Instability Constraints and Development Traps
An Empirical Analysis of Growth Cycles and Economic Volatility in Latin America

Abstract

Latin America is a region marked by a constant and endogenous pattern of volatility that halts its development process. This article consists of empirically testing its volatility characteristics in terms of their regularities, using cycle theory, comparing it to other developing and developed regions. This paper (1) uses an asymmetric band pass filter decomposition to isolate economic cycles of distinct natures on the GDP growth time series for 136 countries in the Maddison Project Database, covering the period 1950-2018. (2) We calculate each country's decomposed cycle amplitude and average duration, and (3) apply K-means clustering methods to classify the results into volatility groups, studying and understanding its features and characteristics. The main conclusions are that the majority of Latin American countries are subject to the relative dominance of the long-run economic cycles explaining the overall volatility, which could be linked to the high dependency in commodity exports, as changes in inputs caused by technology drive changes in specialization. Data shows that LAC is not the most volatile region of the world, as argued in the Structuralist literature. However, it has some common characteristics as a region in terms of the origin of its volatility.

Keywords: Macroeconomic Volatility, Economic Cycles, Time Series, Filter Decomposition, Cluster Analysis

JEL: C21, C32, 047.

Introduction

Historically, sustaining growth has been a central problem for a virtuous development strategy in many developing countries (Foster-McGregor et al., 2015). Short-term growth and high volatility in macroeconomic prices are constantly observed in developing countries, reducing their average period of stable growth. That results in an endogenous pattern of instability, reproduction of inequality, net outflows of financial capital, and halt in investments. Macroeconomic volatility creates major constraints to the process of economic development, affecting long-term decisions and imposing periodic crises (Stiglitz, 2000). This volatility impacts the economic structure, affecting long-run economic growth (Ocampo et al., 2009).

Macroeconomic volatility is not a new issue, but it is a central problem currently affecting developing countries. Despite its importance, little effort has been made to understand the consequences of the type of volatility that emerges from the productive structure, affecting the potential growth rates of economic systems. It is mostly treated in the literature as related to fluctuations in stock markets and government debt (Eichengreen & Hausmann, 2010) and not linked to structural fragility and to the productive structure, which opens a gap in the literature.

Based on the Structuralist theory (Ocampo, 2002; Taylor, 1991), we plan to address the periodical phenomenon of volatility as an element that emerges from the structural fragilities (defined as the weakness of an economy to absorb external economic shocks). We focus on understanding the aspects concerning GDP growth volatility. We empirically show distinct patterns of volatility that emerges from different countries and regions.

Many structuralist authors have claimed that the structural causes of volatility in Latin America are related to its peripheral position in the international division of labor (Ffrench-Davis, 2005; Ocampo et al., 2009; Prebisch, 1950). That position is defined by external fragilities, which are related to these countries' specialized productive structure. The fragilities result in a low resilience to external shocks, which is an important source of volatility. In this sense, authors from the Structuralist theory argue that the historical development of Latin American economies gave them an idiosyncratic aspect that makes these countries more fragile (Furtado, 1965). Nonetheless, there is a lack of empirical research to prove (or disprove) these claims. **Are Latin American economies**

different in terms of their volatility patterns than developed countries and other developing regions?

To answer the above question, we: (I) Show some stylized facts about GDP growth volatility for the available countries in our dataset. (II) Apply filtering techniques to decompose economic growth time series in distinct types of cycle and analyze the patterns that emerge from the data. (III) Build a typology using cluster analysis that groups countries by the patterns of volatility. This methodological strategy allows us to analyze which type of expansion-cycle processes are followed by each specific country.

In Section 1 we offer a brief literature review relating (1) the main theories behind the idea of economic cycles, (2) the Structuralist perspective, and (3) empirical evidence about the existence of cycles. In Section 2 we present the data used in this research. Section 3 focusses on the methodologies employed – the Christiano-Fitzgerald's Band Pass Filter, and the K-Means method of cluster analysis. In Section 4 we present evidences from the original data before applying the filtering method. Section 5 shows the results after applying the filters in the data, discussing them for the different types of cycle. Finally, Section 6 consists of a summary of the main results and the conclusion of the paper.

1. Literature Review

This section consists of a literature review about the classical and the current state of the discussion on economic cycles and volatility, raising three main aspects: (1) the relevance of cycles to economic theory. (2) How volatility is approached in the Structuralist theory. (3) Some methodological and empirical evidence on the presence of cycles in growth theory.

1.1.Cycle Theory

The study and development of cycle theories has enabled many analysts to understand the behavior of economic dynamics. Distinct theories approached the observance of economic cycles with its own explanations of the phenomenon (Korotayev & Tsirel, 2010). The relevance on the study of these cycles lays in the fact that their occurrence for some key economic variables affects countries' short- and long-run economic behavior and their development strategies. Understanding

the existence and causes of a cyclical behavior is a topic largely addressed by a whole tradition in cliometrics and cliodynamics.

