# The Role of Exchange Rate Volatility on Trade Flows: an Empirical Panel Study on South American Economies

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**Keywords:**

Exchange rate, volatility, risk, trade, South America, empirical, error correction, currency, exports, hedge.

**Abstract**

**This thesis emphasizes, in particular, on the influence of exchange rate fluctuations on goods exports in South American economies by making use of a panel Vector Error Correction Model. In line with the majority of existing empirical evidence and literature, the results suggest that there is both a short run and a long run significant, negative relationship between exchange rate volatility and goods exports at an aggregated level. However, the results from multiple robustness checks, consisting of alternative operational measures of volatility, suggest that there is ambiguity to some extent with respect to the volatility-trade nexus. Moreover, a country-specific analysis shows that the volatility effects on the export industries of key importance are wavering in both direction and magnitude.**

**This research contributes to a voluminous body of empirical work on the volatility-trade nexus, while fulfilling an exceptional role in the choice of the panel countries and in its idiosyncratic analysis in a disaggregated context.**

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## Preface

Dear reader,

With the greatest pleasure, I hereby present to you my thesis on the effect of exchange rate volatility on trade flows in South America. By means of this research, I intend to contribute to the academic field of international economics and enhance the understanding on this specific nexus. Considering that Suriname is my country of origin, I have conducted this panel study on the South American economies with great fascination.

I am very grateful for the contribution and supervision of Dr. J. Emami Namini and thank him for his insightful support and academic guidance during this research. Furthermore, I would like to express my gratitude to the Erasmus University Rotterdam for giving me the opportunity to obtain both my Bachelor and Master's degree in the field of Business Economics and International Economics respectively. Last but not least, I would like to thank my family for supporting me during my study.

## List of Abbreviations

| | |
|---|---|
| AAF | Agricultural, Animal & Food |
| ADF | Augmented Dickey-Fuller |
| BRICS | Brazil-Russia-India-China-South Korea |
| CARICOM | Caribbean Community |
| DW | Durbin Watson |
| FDI | Foreign Direct Investment |
| GARCH | Generalized Autoregressive Conditional Heteroskedasticity |
| GDP | Gross Domestic Product |
| IMF | International Monetary Fund |
| MA | Moving Average |
| Mercosur | Mercado Comun del Sur |
| MNE | Multinational Enterprise |
| OECD | Organization for Economic Co-operation and Development |
| OPEC | Organization of Oil Producing and Exporting Countries |
| PIIE | Peterson Institute for International Economics |
| TiSA | Trade in Services Agreement |
| TPP | Trans-Pacific Partnership |
| TTIP | Transatlantic Trade and Investment Partnership |
| UNASUR | Union of South American Nations |
| UNCTAD | United Nations Conference on Trade and Development |
| VAR | Vector Auto Regression |
| VECM | Vector Error Correction Model |
| WTO | World Trade Organization |

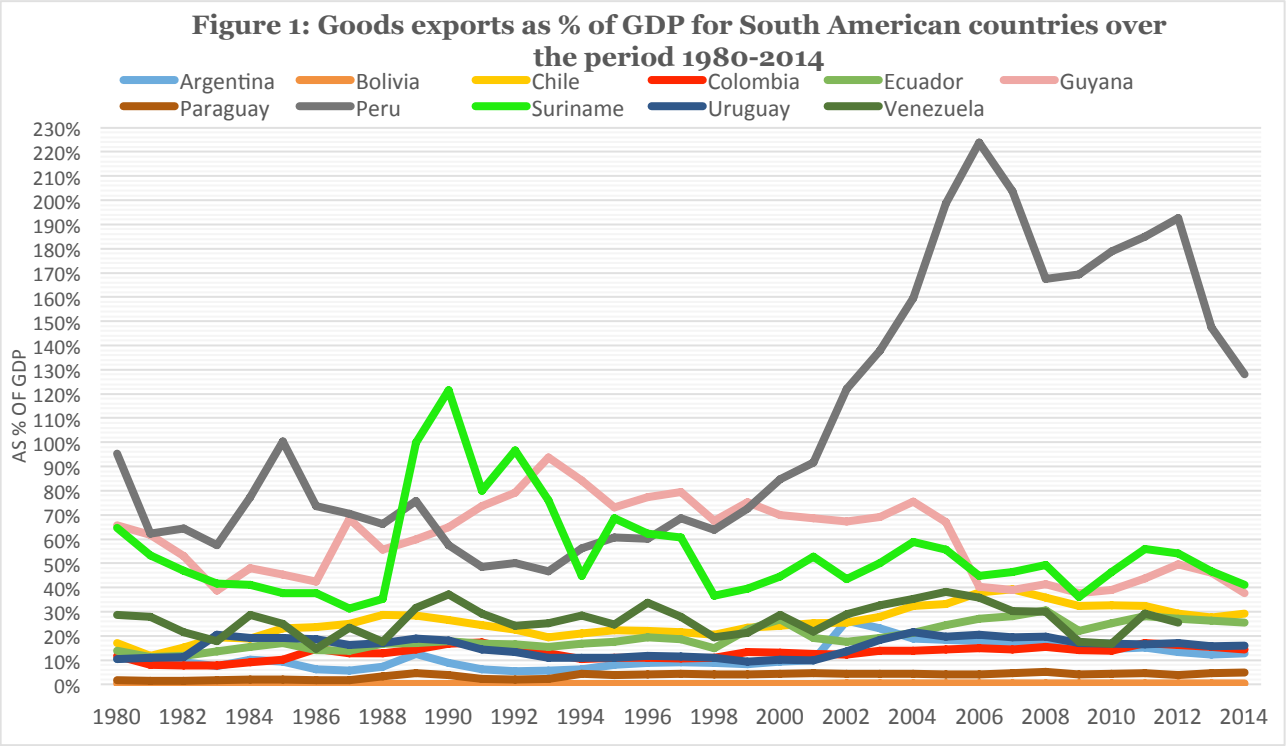
# 1. Introduction

As far as economic research goes, there is seldom disagreement among economists on something: trade is one of the most important drivers for economic growth. This thesis studies the relationship between exchange rate volatility and trade for South American countries by making use of a panel regression model with incorporated vector error correction features.

The latest trade news is shaped by a marked slowdown in 2015 world exports. According to UNCTAD and WTO estimates, global merchandise exports plummeted by 13% in 2015 (UNCTAD, 2015). Examining a breakdown of world merchandise exports, South American economies appear similarly affected by this large drop. These countries, which are either classified as transition or developing economies according to the IMF, experienced a decline of respectively 31% and 13% in 2015. Between 1986 and 2010, Latin America's share of global exports increased from 4.4 percent to 6.9 percent, according to the World Bank, but underdeveloped infrastructure places even its fastest-growing nations — Brazil, Chile, Colombia and Peru — at a competitive disadvantage (World Bank, 2015). According to trade economists of the PIIE "unless the three T-talks—the Trans-Pacific Partnership (TPP), the Transatlantic Trade and Investment Partnership (TTIP), and the Trade in Services Agreement (TiSA)—are soon concluded and ratified, relative stagnation will endure at least through 2020" (Hufbauer & Jung, 2016). Moreover, the recent oil price collapse, which started around the last quarter of 2014, has caused tremendously growing turbulence in the worldwide economy. This sharp fall of the world's most consumed commodity hit in particular developing economies strongly dependent on its export revenues the hardest.

However, the South American continent is frequently forgotten as it only accounted for approximately 3.62 % of global total merchandise in 2011, which was the equivalent of 664 billion US dollars. From 2011 to 2015 its share in worldwide goods trade dropped gradually and arrived at 2.97 %, equivalent to roughly 490 billion US dollars. While one could argue that this was a result of the sharp global drop in 2015, South American countries seemed to be disproportionately negatively

hit by this shock.



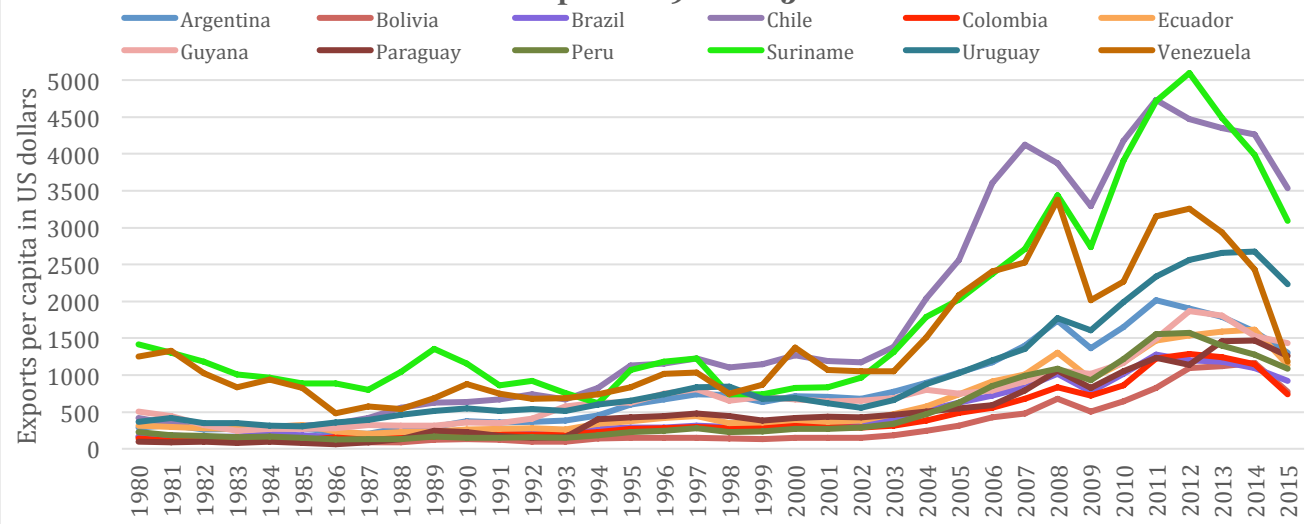

Data source: WTO

To illustrate the over-time development of exports, figure 1 displays the goods exports in millions of US dollars at current prices as % of GDP at market prices in current millions of US dollars for South American economies excluding Brazil. For the sake of simplicity of the figure Brazil was excluded, as Brazil historically has been an undisputed, major exporter (and also importer). In 1980 Brazil's total goods exports to GDP was 444% and this steadily increased afterwards. Its peak of 1224% was in 2007, after which it gradually decreased again and ended up at 682% in 2014.

In addition, figure 2 shows the development of goods exports per capita over time (period 1980-2015). The first observation that can be made is the presence of a general positive trend of growth in exports per capita over this period. The steep increase for Suriname can be explained by the fact that Suriname enjoyed relatively huge revenues through oil and gold exports, while the population of Suriname grew only marginally. Venezuela profited from the same commodity price booms over the last decade but, just as Suriname, was hit the hardest by the oil crash in late 2014. Chile's exports per capita soared as a result of a strong increase in production

and exports of in particular copper and ores. This economic indicator does, however, not provide in depth information on the robustness of these economies with respect to trade flows. In fact, the countries in figure 2 that appear to fluctuate mostly in exports per capita are in practice the most vulnerable to world shocks and bubbles.

**Figure 2: Goods exports per capita for South American countries over the period 1980-2015**




Data source: WTO

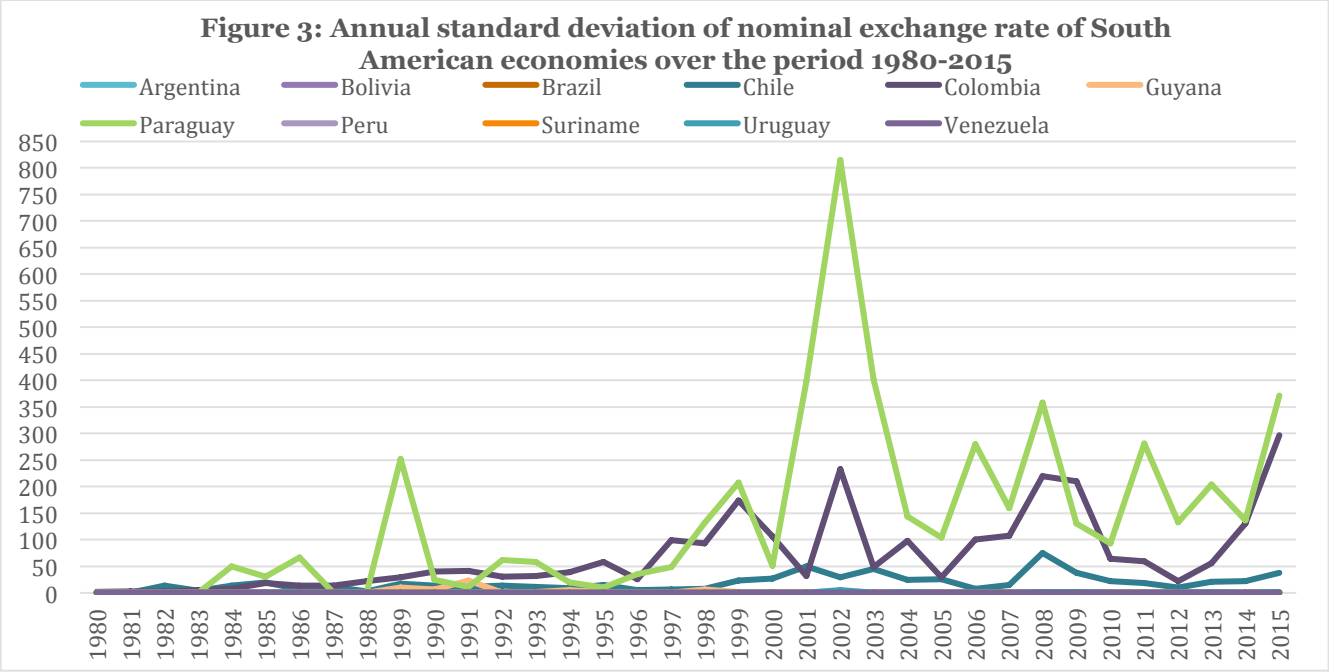
Nowadays, South American countries such as Brazil, Venezuela and Suriname are experiencing several worrisome phenomena simultaneously. Brazil, one of the famous BRICS countries and having the world's seventh largest economy by nominal GDP, is currently experiencing the largest economic and political crisis in its history. At roughly 70% of its GDP, public debt is worryingly large and rising fast while meanwhile the majority of Brazilian Congress has already voted in favor of President Roussef's impeachment (Economist, 2016). Contemporaneously, Suriname's currency has devaluated by approximately 50% over a relative short time span and faces the same critical problem as Venezuela: a huge shortage of US dollars in their central banks. Even worse, Venezuela faced an inflation rate of 180.9% in 2015 and IMF expects it to reach 720% this year (Business Insider, 2016). As the condition of such economies appears difficult, their domestic currencies also are troublingly volatile as result of the large risk and uncertainty. This causes investors to abandon the domestic currency, which contributes to the self-feeding mechanism of deterioration of the exchange rate.

