As for the income effect, the measure reduces wealth due to the loss of efficiencies attributable to this distortion, bringing about a fall in demand for all goods. This causes a depreciation of the real exchange rate.

The RER movement that will follow as a consequence of the substitution effect, will depend on whether the imported goods and the non-tradable goods are substitute or complementary. If tariffs rise and these goods are complementary, it will require RER to increase, since the demand for non-tradable goods will decrease. If they are substitute goods, the higher prices of imported goods will increase the demand and thus the prices of non-tradable goods, resulting in a lower RER.

In short, the widespread perception that a permanent increase in tariffs requires, in order to return to a position of equilibrium, a lower RER; this will only occur when there is substitution between domestic and imported goods and also when the substitution effect dominates over the income effect. In other words, when these conditions exist, the general argument could be reached that a tariff reduction allows the economy to adopt a lower equilibrium real exchange rate, and due to this effect exporters will see their competitiveness increase.

The relationship between RER and fundamental variables is typically estimated applying co-integration methods. In particular, an error correction model is estimated where RER is moved to correct any long-run deviation:

$$\Delta q_t = -\lambda \begin{pmatrix} q_{t-1} - \beta_1 TNT_{t-1} - \beta_2 TOT_{t-1} - \beta_3 \left(\frac{G}{Y}\right)_{t-1} \\ -\beta_4 \left(\frac{NFA}{Y}\right)_{t-1} - \beta_5 TARIFF_{t-1} \end{pmatrix} + \theta \Delta T_t ,$$

where θΔT are variables that have temporary effect on RER.

In Chile various studies have been conducted that estimate a similar relationship to the aforementioned. In general it is concluded that there is a relationship between fundamental variables and the real exchange rate; specifically, most estimates indicate that β are negative and statistically significant. In fact, table 1, extracted from Caputo and Núñez (2008), provides a summary of elasticities obtained by different studies, generally indicating the magnitude of elasticity.

Once the beta coefficients for the error correction model have been estimated, the short-run equilibrium RER may be calculated. This is determined by the contemporary values of the fundamentals, leaving aside temporary elements and random shocks. This is calculated as:

$$q_t = \beta_{BASE} + \beta_1 TNT_t + \beta_2 TOT_t + \beta_3 \left(\frac{G}{Y}\right)_t + \beta_4 \left(\frac{NFA}{Y}\right)_t + \beta_5 TARIFF_t ,$$

Table 1. Summary of RER Elasticity to its Fundamentals

Fundamental Variables	*Céspedes - De Gregorio*	*Soto - Valdés*	*Calderón*	*Caputo - Dominichetti*
TNT	-0.34	-0.49	-0.20	-0.47
TOT	-0.59	-0.16	-0.89	-0.35
G/Y	-1.10	-1.60	-0.89	-0.13
NFA/Y	-0.18	-0.17	-0.07	-0.14
TARIFF	-	-	-	-0.02

Note: Calderón (2004), and Caputo and Dominichetti (2005) introduce variable G/Y in logarithm, while Céspedes and De Gregorio (1999) and Soto and Valdés (1998) do it in levels. Therefore, the comparison between different studies is not direct.
Source: Caputo and Núñez (2008).

where β_{BASE} incorporate the difference between the calculation of RER for a base period (where explanatory variables and RER are believed to be in equilibrium)[4] and the actual value (hence, in the base period the predicted value and the effective value are the same).

On the other hand, medium-run equilibrium requires the determination of sustainable or trend values for the fundamental variables. This is calculated by the following expression:

$$\hat{q}_t = \beta_{BASE} + \beta_1 \hat{TNT}_t + \beta_2 \hat{TOT}_t + \beta_3 \left(\frac{\hat{G}}{Y}\right)_t + \beta_4 \left(\frac{\hat{NFA}}{Y}\right)_t + \beta_5 \hat{TARIFF}_t,$$

where the hat symbol indicates the corresponding variable's medium-run (or sustainable) value. One way of calculating these values is to apply statistical filters to the fundamentals, such as the Hodrick-Prescott filter, that separate the cyclical component from the trend component (considering the latter as a medium-run component). Alternatively, sustainable values may be determined based on the historical component of the series and applying judgment elements.

1.3 Effect of Structural Surplus Rule on RER

Since the early 2000s, the Chilean economy has been applying a structural balance rule[5] to manage its public finances. This fact is a fundamental change in the economic policy, allowing to align public spending with the more permanent revenues received by the Treasury, reducing nearly all the habitual pro-cyclical response demonstrated by government public spending in prior years. In particular, evidence shows that every time copper prices rose sharply and, therefore the economy confronted a positive terms of trade shock as a result of this rise, government spending tended to grow a lot more than the actual economic growth as well as the trend economic growth. In this context, it was normal that in response to positive terms of trade shocks, caused by copper price increases, a significant RER appreciation would be observed. This is the case for the period 1995-96, when copper prices rose from levels close to US$0.80 per

4. According to Caputo and Núñez (2008), the analyses conducted by the Chilean Central Bank consider two alternative base periods: 1994 and the period 1990 - 2002.

5. Initially, it was a structural surplus rule of 1% of GDP, subsequently it was moved to a structural balance rule and recently it has tended to a rule to reduce structural deficit to a certain value, which today is set at 1% of GDP.

pound at the beginning of 1994 to approximately US$1.35 towards mid-1995; during this period RER appreciated by about 17%.

Undoubtedly, the existence of a structural fiscal rule has tended to modify this behavior, since the surplus revenues received by the Treasury, due to higher copper prices, is saved. This situation should significantly reduce the effect that improved terms of trade would have on RER caused by a rise in copper prices. Then, the fiscal rule, by constraining public spending based on the evolution of revenues considered sustainable, makes the appreciation effect on RER of most terms of trade to be significantly lower than what was observed when the fiscal rule was not applied.