Economists claimed the discovery of cyclical patterns for economic prices and growth. Since the beginning of the discipline, Juglar (1863) had shown that the presence of cycles was related to business activities. The cycles ranged from 8 to 11 years and were caused by the maturity of investments. This behavior was later developed in the Business Cycle Theory, now in the mainstream of the economic discipline. In terms of long-run cycles, Kondratiev (1935) discussed the existence of periods of volatility every 45 to 60 years in the world economy (Korotayev & Tsirel, 2010). These long cycles are still the subject of debates in terms of their identification and causes as will be further discussed. Another type of cyclical behavior, for the medium-run, was discovered by Kuznets (Kuznets, 1940), who related them to the behavior of infrastructure investments. This type of cycle was discussed by Abramovitz (1961, 1969), who empirically analyzed the recurrence of growth-crises periods for a broad range of countries at similar intervals. The very short-run cycles (Kitchin cycles) are usually related to changes in inventories (Korotayev & Tsirel, 2010) and to international portfolio flows that create short-run oscillation.

On his classical book on the business cycles, Schumpeter (1939) described how technological aspects are related to the cyclical behavior of an economy and proposed a typology for them according to their periodicity. An update of his typology (Jadevicius & Huston, 2014) leads us to identify four types of cycles: the Kitchin cycle (3 to 5 years); the Juglar cycle (8 to 11 years); the Kuznets cycle (15 to 25 years) and the Kondratiev wave (45 to 60 years). In this research we base ourselves on this typology. We use an expanded range of each cycle in order to have full time-frame coverage in the band-pass filter calibration, which ranges between 2 and 60 years. In terms of economic cycles the fluctuations are not only related to a certain specific aspect of a particular economy, but are present in every economy, each with its specific nature.

The reasons behind the existence of cycles are a topic of great debate in the economic theory. Different authors try to understand the causes of these cycles. These arguments range from (a) the accumulation of inventories (Kitchin, 1923). (b) credit behavior. (c) The maturity of investments (Besomi, 2013; Fukuda, 2009). (d) investments in infrastructure (Abramovitz, 1969; Kuznets, 1940). (e) Technology development (Perez, 2010; Schumpeter, 1939). (f) International financial

flows - it is also worth noting Fischer's Debt Deflation theory (Palley, 2008) and the Financial Instability Hypothesis (Minsky, 2016).

The Structuralist tradition is composed by theories that seek to explain the behavior of cycles in developing countries, looking for both supply and demand-side aspects of the macroeconomic system. The specificity of these theories is that they observe cycles as endogenous to the behavior of the system. In this sense, they differ from the traditional Real Business Cycle (RBC) framework that observes the main sources of cycles as exogenous (Kydland & Prescott, 1990). In this RBC's perspective, well-functioning markets results in a stable equilibrium. Therefore, fluctuations are the result of real (such as technological) shocks that lead to efficient responses from the market, not a structural characteristic feature of some particular economic systems.

1.2. Structuralism and volatility – Why are developing countries so volatile? What is the insertion of Latin America?

The concept of center-periphery is at the center of the research performed by the Economic Commission of Latin America and the Caribbean (ECLAC), historically linked to the Latin American Structuralist tradition. Latin America has always been seen as a region with a specific economic dynamic compared to other regions, since the works of Prebisch (1950), Furtado (1983), Sunkel (1972) and Fajnzylber (1990), and more recently with Caldentey & Vernengo, (2010); Cimoli, Porcile, & Rovira (2010); Botta (2010) and Ocampo (2002). Latin America is a region with a peculiar economic dynamic caused by its peripheral position in the international division of labor. Taylor (1991) models and summarizes the effects of the center-periphery dynamic to the constitution of a cyclical dynamic. His argument is that steep cycles are caused by the idiosyncratic economic and institutional historical development of the region. This specificity has impacts on the growth dynamic in the short- and long-run.

Prebisch (1950) developed a theory explaining the emergence of a center-peripheral (or core-peripheral) dynamic in the international system. The position of each country in the system depends on which types of products a country produces (depending on the product's technology intensity), which defines the country's insertion in the international division of labor. The center (the North, central/core countries of the system) is the locus of technological change, producing new advanced products, with high technology intensiveness and high income elasticity of demand.

On the other hand, the periphery (the South) inserts itself in the international dynamic by producing and exporting raw goods and low technologic intensive products. This theory marks the beginning of the Latin American Structuralist tradition. Bielchowsky & Torres (2018) track all the improvements in the Structuralist theory during the 70 years of the economic thought at ECLAC.

In this sense, an uneven distribution of productive and technological capabilities that are reproduced endogenously over time emerges. This leads to the constitution of institutional differences in which the periphery has a distinct economic dynamic in its long run development when compared to the center. In the center-periphery framework, the underdevelopment of the productive structure is seen as the main factor generating an increasing fragility into the developing countries (periphery). Following the long-run perspective, the theory argues for the presence of a long term decline of the terms of trade (Prebisch-Singer Hypothesis) that creates barriers to economic development.

Moving to the Post-Keynesian tradition, Thirlwall (1979, 2012) developed the Balance of Payments constrained model (BPCM). In this theory, countries are constrained in the long run by the income elasticity of demand from imports and exports of the products they trade. An increase in the growth rate should be compatible with the stability of the external sector, which depends on the productive structure, and defines the fragility pattern. More recently, Cimoli & Porcile (2014) linked external constraints to the technological capabilities of peripheral countries, merging the Post-Keynesian, the Structuralist and the Evolutionary perspectives.

The lack of dynamism in the productive structure of developing countries and the aforementioned fragility result in a specific pattern of specialization in international trade. Developing countries concentrate their activities in low technological intensive products and highly standardized goods (commodities). This creates an additional issue to the Terms of Trade decline: the specialization in commodities results in higher volatility. Relevant works as Ziesemer (2010) observed the trends in these prices, measuring Terms of Trade. Commodity prices in international markets are more volatile than high-technology manufactured goods. This volatility affects the Balance of Payments conditions of developing countries not only in the long-run, as discussed by Thirlwall (2012) but also in the short-run. This results constraints the process of economic development. High volatility in developing countries may have its roots based on the increased fragility created by a specialized

and low dynamic productive structure (Hausmann & Gavin, 2011). This is the result of a specific peripheral insertion in the international division of labor.