Currency crises tend to be regional; they affect countries in geographic proximity. This suggests that patterns of international trade are important in understanding how currency crises spread, above and beyond any macroeconomic phenomena (Glick & Rose, 1999).

Up till now, a great amount of both theoretical and empirical research has been dedicated to the behaviour of the exchange rate and its influences on trade flows of countries. However, most research results suggest mixed findings and ambiguous inferences. Similarly to a previous conducted study for eight Latin American countries by Arize, Osang & Slottje (2008), this research analyses the presumed relationship for both short-run and long run by including both cointegration and error-correction techniques into the empirical model. Before proceeding to the theoretical background on this topic, it is important to familiarize with the link between historical exchange rate regimes and current developments.

### 1.1. Historical review and status quo of exchange rates

In 1945 the Bretton Woods monetary system, where the US dollar was pegged to gold, was introduced with the primary purpose of enhancing trade and economic growth through exchange rate stabilization. After a period of nearly 3 decades of relative stability of both nominal and real exchange rates under this system, increased volatility of exchange rates from the early 1970s triggered a lively debate on the channels through which such increased variability could affect the real economy (World Trade Report, 2013). At the end of the Bretton Woods era in 1973, a trend of continuous disparity of exchange rates persisted for decades.




Data source: IMF

Figure 3 provides a preliminary view of the volatility, measured by the annual standard deviation[1], of the domestic nominal exchange rates over 36 consecutive years. Evidently, in particular Paraguay and Colombia exhibit several surges and tremendous drops over time, with Paraguay peaking at a standard deviation of slightly more than 800 in 2002 (not shown in figure). According to the IMF[2], Argentina's domestic currency has devaluated for roughly 800% over the past two decades with respect to the US dollar. In this line of highly volatile countries, we can add Colombia, Chile and definitely Paraguay also, where the latter has seen its domestic currency lose its value by almost 17% in 2015 compared to 2014.

In contrast, countries such as Bolivia and Suriname have managed to maintain a quite stable exchange rate over certain periods. The latter case can be explained by the fixed exchange rate regime of the Central Bank of Suriname, which lasted from 2003 to the second quarter of 2015. Note that Ecuador (omitted in figure 3) is an exceptional case with respect to exchange rate volatility, as the former Ecuador Sucre has been converted to United States Dollars. This conversion came after a period of high volatility. Correspondingly, a fully dollarized economy such as that of Ecuador does not encounter unfortunate exchange rate risk with respect to dollar exports.

[1] The annual standard deviation is calculated from the data on monthly exchange rates,
[2] IMF database on international financial statistics

### 1.2. Research emphasis and study scope

On the one hand, a number of studies have argued that exchange rate volatility will impose costs on risk averse market participants who will generally respond by favoring domestic to foreign trade at the margin. The argument views traders as bearing undiversified exchange risk; if hedging is impossible or costly and traders are risk-averse, risk-adjusted expected profits from trade will fall when exchange risk increase (Chowdhury, 1993). In a study done with panel data from the European Union, Dell' Ariccia (1998) also finds that exchange rate volatility depresses international trade, although he highlights that the absolute size of this effect appears to be very small.

On the other hand, Giovannini (1988), Franke (1992) and Sercu and Vanhulle (1992) have shown that trade benefits from exchange rate volatility or risk. According to these studies, trade can be considered as an option held by firms. Like any other option, such as stocks, the value of trade can rise with volatility. Franke (1992) developed a model in which a firm evaluates the exit (entry) costs associated with leaving (entering) a foreign market against losses (profits) created by exports. Furthermore, exchange rate volatility might lead to higher prices for internationally traded goods by causing traders to add a risk premium to cover unanticipated exchange rate fluctuations (Maskus, 1986).

The main issue addressed in this research is whether exporters encounter substantial risk from nominal exchange rate volatility. The relevance of getting a deeper understanding of how exchange rates alter exports and imports is largest for in particular South American countries with a weak domestic production. In particular, the countries experiencing volatile domestic currency rates and where the majority of consumption goods are imported appear to be highly sensitive to unfavourable currency movements.

Although it is clear that a large body of research has been conducted in this area, this research delivers a unique contribution to the contemporary academic approach of international trade. Firstly, the selection of the panel countries that is scrutinized in this research is unique. To my knowledge, this is the first to

exclusively choose South American economies as scope. While this research treats this panel as to make general conclusions, I will also place focus throughout this thesis on 3 countries that are, as we speak, in the worst economic shape of this region namely Brazil, Venezuela and Suriname.

Secondly, this research provides better insights on the modeling of exchange rate volatility, as the majority of empirical studies have been conducted for volatility in stocks and such. Thirdly, the total exported merchandise goods are decomposed to provide a more in-depth analysis on the exports-exchange rate risk nexus. Hence, this research takes the investigation to the next level and provides industry-level effect research. Moreover, I present some practical elucidations and policy recommendations for the main issue of the hefty exchange rate risk for exporters.

Also, in particular non-stationarity has become a large issue, mainly after the 1970s when economists discovered this property of time series. The famous economist Robert Hall introduced this concept of random walks some decades ago, which induced a revised way of examining time series. Allowing non-stationary variables into regression models can lead to highly significant, spurious effects and result into wrongful inferences. While two series can appear to be non-stationary individually, they can prove to be stationary when combined through their cointegrated relationship (Hall, 1978). This research, in contrast to most previous academic work on this specific nexus, takes the dynamics of cointegration into account through an exquisite model.

To conclude, a review of conventional theories of the effect of risk on trade volumes prevails a certain amount of theoretical ambiguity. Admittedly, empirical findings also show there is no real consensus found on this topic so far. This research intends to shine some light on both sides.

Hence, the central question in this research is: **"*To what extent, if any, does exchange rate volatility affect the goods exports of South American economies?*"**

The main research question will be answered by a comprehensive, multi-layer analysis, which will undergo a breakdown into five related hypotheses. These

hypotheses are introduced and further elaborated upon in chapter 4. In addition, the estimated results clarifying the central research question are placed under closer scrutiny at a disaggregated level. The effects measured at country level will be related to the panel effects in order to, ultimately, shape our paradigm on this matter.

The structure of this thesis is as follows. The first chapter consists of an introductory compilation of trends in international trade and provides a sketch of goods trade of South American countries. Furthermore, the central research question is introduced. In the second chapter, the theoretical framework consists of the theoretical building blocks, which links various theoretical concepts. Subsequently, the third chapter explains and analyses the collected data of several macroeconomic indicators of South American economies. Chapter four underpins the methodology per model in a detailed and coherent way.
The remainder of this research consists of the results on the different estimated models (chapter five) and a comprehensive, closing chapter six. This final chapter includes a short summary, a tedious conclusion, policy recommendations and drawbacks.

# 2. Theoretical framework

The second chapter of this research provides a theoretic framework, which interconnects various theoretical concepts derived from existing literature on the topic. The emphasis on this nexus suggests that exporters exhibit some determined behaviour towards risk.

## 2.1. The exchange rate risk and international trade nexus

In this subchapter several coherent views and approaches to the exchange rate risk and trade nexus will be discussed.

In a similar study done by Bailey, Tavlas & Ulan (1987) it is mentioned that earlier studies (e.g. Makin 1976, Hooper and Kohlhagen 1978) failed to find a relationship, but this can possibly be explained by the fact that these studies were based primarily on data prior to the shift to floating of exchange rates in 1973. In subsequent years, a large body of evidence was presented from which the majority was in favor of the proposed negative relationship between exchange rate volatility and trade. As Chowdhury (1993) notifies, there is conflicting evidence in the literature about the relationship between exchange rate volatility and trade flows. Furthermore, previous research solely focused on predetermined country groups such as OPEC countries or Latin American countries, which might not give a clear, solid view in the bigger picture. As Viaene & de Vries (1992) prove with their theoretical model and contrary to popular belief, it does not take risk-loving exporters to take a 'speculative' position.

The somewhat adopted conjecture by most researchers was startled when De Grauwe (1988) proposed a positive relationship between trade and exchange rate volatility. Dependent on the degree of risk aversion, he argues that if exporters are sufficiently risk-averse, an increase in exchange rate variability raises the expected marginal utility of export revenue and therefore induces them to increase exports. Hence, an exporter with a very high degree of risk aversion who worries about a decline in revenue may export more when risks increases. De Grauwe's findings were confirmed by Franke (1991), however not for the same particular reasons. His

approach suggests that, in contrast to early theoretical papers, an exporter does not sell a constant quantity of a product, irrespective of the exchange rate, but rather adjusts export volume to the level of exchange rate (Franke, 1991). Thus, he concludes that exporting is a strategic option for a firm and only pursued when profitable (Franke, 1991).

The arguments provided by Bailey & Tavlas (1988) and Tavlas & Swamy (1997) are in line with that of De Grauwde with respect to the view that risk derived from changing exchange rates could also stimulate exports. They discuss the more practical case in which exporters accumulate knowledge through their trading businesses and thereby are in a better position to anticipate on movements in the exchange rates. As short run movements of the exchange rate can either be favorable or unfavorable for the exporter and prices tend to be rigid to a certain extent, an anticipating trader can profit from his knowledge. This incremental profit generated through clever anticipation may offset the risk caused by the fluctuating exchange rate. Under the assumptions of a world with information asymmetry and exporters having an information advantage, a forward-anticipating exporter would optimize its export level with respect to the exchange rate movement. Consistently, such an exporter would temporarily increase exports when the domestic currency depreciates and vice versa.

As most South American countries are appealing to large, international investors such as Multinational Enterprises (MNE's), particularly in the mining sector, a few key players are responsible for the major fraction of the supply of foreign currencies. For example, in Suriname there are currently only three MNE's active in the gold sector, which together accounted for an estimate of 65 % of the inflow of US dollars in 2011. As a result, these dominating corporations are able to control the exchange rate to a certain degree, which places the country under consideration in a very fragile and unfavorable position of dependence. Especially during times where state-owned firms appear to be performing very poorly, the government of such a country is put into a grapple with very few options left to minimize movements of the exchange rate.

The previous reasoning is in line with general framework of world trade, which evolves at two margins, namely the intensive and extensive margin. This so-called intensive margin refers to variations through time of the amount of trade of incumbent exporters who are already active on the foreign market. The extensive margin captures the new firms who have not yet entered the market but wish to engage this foreign market through exports on the short run. As Dixit (1989) indicates, successfully entering a foreign market for exporters usually requires certain investments such as entry costs, investments in research and development, relocation and distribution systems, capital investments or other transaction costs. These costs are eventually classified as sunk costs, once the firm has started exporting its goods. By definition, sunk costs cannot be recovered if a firm decides to end their trading relationship and retreats from the foreign market. As potential exporters realize this and take more time to assess their best options, the interval grows in which neither exit nor entry occurs. Hence, exchange rate shocks are expected to possibly lead to hysteresis (Baldwin, 1988).

International trade can be affected in many ways by exchange rates. According to the World Trade Report 2013, the impact of trade on exchange rates can be analyzed through two effects: the fluctuations of exchange rates and prolonged deviations of currencies from their equilibrium levels - so called misalignments - which are regarded as important distortions in international price competition. In Friedman's view, a system of flexible exchange rates would adjust to offset differences in national inflation rates. As some economists argue, research on the explanation of the movements of the exchange rate should rather focus on the real exchange rate instead of the nominal exchange rate, as the former is the real driver of a country's competitive position in multilateral trade.