Indeed, a fact that has stood out in recent years is the steep increase in copper prices on world markets since 2003, raising copper prices from an average US$ 0.74 per pound during the period 1998-2002 to about US$ 3.90 in mid 2008, falling to US$ 1.39 towards the end of that year, then starting an upward trend to about US$ 4.50 in February 2011. The country's subsequent abundance of resources is certainly a source of concern among those who consider that this could result in what is known as the Dutch Disease.[6] However, evidence shows that RER has had a limited appreciation during the last seven years, at a an average annual rate of 1.9%, even though the price of copper has multiplied by four during the same period and the terms of trade grew at an average annual rate of 8.7% between 2004 and 2010. However, the implementation of the fiscal rule has entailed an important change in the role played by certain fundamentals in explaining RER behavior and, therefore, prior RER models have started to include this new scenario for the Chilean economy.

In this context, Caputo and Núñez (2008) put forward that implementing the new structural balance fiscal rule based had mitigated the TOT shock effect, resulting from the increase in copper prices,[7] on RER. This, insofar as the structural rule avoids

6. It is worth noting that Chile is an important copper producer in the global market, according to 2006 figures, accounting for approximately 35% of the world copper production and 40% of net exports. In Chile, the copper sector accounts for nearly a quarter of GDP and more than half of the country's total exports. Additionally, the copper industry delivers to the Treasury nearly 30% of its total revenues.

7. An important point to consider is that Codelco's production is only 30% of the total copper produced in Chile, the rest is owned by private mining companies. Therefore, insofar as the Treasury saves Codelco's revenues, and private investors either reinvest part of their revenues and the rest is sent overseas as profits, that the appreciation effect on the real exchange rate due to high copper prices tends to significantly decrease.

positive terms of trade shocks, resulting from increases in copper prices, are fully transferred into the economy, since when the price of copper exceeds the long-run equilibrium price, the resources are saved. This situation would make the terms of trade elasticity in the RER equation, using 2007 data, become insignificant and eventually positive, which is not consistent with the theoretical aspects under which the RER reduced-form equation was obtained.

In fact, the information provided by Caputo and Núñez (2008) indicates that the correlation between RER and the terms of trade, from 1977 to 1999, is negative and statistically significant, but this relationship begins to weaken in 2000. Additionally, the dynamic OLS estimate carried out by the authors for the period between the first quarter 1977 and the second quarter 2007 confirms that RER response to TOT is not statistically different to zero and in one case it is even positive (and statistically significant). This contrasts with the estimates applying different models with a horizon covering dates prior to 2004, where RER elasticities to TOT were negative and statistically significant (table 1).

In other words, everything indicates that the implementation of the structural fiscal rule meant a structural change that affected the estimate of RER reduced-form equations. This hypothesis is approved by Caputo and Núñez (2008) by obtaining recursive estimates of RER elasticity to TOT, confirming that elasticity changes when more recent data is included and it becomes positive and not statistically significant as of 2003.

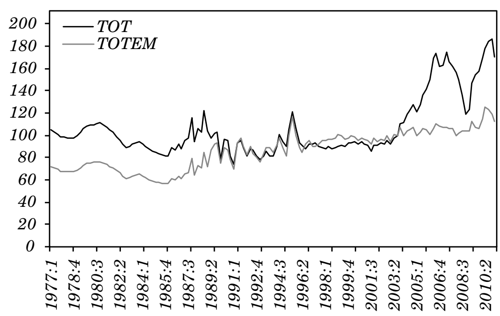
Therefore, everything would indicate that the terms of trade variable that would be included in the RER reduced-form equation must be redefined, given that its impact will be limited to prices variations of imported and exported goods which may change spending patterns; this condition would permit to exclude all copper price variations that exceed the long-run price of copper defined in compliance with the rule.

The above is implemented by Caputo and Núñez (2008) by excluding the price of copper from the terms of trade index. Figure 1 displays the different behavior, from the end of 2003, of the terms of trade with and without copper prices. According to these authors, the reduced model re-estimate, incorporating a terms of trade index that excludes mining (TOTEM), from the first quarter 1977 to the second quarter 2007, results in a RER elasticity to TOTEM of -0.544, resulting in the correct sign, statistically significant and relatively more stable throughout the estimate period.

However, the existence of the fiscal rule should lead to, faced with a positive copper price shock, the appreciation effect on RER should be significantly lower than when there was no rule. In order to validate this hypothesis and use the Central Bank of Chile Simulation and Analysis Model (SAM), Caputo and Núñez (2008) assess the effect on the different macroeconomic variables of a copper price shock, when a structural surplus rule (SSR) is applied and when the rule is not applied (i.e., the Treasury adjusts its spending in line with the changes in its revenues, keeping the cash balance constant).[8]

The general SAM equilibrium model reveals that, in the absence of a structural rule, the positive copper price shock increases public spending and private consumption, appreciating RER. Whereas under a SSR, part of the positive copper price shock is saved, thus GDP, demand for domestic goods and inflation have a minor reaction. Consequently, the real appreciation required is also less than when there is no structural rule applied (1% versus 0.4%). Additionally, if the *TOT* shock results from other components different to the price of copper, the fiscal rule is irrelevant. Therefore, *the RER response to TOT depend on the fiscal rule and the nature of the TOT shock*.

Figure 1. Terms of Trade Index, Including and Excluding Mining



Source: Central Bank of Chile.

8. It is important to note that the structural rule does not lessen the impact of the oil and imported product price evolution. Consequently, an oil price shock affects RER independently from the fiscal policy rule.

In brief, the implementation of a structural balance rule changes the RER response to TOT shocks, provided that these shocks originate from copper price movements. This explains why elasticity estimates only started to change towards the end of 2003, given that it is from this date that copper prices began to rise sharply.

Nevertheless, the fiscal rule mitigates the impact of copper price shocks on RER, which is consistent with stating that if this rule had not been applied, the real appreciation of the exchange rate would have been higher than the effective rate shown by this indicator over the period 2004-2010.

