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Exchange rate volatility effect in emerging countries: the Chilean manufactures exports case

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Contents

Abstract

Literature around the world has shown mixed evidence regarding the sign of the effect of volatility exchange rate on exports. This is not only true for the empirical evidence, but also for existing models that attempt to explain the relationship between the two variables. Even so, it has been confirmed that exchange rate volatility could have a greater effect in emerging economies. Using a dynamic panel with quarterly information, this research aims to study the impact of volatility exchange rates on manufactures exports of Chile, an emerging country with an almost perfectly floating exchange rate. According to the results of this research, it is shown that exchange rate volatility in Chile has not damaged manufactures exports, contrary to rudimentary hypotheses made at the start of this research. Rather, it is found that the impact of volatility on exports has been positive and statistically significant in the long-run. Additionally, it is found that the level of the exchange rate and external demand play a key role as determinants of exports, which is in line with the international literature.

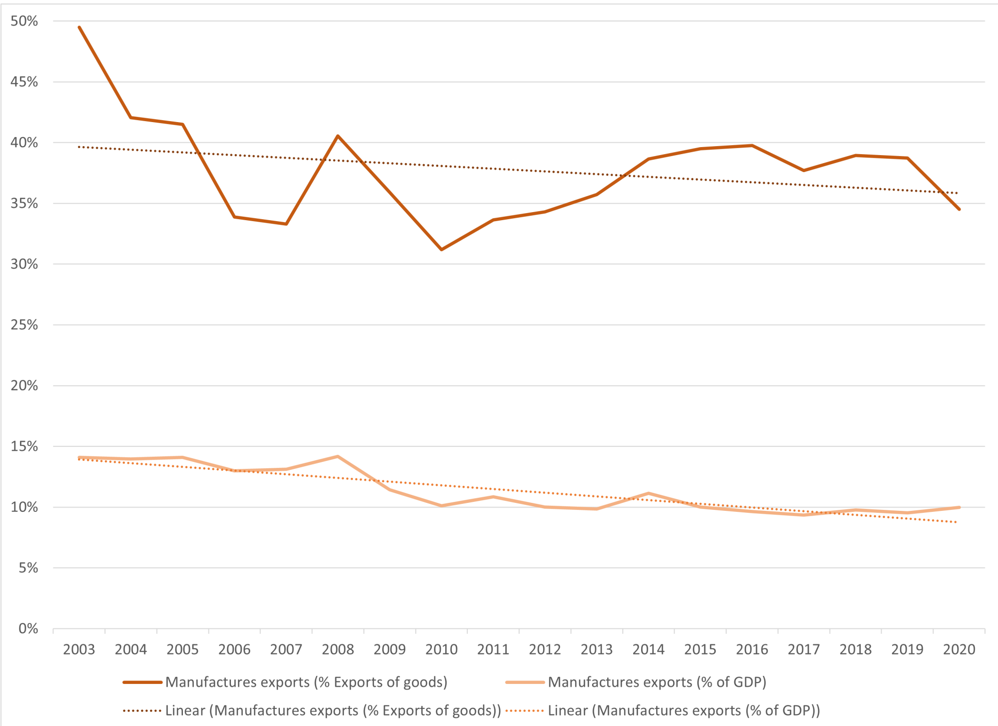
Key words: Exchange rate volatility, exports, trade, developing countries.

1 Introduction

In many ways, the trade-openness policies implemented in Chile since the end of the 20th century have been successful. The exchange rate runs almost freely since the ends of 1999 and it has only been intervened in specific emergency occasions[1]. The success of the free floating regimen is well documented by the report of Albagli et al. (2020). The author shows how, in front of negative external shocks, the Chilean's economy has been able to recover faster than in previous periods of rigid exchange rate and exchange interventions (prior to 1999).

However, the real exchange rate in the flexible regime, acting as a mechanism for absorbing external shocks, experiences larger fluctuations, at least in the short-run, as it is shown by De Gregorio et al. (2011) who compares the 2000s and the 1990s and finds evidence of a greater volatility in the later.

Figure 1: Share of manufactures exports on total exports of goods and GDP. Chile, 2003-2020.



Source: produced with data from the Central Bank of Chile.

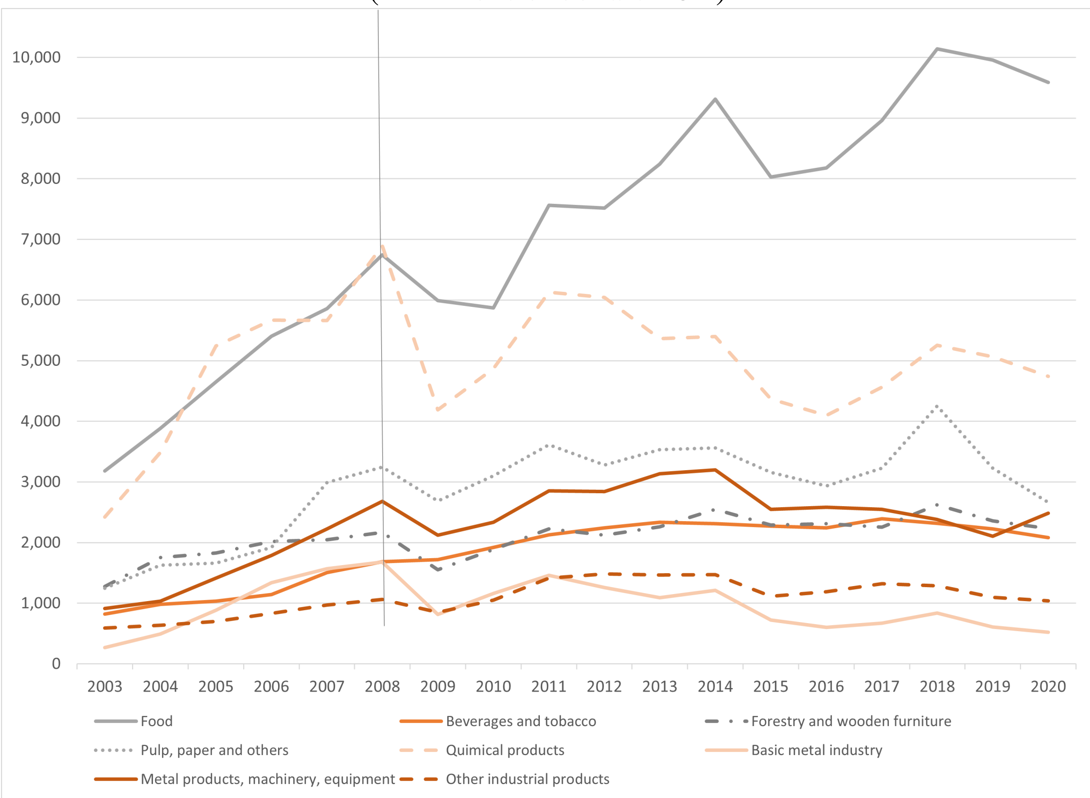
Although trade liberalization policies were a popular phenomenon among countries around the world, not all countries have opted for total flexibility and not all exchange rates have presented a homogeneous behavior afterwards. Particularly, it has been observed that the volatility of the real exchange rate has been significantly higher in emerging countries than in developed countries. However, the literature that addresses the effects of high volatility on production and trade patterns has not been