### 2.2. Theoretical model

Bowen, Hollander & Viaene (2012) provide a useful theoretical approach to exemplify the case of a risk-averse trader, which I will partly follow. This theoretical model will serve as a fundament to the empirical model, which will be introduced later on.

### 2.2.1. Presence of forward exchange market

In this setup the major cause of the specific exchange rate risk is introduced: extending trade credit. That is, the exporter can allow the foreign buyer to defer payment until a fixed future date, which is a common characteristic of international trade. Thus, there are two dates: one on which goods are produced and delivered, and one on which they are paid for. Consequently, the specific exporter receives $\tilde{e}p^*q$, where $\tilde{e}$ is the unknown future spot exchange rate, $p^*$is the price of the exported good expressed in foreign currency and $q$ is the quantity exported. The nominal exchange rate is defined as the domestic currency price of the foreign currency and the tilde refers to the random nature of the future spot rate. As the exporter realizes the unfortunate riskiness of this transaction, he can decide to cover the exchange rate uncertainty arising from his foreign currency exposure by selling an amount k of foreign currency forward at the known forward exchange rate $e_f$. Thus k is the amount of foreign currency that is being used to hedge. Hence, the exporter's profit function is expressed as: $\tilde{\Pi}(q) = \tilde{e}p^*q - C(q) + (e_f - \tilde{e})k$, where $(e_f - \tilde{e})k$ is the forward transaction that will add to the profits and $C(q)$ represents the variable costs. Thus, the exporter maximizes the expected utility of profits $EU(\tilde{\Pi})$ and chooses the corresponding level q and amount of k. Making use of a Von Neumann-Morgenstern utility function with U(.) being strictly concave, increasing and differentiable defined over the trader's profits, the first order conditions for the maximization problem are:

For q: $EU'(\tilde{\Pi})[\tilde{e}p^* - C'(q)]=0$

For k: $EU'(\tilde{\Pi})[e_f - \tilde{e}] = 0$

Where U'(.) is the marginal utility and $EU'(\tilde{\Pi}) > 0$. By substitution, the solution for the optimal level of exports is given as: $e_f p^* = C'(q)$, which can be interpreted as the widely known marginal revenues equals marginal costs rule. To conclude, the optimal level of export is chosen to equate the previous terms and independent of exchange rate uncertainty in the presence of hedge possibilities.

### 2.2.2. Absence of forward exchange market

To show the conditions to hold in the absence of a forward exchange market, further elaboration is necessary. For the sake of analytical convenience, only the derivations of the relevant intermediate steps are shown here. Making use of the traditional [3]mean-variance utility function: $EV = E\tilde{\Pi} - \frac{\alpha}{2} var\tilde{\Pi}$ and of an exemplary profit function: $\tilde{\Pi} = \tilde{e}p^*q - dq - \frac{q^2}{2} + (e_f - \tilde{e})k$, the expected profits, variance of this and the corresponding expected utility of these can be derived as follows. Note that in the situation without access to a forward exchange market, k = 0 for the standard exporter.

$$E\tilde{\Pi} = p^*qE\tilde{e} - dq - \frac{q^2}{2} \quad [1]$$

$$\text{Var}\tilde{\Pi} = E\left[\tilde{\Pi} - E\tilde{\Pi}\right]^2 = E[\tilde{e} - E(\tilde{e})]^2[p^*q] = \sigma^2[p^*q]^2 \quad [2]$$

$$\text{EV} = p^*qE\tilde{e} - dq - \frac{q^2}{2} - \frac{\alpha}{2}\sigma^2[p^*q]^2 \quad [3]$$

Subsequently, when maximizing [3] with respect to q, the optimal solution is:

$q = \frac{p^*E\tilde{e} - d}{1 + \alpha p^{*2}\sigma^2}$, where it is proven that the popular conjecture of the adverse relationship between volatility $\sigma$ and the export volume q holds. Furthermore, an increase in $\sigma$ also reduces the expected value of a certain exporter. In this research, in particular the case without presence of forward exchange markets is highlighted; no hedging options for exporters to hamper their risk.

This hedging method is not possible in economies with poorly developed financial markets and institutions (e.g. banks or hedge funds) or in cases where exporters cannot make use of this financial instrument to hedge their exposure. In chapter 6.2 various solutions will be discussed in the context of alleviating the issue of the

[3] This function assumes a normal probability distribution function of the exchange rate $\tilde{e}$ by definition. Thus, profits $\tilde{\Pi}$ are also normally distributed with mean $E\tilde{\Pi}$ and variance $var\tilde{\Pi}$.

absence of a forward exchange market or of its accessibility. Maskus (1986) notes that even in their presence, forward markets do not ensure completely against nominal foreign exchange rate as insurance is costly. Accordingly, as a result of uncertainty about the future spot exchange rates the financial institution bearing the risk demands extra compensation, known as the risk premium, to provide currencies at a guaranteed forward exchange rate (Maskus, 1986).

Moving on, I will define certain key concepts. In this research I define trade as to be *the selling or purchasing of merchandise goods to consumers or from producers outside the country's borders*; thus we exclusively take international trade transactions into account. To narrow this research down, I solely take goods export values at current prices into account when analyzing trade. Moreover, I adopt the definition used by Adler & Dumas (1984): *a hedge is the amount of foreign currency financial transaction required to render the future, real, domestic currency market value of an exposed position statistically independent of unanticipated, random variations in the future domestic purchasing powers of these foreign currencies.*

Furthermore, exposure is defined by *the amount of foreign currency which represents the sensitivity of the future, real domestic currency (market) value of any physical or financial asset to random variations in the future domestic purchasing powers of these foreign currencies, at some specific future date.*

Moreover, it is important to stress certain assumptions that I will make in this phase to limit the scope of this research. Firstly, the assumption is made that exporters only suffer risk through exchange rate uncertainty. Henceforth, all other sources of potential risk for the trader (e.g. doubtful receivables) are not accounted for. Secondly, the assumption that all economic actors (in this case traders) behave rationally is also applied.

## 2.3. Causes of nominal exchange rate variability

In this subchapter two major categories of causes are discussed, which often appear to overlap in practice. Firstly, as Bloom (2014) concludes from a historical review, 'bad' events often increase uncertainty such as oil-price shocks, terrorist attacks and wars. Intuitively, these can be interpreted as unfavorable, exogenous and disrupting shocks to the macro economy.

The second category can be called 'domestic distrust' and can be seen as a more gradually developed culprit. Phenomena as corruption, non-transparency, nepotism etc. often lead to bad policies, distrust in the financial authorities and thus in the domestic currency. By definition, money has a fiduciary function and obtains its value through collective belief. Failing governments, which are unable to develop effective policy, particularly in times of economic crisis, lose trust of society and therefore are directly responsible for weakening of the domestic currency. Hence, a sequence of disequilibria on the money markets lead to increased movements of the exchange rate. Speculative investors and so called forex traders enforce this shakiness of the domestic currency, as they tend to buy and sell in order to gain profits. Both in fixed and flexible exchange rate regimes, the supply and demand for domestic and for foreign money on the local money markets determine the equilibrium exchange rate. However, in fixed exchange rates the financial authorities, usually the Central Bank, intervenes on the local money market when necessary by making use of its financial instruments such as selling or buying of foreign reserves (Dominguez, 1998). According to empirical evidence presented by Boykorayev (2008) GDP growth, inflation, country size, openness, terms of trade and government debt can also strongly affect the developing behaviour of the exchange rate.

## 2.4. Measures of exchange rate variability

Historically, many academic researchers have adopted a variety of operational measures of volatility. The most frequently and admissible derived measure is the standard deviation of the nominal exchange rate. This is calculated as:

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2}$$

However, this straightforward operator is often criticized for its simplicity and its inability to sufficiently capture dynamics. In particular, the assumption that exchange rates approximately follow a normal distribution can be held questionable. Another frequently used measure is the simple moving average (MA) method, which is calculated as:

$$V_t = \sqrt{\frac{1}{m}\sum_{i=1}^{m}(logX_{t+i-1} - logX_{t+i-2})^2}$$

where m = 12 is the order of the moving average. As argued by Chowdhury (1993) and other researchers, this measure captures the temporal variation in the absolute magnitude of changes in the nominal exchange rates and therefore serves as a measure of exchange risk.

Alternatively, a conditional standard deviation measure can be used as proxy for exchange rate risk. Following the approach developed by Engle (1983) and Bollerslev (1986), it is argued that the conditional variance is of more relevance to economic agents planning their behavior, widely known as a Generalized Autoregressive Conditional Heteroskedasticity model (GARCH). This more sophisticated measure distinguishes itself by assigning a certain weight to the long-run average variance rate ($V_L$) in addition to the periodic changes and variances.

$$\sigma_n = \sqrt{\gamma V_L + \alpha u_{n-1}^2 + \beta \sigma_{n-1}^2}$$

where γ is the weighted assigned to the long-run average variance rate, α is the weight assigned to the lagged squared returns term $u^2$ and β is the weight given to the lagged variance (or equivalently squared standard deviation) term $\sigma^2$. These self-determined weights should follow the constraint of γ + α + β = 1. Approximating the long run variance is usually handled as follows. By setting ω =

$\gamma V_L$, this leads to the computation of $V = \omega/(1- \alpha - \beta)$. Determining $\beta = 0.8$, $\gamma = 0.1$ and $\alpha = 0.1$ and by computing the long run average variance as the average of the monthly squared change in the exchange rate over the sample period per country, $\omega$ can be calculated. GARCH models incorporate mean reversion, in contrast to (weighted) moving average models. Hence, it is assumed that the mean reversion term $\omega$ enhances the accuracy of measuring risk exhibited by exchange rate volatility over time. This Generalized ARCH model is also proposed as a useful model for exchange rate volatility in the empirical work of Erdemlioglu, Laurent & Neely (2012) and can describe volatility clustering.

### 2.5. Uncertainty and risk exposure for exporters

Clark (1973) was one of the first to discuss the theoretical concepts of exchange rate uncertainty and risk, in particular for exporters. One of the most crucial assumptions for the above mentioned theory to hold is the high degree of risk aversion of exporting producers. To this extent, one might argue that risk-neutral traders are unaffected by excessive movements of the exchange rate. As Adler & Dumas (1984) emphasize, a currency is not risky because devaluation is likely; if devaluation were certain as to magnitude and timing, there would be no risk at all. Expected exchange movements can be anticipated by actors in the economy. Thus, risk or uncertainty is a matter of randomness (Adler & Dumas, 1984). Traditional analyses of currency exposure focuses on contractual items on the balance sheet such as debat, payables and receivables denominated in a foreign currency (Lessard & Lightstone, 1986).

As the findings of Arize, Osang & Slottje (2000) suggest, the variability of the real exchange rate had an adverse effect on the exports of their Latin American sample countries. Thus, contrary to theoretical expectations, even countries classified as middle-income economies from which we can believe that they have forward markets for traders to hedge their exposure, appear to be unable to completely protect themselves from this risk. The relevance for finding out what the implications for South American economies are, is thus of key interest.

# 3. Data Analysis

## 3.1. Panel countries

A panel of a total of twelve South American countries is examined in this study: Bolivia, Colombia, Uruguay, Paraguay, Ecuador, Peru, Suriname, Guyana, Argentina, Chile, Brazil and Venezuela. The whole panel is considered in all analyses, as long as data was available. Note that French Guyana, a current department of France, is excluded from this research due to a lack of available data. Also, as it is the only country in South America using the Euro as main currency, it becomes of less relevance when considering volatility effects.

## 3.2. Estimation period

The [4]data used in the analysis covers the period 1980-2015 and consists of cross-sectional and time series data. Examining the relationship between, in particular, the amount of exports and the nominal exchange rate (volatility) requires making use of panel data, as the economic relationship between the exchange rate volatility and the exports involves a dynamic adjustment process. Thus, this research compiles both cross-sectional observations (K = 12) and a consecutive time series dimension (T = 35). Consistently, a panel size of K x T = 420 observations will be used. Note that in this research the models are estimated making use of unbalanced panel observations, as a result of occasional missing values; thus, usually leading to less than 420 observations.

According to previous research and existing literature on international trade, there is a combination of mostly macroeconomic factors that influence the level of exports. These variables are included in this analysis in order to identify and quantify their effect on exports in South America. In addition, a few interaction terms are included, which allow us to expand the explanatory power of the hypothesis.

[4] In the tables of this research .. indicates unavailable data, 0 indicates zero or became due to rounding and - means not applicable (unless expressing a minus sign).

Table 1 presents each variable of the specified model with a description and corresponding source. Furthermore, the expected sign according to economic theory is also included, as this will serve as bridge to the empirical findings. The expected signs will be explained in the next chapter, hypothesis 1.

Note that data for the variable EXPTIME, which is measured as the yearly average amount of days necessary to finish an export transaction, is limited to the period 2005-2014. This can be viewed in the annex A.5. A quick observation shows that all included countries have seen the time needed to export gradually lowered over this period with the exception of Suriname and Venezuela.