2. Empirical Analysis of the Real Exchange Rate under the Fiscal Rule

2.1 Estimate for RER Reduced-Form Equation

Considering the evidence that the implementation of the fiscal rule, faced with a significant increase in copper prices as of 2004, implied a structural change in both public spending behavior and the country's net foreign asset stock, a reduced-form equation was estimated for the real exchange rate in line with the work undertaken by Caputo and Núñez (2008), but the estimate period was also extended by 15 quarters. Basically, the estimate aims to verify if previous results are still the same, especially during the last few years where the domestic economy has had to face a severe global crisis, together with a significant increase in copper prices. In this context, the structural balance fiscal rule is expected to have significantly absorbed RER volatility faced with the sharp increases in copper prices in recent years, since the variable that has become fundamental to RER has been the terms of trade, excluding copper mining. This estimate was conducted by dynamic least squares[9] from the first quarter 1977 to the first quarter 2011.

Before estimating the equation by dynamic least squares the co-integrated RER reduced-form equation was verified, including the

9. The dynamic least square technique allows for corrections of the inverse causality problem caused by the correlation between RER shocks and the fluctuations of its fundamentals, if this problem were to affect an estimate carried out by ordinary least squares. This inverse causality problem may be parametrically solved by including lags and advances of the first differences of the explanatory variables in the co-integration equation.

explanatory variables: TNT, TOTEM (or TOT), G/Y, NFA/Y, TARIFF. This exercise is carried out applying the Johansen-Juselius method, indicating the existence of a co-integration vector.[10]

Applying the exercise conducted by Caputo and Núñez (2008), table 2 displays the estimates for the RER reduced-form equation, including as an explanatory variable the terms of trade, both total and excluding mining.

Like the authors, when considering the estimates for total terms of trade, the coefficient is positive and non-significant. Whereas for the term of trade that excludes mining, the coefficient is negative, but not significant. A residual analysis for the latter estimate indicates that as of the last quarter 2008, a structural change had occurred caused by the severe global economic crisis. This event is endogenized by including the U.S. GDP deviation with respect to its potential in the RER reduced-form equation, as a proxy variable of global deceleration. The results, displayed in table 2, indicate that all coefficients show the expected signs and are significant, the same as the results obtained by Caputo and Núñez (2008).[11]

Table 2. Estimate for RER Reduced-Form Equation

	TOT incl. Mining				*TOT excl. Mining*			
	Coefficient	*t-Student*	*Coefficient*	*t-Student*	*Coefficient*	*t-Student*	*Coefficient*	*t-Student*
TOT (TOTEM)	0.186	2.460	0.107	1.542	-0.092	-0.743	-0.429	-4.283
TNT	-0.317	-3.404	-0.360	-4.280	-0.154	-1.776	-0.137	-2.048
G/Y	-0.163	-2.991	-0.141	-2.829	-0.216	-2.493	-0.369	-5.470
NFA/Y	-0.149	-5.886	-0.183	-7.728	-0.109	-4.829	-0.137	-7.020
TARIFF	-0.004	-1.017	-0.010	-2.720	-0.009	-1.614	-0.023	-4.519
$(Y_{USA} - Y^*_{USA})$	-	-	0.000	-5.109	-	-	0.000	-6.614
Observations	132		132		132		132	
R^2 adjusted	0.723		0.777		0.714		0.783	

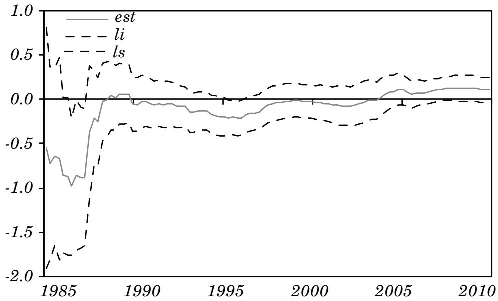
Source: Authors' estimations.
Note: All variables are expressed in natural logarithms, except for Net Foreign Assets and Tariff. The estimate period was the 1st Q 1977 – 1st Q 2011. The model was estimated by dynamic least squares, with two advances and two lags in the first difference of explanatory variables.

10. The data used was provided by R. Caputo and M. Núñez from the Central Bank of Chile.

11. In order to verify that this result is not due to applying the variable used to control the structural change, table 2 shows the estimate including the total terms of trade; the coefficient for this variable is positive and not significant.

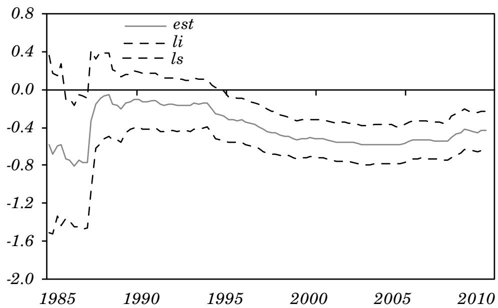
The effect of introducing the terms of trade excluding mining in the estimate for the RER reduced-form equation is displayed in figures 2 and 3, which show the evolution of the recursive coefficients for the terms of trade parameter, including and excluding mining. In particular, if we look at the recursive estimate figure for the total terms of trade parameter, it was negative for most of the estimate period, and it becomes positive towards the end of the period, matching the period when the fiscal rule became relevant. While figure 3 shows the recursive coefficient evolution of the terms of trade excluding mining, indicating that throughout the period it is negative, as expected.

Figure 2. Recursive Estimates of RER Elasticity to TOT Including Copper Mining



Source: Authors' estimations.

Figure 3. Recursive Estimates of RER Elasticity to TOT Excluding Copper Mining



Source: Authors' estimations.

2.2 Real Exchange Rate Volatility and Fiscal Rule

Additionally, it may be stated that the implementation of the fiscal rule should have resulted in copper price fluctuations losing relevance in explaining the behavior of the real exchange rate; therefore, the increased stability of the terms of trade excluding mining would imply that real exchange rate volatility should be less with a fiscal rule in operation than without one.

To prove the hypothesis that RER volatility has fallen, an extension of the ARCH and GARCH models is used. The advantage of using these models is that they require a minimum amount of data, basically a time series that includes data for the before, during and after variables of implementing a certain event, that in our case is the operating capacity of the fiscal rule.