[1]Until the defense of this thesis, the Chilean exchange rate was intervened in five specific occasions: 2001 (Argentina's convertibility crisis); 2002-2003 (disruptions associated with the presidential elections in Brazil); 2008 (United States' financial crisis); 2011 (global weakness of the US dollar and high copper prices); and 2019-2020 (Chilean political and civil unrest (known in Chile as "Estallido Social")). These interventions were based on "situations of extreme volatility, or in moments when the Chilean peso moves against its fundamentals" (Guzmán, 2014; de Ramón, 2020).

extensive or conclusive, as it will be further explained in the following section (Khosa et al., 2015; Huchet-Bourdon and Korinek, 2012).

At the same time, the stagnation and decline of Chilean manufacturing exports as a fraction of gross domestic product and as a fraction of total exports has been a phenomenon within the last two decades (see Figure 1). Furthermore, as it has been pointed out by Fornero et al. (2020), considering the seven sectors in which manufactured exports are classified, it is observed that, when comparing the years 2016 and 2013, the total volume exported for five of these sectors fell. If we extend this analysis and repeat the comparison for 2020 and 2003 (see Figure 2), we see that, until 2008, there is an increase in the exports of all manufactures exports' components. Nonetheless, from 2008 onwards the pattern changes. That is, between 2008 and 2020 only two sectors (food and beverages and tobacco) have shown an increase in exported volume; the rest of them has stagnated or fallen.

Figure 2: Manufactures exports by its components
(in millions of dollars FOB)



Source: produced with data from the Central Bank of Chile

Could a high volatility be related to the stagnation of manufactures exports? This research focuses on empirically studying the relationship between the volatility of the real exchange rate and the performance of manufactures exports in the last two decades in Chile and, specifically, to identify the direction of the effect of the former on the latter. Since in Chile this relationship has not been fully explored by the literature until now, measuring it can help to understand underlying effects of a free floating regime on the national industry, considering that omitting these potential effects could lead to the formulation of suboptimal industry development policies.

2 Theory and Literature Review

2.1 Theoretical Models

Four decades ago Marston (1987) stated that the exchange rate volatility is a random movement that increases the uncertainty of benefits. However, to this day, there is still no consensus on the direction of this effect on production and exports.

The theory behind the exchange rate volatility effects on trade is based on the producer theory of the firm under uncertainty. Depending on the model, this firm will produce exclusively an export product (undiversified), or a product that can be both sold in the home-country and abroad. In both cases the profitability of the firm is directly and unambiguously related to the movement in one bilateral exchange rate (Coté, 1994).

On the side of theory that supports negative effects on trade, three of the most important models that sustain theoretical link between exchange rate volatility and trade are highlighted by Agathe Coté (1994):

- Clark (1973) studies an exporting firm under perfect competition that produces a homogeneous commodity that is sold entirely abroad. The firm is paid in foreign currency and the price of the exported good in foreign currency is an exogenous variable. Hedging is limited, and uncertainty about future exchange rates translates into uncertainty on future export receipts in domestic currency. The firm must decide on a level of exports that takes this uncertainty into account.

  The firm will maximize the expected value of utility, which is assumed to be a quadratic function of profits expressed in the home currency (U(p) = ap + bp2). With risk aversion (b ¡ 0), the first-order condition requires that marginal revenue exceed marginal cost. Hence, the firm must be compensated for the exchange risk it bears. The supply curve shifts leftwards and the volume of production and trade is reduced. To reduce its risk exposure the firm reduces sales, then both expected profits and the variance of profits decline, but expected utility increases. The basic model does not account for imported inputs. When it does, the contraction in the supply of exports would be smaller and the variance in profits would not rise in proportion to the increase in the variance of the exchange rate.

- Baron (1976) relaxes the assumption of perfect competition to analyse the effect of exchange rate volatility on prices, highlighting the role of invoicing currency. When the exporter invoices in foreign currency, as in the preceding example, the exporter faces price risk. The quantity demanded is known, since prices do not change during the contract period, but the revenue stream and profits are uncertain. When invoicing in the home currency, the exporter faces quantity risk. Quantity demanded is uncertain because the price facing the buyer is unknown. In addition to revenues, costs of production become uncertain. In both cases, the risk-averse firm wants to reduce its risk exposure but the price effect will differ. If the firm invoices in foreign currency, an increase in risk results in a higher price (the supply curve shifts up). This will reduce the expected profits (demand is elastic at the optimal price) but will increase the expected utility. If the firm invoices in domestic currency, its response depends on the properties of the demand function in the destination market. If the function is linear, Baron shows that prices declines and demand increases, but the price-cost margin diminishes, which reduces the expectation and variance of profits.

- Hooper and Kohlhagen (1978) also examine the effects of exchange rate volatility in a bilateral framework, where the only source of uncertainty is the nominal exchange rate. They first derive demand and supply functions for individual firms and then aggregate them to obtain a reduced-form equation for the market equilibrium price and quantity. The key parameters in their model are the currency denomination of the contracts, the proportion of forward hedging and the relative degrees of exporters' and importers' risk aversion. A fraction of the contracts is assumed to be priced in foreign currency and a fraction of transactions is hedged in the forward market. These parameters are exogenous and determine the degree of risk exposure.