**Table 1: Data description**

**Dependent: Total goods exports (X) - Source: WTO Database ( http://stat.wto.org)**

| Variable | Expected Sign | Unit | Description | Source |
|---|---|---|---|---|
| Pt/Q*t | - | % | The ratio of the country's consumer goods price level and the world's consumer goods price level | IMF Database: http://data.imf.org/?sk=5DABAFF2-C5AD-4D27-A175-1253419C02D1 |
| σ | - or + | .. | Standard deviation measured as yearly standard deviation based on monthly exchange rate data | IMF Database: http://data.imf.org/?sk=5DABAFF2-C5AD-4D27-A175-1253419C02D1&ss=1390030109571 |
| WD | + | % | Real world economic activity growth, measured as annual weighted average of real GDP growth of 5 most important trading partners | Trade map data used from Comtrade UN Statistics: http://comtrade.un.org/data/ |
| EC | - | .. | Error Correction term | Eviews - Fisher (Combined Johansen) Cointegration Test |
| GDP | + | Mln $ | Gross Domestic Product at market prices in current dollars | World Bank Database: http://databank.worldbank.org/data/reports.aspx?source=2&Topic=21 |
| EXPTIME | - | Days | The yearly average amount of days needed to complete an export transaction | World Bank Database: http://databank.worldbank.org/data/reports.aspx?source=2&Topic=21 |

| Table 2: Panel descriptive statistics | | | | | | |
|---|---|---|---|---|---|---|
| | **EXPORT** | **P/Q*** | **σ** | **WD** | **GDP** | **EXP_TIME** |
| **Mean** | 19405.39 | 17.03 | 21.26 | 3.24 | 135554.63 | 21.81 |
| **Median** | 5736.64 | 2.16 | 0.11 | 3.56 | 30512.78 | 19.00 |
| **Maximum** | 256039.90 | 1608.52 | 814.89 | 8.16 | 2614573.17 | 56.00 |
| **Minimum** | 189.00 | -0.36 | 0.00 | -3.64 | 336.71 | 12.00 |
| **Std. Dev.** | 35590.79 | 99.18 | 69.91 | 2.06 | 326218.45 | 9.85 |
| **Skewness** | 3.79 | 12.22 | 6.02 | -0.62 | 5.15 | 1.75 |
| **Kurtosis** | 20.65 | 177.64 | 52.39 | 3.67 | 33.73 | 5.70 |
| **Observations** | 432 | 413 | 396 | 416 | 418 | 119 |

### 3.3. First evidence on South American economies

The previously described model analyses in an aggregated context, as the effects we will find will reflect generalized effects for the panel countries. Nevertheless, it is of utmost importance to scrutinize further in order to gain a more insightful way of understanding the effect of exchange rate fluctuations on goods exports. Annex B provides a breakdown of the total annual goods exports per South American country. The figures each represent one of the 12 economies with its composition of key product categories in different years, over the past 15 years, measured by total export value in US dollars. This detailed trade data was extracted from the US trademap ITC database. I will provide a brief analysis of the developments of the main export product categories over time. The corresponding figures are presented in annex B, figure 1-12. These figures are self-constructed by applying the following criteria. An 'important' product category is qualified if the export category's value is 5% or more of the total export value in 2015. Consequently, all other export product categories of less than 5% of total value in 2015 have been cumulated into an "other" category.

To start with, the Argentinian exports appear moderately diversified with "residues, wastes of food industry and animal fodder" growing to its most important export category. Furthermore, "vehicles other than railway, tramway" grew to its second most important category, while most others remained relatively constant over time.

Bolivian exports appear reasonably well diversified with "mineral fuels, oils, distillation products, etc." evidently growing and maintaining its leading position.

In addition, the other large categories provide good reason to conclude that Bolivian exports are strongly dependent on its mining industry.

The exports of Brazil are well diversified over time with the majority of important categories also dedicated to the local mining industry, with its Petrobras being the largest corporation on this continent. Note that the export value of oil exports has decreased between 2010 and 2015. However, its cause cannot automatically be directed to the drop in oil prices, as it is unclear whether production levels have remained constant.

The Chilean economy's exports have historically and increasingly been dependent on exports of commodities such as copper, ores, slag and ash. These two product categories together consist of more than 50% of total export value since 2005.

Relying on coffee, tea and spices and in particular on mineral fuels, oils, distillation products etc., the Colombian export composition shows a strongly unvaried export side of the economy. Once again, oil production and exports seemingly dominate the total export bill. Note that, just as in the case of Brazil, we can observe a slight reduction in the importance of oil exports in 2015 relative to 2010.

Though of minor interest in this specific research, Ecuador has seen its oil and oil products share of total value drop significantly over the last decade, while fishing products have grown in importance.

Guyana has a strongly diversified export base relative to the other regional countries. With the smallest percentage in the 'other' category of all countries, it has a multiple very important export categories such as "pearls, precious stones, metals, coins etc." and "cereals". Furthermore, note that Guyana only started exporting "railway, tramway locomotives, rolling stock, equipment" for 10% of total value in 2015.

Worldwide exports of Paraguay were historically dominated by "oil seed, oleagic fruits, grain, seed, fruit etc." but have seen this category's share gradually decrease. Remarkably, the data on exports in 2010 and 2015 show that the oil industry in

Paraguay has received a large boost in growth, as it nowadays exports for at least a quarter of total export value.

The export base of Peru looks quite similar to that of Chile, as it mainly consists of ores, slag and ash and pearls, precious stones, metals, coins, etc. Within this economy of mainly mining commodities, copper seems to have a decreasing role. To conclude, the level of diversification in export products in Peru is considerably low.

The data on worldwide export categories of Suriname shows an increasing trend for almost all export categories. Note that the accuracy and reliability of the data on detailed exports in Suriname can be questioned, as the category "commodities not elsewhere specified" consists of a huge share of total export value only in this specific country. Nevertheless, it is clear that exports of mining commodities are crucial for the inflow of key foreign currencies such as US dollars. While gold exports as part of "pearls, previous stones, metals, coins etc." dominate in 2015, the oil export value as % of total dropped in 2015 relative to 2010.

Uruguay's economy has seen the shares of export categories such as "wood and articles of wood, wood charcoal" and "oil seed, oleagic fruits, grain, seed, fruit etc." grow in importance over time while "meat and edible meat offal" appears constant. All in all, this economy is relatively diversified.

As generally known of Venezuela, the country with the largest proven oil reserves in the world, domestic oil production and exports are paramount for this country's economy. Keeping in mind that a blessing can also be a burden, this export commodity gained even more dominance in total exports over time and consisted of 91% of total export value in 2015. In line with other oil exporting countries previously mentioned, we observe a small drop in oil exports in 2015 compared to 2010.

A preliminary but evident conclusion of this regional analysis is that the majority of South American economies are heavily leaning on the exploitation of their

(abundant) natural resources, in particular, their mining products such as oil, gold, copper etc. with respect to their exports. Unfortunately, such commodities are considered unsustainable and potential risk stemming from their exports should be, while it lasts, mitigated if possible. Industrial or manufacturing production for export appears to be of minor importance in this region, as such industries are predominantly capital-intensive.

In the light of this finding, it is of large interest and relevance to investigate whether exchange rate volatility will affect the goods exports, at a disaggregated level. Further elaboration on this empirical extension follows in the next chapter.

# 4. Methodology

In this chapter, the model specification, hypotheses and econometric properties will be explained. The empirical model that is used to estimate the effects of exchange rates and exchange rate volatility on exports is a Vector Error Correction Model (VECM). Furthermore, a dynamic, stochastic dimension is added to the model to enhance the quality and sophistication of the model. The dynamics in the model, including time dimensions, provide a better in order to capture time effects and account for expectations. Carnot, Koen & Tissot (2011) argue that a time trend is sometimes added to the export equation to proxy for product quality in the wider sense, which can be difficult to measure. According to them, the role of a time trend in this function is rather to capture any long-running changes in market shares linked to changes in non-price competitiveness.

The statistical models in this research are intensively conducted with the statistical software Eviews. All of these models are estimated by EGLS (Estimated Generalized Least Squares). To expand our in-depth analysis on the magnitude of changes in exchange rates and to achieve a better understanding of its real effects, we expand our research by including some interaction terms. These are added to the benchmark regression model in order to identify whether there is any particular reason to believe that there are non-linear relationships between the dependent and the explanatory variables.

As Arize (1996), Arize, Osang & Slottje (2008) and Chowdhury (1993) recommend in their similar research, making use of a Vector Error Correction Model as statistical approach has certain advantages. In particular, the short-run and long-run coefficient estimates are more efficiently provided, as this will be highlighted later on. The general equation for the panel data regression model is the following:

$$Y_{it} = \beta + \gamma' X_{it} + \alpha_i + \epsilon_{it}, \qquad [4]$$

where i = 1, 2, 3, …, N and t = 1, 2, 3, …, T. N being equal to the number of countries (N=12) and T being equal to the number of years (T=36). Additionally, α is the term that captures the general unobserved heterogeneity.

### 4.1. Hypothesis 1 - Model 1

The functional form and specification of the regression model 1 is constructed as follows.

$$X_{it} = \beta + \gamma_1 \frac{P_{it}}{Q_t} + \gamma_2 WD_t + \gamma_3 \sigma_t + \gamma_4 S_t + \tau_1 GDP_t + \tau_2 GDP_t * \sigma_t + \varphi EC_t \quad [5]$$

where $X_t$ denotes the natural logarithm of a country's total value of exported merchandise goods at current prices. This variable plays a central role within this research as dependent variable, is measured in millions of US dollars. Following empirical work of Arize, Osang & Slottje (2008) and Chowdhury (1993), I make use of the total value of exports instead of exports relative to GDP. Furthermore, a change in exports/GDP could arise from a change in GDP and would therefore provide an unclear inference of the effect of volatility on exports.

$WD_t$ is the natural logarithm of growth of world GDP, which serves as a proxy for real economic demand of foreign countries (or interpretable as real world economic activity). This predicting variable is constructed by computing the average GDP growth of the five main importing partners per specific country. The weights are calculated using the relative total export values per country to the total export value of these five countries. As literature suggests, there are no readily available indicators of demand, so self-construction is necessary.

$P_t/Q_t$ is the logarithm of relative consumer prices and is measured by the ratio of that country's consumer price as index to the world's consumer prices. This explanatory variable has the empirical purpose of serving as a competitiveness indicator in the model, as academic literature highly recommends.

According to Carnot, Koen & Tissot (2011), the export function of a country is primarily determined by world income and the relative prices of exports. Thus, as proxy for world income I use the self-fabricated world demand variable. As reliable data on relative prices of exported goods is difficult to find for the panel countries, I use an alternative measure of the relative consumer price indices. By including

other key regressors, I expand their applied simple export model with the following covariates: the nominal exchange rate, volatility and GDP.

$XR_t$ is the spot exchange rate or the nominal exchange rate, expressed as the domestic currency price of the foreign currency. Hence, it can be expected that a depreciation of the nominal exchange rate will lead to a boost in exports, as domestic products become relatively cheaper for foreigners. This is the so called 'level' effect of the nominal exchange rate on trade. Importantly, it is argued that the exchange rate has both 'level' and 'risk' effects on exports.

The measure of exchange rate volatility is the standard deviation $\sigma_t$, which is a commonly used operator to capture variability of a series over time. As Arize, Osang & Slottje (2008) also mention, most empirical research sees volatility of the exchange rate as risk. Thus, the conjectured causal inference is that higher risk leads to higher costs for risk-averse traders and, as a result, to less trade. In practice, it is remarkably difficult to predict the movements of the exchange rates. This could be due to the fact that the nominal exchange rate is a random walk and can basically go anywhere over time.

Finally, $EC_t$ is the error correction term and operates as a disturbance term in the equation. An explanation on how this term is estimated and coupled follows later.

Hence, the model [5] will serve as econometric model to test the first and main hypothesis and will be slightly modified per additional hypothesis. This hypothesis tests the key relationship of interest; hence the null-hypothesis is stated as:

$H_o$: $\gamma_3 = 0$
$H_a$: $\gamma_3 \neq 0$

We are in particular interested in the effect of the exchange rate volatility on the exports. However, the null hypothesis does not inform us which sign is expected. According to theory, a negative sign is expected. Nonetheless, evidence shows that both positive and negative signs are possible, which will be tested in this research.

### 4.2. Hypothesis 2 – Model 2

In addition, the objective is to investigate where the risk that exporters encounter during volatile periods comes from. The theoretical chapter of this research suggested that the risk that undermines enhancement of exports stems from a deviation in contract due dates. As time passes, the risk conceived from movements in the exchange rate grows. Thus, this can be proxied by the time needed for an export transaction to be completed. Hooper & Kohlhagen (1978) develop a model that takes normal contract leads and payment lags into account. As discussed previously, fluctuations in the spot exchange rate cause expected profits to be lower for the exporter. To estimate this interaction effect, the variable $EXPTIME_t * \sigma_t$ is added to the main model 1, generating model 2.

$$X_{it} = \beta + \gamma_1 \frac{P_{it}}{Q_t} + \gamma_2 WD_t + \gamma_3 \sigma_t + \gamma_4 S_t + \tau_1 GDP_t + \tau_2 EXPTIME_t \sigma_t + \varphi EC_t \quad [6]$$

Thus, the null-hypothesis that is tested is:

$H_0$: $\tau_2 = 0$
$H_a$: $\tau_2 \neq 0$

The expectation is that the coefficient of $\tau_2$ is significant, as this would confirm that the relationship between exports and volatility is strongly influenced by the time needed to export.