The argument above defined can be explained through some specific channels. Higher volatility in international prices generates a mismatch in the Balance of Payments (exports, imports and capital flows). It affects economic growth through the following mechanisms:

(1) In a Keynesian perspective, it increases uncertainty, affecting economic agents' decisions in the short- and long-run. In this sense, investment projects with high capital immobilization are perceived as less profitable. It results in reduced marginal capital efficiency, as described by Keynes (1936). This results in a reduction in long-run projects, with smaller investment and less aggregate demand (reducing then economic growth).
(2) Instability in the external account reduces the possibilities to import capital goods. This is particularly relevant for developing countries in which a virtuous catching-up strategy demands access to capital goods (machinery) situated in the technologic frontier (Stiglitz, 2000).
(3) Volatility in external prices affects the real exchange rate of a country. Increasing oscillation in the exchange rate raises uncertainty, which may generate higher arbitration and speculation possibilities, but do not positively improve development possibilities. (Andrade & Prates, 2013).
(4) Uncertainty affects not only investment but also consumption. Real wages are very sensitive to changes in the exchange rate. The price channel in an uncertain environment reduces consumption and aggregate demand. (Gabriel, Jayme, & Oreiro, 2016).
(5) Increased uncertainty in investments and in the exchange rate affects agents' behavior through higher price volatility. Agents defend themselves by protecting their Mark-up (Steindl, 1979), increasing prices. In this sense, volatility is also seen as an inflationary mechanism.
(6) Reduction in investments, especially in the manufacturing sector, is also linked to a reduction in productivity. Following the classical Kaldor-Verdoorn (Kaldor, 1975) discussion, debated by McCombie & Spreafico (2016), investment and growth boost not only the capital stock but as well as its quality, generating economies of scale and higher

learning opportunities. In this sense, this is another mechanism that reinforces underdevelopment, through the specialization in low technological intensive activities.

In the mainstream economics, relevant economists argue that fragility is related to a higher resilience to shocks. This especially for external shocks that comes from abrupt price changes (Blanchard & Gali, 2007) and also from institutional issues (Acemoglu & Robinson, 2012). Countries with less diversified exports suffer mostly from external price volatility. Volatility in low technology intensive goods is historically much higher than for high technology intensive manufacturing goods. This boosts fragility in developing countries.

We observe that most of the literature usually focuses on the short- and medium-term aspects of development. We would like to also focus on the long-run element that, as we see from our empirical analysis, may be central to explain important part of the oscillatory mechanisms behind Latin America.

Further to the traditional analysis to explain cycles, we argue that another important source of explanation for the volatility dynamics, especially for developing economies, resides in the changes in input composition in a new emerging technology paradigm (Bollen & Appold, 1993; Bunker, 1985; Brady et al, 2011). This relates the idea of long-waves with the idea of dependence on natural resources. An interesting piece of evidence comes from the long historical analysis of Latin America developed by Bertola and Ocampo (2012). The authors observe the central role that international dynamics have had in the composition of the historical development, and the reorganization of economic (natural resource) activities has played a historical central role on defining patterns of development, volatility and crises. In a further work, Bulmer-Thomas (2013) associates the dependence to input integration to the colonial legacy of Latin American countries, in the same line of argument as Furtado (1959), when discussing the constitution of the economic formation of Brazil. Those contributions focus on the structural reasons why developing countries, in special in Latin America, show a permanent and strong pattern of boom-bust dynamics.

The import-export pattern is a central element in this discussion, either related to the short-run fluctuation, or to long-run waves. As discussed above, there is a whole tradition of literature that searched for the sources of volatility in the short- and long-run, but very few that have tried to

measure and explain them. In this sense, this study aims to measure distinct aspect of volatility using economic cycle theories.

1.3.Methodologies used for cycle analysis and empirical evidence for economic cycles

Distinct methodologies in the field of time series have been developed to extract cycles from the original GDP growth time series data. There is a whole tradition in fields such as physics (oscillatory dynamics) in which frequencies as are essential to understand the behavior of certain volatile phenomena. That is similar in economics, in which we can observe empirically the existence of a cyclical behavior in many economic variables.

In terms of the main methodologies used to observe empirically extract the existence of cycles, we cite three: the **Spectral Analysis** (Bossier & Huge, 1981; Korotayev & Tsirel, 2010; Van Ewijk, 1981), the **Filter design approach** (Kriegel, Kröger, & Zimek, 2009; Metz & Stier, 1992), and the **Wavelet analysis** (Gallegati, Gallegati, Ramsey, & Semmler, 2017). These methodologies focus on analyzing the distinct frequencies that emerge from real time series.

Spectral analysis applies Fourier transformations to time series and observes its spectrum in different frequencies. Using power accumulated frequencies it is then possible to identify the existence of periodic oscillations in the time series. This method initially removes the trend from the series as a requirement of stationarity. Fourier transformations uses combinations of sines and cosines to represent a non-local function – so changes affect the whole function. This restriction allows the use of windowed transformation (use of bands). The wavelet analysis is analogous to the Spectral analysis but it uses a finite domain.