  Exchange rate variability will affect exclusively the portion of profits that is not hedged. The demand for imports is a derived demand schedule, with imports being treated as inputs used in fixed proportion in the production of goods sold entirely in the domestic market. The importer, although assumed to be a price-taker in the import market, faces a known demand curve for his product. An increase in exchange rate volatility results in a higher variance of profits and shifts the demand curve downwards, leading to a decline in quantity and prices. The size of the response increases with the magnitude of the price elasticity of the demand curve, the degree of risk aversion, and the degree of exposure to risk. Export supply is modelled in a monopolistic market framework. As in Clark, exporters are assumed to sell all their output in the foreign market. An increase in exchange risk leads to a contraction of the supply curve. The trade quantities diminish and prices become higher. The reduced-form of the model shows a clear negative relationship between exchange rate variability and the volume of trade. The price effect, however, is ambiguous. An increase in exchange risk will lead to a reduction in trade prices if importers bear the risk. The price will fall as import demand falls. However, if exporters bear the risk, the price will rise as exporters will charge an increasingly higher risk premium.

But, not all the theories that address the impact of exchange rate volatility on trade agree on a negative effect. Thus, Broll and Eckwert (1999) present a model that argues that position and predicts a positive effect on trade.

Broll and Eckwert's model is based on a risk-averse firm that produces a commodity to be allocated to the domestic market and foreign market. The foreign spot exchange rate is a random variable and the firm is a price taker. The objective of the firm is to maximize the expected utility of its local-currency profits, and given a total production y the firm's random revenues in domestic currency are $px+eq(y-x)$, where p,q are the prices of goods at home and abroad, y is total production, x is domestic supply, and $y-x$ is the export volume.

At the initial date, $t=0$, the production decision is made and it is fixed in the sense that it must be chosen before the spot exchange rate is realized. At t = 1 all uncertainty is resolved, the exchange has been observed and the produced goods are allocated to the domestic or foreign market. Therefore, higher volatility increases the potential gains from international trade by making extremely high realizations of the foreign spot exchange rate more likely. The corresponding higher probabilities of low realizations of the foreign spot exchange rate do not offset these gains because the firm may choose to walk away from the export option. Losses are effectively truncated.

An important feature of Broll and Eckwert's model is the assumption that firms are price-takers and hence, that their actions do not affect the market. But, this statement is arguable. Since a changes in exchange rate volatility pattern affect all exporters, it could be rational to think that a sector with firms producing similar products will react in the same way. Then, the movement of production between local and external markets might cause a reaction of local prices that firms can expect and the model is not taking into account.

2.2 Literature Review and Empirical Findings

According to Khosa et al. (2015), researches that support a negative effect on exports are based on the perception that "since exchange rate volatility presents uncertainty in the business environment, rational traders tend to avoid or reduce their exposure to uncertainty and any other form of risk by adjusting trade activities". Furthermore, Caballero and Corbo (1989) raised that asymmetric costs as investment irreversibly and risk aversion generate a negative sign in the investment-uncertainty relations and, through that channel, in exports.

On the contrary, under certain conditions [2], a part of the literature have argued a positive effect, stating that a rise in uncertainty increases the expected benefits (Caballero and Corbo, 1989).

Finally, there are researches that advocate null effects of volatility exchange rate on trade commerce. One of the main arguments that sustains these findings is the presence of currency hedges that allow producers to deal with exchange currency risk (Raddatz, 2011).

Albagli et al. (2020) show that the Chilean derivatives market is deep due to the country's macroeconomic structure, allowing easy access to currency hedge instruments. But, the relevance of the dampening effect of these instruments on exports can be arguable if the planning of export projects exceeds the extension of the coverage period [3].

Previous researches that study Chilean manufactures exports are not conclusive. Thus, Huchet-Bourdon and Korinek (2012) studied the impact of exchange rate volatility on two Chilean export sectors (Agriculture and manufactures-Mining) with data from 1999 to 2009. The authors are able to recognize a bigger effect than in developed economies, but they cannot distinguish the sign of the impact. More recently, Mordecki and Miranda (2019) found a negative effect of exchange rate volatility on total exports in the country, but the coefficient was not significant. However, it is highlighted by Raddatz (2011), that it could be a mistake to assume "a uniform impact of this volatility on exporters across sectors", since each sector have different levels of natural hedge against exchange rate fluctuations, something that these two document does not account for.

[2] Convex benefit function, plus perfect competition and neutral risk agents would lead to an increase in investment in presence of a higher price uncertainty (real exchange rate, in this case).

[3] In Chile, "the most usual coverage length is between 8 days and one year; particularly, the operations up to 42 days count for the 72% of the total (Central Bank of Chile, Boletín Mensual)"(Acharán et al., 2011; Avalos and Moreno, 2013).

3 Model and method

The standard model of trade flows and their determinants is well known by the literature. In terms of exports, the model focused on a basic structure in which the export depends on the movements of an exchange rate volatility proxy, the real exchange rate and a external demand measurement (in this case, the economic activity of the trade partner).

The long-run specification of the model is:

$$XR_{i,t} = C + \beta_{LR} V_{i,t} + \lambda_{LR} Y^*_{i,t} + \gamma_{LR} BRER_{i,t} + u_{i,t}$$

with $u_{i,t} = \alpha_i + \alpha_t + \alpha_{i,t}$

Here, $i = 1,...,N$ representing the N cross-sectional elements (countries) considered in the sample[4] and $t = 1,...,T$, the time periods included. As for the variables, XR denotes exports, V represents the exchange rate volatility proxy, Y^* the external economic activity variable, and $BRER$ the real bilateral exchange rate, between Chile and each trade-partner considered in the study. All variables are in natural logarithm.

The short-run specification is:

$$\Delta XR_{i,t} = c + \beta_{SR} \Delta V_{i,t} + \lambda_{SR} \Delta BRER_{i,t} + \gamma_{SR} \Delta Y^*_{i,t} + \delta EC_{i,t-1} + \varepsilon_{i,t}$$

where Δ denotes the difference between t and $t-1$ and EC is the error correction term, which accounts for deviation from a long-run equilibrium.

The parameters of interest of the model are β_{LR} and β_{SR}, which measure the effect of the volatility exchange rate proxy on real exports on the long-run and short-run, respectively. Since it has been shown that there is contradictory evidence in the empirical literature and in theoretical models, there is no expectation to the sign of these coefficients.