The model used searches for potential regime changes, incorporating into the estimated equation a dummy or binary variable that controls during the period the fiscal rule has been in operation in the conditional variance. In this context, the model for two equation estimates is as follows:

Mean Equation:

$$y_t = \beta_0 + \beta_1 y_{t-1} + u_t + \beta_2 u_{t-1}, \quad (4)$$

Conditional Variance Equation:

$$h_t = \alpha_0 + \alpha_1 u_{t-1}^2 + \alpha_2 h_{t-1} + \alpha_3 Dummy_t + w_t, \quad (5)$$

where u is a process of white noise with zero mean and finite variance; u^2 is the non-conditional variance and h is the conditional variance; w is the white noise process.[12]

In order to estimate if RER volatility diminishes by implementing the fiscal rule, a model was used for RER deviations from a trend.[13] This model involved ARMA(1.1) processes for the conditional mean and GARCH(1.1) for the conditional variance. The dummy variable

12. Before estimating equations (1) and (2) the null hypothesis of homoscedasticity and no autocorrelation was proven in the equation errors (4). As these hypotheses are rejected it is possible to state that the ARCH and GARCH models can describe the error process of such an equation. The evidence found showed a strong rejection of the null hypothesis of the $\Delta(TCR)$ quadratic residuals.

13. This trend was estimated using the Hodrick-Prescott filter.

incorporated into the GARCH models took the value 1 from the first quarter 2004 onwards. Basically, the fiscal rule only began to be operational in 2004, when the difference between the terms of trade excluding mining and total become significant, as shown in figure 1. Prior to this date, the fiscal rule, although it existed, had not been challenged nor tested, since copper prices only started an upward trend towards the end of 2003, when the actual copper price exceeded the long-run copper price estimates considered in the budgets.[14] The results obtained are presented in table 3.

The results indicate that the dummy is significant and with a negative sign, reflect that RER volatility declined when the fiscal rule has been in operation.

Considering that the terms of trade index that excludes copper prices has continued relatively stable during the last ten years—at just over 100, as shown in figure 1—it is highly probable that once foreign prices become normalized the index will not significantly vary from current values. Therefore it may be stated that the long-run terms of trade excluding mining, required to estimate the equilibrium real exchange rate, should not be very different from the level shown by this index in recent years. Therefore, and with the same long-run behavior of the other variables included in the RER reduced-form equation, the fiscal rule allows the economy to adjust to a lower equilibrium real exchange rate than would be required if there was rule no applied. Thus, if there is no fiscal rule, the relevant terms of trade are those that include the price of copper, then in the long run, a significant copper price fall would have to be considered compared to the current value, which makes the real exchange rate, that balances the domestic and foreign market, be above not only of the current rate, but also of the rate obtained when there is a rule. Also in this context, it can be anticipated that given the significant increase in copper prices, the misalignment of the actual RER compared to the equilibrium RER should be higher in the case with no rule applied in relation to the misalignment obtained when the fiscal rule is in operation.

14. From the early 2000s, when the structural balance fiscal rule concept started to be used, the long-term copper price assumption employed was constantly above the actual one, which not only meant that copper funds at the Central Bank decreased nearly in full, but also that this rule lacked credibility until that date. Credibility in the rule came when the actual copper price exceeded the long-run price estimated and the Treasury saved the surplus revenues overseas.

Table 3. RER Volatility - GARCH Model Estimate

Dependent Variable: RER Deviations with respect to its Trend			
For Conditional Mean	*Coefficient*	*z-Statistic*	*Probability*
C	-1.17	-0.93	0.350
AR(1)	0.68	8.49	0.000
MA(1)	0.43	4.36	0.000
For Conditional Variance	*Coefficient*	*z-Statistic*	
C	21.06	10.30	0.000
ARCH(1)	0.07	2.43	0.015
GARCH(1)	-1.04	-40.30	0.000
Dummy 2014	-8.39	-2.24	0.025
Observations	136		
Sample Period	1977:1 - 2011:1		

Source: Authors' estimations.

However, evidence allows to state that the significant increase shown by copper prices since 2004 has had a limited effect on the real exchange rate, which is explained by the existence of a fiscal rule that enables the Treasury to save most of the revenues generated by higher copper prices. Furthermore, this fiscal rule has reduced RER volatility.

Then, at a real exchange rate level, it can be concluded that this variable has behaved in keeping with what was expected after implementing a fiscal rule. This, given that the rule significantly reduces the impact that copper price fluctuations have on the terms of trade, limits the importance of this channel as one of the fundamentals of the equilibrium real exchange rate.

3. Nominal Exchange Rate and Structural Fiscal Rule

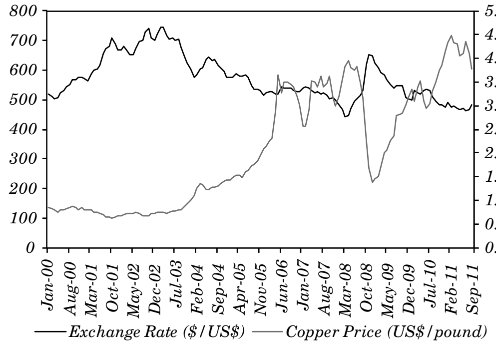
As shown in figure 4, the exchange rate in Chile demonstrates a high negative correlation to copper prices. Historically, this relationship has been explained by higher U.S. dollar returns than by higher copper prices generated in our exports, which when entered into the country and settled in the local exchange market produces a fall in the peso-U.S. dollar parity. However, the importance of this channel, at least, had to be significantly reduced after implementing the fiscal rule. Then this correlation would have been expected to significantly decrease, especially as of 2004 when the rule became operational, however, this behavior is not observed in figure 4, since this relationship has remained the same or stronger than when the fiscal rule was not applied.