### 4.3. Hypothesis 3 – Model 3

There may possibly be structural differences between the countries, also known as unobserved heterogeneity. For example, size of the economy, structure of the economy, natural resource endowment, exchange rate regime, openness of the economy are but a few that could be classified as structural heterogeneity between these twelve South American countries. The Hausman test (1980) indicates whether it is appropriate to make use of random effects. To correct for possible country-specific unobserved heterogeneity within the panel data, the models are estimated by including country-specific random effects. The null hypothesis for this

test is thus that the random effect model is suitable and convenient in this case. The possibility of some weak multicollinearity is acknowledged within our models but assumed negligible in general.

As we only suspect that export has a long run relationship with some other regressor(s), we can test this by conducting the Fisher (Combined Johansen) Panel Cointegration Test. After proving whether there are signs of long-run relationships between the non-stationary variables, if any, the amount of cointegration equations should be assessed. If these equations show adequate reason to believe that the proper dynamic adjustment in the long run is influenced by cointegration, this can be improved by adding an error correction term.

Thus, the null-hypothesis states that there is no relevant Error Correction term to be added to the equation in model 1.

$H_o: EC_t = 0$
$H_a: EC_t \neq 0$

### 4.4. Hypothesis 4 – Robustness checks

Alternatively, it is recommended to make use of more sophisticated operational measures of volatility. In addition to a moving average (MA) method, the conditional standard deviation in a GARCH model will also provide as robustness check in this research. This can be related to a second hypothesis, where the null-hypothesis is stated as:

*$H_o$: both MA and GARCH alternative measures of exchange rate volatility have significant, negative effects on exports*
*$H_a$: none or at most one of the alternative measures of exchange rate volatility has the presumed effect.*

### 4.5. Hypothesis 5 – Disaggregated analysis on industry-level

According to a study done by Maskus (1986), real exchange rate uncertainty reduced U.S. agricultural trade by 6% during the 1974-1984 period. With this large plummet, the agricultural sector appeared to be the most susceptible to exchange rate uncertainty. In this research we dive a bit deeper and investigate whether there are intersectoral differences with respect to the effect of volatile exchange rates. Subsequently, a regression analysis will be conducted per individual country to test for the effect of volatility, if any, on the different industry exports. Hence, the fifth and final hypothesis that will be tested can be expressed as follows.

*$H_o$: Exchange rate volatility has a significant, negative effect on exports on country level*
*$H_a$: $H_o$ is false*

### 4.6. Econometric properties

In this subchapter the key econometric properties arising in the empirical analysis is explained, accompanied by useful statistical techniques. As proven by Granger (1996) in the so called Engle and Granger representation theorem, if a set of I(1) series are cointegrated, a dynamic error-correction representation of the data exists (Granger & Engle, 1987). Although two series can deviate in the short-run, they can have an established long run relationship.

Prior to conducting the Panel Cointegration test, it is essential to investigate the time series properties of each variable in the specified model. To test whether a variable is stationary or non-stationary, I make use of the Augmented Dickey Fuller (ADF – Fisher Chi-square) test. Following the methodology of Arize (1996), Chowdhury (1993) and Arize, Osang & Slottje (2000), the ADF test proves which variable is a random walk and which is not. As the Panel Cointegration test requires variables that are included into this test to be I(1), only variables that are non-stationary can be included. Making use of the Pedroni (Engle-Granger based) Panel Cointegration test with automatic lag length selection, the relevant non-

stationary variables are added and tested upon cointegration. The Pedroni Residual Cointegration test has the null-hypothesis of no cointegration. As panel cointegration tests require looking at various statistics to derive a conclusion, the majority of the test statistics will determine the outcome. While I only make use of the Pedroni Residual Cointegration test to determine significant cointegration, this does not yet provide a clear indication which variables are cointegrated exactly. As explained, this then is tested with the Fisher (Combined Johansen) Cointegration test.

To solve the problem of variables following a random walk process and to avoid estimating spurious effects, a simple procedure of differencing is applied (Hall, 1978). Subsequently, the residuals of a cointegrating equation are called the error-correction term and if stationary, can be included in the specified export model. Hence, in estimating these effects, we follow the approach introduced by Arize, Osang, and Slottje (2000) who examine the impact of exchange-rate volatility on the export flows using both cointegration and error-correction techniques.

# 5. Results

## 5.1. Panel regression analysis and VECM

| Table 3: Results on Panel Regression Models - Dependent Variable: DLOG(EXPORT) | | | | | | |
|---|---|---|---|---|---|---|
| | Model 1 | | Model 2 | | Model 3 | |
| **Variable** | **[5]Coefficient** | **Prob.** | **Coefficient** | **Prob.** | **Coefficient** | **Prob.** |
| **Intercept** | -0.001862 (0.015874) | 0.9067 | -0.016202 (0.037665) | 0.6681 | -0.002455 (0.015802) | 0.8767 |
| **WD/WINFL** | 0.079044*** (0.017663) | 0 | 0.060353*** (0.027029) | 0.0281 | 0.088585*** (0.017953) | 0 |
| **INFL/WINFL** | -0.0000713 (0.000111) | 0.5195 | -0.015612 (0.012182) | 0.2034 | -0.0000706 (0.000109) | 0.519 |
| **VOLATILITY** | -0.000324*** (0.000153) | 0.035 | 0.000173 (0.000245) | 0.482 | -0.000328*** (0.000151) | 0.0308 |
| **DLOG(XR)** | 0.001913 (0.017422) | 0.9126 | 0.022708 (0.237742) | 0.9241 | 0.001444 (0.017219) | 0.9332 |
| **DLOG(GDP)** | 0.244541*** (0.051575) | 0 | 0.664817*** (0.167530) | 0.0001 | 0.251038*** (0.051051) | 0 |
| **VOL*DLOG(GDP)** | 0.005531*** (0.001288) | 0 | - | - | 0.005423*** (0.001274) | 0 |
| **VOL*DLOG(EXPTIME)** | - | - | -0.001074 (0.001273) | 0.4013 | - | - |
| **EC** | - | - | - | - | -0.0000192*** (0.00000842) | 0.0236 |
| **$R^2$** | 0.2 | | 0.3 | | 0.21 | |
| **Durbin-Watson** | 1.86 | | 2.12 | | 1.86 | |
| **Prob. Hausman test** | 0.95 | | 0.22 | | 0.59 | |
| **RE/FE[6]** | RE | | RE | | RE | |

## Hypothesis 1

Table 1 in Annex A shows the result of the ADF statistics. As displayed, the variables EXPORT, GDP, XR and EXPTIME are random walks and are thus differenced to avoid spurious effects. The panel regression output for all models is shown in table 3. Initially, the regression model 1 is tested with random effects for our panel data. Hence, we conduct the Hausman test but cannot reject the null-hypothesis (P-value = 0.97). This clearly suggests that the null hypothesis of the random-effects model cannot be rejected and that using random effects, in this case country-random effects, is a proper estimation method to apply. Furthermore, the Durbin Watson statistic tests for signs of autocorrelation in the residuals from the panel regression analysis and always has a score between 0 and 4, where 2 indicates no disturbing autocorrelation in the sample (Moore, McCabe, Alwan, Craig & Duckworth, 2011). The DW statistic is 1.86, which is reasonably close to 2;

[5] Each coefficient is displayed unrounded with its corresponding standard error expressed within the brackets. *** indicates significant at 1%, ** significant at 5% and * significant at 10%.
[6] Random Effects/ Fixed Effects estimation.

thus, there is no significant autocorrelation to be accounted or corrected for. The $R^2$ of this model is 0.20, which means that around 20% of the variation in the data is explained by the chosen explanatory variables.

The coefficient of the deflated world demand (WD/WINFL) is approximately 0.079, positive and highly significant. This is consistent with economic theory and can be interpreted as: a 1% increase in the average growth of the economies of the top 10 most important trading partners of a specific South American country is associated with a 0.079% increase in the amount of goods exports.

The coefficient of the relative prices of consumer goods, measured as domestic inflation relative to the world inflation (INFL/WINFL), is -0.00007. It can be interpreted as: an increase in the relative consumer prices by 1 % is related to a decrease in the amount of exports by 0.00007 %.

This negative but insignificant effect appears small in size, in contrast to theoretical predictions. Nonetheless, this negative effect is consistent with what is considered intuitively and theoretically plausible, as an increase in domestic consumer prices is typically associated with a (marginal in this case) drop in exports.

The coefficient of the volatility of the exchange rate is -0.000414, thus negative and highly significant. The interpretation of the main determinant of interest can be interpreted as follows. If the standard deviation of the average annual exchange rate rises with 1, the amount of exports is expected to drop by roughly 0.0003 %.

The estimated coefficient of the nominal exchange rate (XR) is approximately 0.002. This insignificant coefficient can be interpreted as follows: on average a 1% depreciation of the domestic currency or equivalently, a 1% appreciation of the US dollar is associated with a 0.0002% increase in domestic exports. Though a weak effect, this is directly consistent with economic theory on this topic, as goods priced in the domestic currency now become relatively cheaper for foreign importers to purchase as they experience increased in their purchasing power.

The estimated coefficient of the size of the domestic economy (GDP) is approximately 0.24 and highly significant. This can be interpreted as: a 1% increase

in the GDP of the domestic economy is related to an increase of goods exports by 0.24%.

An important remark is that the above individual effects of regressors on the dependent variable are based on the well known ceteris paribus assumption, which is important when understanding the correct interpretation. As there is also an interaction term included in model 1, the interpretation of the coefficient of the variables volatility and GDP are not unique effects as they are also dependent on each other.

Hence, the final regressor's estimated coefficient is approximately 0.006 and significant. This coefficient of the interaction term requires somewhat other interpretation as it implies that the effect of volatility on goods exports depends on GDP. In this research I have no particular interest in marginal effects of the explanatory variables, but rather in the general relationship between these macroeconomic regressors and aggregate exports over time.

**Hypothesis 2**

The purpose of model 1 was primarily in testing the main relationship between volatility and goods exports. Subsequently, model 1 is modified to include another relevant interaction term, which has a deliberate meaning in the analysis. The estimated coefficient of the interaction term of the volatility and the time needed to export is approximately -0.001 and appears statistically insignificant. Thus, the null-hypothesis cannot be rejected. That aside, the explanatory power of model 2 appears much better compared to model 1, as the $R^2$ is now 0.30. The DW statistic is 2.13, which is presumed to be reasonable. To be certain the estimation method is correct, the Hausman test was conducted in advance, reassuring that using random-effects is the appropriate method.

**Hypothesis 3**

As observed previously in Table A.1, the *Export*, *GDP* and *Exchange Rate* are non-stationary variables and are thus tested for cointegrating relationships by a Panel Cointegration test. The outcome of this test can be found in table A.2, where the

Pedroni (Engle-Granger based) version of the test was executed. As the majority of the test statistics indicate a probability of lower than 5 %, the conclusion can be derived that there are signs of cointegration between these variables within the panel. To investigate how many cointegrating relationships are present, a different version of this test is conducted namely the Fisher (combined Johansen) test. The outcome of this test can be viewed in table A.3. As the hypothesis of 'at most 2' cannot be rejected, it can be suggested that at least 2 cointegrating equations/relationships are present.

Thus, this confirms the intuitive expectation that there is also a long-run relationship between exports, gdp and exchange rates. Thus, to fully build the Panel VECM an Error-Correction term is produced through estimation and included to the regression model, becoming model 3.

The Error Correction term estimated through a Vector Auto Regression (VAR) estimation method consists of the following expression: *0.0282078057413*(EXPORT(-1) - 0.0208817635245*GDP(-1) + 0.807020255883*EXCHANGE_RATE(-1) - 19.432357823*@TREND(80) - 12450.8788169 ).*

Adding this whole expression, which will thereon be referred to as the EC in the regression equation and reiterating the estimation, I find that it is highly significant at a p-value of 0.0028. The coefficient of the EC term is, as expected, negative and approximately -0.00004. However, the size of the effect of the EC appears extremely small but this fortunately appears to be a common finding when estimating error correction terms. Consequently, the null-hypothesis that states that the EC is equal to zero can be rejected. Hence, the estimated coefficient measures the average speed of adjustment at which exports change to movements in the equilibrium conditions.

Another interpretation of this term is that the EC term measures deviations of actual and long run exports; this term corrects the estimated equation to adjust exports sufficiently downwards (because the term had a negative sign) to reach its long run equilibrium value. Additional backtesting is also strongly improved by including the EC term. The sign and significance level of the EC term imply that

there is long run causality between the cointegrating variables. Whether there is short run causality is up till now unclear and can be tested by making use of the Wald test on coefficients. This tests whether the coefficients of GDP in the cointegration equations are jointly zero. I find a test statistic of 0.51 with a corresponding p-value of 0.77, which implies that the corresponding null-hypothesis cannot be rejected. By reiterating this test, now on the coefficients of the exchange rate, a test statistic of 0.53 and a p-value of 0.76 suggest that the same meaning holds for this variable.