On the other hand, the relationship between real exports and the real exchange rate and the external demand is well explained by De Gregorio (2007): “Exports are basically the demand of the rest of the world for national goods. Like any demand, they will depend on the price and income. If the price of national goods falls, the world will demand more of them.”. In other words, “when the real exchange rate rises, fewer units of the foreign good are needed to acquire a national good”. In the same way, “if the world’s income level rises, the world will demand more of the national goods.”. Therefore, it is expected that increases in these two components lead to an increase in national exports, and we will expect that $BRER$ and Y^* coefficients will have a positive sign.

3.1 Estimation technique

To study the effect of the exchange rate volatility on exports, the Generalized Autore-gressive Conditional Heteroskedasticity (GARCH) estimation will be used as the proxy for the exchange rate

[4] To see the countries included see Table A2.

volatility[5].

Following Fornero et al. (2020), manufactured exports are deflated by the unit value index of exports and then seasonally adjusted by standard methods (ARIMA-X13). On the other hand, real bilateral exchange rates are obtained based on:

$$BRER_i = \frac{BNER_i P_i^*}{P}$$

where $BNER_i$ is the nominal bilateral exchange rate between Chile and trade parter i, P_i^* is the production price index of the destination country (trade partner) and P is the consumer price index of Chile. Finally, as external economic activity variables, real GDP is estimated using nominal GDP and the GDP deflators and real consumption is obtained using nominal consumption and the consumer price indices. Both variables are then seasonally adjusted.

In addition to the real exchange rate and external demand, some additional controls will be used: the added value of the manufactures sector as a percentage of GDP (Y) in order to control for idiosyncratic shocks in the local industry; and a dummy variable to account for the Global Financial Crisis ($D2009$).[6]

As the financial crisis of 2009 led to a decrease in the international economic activity, we will expect that the coefficient associated to this shock ($D2009$) will be negative. Meanwhile, idiosyncratic shocks, as ones related to the manufactures industry development, will be expected to have a positive sign on the exports activity, since it could lead to the production of more competitive goods. These two expectations are validated by the results of Fornero et al. (2020).

The presence of multicollinearity between the main variable and controls (V, Y^*, $BRER$) is discarded through correlation and the variance inflation factor (VIF) test analyzes. Nonetheless, adding the added value of manufactured exports on GDP (Y) results in certain degree of collinearity in the regression trough a strong relationship with Y^* and, at the same time, can cause simultaneous effects between exports and production. To mitigate these two effects, Y is predetermined and introduced as a lagged variable in the short-run equation. In addition, the bilateral real exchange rate trade will be predetermined and introduced as a lagged variable to avoid a potential reverse causality with the manufactures exports, since this sector represents an important fraction of national exports (around 37%). It is important to highlight that in both cases the endogeneity is being avoided, but not solved. This does not represent a problem to the objectives of this research, since both variables are control regressors and the main focus is on the volatility of the exchange rate's effect. Finally, flows tend to follow autoregressive patterns. Thus, the model also considers the lagged value of the manufactures exports as an independent variable (Fornero et al., 2020; Rodrik, 2008).

In terms of the volatility exchange rate, as it is a fast moving variable and is not directly explained by real manufactured exports, we can argue that the volatility proxy is exogenous. In the same way, neither the external demand proxies nor the financial crisis of 2009 are directly explained by Chilean real manufactures exports movements and, consequently, we can state that these controls are also exogenous.

[5]To see more about the GARCH model, see Table A3.

[6]Fornero et al. (2020), who studied the external demand and real exchange rate effect on the manufactures exports, used this dummy as a control variable and found that the crisis' coefficient was negative and significant.

3.2 Empirical approach

The addition of the lagged value of the dependent variable as regressors transform the panel into a dynamic one.

As it is pointed out by Senadza and Diaba (2017), fixed and random effects estimators are ideally applied in large N and small T panel frameworks. Using these estimations, individual groups are pooled and only the intercepts are allowed to differ across panel units, thus, assuming homogeneous slope parameters. Nonetheless, using fixed effects can cause inconsistency by the dependence of the fixed effect with the lag of the dependent variable. Furthermore, the assumption of homogeneity of slope parameters often fails to hold with large N and large T dynamic panels, as is the case in this research (Pesaran et al., 1999).

Here, even when a Within Group (WG) estimator panel can help to solve this identification problem, since the stated model is related to a dynamic panel, the WG does not cancel out the still existing correlation between the autoregressive variable ($XR_{i,t-1}$) and the error term. This phenomenon is known as the Nickell bias (Nickell, 1981; Fornero et al., 2020; Senadza and Diaba, 2017).

The estimation of non-stationary dynamic panels with heterogeneous parameters across groups was addressed by Pesaran et al. (1999), who developed the mean-group (MG) and the pooled mean-group (PMG) estimators. “The MG estimator averages the coefficients of an estimated N time series regressions, whereas the PMG estimator depends on an amalgam of averaging coefficients arithmetically as well as pooling” (Senadza and Diaba, 2017). These models re-parameterise the ARDL dynamic panel model into an error correction model and are estimated using the maximum likelihood estimator (ML).

An alternative model to MG and PMG is the generalized method-of-moments (GMM). This model is able to generate consistent coefficients in the circumstance of endogenous regressors, but “there is still the high plausibility of turning out misleading and inconsistent outcomes if slope coefficients fail to be truly or significantly identical across groups” (Senadza and Diaba, 2017). This is a common case in most panel frameworks. Moreover, the PMG model permits the error variances intercept and short-run coefficients to differ across panel units, while constraining the long-run coefficients to be homogenous or equal across the spatial dimension. Hence, two advantages of PMG estimator is that it can generate relatively more consistent and reliable average parameter estimates, but furthermore, this model can also provide both long- and short-run empirical estimates simultaneously (Senadza and Diaba, 2017).

For the listed reasons, the PMG model is selected as the main model in this research. Additionally, WG estimators will be used in order to check the robustness of the estimated coefficients and compare results. GMM estimators are discarded since we can not assume that the slope coefficients between countries are equal[7].

In terms of WG, the approach will be based on the error correction mechanism attributed to Engle and Granger (1987). This approach consists in a two-stage procedure in which the first step corresponds to a long-run model, and the second stage corresponds to the estimation of the error correction term, which is included into the short-run model (Polemis and Fotis, 2013).