It is important to mention the literature on **Structural Breaks**, aimed at capturing shifts in growth regimes, based on Pritchett (2000) and Bluhm et al (2016). In this literature, the time series is not seen as a cyclical component around one stable trend, as the breaks change the slope of the trend on time – as seen in the trend-cycle decomposition of Perron and Wada (2016). This could help us understand further changes development strategies. Because of the focus on the historical cyclical components and the need for a higher number of observations, we opt to study the filter decomposition with structural breaks in a later development of the research. The high number of breaks reduces the number of observations used to observe the overall cycles, which potentially

reduces the accuracy of the cyclical results. We opt to do not use structural breaks in this analysis, leaving for a future comparison between the results we have in this analysis with the one using breaks.

This paper uses a **Filter Design approach**, which is a development of the Spectral Analysis by defining a specific band filter. There are distinct possible filters, as described and enumerated by Pollock (2013). One commonly used filter is the low pass filter, also known as the Hodrick-Prescott's filter (Hodrick & Prescott, 1997). Despite being one of the most used methods, this methodology was heavily criticized by Hamilton (2017) for its strong bias. Another important methodology is the Band-Pass (BP) filter, in which we observe the symmetric (Baxter-King) and asymmetric (Christiano-Fitzgerald) versions. This latter method is used to observe long waves and growth cycles. The procedure filters coefficients to isolate specific frequencies looking for the ideal filter band. We use the asymmetric BP filter of Christiano & Fitzgerald (2003), which was also used by Erten & Ocampo (2013) to identify commodity cycles.

We observe some empirical evidences on the existence of regular patterns of volatility (cycles) in GDP growth. There are many studies which test the existence of cycles at the global level. Korotayev et Tsirel (2010), using spectral analysis, claims that it is highly likely that Kitchin, Juglar and Kondratiev cycles exist at a global level. Kuznets' cycles are the third harmonic of the Kondratiev cycle, detected for the world level for each 17 years. In another relevant work, Diebol & Doliger (2008) identified Kuznets swing for GDP growth.

Despite the fact that these works pointed to the existence of cyclical behavior in the economic systems, it is important to point out that the results found in the literature are still open to debate, with contradictory results, which are sensitive to the methodology applied. There are still disagreements about the empirical existence of short and long waves (Bosserelle, 2015). This debate is not a topic we focus in this work, and it does not aim to question the results of this research, but it is worthy to mention that the existence of GDP growth regular cycles is yet a controversial topic.

2. Data

This paper uses the Maddison Project Database (MPD), updated with data from the World Bank Database (WBD)'s World Development Indicators (WDI). The MPD continues the works of Maddison (2001) and Maddison (2003). The database was most recently updated by Bolt and Van Zanden (2014). These authors calculated the long-run historical data of per capita GDP for a large number of countries and regions. The MPD has data since ancient times until 2010. We select from the MPD the period from 1950 to 2010 and update for 2010 to 2018 using the growth rates of per capita GDP from the World Bank Database (WBD). The updating procedure involved removing the population growth from the MPD in order to find GDP growth data (not per-capita). Because of data problems, the former soviet republics and former Yugoslavia were excluded from the database.

The treated database consists of GDP growth data[1] from 1951 to 2018 for 136 countries. For each country's time series, the Christiano and Fitzgerald (2003)'s Band Pass Filter was applied and the original data was decomposed in distinct cycles. After we extend the cycle data, these cycles cover very-short-run 2-8 years (Kitchin Cycle), short-run 8-15 years (Juglar cycle), medium-run 15-30 years (Kuznets cycle), and long-run 30-60 years (Kondratiev cycle) period. The results were grouped in clusters using the *K-means* methodology, dividing the instability patterns in different groups.

GDP growth data is used in this research for two main reasons: (1) There is a requirement of stationarity in order to apply the filtering methodology. (2) GDP growth focuses only on the dynamic aspect of volatility. The focus is not to observe how the stock of richness (GDP level) affects volatility, but how the flow (growth) is related to an oscillatory pattern.

3. Methodology

3.1.Band-Pass filter

Erten and Ocampo (2013) use the Asymmetric Band-Pass (ABP) filter to identify cycles for commodity prices. The same method is used here to filter the GDP growth time series. The ABP

[1] Growth data removes the problem of non-stationarity of the time series, which is a fundamental requisit to run the filter decomposition analysis.

filter allows a time-series to be decomposed into different frequency components, which are then used to identify the cycles in the different time series. This approach is combined with the identification of medium-run cycles, following Comin and Gertler (2003) and Drehmann et al. (2012). The adopted approach splits the per capita GDP growth (y) into five components: (i) a long-run cycle (y^{LR}) – with periodicities of 30 to 60 years, corresponding to the Kondratiev cycle; (ii) a medium-run component (y^{MR}) – with periodicities between 15 and 30 years corresponding to the Kuznets cycle; (iii) a short-run cycle (y^{SR}) – with periodicities between 8 and 15 years corresponding to the Juglar cycle; (iv) a very short-run cyclical component (y^{SSR}) – with periodicities less than 8 years corresponding to the Kitchin cycle; and a residual component (e), that will be later discussed as the structural component.

$$y_t \equiv y^{LR}{}_t + y^{MR}{}_t + y^{SR}{}_t + y^{\mathrm{SSR}} + e \qquad (1)$$

The average length of a super-cycle, as reported by Erten and Ocampo (2013) in their analysis, is 35.7 years, with a minimum of 24 years and just three (out of 18) super-cycles being more than 40 years in length. The Kuznets cycles is considered as having a periodicity between 15 and 30 years. The long-run trend therefore has a periodicity greater than 30 years, until 60 years, following the Kondratiev waves. A medium-run cycle Juglar wave is then defined as having a periodicity between 8 and 15 years, with the short term cyclical Kitchin cycle trend having a periodicity of less than 8 years.