Basically, the rule during the last eight years has gained credibility; therefore the government has consistently saved overseas the surplus revenues resulting from higher copper prices. While, it is also known by agents that private mining companies do not bring into the country additional revenues obtained from higher copper prices than what had been considered in their budgets. Then, it can be assumed that domestic agents should have internalized in their decision that this transfer channel—copper price to exchange rate—is no longer relevant in order to determine domestic parity.

In short, the structural balance rule of public accounts should have significantly reduced the correlation between copper prices and nominal exchange rate, and hence parity volatility, especially after 2003, when copper prices began to rise. However, evidence shows that nominal parity continues to be affected by copper price changes, even when agents know that this capital flows will not enter the country. Our thesis is that a copper price rise is an indicator that in view of a better domestic and global economy outlook, which would imply, on one hand, that the remaining goods exported by the country, both in terms of price and demand, will improve and, on the other, that domestic agents feel wealthier increasing their future demand, behavior which would also imply parity appreciation. In this context, the existence of the fiscal rule would have eliminated (or significantly reduced) the direct effect caused by higher copper prices on the nominal exchange rate, breaking the direct relation with a higher currency settlement, but it would have generated (or intensified) an indirect channel that related the copper price to the general outlooks for the Chilean economy.

This section analyzes this puzzle that causes agents to react to copper price changes, when theoretically (under a fiscal rule that uses the copper price as one of its structural parameters to set its sustainable revenues) it should not occur, since the price change should not affect the agents' outlooks for the currency amounts that will be settled by copper exporters (public and private) in the local exchange market.

Figure 4. Copper Price – Nominal Exchange Rate



Source: Central Bank of Chile.

3.1 Nominal Exchange Rate and Monetary Policy

One of the expected effects from implementing the fiscal rule was the reduced volatility of the peso-U.S. dollar parity, given that one of the main variables by which it was affected, the price of copper, tended to be excluded as an indicator of currency flow into and out of the local exchange market.

However, when the fiscal rule was implemented, the Central Bank also made changes to its monetary and exchange rate policy. In fact, towards the end of the 1990s (fourth quarter 1999), the Central Bank abandoned its crawling peg system to adopt a flexible exchange, while in August 2001 it carried out the nominalization of its monetary policy, using a nominal interest rate as the monetary policy interest rate. Its aim was for the shocks that affected the economy not to be reflected in the interest rate fluctuations but in the nominal exchange rate (NER). Then, these exchange rate and monetary policy changes should be that the exchange rate volatility should increase while the nominal interest rate stabilized. Whereas, implementing the fiscal rule aimed to reduce the volatility of the peso-U.S. dollar parity. However, it is not clear which effect dominated the exchange rate volatility. However, if volatility falls after 2003 (when the fiscal rule is in operation) it would be feasible to say that the implementation of the fiscal rule could be responsible for this result. If the exchange rate volatility increased after 2003, it is not clear if it increased because the fiscal rule has no effect on exchange rate volatility or if this effect has a lower magnitude to the higher volatility caused by moving to a flexible exchange rate.

Using the GARCH model similar to the model shown in equations (4) and (5), it was estimated that if the volatility of the exchange rate parity increased with the change to a flexible exchange rate policy at the end of the 1990s. In particular, an MA(1) model was used; its dependent variable was the change in the nominal exchange rate logarithm, together with a GARCH(1.1) model for the conditional variance. Both in the conditional variance and mean of this model a dummy variable was included that took the value 1 from the fourth quarter 1999, when the flexible exchange rate started to be used. This model was estimated using quarterly data from the first quarter 1984 until the first quarter 2011 and the results are shown in table 4. In particular, the estimate indicates that the dummy coefficient was positive and significant for the conditional variance, reflecting that from that date onwards, nominal exchange rate volatility increased.

Table 4. Volatility NER - GARCH Model Estimate

Dependent Variable: first difference of NER logarithm			
For Conditional Mean	*Coefficient*	*z-Statistic*	*Probability*
C	0.02	5.69	0.000
Dummy 1999,4	-0.02	-2.61	0.009
MA(1)	0.13	1.75	0.081
For Conditional Variance	*Coefficient*	*z-Statistic*	
C	0.00	5.88	0.000
ARCH(1)	-0.13	-6.14	0.000
GARCH(1)	1.04	23.63	0.000
Dummy 1999,4	2.43E-04	6.06	0.000
Observations	108		
Sample Period	1984:1 - 2011:1		

Source: Authors' estimations.

Additionally, table 5 displays the estimate for interest rate volatility. For this purpose an ARMA(1.1) model was used; its dependent variable was the change in the nominal interest rate, 30 to 89 days, together with a GARCH(1.1) model for the conditional variance. The conditional variance of this model included a dummy variable that took a value 1 from the fourth quarter 1999, period when a flexible exchange rate was adopted. This model was estimated using quarterly data from the first quarter 1990 until the first quarter 2011. Basically, the estimates indicate that the dummy coefficient was negative and significant for the conditional variance, reflecting that from that date onwards the volatility of the nominal interest rate fell, as was expected in a flexible exchange rate regime.

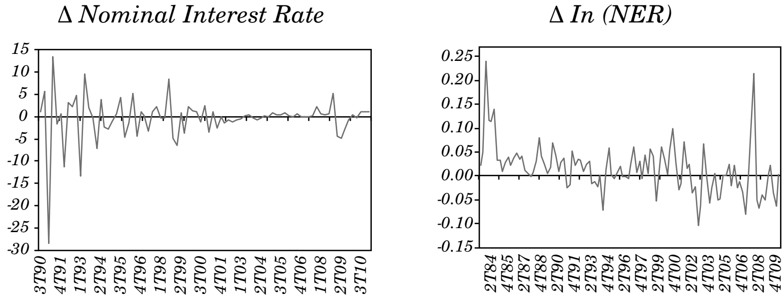
Figure 5 shows the first logarithm differences of the nominal exchange rate and the nominal interest rate; it can be observed that as of 2000 the exchange rate variability increased and the nominal interest rate variability dropped.