[7]This is consistent with the results of cross-sectional and time effects tests, which indicate that country effects are significant.

4 Data

The database is built with data from the Central Bank of Chile (information about exports, bilateral exchange rates, the industry value added to national GDP and the unit value index of exports) and the International Monetary Fund (IMF) (Trade partners' GDP [8], consumer price index, producer price index, GDP deflators) [9].

The time length of the panel data-set is based on the availability of information. Consequentially, the panel is constructed with quarterly series from 2005 to 2017 ($T = 48$) for the 17 of the most important trade partners of Chile. This sample accounts for the 68% of total manufactures exports in the last two decades. [10].

Before running the main model, GARCH models for each country were estimated [11]. To understand the properties of the variables and the short-run and long-run dynamics, unit root tests and cointegration tests are applied. Unit root Im-Pasaran-Shin (2003) tests for panel data-sets revealed the presence of some non-stationary variables [12]. Finally, tests for cointegration showed evidence of a long-term relationship between the variables[13], whilst tests for cross-sectional and time effects shows that both are statistically significant (Kratzig and Kratzig, 2004).

[8]In some cases, IMF's lack of data was fulfilled acceding directly to trade partners' Central Banks databases).

[9]Descriptive statistics of the main variables (Manufactures exports, GARCH estimations, BRER and real GDP) can be find in Table A4.

[10]Countries and their shares in total manufactures exports can be found in Table A2

[11]See results in Table A3

[12]Unit roots are studied for GDP, Consumption and Industry added value to GDP. See results in Table A5.

[13]See Table A6.

5 Results

The results of the model are presented in Table 1. The first two columns show the long-term (LR) and short-term (SR) results of the basic model, that is, without additional regressors. Then, the next four columns show the long-term and short-term results for the model incorporating the additional controls for the financial crisis of 2009 ($D2009$) and idiosyncratic industry shocks measured as the added value of the manufacturing sector to the Chilean GDP (Y) (regressions (2) and (3)).

The results show that the coefficient associated with the long-term effect of exchange rate volatility on manufactures exports is positive, with an impact level of 0.09% of increase of each 1% of increase in the exchange rate volatility. This coefficient is also highly statistically significant (1%). Here, it is important to note that the sign and the statistical significance remains when adding the two extra controls. Moreover, the parameter is highly consistent in terms of levels, increasing 0.02 percentage points in regressions (2) and (3). However, when we focus on the effects of volatility in the short term, the sign of the effect is still positive, but the impact of the movement is close to 0% and the coefficient is no longer statistically significant. This shows that the effects of volatility tend to affect export levels primarily in the long term.

In terms of the control variables, we see that in the long run, the coefficients of the external demand proxy (Y^*) are positive in the three specifications. This coefficient growths from 0.27% to 1.11% when adding the controls for the 2009 financial crisis and the idiosyncratic industrial shocks, whilst the statistic significance increases from 10% to 1%. The bilateral real exchange rate's coefficient ($BRER$), is positive and highly statistically significant (1% in all cases) and increases from 0.56% to 0.88% when incorporating the two additional controls. Thus, the impact of an increase of 1% of the trade-partner GDP causes an increase of 0.29%-1.11% in the manufactures exports of Chile. In the case of the bilateral exchange rate, an increase in 1% of this variable produces an increment of 0.56%-0.88% of the manufactures exports in the long-run. These two results are consistent with the expectations, the theory and the literature.

The signs of the external demand and real exchange rate's effects remains in the short-term specification, being positive in the three regressions. However, none of these coefficients is statistically significant.

In terms of the additional control, the coefficient associated with the financial crisis is negative and statistically significant (5%), which shows that, by not controlling for this event, there is an underestimation of the rest of the regressors in exports. This explains the change in the coefficients link to the external demand and the exchange rate in the long-run.

On the other hand, the effect of idiosyncratic industry shocks on exports is positive, but not statistically significant, and the addition of this variable does not produce an important change in the rest of the coefficients. This could suggest that the events associated with the manufactures industry in the domestic market would not necessarily translate into the industry associated to the international market.

Table 1: PMG Estimation. Real manufactured exports (XR) as dependent variable

	(1)	(1)	(2)	(2)	(3)	(3)
VARIABLES	LR	SR	LR	SR	LR	SR
V	0.09***		0.11***		0.11***	
	(0.02)		(0.02)		(0.02)	
Y^*	0.27*		1.11***		1.11***	
	(0.16)		(0.08)		(0.08)	
$BRER$ (t-1)	0.56***		0.88***		0.87***	
	(0.13)		(0.10)		(0.10)	
ΔV		0.01		0.01		0.01
		(0.02)		(0.02)		(0.02)
ΔY^*		0.28		0.11		0.11
		(0.43)		(0.48)		(0.52)
$\Delta BRER$ (t-1)		0.04		0.02		0.04
		(0.14)		(0.14)		(0.15)
ΔXR (t-1)		-0.20***		-0.19***		-0.18***
		(0.03)		(0.04)		(0.04)
EC (t-1)		-0.24***		-0.26***		-0.26***
		(0.04)		(0.05)		(0.05)
$D2009$				-0.05**		-0.05**
				(0.02)		(0.02)
ΔY (t-1)						0.11
						(0.09)
Constant		-0.40***		-4.05***		-4.04***
		(0.10)		(0.77)		(0.77)
Observations	1,039	1,039	1,039	1,039	1,039	1,039

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note: LR represents the long-run estimations and SR the short-run the real bilateral estimations. Δ represents the first difference. $BRER$ represents exchange rate; Y^* the real GDP of the trade partner; Y, the industry added value to GDP; XR, the deflated manufactures exports; EC, the error correction term ; and, GARCH is the proxy for BRER volatility.

All the variables are expressed in natural logarithm.

Finally, in the three specifications the correction error is negative and highly statistically significant (1%), which represent an additional support to the evidence of a long-term relationship between the variables, while the coefficient associated with the lag of the exports is negative and highly statistically significant (1%). The lagged regressor of the dependent variable is also negative and highly statistically significant, but its level is smaller than one. This can be interpreted as a certain degree of persistence of shocks on the real exports between periods, but, that fades over time whilst the exports return to its equilibrium level.