The idea behind following this procedure is to find different types of cycle from the original time series, and apply the methodology for all countries we have data available. We then group countries with similar cyclical characteristics (for instance, higher oscillations in short-run cycles) in clusters. Finally, we study the characteristics of each group category. The asymmetric BP filter is useful in this sense, as it allow us to define bands for the periods in which we would like to extract the cycles.. After defining the categories, that would allow us to check if there is anything similar in terms of Latin American countries and what are the reasons behind those similarities.

Table 1. Cycles in economic theory and their respective time periods

Cycle Name	Main origin	Period	Possible cause as discussed in the theory
Kitchin	Market Cycle/Financial Flows	0y-8y	Inventories (Consumption)/Portfolio Decisions
Juglar	Business Investment Cycle	8y-15y	Medium-run Investments
Kuznets	Structural Investment Cycle	15y-30y	Long-run Investments (Infra-Structure)
Kondratiev	Technological Cycle	30y-60y	Technological paradigm change
Residual	Trend	-	Structural element, Human capital

Initially, we use the band-pass filter to remove the high frequency Kitchin cycle from the original time series. Then we readjust the band to extract the Juglar cycle from the residuals of the Kitchin cycle. From the residuals of the Juglar cycle, we extract the Kuznets cycle. The same procedure is used to extract the Kondratiev cycle from the residuals of the Kuznets cycle. The resulting data consists in a residual, which is linked to long-run economic growth. The sum of the five components results in the original time series. The different patterns of cyclicality extracted for different countries can be grouped using cluster analysis.

3.2.Cluster Analysis

Cluster Analysis consists of organizing elements in similar groups according to some selected attributes. There is no standard way of clustering, but many distinct methodologies are used to group elements with similar aspects. In this paper, selected countries are divided into distinct groups based on their cycle standard deviations. The methodology used in this article is the *K-Means*, a method of vector quantization that partition observations in clusters, partitioning the data space into regions.

The *K-means* is a method that minimizes distance in a graph in order to group elements with similar (selected) characteristics. We have to define the number of groups (clusters) we would like to find. The method selects which observations are similar according to their distance. The *K-means* can use many variables, *i.e.* we could choose (for instance) eight interest characteristics to group people with similar interests from a selected population.

Technically, the *K-Means* is a randomized method that divides the data into k distinct clusters. The n objects are grouped according to the nearest mean to the clusters. The optimal number of

clusters is not known and must be exogenously defined (however, there are tests available to help us define that). The objective of this methodology is to minimize intra-cluster variance (the squared error function). This is done through the definition of an objective function j that calculates a distance function that must be then minimized. The objective function can be written as:

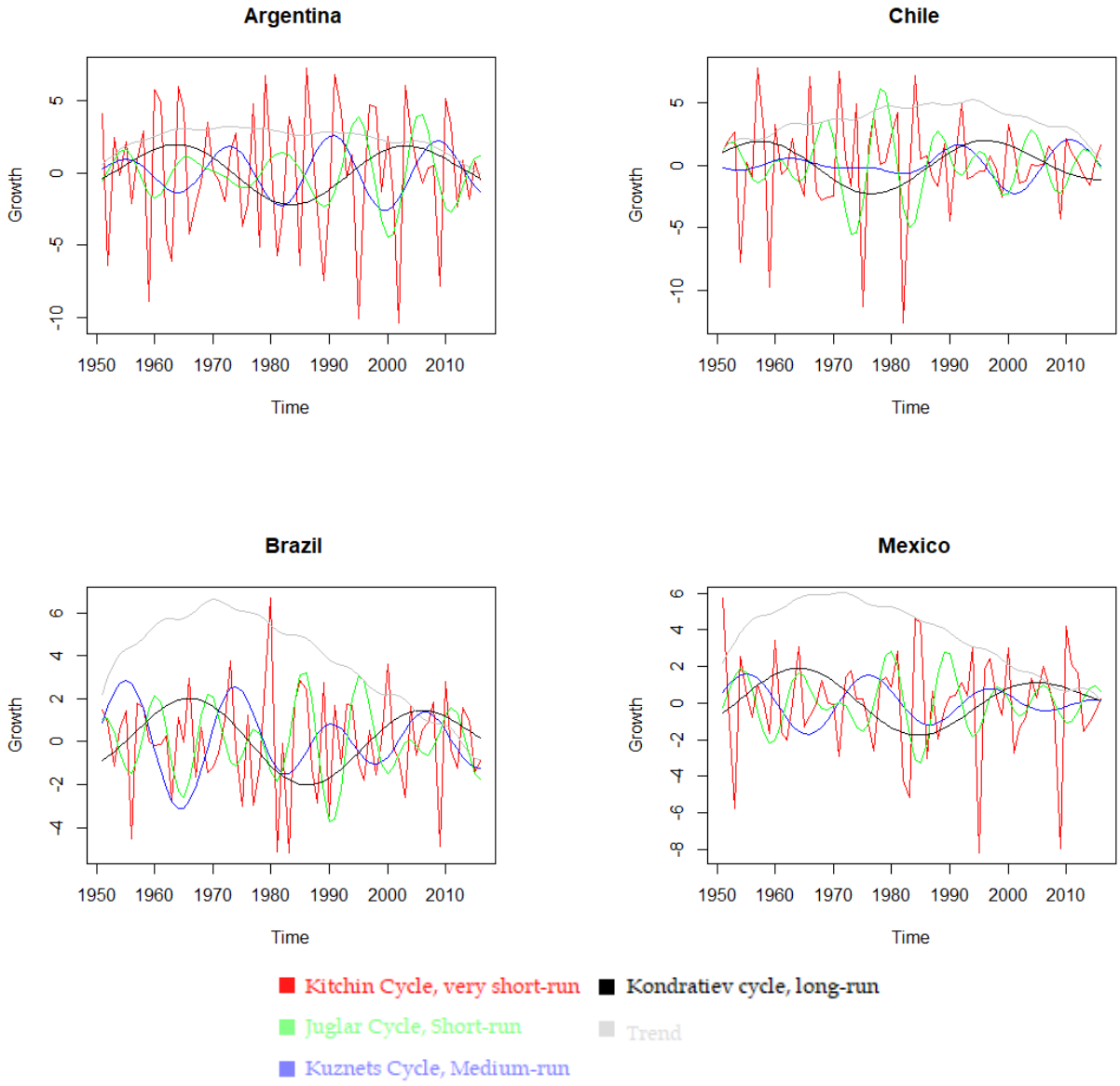
$$j = \sum_{j=1}^{k} \sum_{i=1}^{n} \left\| x_i^{(j)} - c_j \right\|^2 \quad (3)$$