Table 5. Interest Rate Volatility - GARCH Model Estimate

Dependent Variable: first difference of NER logarithm			
For Conditional Mean	*Coefficient*	*z-Statistic*	*Probability*
C	-0.11	-0.15	0.881
AR(1)	0.94	21.04	0.000
MA(1)	-1.11	-9.17	0.000
For Conditional Variance	*Coefficient*	*z-Statistic*	
C	3.29	1.92	0.055
ARCH(1)	0.13	1.06	0.291
GARCH(1)	0.66	5.44	0.000
Dummy 2004	-2.94	-1.77	0.076
Observations	85		
Sample Period	1990:1-2011:1		

Source: Authors' estimations.

Figure 5. Exchange Rate – Interest Rate Volatility



Source: Central Bank of Chile.

Table 6. NER Volatility – GARCH Model Estimate

Dependent Variable: First difference of NER Logarithm			
For Conditional Mean	*Coefficient*	*z-Statistic*	*Probability*
C	0.02	4.39	0.000
Dummy 1999,4	2.59E-03	0.22	0.829
Dummy 2004,1	-0.04	-2.14	0.032
MA(1)	0.15	4.09	0.000
For Conditional Variance	*Coefficient*	*z-Statistic*	
C	0.00	4.68	0.000
ARCH(1)	-0.13	-5.25	0.000
GARCH(1)	1.03	20.20	0.000
Dummy 1999,4	2.06E-04	4.33	0.000
Dummy 2004,1	9.47E-05	0.73	0.467
Observations	108		
Sample Period	1984:1 - 2011:1		

Source: Authors' estimations.

Subsequently, a similar GARCH model was used to prove if this parity volatility was affected once the fiscal rule was applied in 2004. This estimate is shown in table 6 which also includes a new dummy variable that takes value 1 from the first quarter 2004, reflecting the start of when the fiscal rule was applied. The results indicate that the dummy coefficient corresponds to the introduction of exchange rate flexibility continues to be positive and significant for conditional variance, while the dummy coefficient for the fiscal rule in operation was insignificant and with the opposite expected sign.

Even though the result does not permit to verify if the fiscal rule affected or not parity volatility, we can state that the increased parity volatility was caused by changing to a flexible exchange rate policy. These because the volatility of the nominal interest rate fell as of 2000, as would be expected in a flexible exchange rate scheme.

In order to isolate the regime change caused by the implementation of a flexible exchange rate system at the end of 1999 on the volatility of the nominal exchange rate, a GARCH mode was estimated from the first quarter 2000 to the first quarter 2011. This estimate is shown in table 7 and no statistical evidence was found that volatility of the nominal exchange rate had been affected by the fiscal rule in operation.

In brief, the nominal exchange rate increased its volatility from the early 2000s, due to applying a flexible exchange rate policy, which is the normal result and goal of such a policy. Nevertheless, it cannot be concluded with this evidence that the volatility of nominal parity had decreased after implementing the fiscal rule, which could have been expected given that a key variable that has historically affected parity, the price of copper, was no longer relevant to explain the entry or exit of currency on the local foreign exchange market.

Table 7. NER Volatility – GARCH Model Estimate

Dependent Variable: First difference of NER Logarithm			
For Conditional Mean	*Coefficient*	*z-Statistic*	*Probability*
C	0.01	0.60	0.549
Dummy 2004,1	-0.03	-1.43	0.152
AR(1)	-0.40	-1.38	0.166
MA(1)	0.70	3.53	0.000
For Conditional Variance	*Coefficient*	*z-Statistic*	
C	0.00	1.09	0.277
ARCH(1)	-0.12	-4.55	0.000
GARCH(1)	1.10	31.83	0.000
Dummy 2004,1	3.25E-05	0.32	0.747
Observations	45		
Sample Period	2000:1 - 2011:1		

Source: Authors' estimations.

3.2 Copper Prices as an Expectation Indicator

The fact that the nominal exchange rate reacts to copper price changes, when the fiscal rule is in operation, should not be a regular movement, since the price change should not affect the expectations of agents for the currency amount that will be settled by copper exporters (public and private) in the local foreign exchange market. However, figure 4 demonstrates that this cause-effect relationship is more general than specific. Then, copper price movements could be interpreted as an indicator anticipating a better outlook for the domestic and global economy, which would lead agents to also expect prices to rise (as well as demands) of the remaining goods exported by the country and therefore more capital flows would enter and be settled on the local market.

Furthermore, higher copper prices could also anticipate increased domestic spending, but not through the direct channel of revenues derived from terms of trade, since it has been interrupted by the fiscal rule, but through a channel that improves the agents' expectations of wealth, boosting domestic spending and hence appreciating the peso.

In this context, the empirical evidence should be in line with the following events:

First, the price of copper shows a close positive relation to the price behavior of Chile's non-copper exports. Basically, financial agents expect that if there is an increase in copper prices, this behavior will also be replicated in other international prices for goods exported by Chile. This relationship is not necessarily unidirectional, it could be bidirectional.

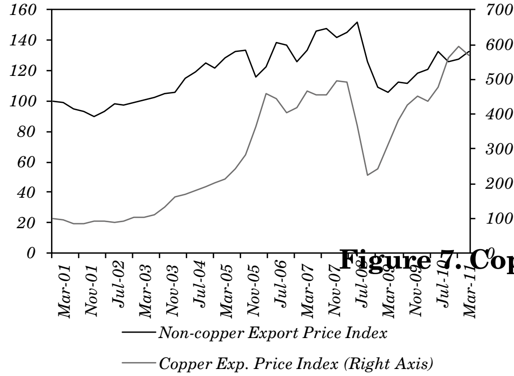
Second, copper prices are positively related to global expectations for Chile's economy; copper prices are expected to be the unidirectional cause of expectations.

Third, copper prices are positively related to domestic spending, expecting unidirectional causality from copper prices to domestic spending, as a result of consumers having higher expectations.