## Hypothesis 4

| **Table 4: Results on MA and GARCH model - Dependent Variable: DLOG(EXPORT)** | | | | |
|---|---|---|---|---|
| | Model 4 - MA | | Model 5 – GARCH | |
| **Variable** | **[7]Coefficient** | **Prob.** | **Coefficient** | **Prob.** |
| Intercept | -0.006023 (0.015764) | 0.7027 | -0.002105 (0.018159) | 0.9078 |
| WD/WINFL | 0.093271*** (0.018309) | 0.0000 | 0.092303*** (0.018374) | 0.0000 |
| INFL/WINFL | -0.0000778 (0.000111) | 0.4857 | -0.0000797 (0.000112) | 0.4774 |
| VOLATILITY | -0.279923* (0.146211) | 0.0564 | -0.066435 (0.150346) | 0.6589 |
| DLOG(XR) | 0.042778 (0.027435) | 0.1198 | 0.008335 (0.022192) | 0.7075 |
| DLOG(GDP) | 0.309557*** (0.050713) | 0.0000 | 0.305346*** (0.051033) | 0.0000 |
| EC | 0.0000201** (0.00000858) | 0.0199 | -0.0000211** (0.00000865) | 0.0150 |
| | | | | |
| $R^2$ | 0.18 | | 0.17 | |
| Durbin-Watson | 1.80 | | 1.84 | |
| Prob. Hausman test | 0.73 | | 0.53 | |
| [8]RE/FE | RE | | RE | |

Table 4 provides the results on the robustness checks, in order to assess whether the prevailed effects in the former models hold, both in sign, size and significance. The estimated coefficient of the volatility, measured by a moving average, is approximately -0.28, thus negative and significant at 10%. While its counterpart in the GARCH model appears also negative and approximately -0.07, it is, however, not significant. In addition, the $R^2$ is 0.18, which is a decline in comparison to the models 1-3. To conclude, the null-hypothesis can be rejected as solely the MA model provides significant effects.

## Hypothesis 5

| Table 5: Individual country regression results<br>Volatility effect on dependent variables | | | |
|---|---|---|---|
| | **Manufacturing exports** | **AAF exports** | **Mining exports** |
| **Argentina** | -0.496808 (0.500316) | -0.448237 (0.858420) | - |
| **Bolivia** | - | 0.363961 (0.454227) | 0.475138 (0.855960) |
| **Brazil** | 1.243028 (0.780953) | 0.702031 (0.591086) | 2.098996** (0.682115) |
| **Chile** | - | 0.002016 (0.001749) | 0.001162 (0.002698) |
| **Colombia** | - | 0.000609 (0.001061) | -0.000267 (0.000740) |
| **Ecuador** | - | - | - |
| **Guyana** | -8.690026 (10.26096) | 0.062055 (0.102905) | 0.511019 (0.341650) |
| **Paraguay** | - | 0.000696 (0.000612) | 0.001986 (0.012680) |
| **Peru** | - | 1.386308 (0.927823) | -1.464105 (2.023609) |
| **Suriname** | - | - | - |
| **Uruguay** | - | 0.050489 (0.063493) | 0.086511 (0.087989) |
| **Venezuela** | - | - | -2.759498** (1.089446) |

Table 5 provides the results of regression analyses conducted on a disaggregated level. The 3 main export categories consisting of the exports from Manufacturing, Agricultural, Animal and Food products (AAF) and Mining industries are computed per panel country by merging the relevant major export categories, as provided in table B.1-B.12. Note that 2 panel countries, Ecuador and Suriname, were excluded from this test, for different reasons. As previously explained, Ecuador uses US dollars as daily currency for payments; Suriname had a serious lack of reliable detailed export data.

A first glance at the results shows that there is no consistency in either the signs or significances of the coefficients. Argentina is the sole country for which a negative effect is found for both industries, though insignificant. Hence, in this country where AAF export products are preponderant, every movement of the standard deviation by 1 (regardless of the direction) is related to a cut of close to a half percent in exports.

In addition, the results show that exchange rate volatility has a significantly large and negative effect on mining products exports in Venezuela. The magnitude of this effect seems massive compared to the volatility effects found in the panel

models 1-3. This can be explained by acknowledging the fact that Venezuela's exports are predominantly oil products and its absolute export value is the vast amount of 34.4 billion US dollars in 2015, while its exports peaked at a value of nearly 94 billion US dollars in 2012. Ceteris paribus, this effect can be interpreted as: an increase in exchange rate volatility by 1 is related to a considerable drop of approximately 2.76% in oil export value. Note that although Venezuela has an immense oil endowment, it is just another price taker on the global oil market, and therefore it cannot be said if a drop in total export value is directly linked to a drop in total export volume.

Conversely, a set of countries, namely Bolivia, Brazil, Chile, Paraguay and Uruguay present positive effects for all included industries. However, these effects appear insignificant with the exception of the mining-industry effect of Brazil. Similarly to that of Venezuela but the opposite sign, the magnitude of the effect seems tenacious and indicates that a change in volatility by 1 unit is associated with a hike in the mining commodity exports by a little more than 2%.

Interestingly, one can clearly observe that the marginal effects mutually differ substantially with the effect for the mining-industry ranging from 0.0002% to 2.76%, that of the AAF-industry from 0.0006% to 1.39% and that of the manufacturing-industry between 0.5% and 8.7%. The latter effect of 8.7% appears extremely large and a more detailed analysis suggests that this can be strongly doubted, as Guyana only started exporting manufacturing products (specifically railway, tramway locomotives, rolling stock, equipment) in 2015 for meaningful amounts. As conclusion, the null-hypothesis can be rejected as a result of a mutual discrepancy of effect signs and significances at country level.

# 6. Conclusion

## 6.1. Short summary

This thesis emphasizes, in particular, on the influence of exchange rate fluctuations on goods exports in South American economies. By making use of a panel Vector Error Correction Model, which basically combines a panel regression estimation model with an incorporated error correction technique, both the level effect of the exchange rate and the volatility are estimated and unraveled. In line with the majority of existing empirical work and theoretical predictions, the results suggest that there is both a short run and a long run significant, negative relationship between exchange rate volatility and goods exports at an aggregated level. However, the results from multiple robustness checks, consisting of alternative operational measures of volatility, suggest that there is ambiguity to some extent with respect to the volatility-trade nexus. Moreover, a country-specific analysis shows that the volatility effects on the export industries of key importance are wavering in both direction and magnitude. This research contributes to a voluminous body of empirical work on the volatility-trade nexus, while fulfilling an exceptional role in the choice of the panel countries and in its idiosyncratic analysis in a disaggregated context.

## 6.2 Detailed conclusion

The statistical appropriateness of all 5 models appear satisfactory, as the diagnostic tests such as $R^2$ ranging from 0.17 to 0.30 and the DW values all seem acceptable.
The results of the analysis can be concluded in five complementary parts.
Firstly, the intention of the regression analysis of the panel data was to provide a deeper understanding on both the statistical and the economic relationship between the exchange rate volatility and the goods exports in South America.
Following the conducted research methodology of Chowdhury (1993) and Arize, Osang & Slottje (2008), the export function was estimated using various macroeconomic explanatory variables. While Carnot & Tissot (2011) claim that the main determinants of the export function are world income and the relative prices of export goods, I found only the former to be true in this research along with some

other added covariates. The regression results suggested that the variables of main importance to determine the goods exports are world demand (as proxy for world income), volatility of the exchange rate and GDP. A possible explanation for the insignificance of the nominal exchange rate is the fact that the existence of transaction costs and transport costs nearly completely eliminate small arbitrage opportunities. Although the effect has the correct sign, a small depreciation of the domestic currency is evidently not related to major jumps in exports. Also, the regression output suggests that there is at least statistical evidence that volatility significantly and negatively affects the value that is exported by such a country, which corroborates with theory. As large fluctuations do not happen often, the majority of movements are marginal fluctuations over time and do not drastically deteriorate export flows, which reflects the small absolute size of the effect at this aggregated level. This is directly in line with the study done by Dell' Ariccia (1998) with panel data from the European Union, where he also found a very small absolute effect. To conclude, while the statistical effect appears significant the economic ramifications of fluctuations in the exchange rates of South American countries on the aggregated goods exports seems not of great concern. One explanation is the fact that the most important export commodities for such countries are based on capacity-related production such as oil production. As seen, the mining industry appears to cover a substantial portion of the total exports in this continent, as result of its natural resource abundance in general. The level of production of oil, gold etc. is little to not dependent on the level of the exchange rate and is rather based on production capacities in place, capital stocks, developments in the renewable energy sector, explorations influencing domestic reserve stocks and future expectations of the world market prices for commodities. Thus, a company producing and exporting oil or gold does not easily shift its export levels if the exchange rate makes sudden unfortunate movements. Furthermore, large corporations (mostly MNEs) active in the area work with long term, standardized contracts on a global scale, which have fixed amounts of traded goods incorporated.

Secondly, the initial fundamental thought on the source of risk from exchange rate volatility was that it stems from the contract durations or, as proxied in this study, the average time that is necessary to complete the export. The results suggest that the time needed to fully export does not significantly affect the effect of volatility on export flows. In other words, the exporter's behaviour towards risk derived from exchange rate fluctuations does not depend on whether it requires a short or long period of time to complete the export deal. Henceforth, export contracts appear of minor relevance regarding the nexus of interest.

Thirdly, overlooking the matter of cointegration between exports, GDP and exchange rates would have caused possible misspecification in the dynamics of the model. Incorporating an EC term into the regression estimation is a prerequisite and accounts for the long lasting effect that exports, GDP and exchange rates have on each other. This research confirmed the appropriateness of using this methodology where both the short and long run effects are estimated, as the speed of adjustment of exports to movements in GDP and exchange rates is crucial for correct inferences. Hence, the inference that there is long run causality between GDP and exchange rates on exports is conceivable. The results of the Wald tests on the coefficients of GDP and exchange rates suggest that there is no short-run causality running from GDP and XR to exports. Note that this could indicate signs of reverse causality as the direction of causality could perhaps be running from exports to GDP. This statement can be supported by the well-known equation that equates the national income or GDP to the sum of consumption, investment, government spending and net exports.

Fourthly, the results from the robustness checks deliver ambiguous findings to some extent. While using the standard deviation seemed to provide the strong relationship between exchange rate volatility and exports as presumed, making use of the MA and the GARCH method respectively confirmed and declined this. Nevertheless, all three measures of exchange rate variability have a negative sign, which contributes to earlier belief. Though not of prime interest, whether the ARCH model factually improved our model is questionable, as it does not

convincingly upgrade the model's explanatory power. Ultimately, it can be said that the robustness of the empirical evidence on this prominent relationship is solid on the direction but merely wavering on its strength.

Fifthly, the results for the individual testing for South American panel countries suggest an inconclusive outcome. On one hand, I find strong, negative effects for volatility on exports for a few countries, as predicted by the majority of literature. On the other hand, the results predominantly indicate a positive but weak effect of volatility on exports on individual country level. These findings strongly suggest that exporters in South American economies differ in their behaviour towards risk exhibited from movements in the exchange rate.

Finally, the main research question can be answered making use of the empirical findings of this comprehensive analysis. This research provides disclosed evidence of a short and long run significant, negative relationship between the volatility of exchange rates and the value of goods exported for South American countries in the aggregated analysis. Though statistically strong, the found effects in the corresponding models appear of minor economic consequence with respect to trade. However, a more refined analysis on a disaggregated level provides a less clear-cut relationship between exchange rate risk and industry-related exports with respect to the sign and significance. Hence, failing to mitigate risk induced from exchange rate variability depresses export flows and therefore undermines economic growth for some countries, whereas others appear to have enhanced exports in volatile times.

Furthermore, note that making causal inferences can be inappropriate in this research. Although trade dropped greatly in almost every country of this panel in 2015, there is no fundamental reason to believe that this was *caused* by the volatile behaviour of domestic exchange rates. As explained before, South American economies mainly produce commodities for which they are price takers; worldwide demand for their products seem to play a much more crucial role when attempting to explain the developments in goods exports.

### 6.2. Policy recommendations

As exporters in such countries rarely have proper access to a functional forward exchange market, the excessive risk they are exposed to can be seen as a serious constraint to enhance trade flows. Even worse, ever-increasing exchange rate variability can severely damage the exporter's financial position. As John Maynard Keynes' popular quote goes: *"Markets can remain irrational longer than you can remain solvent."* Though not of immense economic repercussion, minimizing or mitigating risk from exchange rate movements can be an important condition for steady economic growth. In this subchapter several policy recommendations are given with the emphasis on creating a financially stable climate as well as fostering trade of goods.