Where x_i represents the case i and c_j represents the centroid for cluster j. The method firstly computes the clusters into the exogenously given k groups. Then it randomly selects cluster centers and assigns observations to clusters, following the distance function, and calculates the mean of each object. This method repeats itself until it minimizes the distances. This method results in groups of clusters in which similar countries are divided from the non-similar ones in terms of the selected variables.

4. Analysis by type of cycle

In order to illustrate the methodology and the results obtained, we present the filtering methodology applied to some selected Latin American and Caribbean (LAC) country data below. In Figure 1 we can observe the four types of cycle filtered from the original GDP growth time series for selected countries. Each cycle has a detailed aspect and can be used to identify some historical turns in those countries' economies. This extraction shows the different degrees of stable volatility. An interesting aspect is the residual non-cyclical component. It shows the long-run aspects, which could be related to the countries' economic structures.

Figure 1. Volatility, cycles and residual in selected LAC countries



Source: Author's own. Data: Maddison Project Database

Figure 1 shows the decomposition of growth time series into cycles and trend for Argentina, Brazil, Chile and Mexico. The scales are different in each graph, which represents the difference in terms of volatility patterns for each country. The short-run Kitchin cycles, in red, have a higher frequency and variance. This cycle is marked by high amplitude and small duration. The presence of major economic crisis can be easily seen in the market Kitchin cycle. This is the case of the 1980's in many Latin Americas countries, as the example of the Mexican peso crisis of 1982.

Each cycle can be linked to a major element, following the literature. The short-run Juglar cycles follows the investment cycles for each economy while the Kuznets cycle is related to longer investment cycles related to infrastructure. The Kondratiev cycle is approached by the theory of technological change (Perez, 2010). We can also observe the presence of the residual component. This latter does not follow a cyclical behavior but a trend. This residual can be used to explain changes in the productive structure – such as the reduction on the weight of the industrial sector in a specialization pattern that happened since the end of the 1970's in LAC (matter for a future work)
.

5. Results of the cluster analysis applied on Cycles

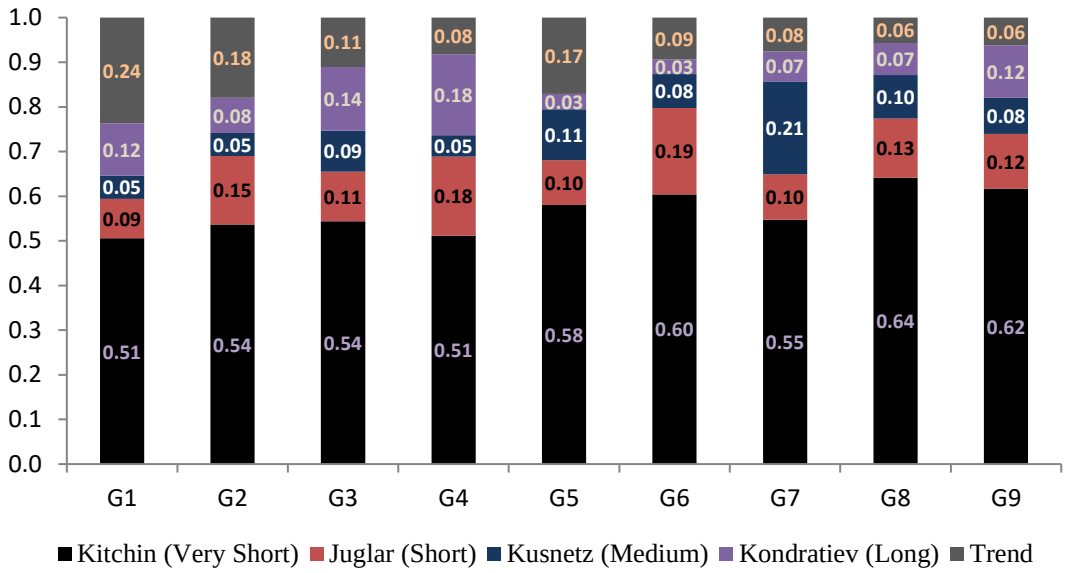
The cluster analysis is applied on the different cycle components of the time series. Countries are grouped by their volatility patterns. We run the clustering algorithm 1000 times, because of the randomized aspect of the K-mean, which resulted in Monte-Carlo frequencies to define the groups. The cluster analysis considered the Short-, Medium- and Long- run cycles as inputs. Isolating the very-short-run cycles was a decision based on the fact that this type of cycles capture all the noise related to not directly related economic aspects (mostly political). The number of cluster was selected using cluster optimization criteria, this defined 9 groups.