Finally, expectations should play an important role in explaining the nominal exchange rate variability. In this context, the peso-U.S. dollar parity would be expected to be explained by copper prices, the domestic-foreign interest rate differential and the international context, as well as the country's economic expectations. The latter channel should be one of the most important to explain exchange rate variability.

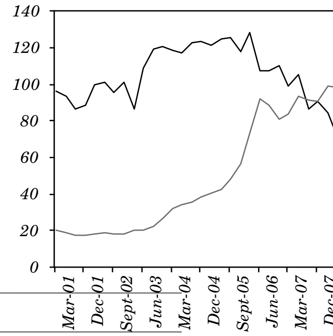
Evidence on the first above mentioned event is shown in figure 6 which demonstrates the evolution of the price index for copper exports and the price index for non-copper exports. Table 8 displays causality test results between these variables (in first differences) from the first quarter 2001 to the second quarter 2011.

Figure 6. Export Price Indices
March 2001=100



Source: Central Bank of Chile and own estimates based on Central Bank of Chile data.

Figure 7. Copper Export Price Index



Source: Central Bank of Chile and University of Chile.
Expectations Index corresponds to the Country's Situation, calcul
Economics, University of Chile.

Table 8. Granger Causality Test
Copper and Non-Copper Export Price Index

Granger Causality Test		
Null Hypothesis	*F-Statistic*	*Probability*
Non-copper price index does not cause copper price index	13.58	0.001
Copper price index does not cause non-copper price index	16.76	0.000
Observations	40	
Sample Period	2001:1 - 2011:2	

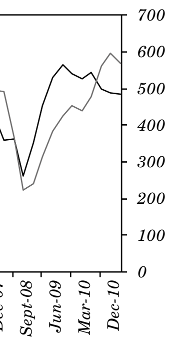
Source: Authors' estimations.
Note: Variables were used in first differences.

Results indicate that the correlation between both variables is high and that causality is bidirectional. This result is consistent with what was expected, since there should not be a unique causality from the international price of copper to other international prices of Chile's other export goods.

As for the second event, figure 7 shows the evolution of copper export price index and the expectation index of the country's economic situation (seasonally adjusted) that is calculated by the Microdata Center, Department of Economics, University of Chile. While table 9 displays the Granger causality test result and the variance decomposition results for a VAR system between both variables (in first differences).

The results show that both variables tend to move together, and there is evidence that causality would move from copper prices to expectations. In fact, the causality test demonstrates that the null hypothesis, that copper prices would not cause expectations, is significantly rejected. Furthermore, the variance decomposition backs this result by indicating that nearly 25% of expectation variability is explained by the price of copper, behavior that does not occur in the copper price variability, which is basically explained in itself.[15]

x–Expectations



(Right Axis)

ated by the Microdata Center, Department of

15. This result was not affected by changing the order of the VAR variables.

This positive relation that copper prices produce on expectations of the country's situation is reflected in that consumers tend to spend more, possibly indicating that consumers feel wealthier or more confident about their source of income. Figure 8 shows the evolution of the copper price index and annual variation in domestic spending, indicating a positive correlation, that according to causality results shown in table 10, it would go from copper prices to domestic spending. In fact, the Granger causality test indicates that the null hypothesis, that one variable would not cause the other, is only significantly rejected in the case of copper prices to domestic spending.

Table 9. Granger Causality Test: Copper Price Index - Expectations

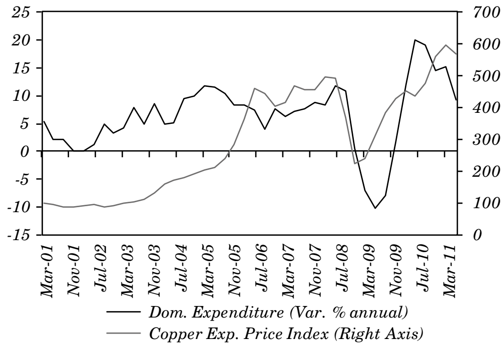
Granger Causality Test		
Null Hypothesis	*F-Statistic*	*Probability*
Expectations does not cause copper price index	1.11	0.358
Copper price index does not cause expectations	4.45	0.010
Observations	38	
Sample Period	2001:1 - 2011:2	

Analysis of Variance Decomposition							
Variance Decomposition of Copper Price Index				Variance Decomposition of Expectations			
Period	*S.E.*	*Copper P.*	*Expec.*	*Period*	*S.E.*	*Copper P.*	*Expec.*
1	0.41	100.00	0.00	1	9.40	0.79	99.21
2	0.42	99.10	0.90	2	10.39	15.11	84.89
3	0.45	94.84	5.16	3	10.56	16.45	83.55
4	0.47	93.82	6.18	4	11.16	24.98	75.02
5	0.47	93.51	6.49	5	11.31	24.47	75.53
6	0.47	93.30	6.70	6	11.42	25.85	74.15
7	0.47	93.26	6.74	7	11.43	25.87	74.13
8	0.47	93.23	6.77	8	11.44	26.02	73.98
9	0.47	93.24	6.76	9	11.45	26.01	73.99
10	0.47	93.23	6.77	10	11.45	26.02	73.98

Source: Authors' estimations.

Note: Variables were used in first differences. For Variance Decomposition the price of copper was used as an exogenous variable.

Figure 8. Domestic Spending - Copper Export Price Index



Source: Central Bank of Chile.

Table 10. Causality Test: Domestic Spending - Copper Price Index

Granger Causality Test		
Null Hypothesis	*F-Statistic*	*Probability*
Domestic spending does not cause copper price index	0.38	0.543
Copper price index does not cause domestic spending	17.78	0.000
Observations	40	
Sample Period	2001:1 - 2011:2	

Source: Authors' estimations.
Note: Variables were used in first differences.

Finally, tables 11 and 12 show the variance decompositions of the nominal exchange rate for a VAR system that includes the following variables: copper price, domestic-foreign interest rate differential, the international context measured by the U.S. GDP gap compared to its potential value and nominal exchange rate. Subsequently, this system also incorporated the expectation variable to observe the role this variable has in explaining the variability of local exchange rate parity (table 12).