The general saying is that governments of countries, in particular those in current crisis, should actively commit to creating financial stability and protection of the domestic currency. Economic setbacks can lead to stronger economies in the long run, if able to identify opportunities of improvement, for example difficult government reforms or revision of outdated laws. While proponents of flexible exchange rate regimes argue that a floating currency provides a better set up of the competitiveness mechanism of the domestic economy, it also can have downsides. In particular for countries experiencing economic turmoil, continuous fluctuations of the exchange rate could cause excessive risk for certain exporters. Policies specifically targeting the stabilization of exchange rates would have the best fit in a bigger picture framework; the most obvious solution, and repeatedly argued by economists, would be in this case to lobby for a unified currency such as the Eurozone has done. In such frameworks individual countries still maintain control of and responsibility for domestic fiscal policies, whereas the region's monetary policy is managed and executed through a centralized system.

Although exporters of relative small economies such as that of Guyana, Peru or Suriname might have difficult access to forward exchange markets or hedge funds, this could be partly solved by other, unconventional approaches. A recommendable

approach would be for exporters to seek hedging possibilities at financial institutions from nearby or neighbour countries. Larger economies such as that of Brazil and Chile have larger, international financial institutions such as banks and pension funds that probably do offer hedging options to risk-undertaking exporters. Moreover, issues of geographical proximity can be easily overcome nowadays, as most financial institutions do business through advanced and sophisticated digital systems globally.

Two South American countries, Guyana and Suriname, have joined the CARICOM along with various Caribbean islands with the intention to create a joined market for goods trade. However, these expected benefits in trade have yet to be reaped by most member countries, as new trade partnerships and deals tend to be put on the back burner. Furthermore, typical South American organizations aiming to promote economic development such as Mercosur or UNASUR are mainly dedicated to the Spanish speaking countries of South America and the Caribbean. According to an official report on trade treaties in South America by Mendoza (2012), countries as Chile, Colombia and Peru have a predominant share in free trade agreements with the rest of the world. Moreover, countries as Bolivia, Chile, Colombia, Ecuador, Peru and Venezuela have the strongest trade relationships, as a result of their mutual trade treaties. Thus, 'regionalism' shows that some specific bundling South American countries greatly benefit from free trade agreements and continue to promote trade within growing frameworks. However, others are not actively taking part in trade treaties and therefore are so far failing to optimally utilize their export capacity and negotiate better trade deals.

With respect to economic diversification and perhaps even transformation, specific policy should be developed which will guide and assist the transition of these primary mining commodity economies to economies driven by sustainable sectors such as agriculture, fishing, tourism, farming etc. If research highlights that the main issue for exporters lies not in their perceived risk through fluctuations of the exchange rate but rather in inadequate export incentives, a proactive government should improve this. South American economies should highly prioritize in

enhancing their sensitivity against sharp drops in commodity prices by creating sovereign wealth funds and stimulating domestic base production.

An additional interesting issue would be to investigate how come some countries with a comparable degree of dependence on mining commodities, measured as % of total export value, have opposite signs with respect to their marginal effects. Note that this would require a detailed field research on the current hedging behaviour and the degree to which hedging is possible and utilized in every individual South American economy.

To conclude, without an auspicious economic climate for the attraction of FDI, economic diversification, strong and effective policies implemented by credible, transparent governments and enhancement of regional/multilateral trade collaboration most developing countries in South America will be unable to prevent a recurring boom-to-bust story.

### 6.3. Drawbacks

This study contributed to closing the gap on academic research for South American countries on topics such as exchange rate volatility, trade, economic growth, risk behaviour and more. Nevertheless, this research has certain shortcomings. As mentioned earlier, there was a small quantity of missing data for some countries. In particular detailed data on contract types/durations or extended data on time needed to export were main shortcomings in this research. Although most companies use standardized contracts, there could be other reasons why some countries take longer to complete the export transaction on average than others. For further research I suggest enlarging the period of analysis and adding more institutional indicators to identify which affect the business climate and thus production dedicated to exports. Further broadening the scope of research might enhance the understanding of the role of natural resource endowment in handling exchange rate risks and the potential consequences for trade.

Another shortcoming is making use of a more accurate and preferred measure for the relative prices of goods, namely the price of exports relative to the world export prices. Unfortunately, this data is difficult to find for South American countries in international databases on trade. This could be an explanation for the fact that we found an insignificant effect of relative consumer prices on exports, as conventional theory predicts that this is one of the key determinants for trade in general.
A more statistical shortcoming is the absence of a normal distribution of the exchange rate, though not uncommonly found. While I made use of multiple operational measures of volatility, future research can attempt to improve the modeling of exchange rate volatility even more by accounting for the degree of skewness and kurtosis in the distribution. Modeling exchange rate volatility has historically been difficult and as also proven by this evidence, it appears to follow random walk behaviour and is subject to periodically alternating speculation.

Altogether, this research sheds light in an insightful way on the trade situation in South American economies and how this is affected by volatile currencies.

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# Annex A

| Table A.1: Panel Unit Root test<br>Augmented Dickey Fuller - Fisher Chi-square Test Statistic | | | |
|---|---|---|---|
| **Variable** | **Test Statistic** | **Prob.** | **Conclusion** |
| EXP | 7.4837 | 0.99 | Random Walk |
| WD/WINFL | 126.099 | 0.00 | Stationary |
| INFL/WINFL | 58.3923 | 0.00 | Stationary |
| VOL | 64.1042 | 0.00 | Stationary |
| XR | 7.24201 | 0.99 | Random Walk |
| GDP | 0.69492 | 1.00 | Random Walk |
| EXPTIME | 32.2223 | 0.074 | Random Walk |

| Table A.2: Panel Cointegration Test<br>Pedroni Residual Cointegration Test | | | | |
|---|---|---|---|---|
| Variables tested: *Export, GDP & Exchange Rate* | | | | |
| **Test** | **Statistic** | **Prob./Conclusion** | **Weighted Statistic** | **Prob. /Conclusion** |
| Panel v-Statistic | 2.615603 | 0.0045 - Reject | 1.6826 | 0.0462 - Reject |
| Panel rho-Statistic | -0.308008 | 0.3790 - Do not reject | -0.344747 | 0.3651 - Do not reject |
| Panel PP-Statistic | 0.638835 | 0.7385 - Do not reject | -0.587344 | 0.2785 - Do not reject |
| Panel ADF-Statistic | -5.71802 | 0.0000 - Reject | -3.722517 | 0.0001 - Reject |
| Group rho-Statistic | 0.353354 | 0.6381 - Do not reject | | |
| Group PP-Statistic | -1.581784 | 0.0568 - Reject | | |
| Group ADF-Statistic | -6.426352 | 0.0000 - Reject | | |

| Table A.3: Panel Cointegration Test<br>Fisher Panel Cointegration Test | | | | |
|---|---|---|---|---|
| Variables tested: *Export, GDP & Exchange Rate* | | | | |
| **Hypothesized No. of CE(s)** | **Fisher Stat (from trace test)** | **Prob.** | **Fisher Stat (from max-eigen test)** | **Prob.** |
| None | 99.64 | 0.0000 | 75.84 | 0.0000 |
| At most 1 | 41.33 | 0.0075 | 33.06 | 0.0610 |
| At most 2 | 24.53 | 0.3199 | 24.53 | 0.3199 |

| Table A.4: The 5 most important trading (importing) partners per South American country over period 2011-2015 | | | | | |
|---|---|---|---|---|---|
| **Source: UN Comtrade Statistics** | | | | | |
| **Country** | **Trading partner** | | | | |
| **Argentina** | Brazil | China | USA | Chile | India |
| **Bolivia** | Brazil | Argentina | USA | Colombia | China |
| **Brazil** | China | USA | Argentina | Netherlands | Germany |
| **Chile** | China | USA | Japan | Republic of Korea | Brazil |
| **Colombia** | USA | Panama | Netherlands | China | Spain |
| **Ecuador** | USA | Peru | Colombia | Vietnam | Chile |
| **Guyana** | Canada | USA | Panama | UK | Trinidad & Tobago |
| **Paraguay** | Brazil | Chile | Argentina | Italy | Russian Federation |
| **Peru** | China | USA | Switzerland | Canada | Japan |
| **Suriname** | USA | Switzerland | Guyana | United Arab Emirates | Belgium |
| **Uruguay** | Brazil | China | Argentina | USA | Venezuela |
| **Venezuela** | China | Colombia | Netherlands | Brazil | USA |

| | **Table A.5: Time to export (in days) over period 2005-2014**<br>**Source: World Bank database** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** |
| **Argentina** | 16 | 16 | 16 | 13 | 13 | 13 | 13 | 13 | 12 | 12 |
| **Bolivia** | 24 | 24 | 24 | 19 | 19 | 19 | 19 | 19 | 21 | 22 |
| **Brazil** | 18 | 18 | 18 | 14 | 12 | 13 | 13 | 13 | 13,4 | 13,4 |
| **Chile** | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 15 | 15 | 15 |
| **Colombia** | 34 | 34 | 24 | 14 | 14 | 14 | 14 | 14 | 14 | 14 |
| **Ecuador** | 22 | 22 | 22 | 20 | 20 | 20 | 20 | 20 | 20 | 19 |
| **Guyana** | 21 | 21 | 21 | 21 | 20 | 19 | 19 | 19 | 19 | 19 |
| **Peru** | 22 | 22 | 22 | 22 | 21 | 12 | 12 | 12 | 12 | 12 |
| **Paraguay** | 36 | 36 | 36 | 36 | 34 | 34 | 34 | 34 | 29 | 29 |
| **Suriname** | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 22 | 22 | 22 |
| **Uruguay** | 23 | 23 | 23 | 18 | 18 | 18 | 16 | 16 | 16 | 15 |
| **Venezuela** | 34 | 32 | 45 | 49 | 49 | 49 | 49 | 49 | 56 | 56 |

# Annex B


Figure 1: Total annual goods exports per product category in Argentina
Other
Cereals
Oil seed, oleagic fruits, grain, seed, fruit, etc, nes
Animal,vegetable fats and oils, cleavage products, etc
Residues, wastes of food industry, animal fodder
Vehicles other than railway, tramway
100%
50%
0%
2001
2005
2010
2015

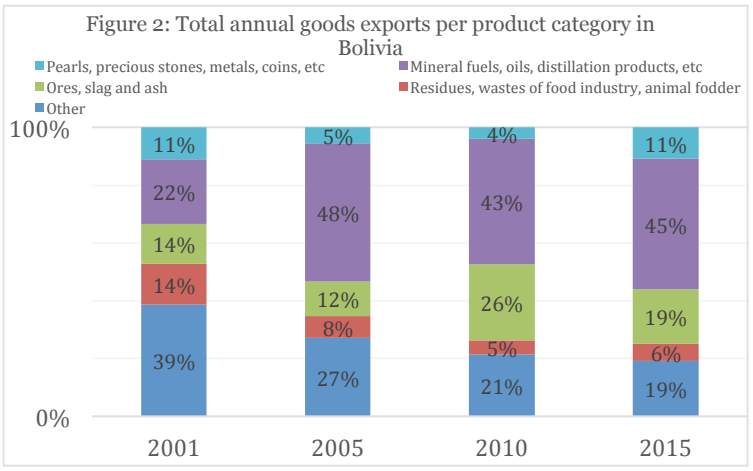
Figure 2: Total annual goods exports per product category in Bolivia
Pearls, precious stones, metals, coins, etc
Mineral fuels, oils, distillation products, etc
Ores, slag and ash
Residues, wastes of food industry, animal fodder
Other
100%
0%
2001
2005
2010
2015

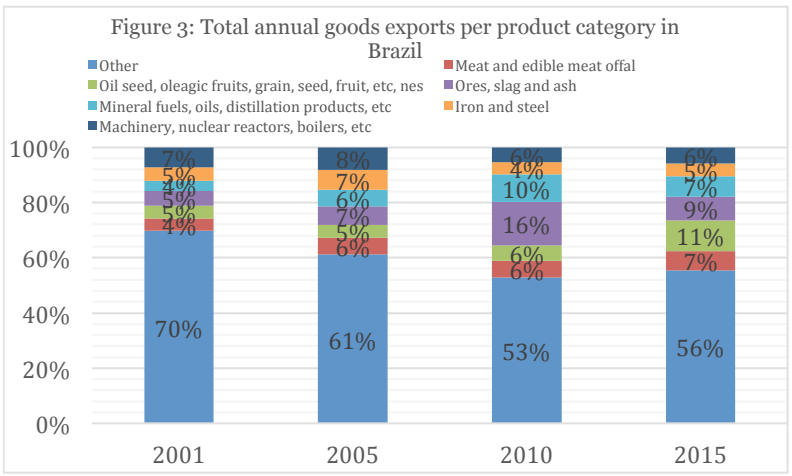
Figure 3: Total annual goods exports per product category in Brazil
Other
Meat and edible meat offal
Oil seed, oleagic fruits, grain, seed, fruit, etc, nes
Ores, slag and ash
Mineral fuels, oils, distillation products, etc
Iron and steel
Machinery, nuclear reactors, boilers, etc
100%
80%
60%
40%
20%
0%
2001
2005
2010
2015