5.1 Robustness checks

To study the stability of the estimated parameters, two robustness checks are analyzed: consumption as the external demand proxy, and the fixed effect approach as an alternative method of estimation.

External Demand Proxy

The basis for assuming that real consumption can be a good proxy for real demand and replace real gross domestic product lies in stating that households, rather than firms, are the largest recipients of Chilean manufactures exports. This assumption is not unreasonable, if it is considered that subsectors such as food, beverages and tobacco, and furniture and papers are relevant categories within total manufactures exports [14]. For this reason, the same model presented in Table 1 will be run using real consumption of the trade-partner as the external demand proxy instead of real GDP.

The results of this estimations are shown in Table A7. When changing this proxy, there is a decrease in the estimated impact related to external demand, which decreases to 0.31%-0.44%. Nevertheless, the most important insight of these estimation is that the rest of the parameters are highly stable with levels, signs and statistical significance levels similar to the previews estimations. In terms of the exchange rate volatility, the estimated coefficient in the long-run is slightly lower (0.08% in the three specifications), decreasing between one to three percentage points in comparison with the main findings (previously 0.09 without additional controls and 0.11 with them), and remains statistically significant at 1%. The coefficient for the short-run remains positive, with a level close to zero (0.01% in the three specifications) and not statistically significant.

Fixed-effects method

Results using the Fixed-effect method (including both cross-sectional and time effects, and real GDP as the external demand's proxy) are similar to the ones presented in Table 1 (See table A8). However, two main differences can be seen. Firstly, the value of the exchange rate volatility coefficient for the long-run specification drops to 0.01% and is not statistically significant. This is also the case of the effect of the bilateral real exchange rate in the long-run, which remains positive but is lower that the one estimated by PMG, decreasing from 0.56% to 0.47%, and is statistically significant at the 10% instead of 1% level Secondly, the effect of the bilateral real exchange rate in the short-run increases from 0.02%-0.04 to 0.21%-0.34% and turns statistically significant (10%), specially when including the two extra controls for the financial crisis of 2009 and idiosyncratic industry shocks (5%).

The differences can be strictly related to the fact that PMG model, contrary to the Fixed effect approach, is: (1) able to estimate non-linear coefficients; and (2), address the endogeneity caused by the

[14] See Figure 2

correlation between the lagged value of the dependent variable as a regressor and the error term.

5.2 Implications

The most important feature of these results is that there is no evidence to support that the volatility of the exchange rate of the free floating regime of Chile has hampered the manufactures export behavior, proving wrong the idea that started this research. Furthermore, PMG estimations shows a positive and statistically significant effect of the volatility on manufactures exports on the long-run. For the short-run, neither the results using PMG nor using Fixed effects show evidence of a significant impact.

To understand these findings we can consider the model developed by Broll and Eckwert (1999) and presented in Section 2. This model states that in an economy in which exporting companies trade simultaneously in national and international markets, an increase in exchange rate volatility produces a positive effect on exports. This is explained because, when volatility increases and as a result, the firm faces lower and higher levels of exchange rate, the firm is able to move its production to the national market in order to avoid to sell in the international market when the exchange rate decrease. On the contrary, when the exchange rate is more competitive, firms increase trade. Therefore, the export profit distribution is truncated strictly in positive numbers and the export company can only benefit from a higher volatility.

5.3 Limitations

The results of this research, however, needs to be considered carefully, since here the examination of the effect on trade is strictly bounded to an specific export sector, namely, the manufactures exports.

At the same time, some limitations of this research are link to the selected proxy for exchange rate volatility. To successfully estimate GARCH, it is required to calculate an stationary model, but it was not possible for some countries, such as Argentina and Ecuador. For that reason these both countries were not considered in the sample.

In addition, in terms of the models and as it was pointed out in Section 3, there is a potential case of reverse causality between the bilateral real exchange rate ($BRER$) and the dependent variable. The same occurs with the added value of manufactured exports on GDP (Y) and the addition of the real exchange rate. This endogeneity was avoided through using the lagged value of both variables, which means that the model was able to deal with the movements of this variables in order to focus the attention into the effect of the exchange rate volatility, but that the endogeneity was not solved.

Finally, an important issue with the collection of data was the impossibility to find publicly available information of two variables: the natural edge of the manufacturer exporter firms and the access to the derivatives market. Then, this study assumes them as constant over time, an assumption that can be too strong but that was not possible to account for.

6 Conclusion

This research aims to understand how the volatility of the real exchange rate can affect the movement of exports in a small open economy, using the particular case of the manufactures exports of Chile, an emerging country that possesses an almost perfectly flexible exchange rate. This examination take places in a context in which the national real exchange rate volatility has increased since insertion of the flexible exchange rate regime (at the end of 1999), and the volume of the manufactures exports has experienced a continuous stagnation that overlaps with the new regime. This constitutes the starting point of the research.

The literature review highlights a mixed evidence around the world regarding the sign and magnitude of the studied effect. This is not only true for the empirical evidence, but also for existing models that attempt to explain the relationship between exchange rate volatility and international trade. Even so, it has been confirmed that exchange rate volatility could have a greater effect in emerging economies, and in certain markets whose composition of assets and liabilities generates a greater mismatch and exchange exposure.

Using a dynamic panel with quarterly information from 2005 to 2017 for 17 of Chile's main trading partner countries, a PMG model is estimated to identify this impact. According to the results of this estimation, it is shown that there exist a relationship between exchange rate volatility and manufactures exports in Chile. Nonetheless, that there is no evidence to support that the volatility has damaged the exports of this sector, as it was thought at the beginning of this study. On the contrary, it is found that the impact has been positive and statistically significant in the long term. Additionally, it is found that the level of the real exchange rate and external demand play a key role as determinants of exports, which is in line with the international literature.

A possible explanation for these results can be found in the model of Broll and Eckwert (1999), which argues that in an economy in which exporting companies trade simultaneously in national and international markets, a increase in exchange rate volatility produces a positive effect on exports. This is due the fact that firms can move its production to the national market in order to avoid to sell in the international market when the exchange rate decrease. Therefore, the export profit distribution is truncated strictly in positive numbers and the export company can only benefit from a higher volatility.