The results show that the expectation variable tends to significantly explain the exchange rate variability; it is much higher that the effect of the interest rate differential and of the international context. Its relevance is comparable to the magnitude directly shown by copper prices.

Table 11. VAR System Estimate

Variance Decomposition of Nominal Exchange Rate					
Period	*S.E.*	*Copper P.*	*U.S. GDP*	*Spread*	*NER*
1	0.40	27.14	10.18	4.41	58.26
2	0.43	24.27	13.10	5.37	57.26
3	0.44	24.40	13.28	5.41	56.91
4	0.44	24.42	13.29	5.40	56.89
5	0.44	24.42	13.29	5.40	56.89
6	0.44	24.42	13.29	5.40	56.89
7	0.44	24.42	13.29	5.40	56.89
8	0.44	24.42	13.29	5.40	56.89
9	0.44	24.42	13.29	5.40	56.89
10	0.44	24.42	13.29	5.40	56.89

Source: Authors' estimations.
Note: Variables were used in first differences. For variance decomposition the price of copper was used as an exogenous variable.

Table 12. VAR System Estimate

Variance Decomposition of Nominal Exchange Rate						
Period	*S.E.*	*Copper P.*	*U.S. GDP*	*Spread*	*Expectations*	*NER*
1	0.44	21.97	10.77	2.65	19.35	45.26
2	0.47	21.37	11.31	7.47	21.62	38.23
3	0.52	29.45	9.61	8.34	16.60	36.00
4	0.56	27.93	9.16	8.19	23.38	31.34
5	0.60	26.98	10.65	8.78	23.30	30.28
6	0.61	26.93	10.09	8.63	23.35	30.99
7	0.62	26.39	9.66	9.25	24.35	30.34
8	0.63	26.60	8.99	12.35	24.07	27.99
9	0.64	26.29	8.98	12.45	24.47	27.81
10	0.64	27.17	8.79	12.29	24.51	27.24

Source: Authors' estimations.
Note: Variables are presented according to the exogenous order assumed by the Cholesky decomposition.

4. Conclusions

Chile's exchange rate shows strong volatility to copper price variations. However, the structural balance rule for public accounts should have significantly reduced real and nominal exchange rate volatility, especially after 2003, when copper prices began showing an upward trend.

As for the real exchange rate, based on the evidence it can be stated that the strong increase in copper prices since 2004 has had a limited effect on the real exchange rate, which is explained by the fiscal rule that allows the Treasury to save most of the surplus revenues resulting from high copper prices. The rule significantly reduces the impact of copper price fluctuations on the terms of trade, limiting the importance of this channel as one of the fundamentals of the equilibrium real exchange rate. Furthermore, the application of the fiscal rule has reduced RER volatility and has adjusted a lower equilibrium real exchange rate.

As for the nominal exchange rate, evidence shows that the peso-U.S. dollar parity continues to be strongly affected by copper price changes, even though agents know that these additional revenues do not enter the country when copper prices are above the prices employed in the government and private mining company budgets (i.e., when the fiscal rule is applied, this has occurred since 2004). Based on the empirical analysis undertaken, this is due to the fact that agents view a rise in copper prices as an indicator that would anticipate a better outlook for the domestic economy, which in turn would imply, on one hand, that the prices of the country's other exported goods will improve and hence a higher settlement for related currencies and, on the other, that domestic agents, faced with a rise in copper prices, would feel wealthier or more confident in their current situation, raising the future demand for goods and services, behavior that in the future would result in parity appreciation.

In this context, and based on evidence, it can be stated that the channel whereby copper prices affect local parity is not just through the possibility that the currencies associated with copper exports may be settled in the local market, but also by the effect that this price has on the country's economic expectations, effect that has most probably been intensified by the economic stability that shows the Chilean economy, where the fiscal rule has been a key policy in this result.

References

Calderón, C. 2004. "Un Análisis del Comportamiento del Tipo de Cambio Real en Chile." *Economía Chilena* 7(1): 5–30.

Caputo, R. and B. Dominichetti. 2005. "Revisión Metodológica en el Cálculo del IPE e Implicancias sobre los Modelos de Series de Tiempo para el TCR." *Economía Chilena* 8(1): 77–88.

Caputo, R. and M. Núñez. 2008. "Tipo de Cambio Real de Equilibrio en Chile: Enfoques Alternativos." *Economía Chilena* 11(2): 59–77.

Cassel, G. 1922. *Money and Foreign Exchange after 1914*. New York, NY: Macmillan Co.

Céspedes, L.F. and J. De Gregorio. 1999. "Tipo de Cambio Real, Desalineamiento y Devaluaciones: Teoría y Evidencia para Chile." Unpublished manuscript, Departamento de Ingeniería Industrial, Escuela de Ingeniería, Universidad de Chile.

Clark, P.B. and R. McDonald. 1999. "Exchange Rates and Economic Fundamentals: A Methodological Comparison of BEERs and FEERs." In *Equilibrium Exchange Rates*, edited by R. MacDonald and J.L. Stein. London: Kluwer Academic Publishers.

Edwards, S. 1989. *Real Exchange Rates, Devaluation, and Adjustment*. Cambridge, MA: MIT Press.

Faruqee, H. 1995. "Long-Run Determinants of the Real Exchange Rate: A Stock-Flow Equilibrium Approach." IMF Staff Papers 42.

Nurkse, R. 1945. *Conditions of International Monetary Equilibrium*. Princeton, NJ: Princeton University Press.

Soto, C. and R.O. Valdés. 1998. "Tipo de Cambio Real de Equilibrio y Desalineamiento Cambiario en Chile." Unpublished manuscript, Central Bank of Chile.

Williamson, J. 1983. *The Exchange Rate System*. Washington, DC: Institute for International Economics.

Williamson, J. 1994. *Estimating Equilibrium Exchange Rates*. Washington, DC: Institute for International Economics.