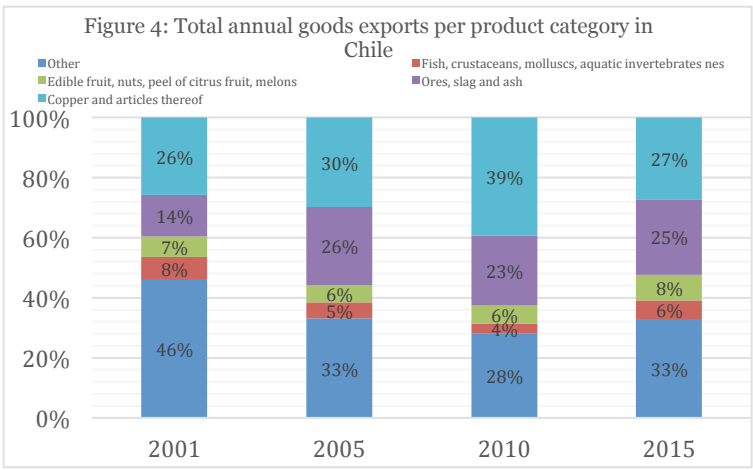
Figure 4: Total annual goods exports per product category in Chile
Other
Fish, crustaceans, molluscs, aquatic invertebrates nes
Edible fruit, nuts, peel of citrus fruit, melons
Ores, slag and ash
Copper and articles thereof
100%
80%
60%
40%
20%
0%
2001
2005
2010
2015

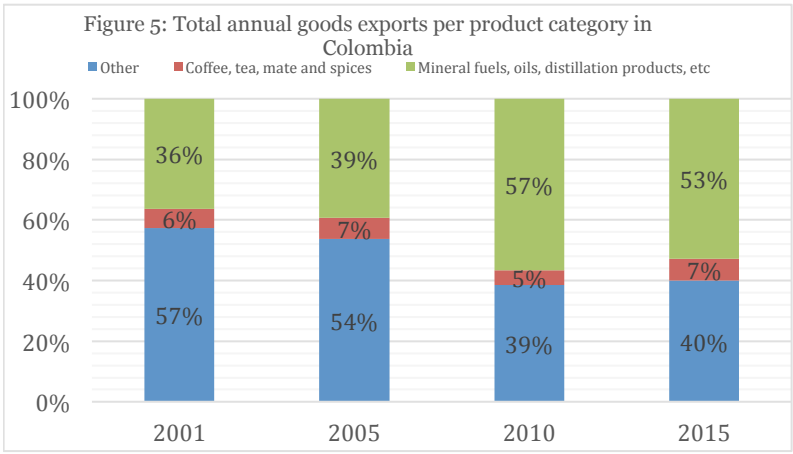
Figure 5: Total annual goods exports per product category in Colombia
Other
Coffee, tea, mate and spices
Mineral fuels, oils, distillation products, etc
100%
80%
60%
40%
20%
0%
2001
2005
2010
2015

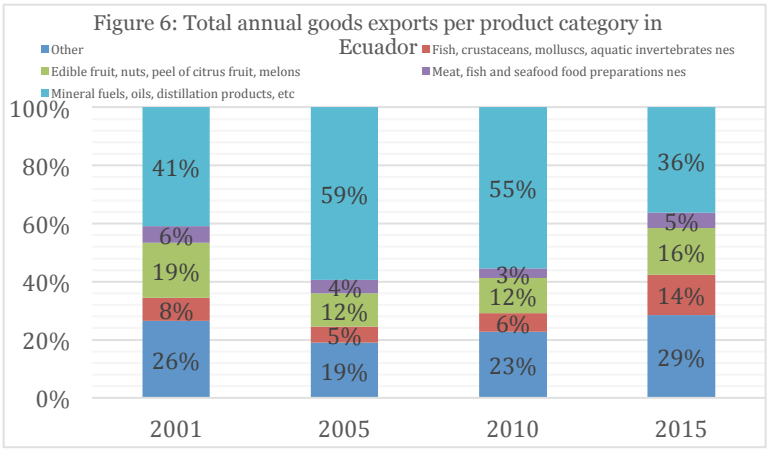
Figure 6: Total annual goods exports per product category in Ecuador
Other
Fish, crustaceans, molluscs, aquatic invertebrates nes
Edible fruit, nuts, peel of citrus fruit, melons
Meat, fish and seafood food preparations nes
Mineral fuels, oils, distillation products, etc
100%
80%
60%
40%
20%
0%
2001
2005
2010
2015

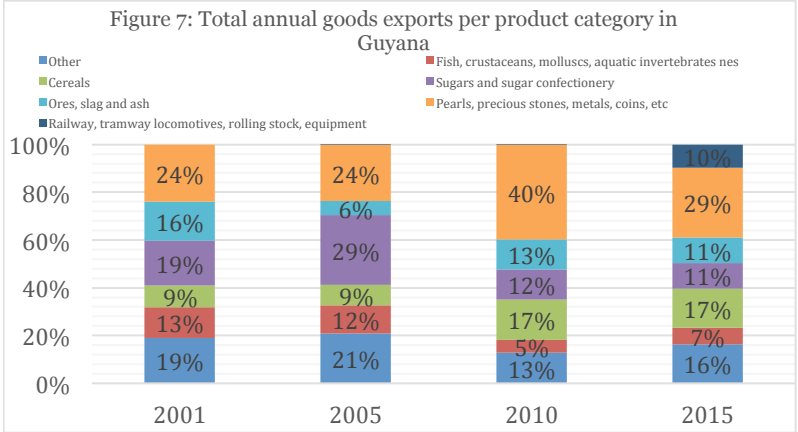
Figure 7: Total annual goods exports per product category in Guyana
Other
Fish, crustaceans, molluscs, aquatic invertebrates nes
Cereals
Sugars and sugar confectionery
Ores, slag and ash
Pearls, precious stones, metals, coins, etc
Railway, tramway locomotives, rolling stock, equipment
100%
80%
60%
40%
20%
0%
2001
2005
2010
2015


Figure 8: Total annual goods exports per product category in Paraguay
Mineral fuels, oils, distillation products, etc
Residues, wastes of food industry, animal fodder
Oil seed, oleagic fruits, grain, seed, fruit, etc, nes
Meat and edible meat offal
Other
100%
80%
60%
40%
20%
0%
2001
2005
2010
2015

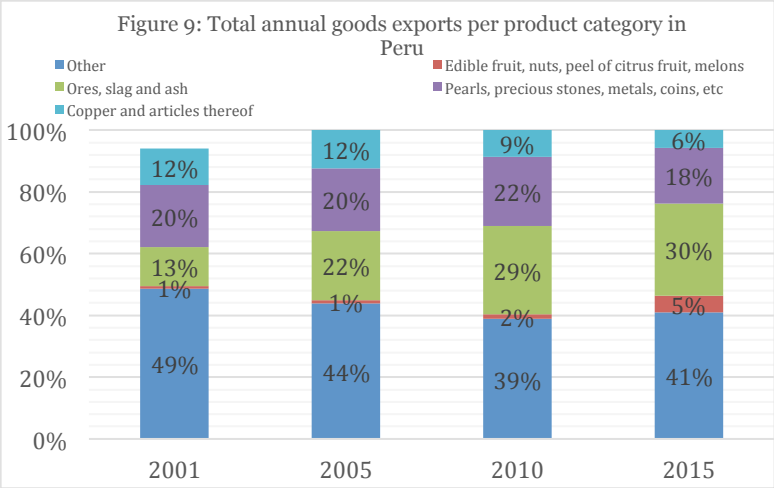
Figure 9: Total annual goods exports per product category in Peru
Other
Edible fruit, nuts, peel of citrus fruit, melons
Ores, slag and ash
Pearls, precious stones, metals, coins, etc
Copper and articles thereof
100%
80%
60%
40%
20%
0%
12%
20%
13%
1%
49%
12%
20%
22%
1%
44%
9%
22%
29%
2%
39%
6%
18%
30%
5%
41%
2001
2005
2010
2015

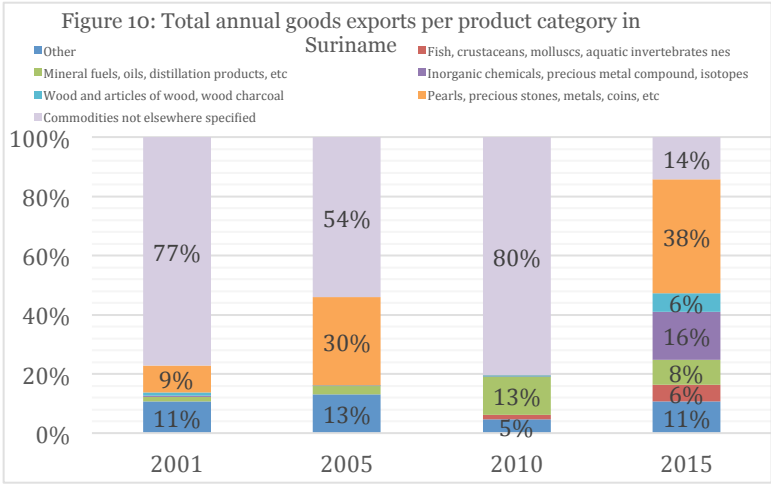
Figure 10: Total annual goods exports per product category in Suriname
Other
Fish, crustaceans, molluscs, aquatic invertebrates nes
Mineral fuels, oils, distillation products, etc
Inorganic chemicals, precious metal compound, isotopes
Wood and articles of wood, wood charcoal
Pearls, precious stones, metals, coins, etc
Commodities not elsewhere specified
100%
80%
60%
40%
20%
0%
77%
9%
11%
54%
30%
13%
80%
13%
5%
14%
38%
6%
16%
8%
6%
11%
2001
2005
2010
2015

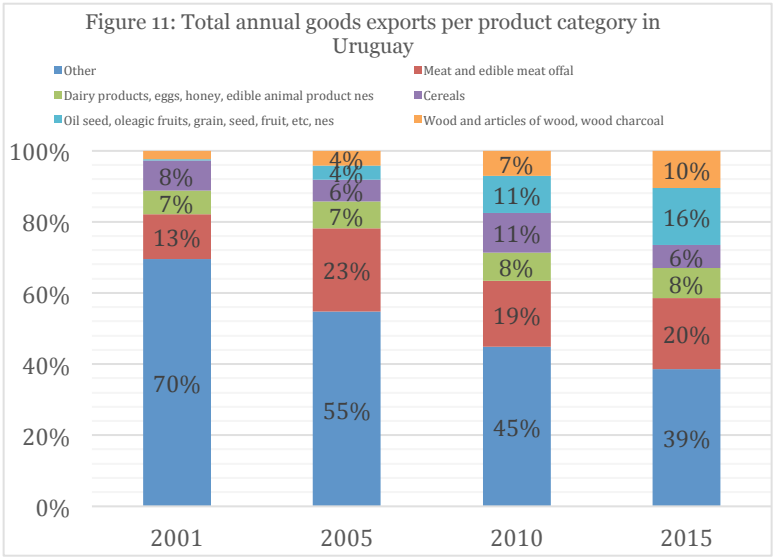
Figure 11: Total annual goods exports per product category in Uruguay
Other
Meat and edible meat offal
Dairy products, eggs, honey, edible animal product nes
Cereals
Oil seed, oleagic fruits, grain, seed, fruit, etc, nes
Wood and articles of wood, wood charcoal
100%
80%
60%
40%
20%
0%
8%
7%
13%
70%
4%
4%
6%
7%
23%
55%
7%
11%
11%
8%
19%
45%
10%
16%
6%
8%
20%
39%
2001
2005
2010
2015

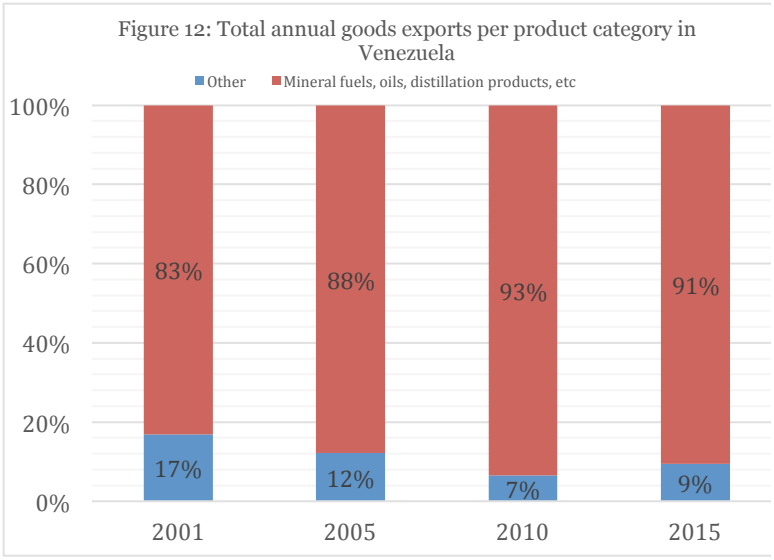
Figure 12: Total annual goods exports per product category in Venezuela
Other
Mineral fuels, oils, distillation products, etc
100%
80%
60%
40%
20%
0%
83%
17%
88%
12%
93%
7%
91%
9%
2001
2005
2010
2015