Table 2. Average growth GDP variance per cluster group

G1	7.90	G4	28.76	G7	33.09
G2	15.93	G5	22.17	G8	69.97
G3	21.84	G6	26.65	G9	181.13

Source: Author's own and Maddison Project Database

Figure 2. Share of each cycle variance on total variance (average per cluster group)



Source: Author's own and Maddison Project Database

Group 1 (G1) represents the less volatile countries, in which most developed countries are included. This group is marked by low variance, high relative importance of the trend component and long run cycles explaining overall volatility. G1 has a smaller relative importance of the very-short- and short-run volatility. Group 2 (G2) has similar characteristics to G1, but a larger variance and higher relative relevance of the very short- and short-run volatilities. It is still composed by a mix of some developed countries with some emerging economies in Africa that show a similar volatility pattern.

Between Groups 3 and 6 (G3 - G6) the overall variance is almost equal, as seen in Table 2. The differences are related to the relative importance of each cycle to explain volatility. In G3 the Kondratiev cycles are more important relatively and the trend, the short- and very-short cycles are below the average on explaining volatility. In G4 both the Juglar and the Kondratiev cycles are relatively more relevant, while G5 shows a pattern with higher relative importance of the trend, the medium-run and the very-short-run cycles. Finally, for G6 we see a very high relevance of the Kitchin and Juglar cycles (group that presents higher share of short-run oscillations explaining the overall volatility).

G7 shows an average variance a little higher than the first six groups and it is marked by the higher presence of the medium-run cycles. Finally, Groups 8 and 9 (G8 - G9) show a much higher

variation in their overall volatility, both with a higher relative relevance of the very-short run cycles and small importance of the long-run cycle and the long-run trend.

Table 3. Summary of the relative characteristics per cluster group

	Kitchin	Juglar	Kuznets	Kondratiev	Trend
G1	--	--	-	+	++
G2	-	+	-	-	+
G3	-	-	0	++	-
G4	--	++	-	++	-
G5	+	-	+	--	+
G6	+	++	-	--	-
G7	-	-	++	-	-
G8	++	0	+	-	-
G9	++	-	-	+	-

-	-1SD< X <0
--	X < -1SD
+	0< X <1SD
++	X > 1SD

X represents the differences in volatility of each cycle component relative to the average share, by group. The data is the same as the one used in Figure 2.
(++) Relatively more important by more than 1 Standard Deviation; (+) Relatively more important by until 1 SD;
(--) Relatively less important by more than 1 Standard Deviation; (-) less relatively important by until 1 SD;

Table 3 shows the relative comparison between different groups by its cycle characteristics. Each group is compared with the average share, showing which cycle is relatively the most relevant to explain differences between the clusters. Each group shows a different behavior which poses some questions: Why is a country more affected by the long-run cycles? What determines that? Is it related to the structural conditions of the economies? Is it a matter of fragility?

Table 4 shows which countries are grouped in each of the clusters defined by the K-means methodology. In this table we observe some regional features. Developed countries are entirely situated in Groups 1 and 2. In these two first groups there are also the presence of many low and middle-income countries in Africa and Asia such as Benin, Bangladesh, Bahrain, Burkina Faso, India, Laos, etc. Most central Asian countries are in G8 and G9. Latin America finds itself between G2-G7 concentrated mostly in G3.

The measure is related to growth volatility, so a catch-up process right after WWII followed by long period of stagnation, as is the case of Japan, is measured in a certain specific way (Heteroscedasticity). On the other hand, countries with a profound stagnation are not volatile, which is the case of some of the developing countries observed in G1 and G2.

Table 4. Cluster Analysis applied on the Standard Deviation of the Juglar, Kuznets and Kondratiev cycles. LAC countries highlighted.

GROUP 1 (G1)		GROUP 2 (G2)	GROUP 3 (G3)		GROUP 4 (G4)	GROUP 5 (G5)	GROUP 6 (G6)	GROUP 7 (G7)	GROUP 8 (G8)	GROUP 9 (G9)
AUS	LAO	BFA	ARG	MNG	ALB	BDI	CAF	CMR	GAB	AGO
AUT	LKA	CHE	BGR	MRT	POL	ECU	CHL	COG	IRN	GNQ
BEL	MAR	COL	BOL	NAM	ROU	EGY	CHN	COM	KHM	IRQ
BEN	NLD	ESP	BRA	PAN	PER	HKG	COD	CPV	LBN	KWT
BGD	NOR	FIN	BWA	PHL	CUB	IDN	LSO	JOR	NGA	LBY
BHR	NPL	GNB	CIV	PRY	NIC	KOR	MUS	SDN	PRK	OMN
CAN	PAK	HND	CRI	SLV	AFG	LBR	NER	TTO	RWA	QAT
DEU	PRI	IRL	DOM	STP	SAU	MWI	SYC	VEN	SLE	
DNK	SEN	JPN	DZA	TZA	DJI	MYS	THA	YEM	SOM	
FRA	SWE	KEN	GHA	UGA	ETH	SGP	URY		SYR	
GIN	UK	MDG	GMB	ZMB	MOZ	TUR	ZWE		TCD	
IND	USA	MEX	GRC		SWZ				UAE	
ITA	ZAF	MLI	GTM		TGO					
		NZL	HTI							
		PRT	HUN							
		TUN	ISR							
		TWN	JAM							
		VNM	MMR							