Finally, it should be noted that these findings are strictly restricted to the manufactures industry and to Chile, but that the results could vary when considering other industries. Furthermore, in this research it was not possible to control for changes in the natural hedge of the manufacturer exporter firms nor in the access of the firms to the derivatives market. This last point calls for further research.

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Appendices

A Description of the manufactures exports of Chile

Table A1: Manufactures exports of Chile by sectors and subsectors

Sectors	Subsectors
Food	Food Fish meal
	Fish oil
	Salmon
	Trout
	Hake
	Canned fish
	Shellfish
	Dehydrated fruit
	Frozen fruit
	Fruit juice
	Canned fruit
	Bird meat
	Pork Meat
Beverages and tobacco	Non-alcoholic beverages
	Bottled wine
	Bulk wine and others
Forest and wooden furniture	Sawn timber
	Wood chips
	Profiled wood
	Wood fiber boards
	Plywood
Pulp, paper and others	Raw conifer cellulose
	Conifer bleached and semi-bleached pulp
	Eucalyptus bleached and semi-bleached cellulose
	Cardboard
Chemical products	Methanol
	Iodine
	Potassium nitrate
	Fertilizers
	Molybdenum oxide
	Tires

Sectors	Subsectors
Basic metal industry	Ferromolybdenum
	Copper wire
Metal products, machinery and equipment	Metal manufactures
	Machinery and equipment
	Transport material

Note: Information reported by Central Bank of Chile

B Sample of countries

Table A2: Countries in the sample and share of total manufactured exports of Chile

Country	%	Country	%
Unites Stated	15.8%	Colombia	2.3%
Japan	9.8%	Spain	2.0%
China	8.2%	Paraguay	1.9%
Brazil	6.1%	United Kingdom	1.8%
Peru	5.8%	Italy	1.5%
Bolivia	4.9%	Canada	1.5%
Mexico	4.3%	Germany	1.5%
The Netherlands	3.8%	Belgium	1.5%
South Korea	3.3%	Rest of the world	32.1%

Note: Average share of total manufacture exports between 2003-2020

Source: produced with data from the Central the Bank of Chile

C GARCH estimations

The Generic GARCH model: One of the requirements to successfully apply a GARCH model is the stationarity of the dependent time-series variable. Then, an ARMA model need to be identified. The ARMA-GARCH model estimation can be writted as,

$$Log(BRER_t) = \mu + \sum_{i=1}^{p} \mu_{1,i} log(BRER_{t-i}) + \varepsilon_t + \sum_{i=1}^{q} \mu_{2,i} \varepsilon_{t-i}$$

$$where \quad \varepsilon_t \; N(0, V_t^2)$$

$$and \quad V_t^2 = \delta + \sum_{i=1}^{a} \delta_{1,i} e_{t-i}^2 + \sum_{i=1}^{b} \delta_{2,i} V_{t-i}^2$$

where e^2 is the ARCH component and V_{2t-1} the GARCH component.

Table A3: GARCH estimations

Country	ARMA(p,q)		GARCH(a,b)	
	p	q	a	b
Germany	1	0	1	1
Bolivia	1	1	1	2
Brazil	1	1	1	1
Belgium	2	0	2	1
Canada	0	2	1	1
China	1	0	2	1
Colombia	1	0	1	1
South Korea	1	1	1	2
Spain	2	1	1	1
USA	1	1	2	1
Italy	1	3	1	1
Japan	1	2	1	1
Mexico	2	0	1	1
The Netherlands	1	0	1	1
Paraguay	2	1	1	1
Peru	1	0	1	1
UK	3	3	1	1

Note: In the table, p represents AR(p) component; q, MA(q)component; a, ARCH component; and b, GARCH component
Source: produced with data from the Central Bank of Chile [15]

D Descriptive statistics

Table A4: Descriptive statistics by country

Country	Statistics	Manufactures Exports	GARCH	BRER	Real GDP
Germany	Min	22.0	0.0001	584.1	576600
	Mean	32.7	0.0013	705.3	665382
	Max	46.1	0.0021	860.9	763429
	S.D.	5.1	0.0004	78.7	50147
Bolivia	Min	50.8	0.0000	57.3	23260
	Mean	104.1	0.0022	82.7	36699
	Max	159.3	0.0160	115.7	53303
	S.D.	26.5	0.0024	18.9	8318
Brazil	Min	53.4	0.0011	176.5	690503
	Mean	125.5	0.0013	244.0	945237
	Max	171.9	0.0019	311.6	1132079
	S.D.	32.5	0.0001	34.7	124173
Belgium	Min	17.8	0.0002	611.2	77235
	Mean	31.3	0.0011	693.6	91979
	Max	55.5	0.0021	802.6	107937
	S.D.	9.5	0.0005	45.3	7172
Canada	Min	17.6	0.0000	434.0	355531
	Mean	31.0	0.0006	498.4	434071
	Max	58.3	0.0011	563.4	524790
	S.D.	8.0	0.0002	30.7	41656
China	Min	50.9	0.0002	65.0	4168157
	Mean	162.5	0.0017	78.5	11200000
	Max	330.2	0.0095	92.3	20000000
	S.D.	76.9	0.0020	6.6	4390258
Colombia	Min	27.7	0.0003	0.2	102000000
	Mean	49.0	0.0016	0.2	151000000
	Max	66.2	0.0031	0.3	195000000
	S.D.	11.3	0.0008	0.0	26100000

Country	Statistics	Manufactures Exports	GARCH	BRER	Real GDP
South Korea	Min	19.7	0.0004	0.4	229000000
	Mean	67.6	0.0011	0.5	338000000
	Max	102.1	0.0019	0.6	433000000
	S.D.	17.0	0.0004	0.0	57600000
Spain	Min	28.4	0.0002	606.1	230417
	Mean	42.8	0.0008	699.5	267053
	Max	62.1	0.0015	814.0	308045
	S.D.	7.5	0.0003	56.2	16970
United States	Min	194.8	0.0000	469.5	3212008
	Mean	332.0	0.0014	555.4	3914343
	Max	446.9	0.0049	692.7	4614183
	S.D.	68.1	0.0009	49.9	355671
Italy	Min	17.4	0.0001	577.3	352694
	Mean	32.8	0.0009	700.8	402278
	Max	53.9	0.0017	849.8	436296
	S.D.	8.3	0.0004	76.0	20100
Japan	Min	137.9	0.0000	4.5	117000000
	Mean	207.6	0.0026	5.5	128000000
	Max	262.7	0.0036	7.4	143000000
	S.D.	26.0	0.0008	0.8	6301065
Mexico	Min	73.8	0.0000	34.4	2861703
	Mean	91.3	0.0013	42.3	3548898
	Max	121.3	0.0019	57.6	4273562
	S.D.	8.6	0.0003	5.2	404171
Paraguay	Min	13.9	0.0007	0.1	21700000
	Mean	39.8	0.0027	0.1	33500000
	Max	65.9	0.0064	0.1	46400000
	S.D.	13.5	0.0013	0.0	7239543

Country	Statistics	Manufactures Exports	GARCH	BRER	Real GDP
The Netherlands	Min	41.1	0.0002	590.9	138570
	Mean	81.5	0.0010	697.3	161750
	Max	126.7	0.0028	841.0	186087
	S.D.	21.5	0.0005	62.6	10862
Peru	Min	72.9	0.0001	158.3	63923
	Mean	121.1	0.0021	187.5	103718
	Max	157.5	0.0187	217.2	144330
	S.D.	23.0	0.0026	14.4	24819
United Kingdom	Min	29.4	0.0000	698.0	363332
	Mean	38.1	0.0009	856.5	419761
	Max	48.3	0.0020	1037.7	480296
	S.D.	4.4	0.0004	89.8	30650
Total	Min	13.9	0.0000	0.1	12609
	Mean	89.0	0.0015	355.3	35000000
	Max	446.9	0.0187	1037.7	433000000
	S.D.	80.1	0.0013	309.6	84400000

Note: Author's elaboration

E Unit root and cointegration tests

Table A5: Unit root tests
Im-Pasaran-Shin (2003) test results for panels

Variable	Level		Trend		First difference	
	W-t-Bar	p-value	W-t-Bar	p-value	W-t-Bar	p-value
lnXR	-3.99	0.00				
lnBRER	-6.66	0.00				
lnY^* (GDP)	2.14	0.98	0.88	0.81	-25.42	0.00
lnY^* (Consumption)	2.06	0.98	1.04	0.85	-19.09	0.00
lnGARCH	-11.68	0.00				
lnY	-0.87	0.19	-5.20	0.00	-10.18	0.00

Source: Author's estimations using data from IMF and Central Bank of Chile
Note: The null hypothesis of Im-Pasaran-Shin test is that all panels contain unit roots, while the alternative hypothesis sustain that some panels are stationary

Table A6: Cointegration test results

Modelo	Pedroni		Kao
	Panel ADF	Panel PP	Panel ADF
Eq.1: XR, GARCH, Y^* and BRER	-10.51***	-9.74***	-3.02***
Eq.2: XR, GARCH, Y^*, BRER and Y	-10.40***	-9.89***	-2.99***

Source: produced using data from IMF and the CB of Chile
Note: If the null hypothesis is correct, there is no cointegration.
The alternative hypothesis is that all panels are cointegrated.

F Robustness check results

Table A7: PMG Estimation. Real manufactured exports (XR) as dependent variable
Real Consumption as external demand proxy

	(1)	(1)	(2)	(2)	(3)	(3)
VARIABLES	LR	SR	LR	SR	LR	SR
V	0.08***		0.08***		0.08***	
	(0.02)		(0.02)		(0.02)	
Y^*	0.31**		0.44***		0.44***	
	(0.14)		(0.12)		(0.12)	
$BRER$ (t-1)	0.56***		0.65***		0.65***	
	(0.11)		(0.10)		(0.10)	
ΔV		0.01		0.02		0.01
		(0.01)		(0.02)		(0.02)
ΔY^*		0.82		0.47		0.44
		(0.68)		(0.91)		(0.89)
$\Delta BRER$ (t-1)		-0.02		0.00		0.01
		(0.13)		(0.14)		(0.14)
EC(t-1)		-0.26***		-0.27***		-0.27***
		(0.05)		(0.05)		(0.05)
ΔXR (t-1)		-0.22***		-0.22***		-0.22***
		(0.04)		(0.04)		(0.03)
$D2009$				-0.05*		-0.05*
				(0.03)		(0.03)
ΔY (t-1)						0.10
						(0.08)
Constant		-0.53***		-1.16***		-1.14***
		(0.12)		(0.20)		(0.20)
Observations	989	989	989	989	989	989

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: LR represents the long-run estimations and SR the short-run the real bilateral estimations. Δ represents the first difference. $BRER$ represents exchange rate; Y^* the real Consumption of the trade partner; Y, the industry added value to GDP; XR, the deflated manufactures exports; EC, the error correction term ; and, GARCH is the proxy for BRER volatility.
All the variables are expressed in natural logarithm.

Table A8: Fixed Effects. Real manufactured exports (XR) as dependent variable

VARIABLES	(1) LR	(2) SR	(3) SR	(4) SR
V	0.01			
	(0.01)			
Y^*	1.18***			
	(0.14)			
$BRER$ (t-1)	0.47*			
	(0.28)			
ΔV		0.00	0.00	0.00
		(0.00)	(0.00)	(0.00)
ΔY^*		0.43	0.25	0.22
		(0.34)	(0.31)	(0.31)
$\Delta BRER$ (t-1)		0.21*	0.32**	0.34**
		(0.11)	(0.12)	(0.12)
EC (t-1)		-0.26***	-0.26***	-0.25***
		(0.04)	(0.04)	(0.04)
ΔXR (t-1)		-0.27***	-0.27***	-0.28***
		(0.04)	(0.04)	(0.04)
$D2009$			-0.07***	-0.07***
			(0.02)	(0.02)
ΔY (t-1)				0.13*
				(0.07)
Constant	-15.58***	0.00	0.01***	0.01***
	(1.81)	(0.00)	(0.00)	(0.00)
Observations	1,056	1,039	1,039	1,039
R-squared		0.21	0.22	0.22
Number of countries	17	17	17	17

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Note: LR represents the long-run estimations, SR, short-run estimations and Δ represents the first difference. BRER is the real bilateral exchange rate; Y^*, the real consumption of the trade partner; Y, the industry added value to GDP; XR, the deflated manufactured exports; EC, the error correction term; and, GARCH is the proxy for BRER volatility. All the variables are expressed in natural logarithm.