Source: Author's own and Maddison Project Database

In Table 4, we see that the Latin American countries are colored in gray. It is possible to observe that half of them concentrate in G3 (11 countries out of 23). The continent is represented in every group with the exception of the two most volatile (G8 and G9). Puerto Rico follows a similar pattern of that of the developed countries. Colombia, Mexico and Honduras have a volatility pattern also more closely similar to that of G2 developed countries. Chile and Uruguay differ from the majority of Latin American countries. This is not caused by differences of their overall volatility, but because in these countries we can observe that the very-short- and the short-run cycles are very relevant to explain the volatility. Peru, Cuba and Nicaragua are in G4. Ecuador is in G5. Venezuela and Trinidad & Tobago are in a more volatile group (G7). In general, however, we see that there are two main groups for LAC countries, the ones in which Short-Run (Juglar)

cycles relatively dominate (G2, G4 and G6) and the majority in which Long-Run Cycles relatively dominate (G3 and G4). These two groups will be respectively called Juglar-dominated and Kondratiev-dominated.

We expect countries in the best situation to be in G1, followed by G2 – the less volatile. The groups G8 and G9 have the countries that suffer the most about volatility. Nonetheless, between G3 and G7 there is no value judgement about which countries are in a "better condition". These groups just define countries in different situation, related to many aspects, such as their integration in the international environment, institutions, their economic structures, among other possible explanations.

Table 5. Latin American countries by cycle dominance

Juglar-dominated	Kondratiev-dominated		Juglar and Kondratiev	Others
CHL	ARG	HTI	CUB	ECU
COL	BOL	JAM	NIC	PRI
HND	BRA	PAN	PER	TTO
MEX	CRI	PRY		VEN
URY	DOM	SLV		
	GTM			

Source: Author's own and Maddison Project Database

Some results for the behavior of economic cycles in Latin America:

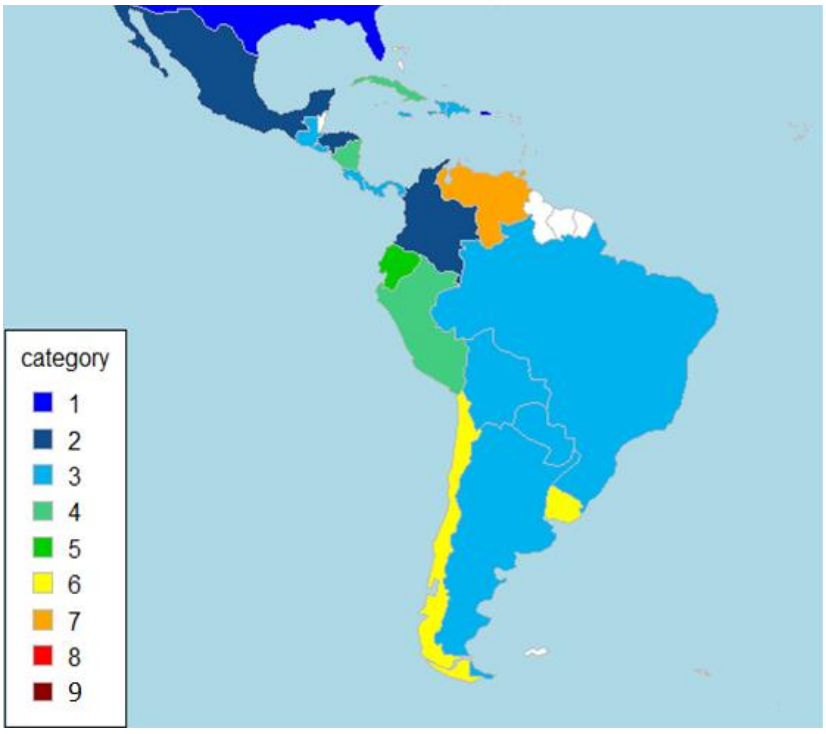
(1) Half of LAC countries are in Group 3, which is characterized by average standard deviation (neither small nor big compared to the world average). In G3 (and G4) there is a high relative importance of the long-run cycles (Kondratiev) despite a smaller relevance of the long-run trend.

(2) Latin American countries are not totally homogeneous as a group in terms of their volatility patterns. This poses a challenge when generalizing results to the whole continent. In this sense, finding a general theory to explain the causes of overall volatility in Latin American countries must take into account these specificities and discuss the causes of these differences. It is still relevant to highlight that we see one group (G3) that characterizes most of the Latin American countries.

(3) On one hand, LAC countries, at lest in terms of volatility, differ clearly from the pattern observed in developed countries. On the other hand, it shows a similar pattern to some other developing regions, especially with central Asia and parts of Sub-Saharian Africa.
(4) Considering only the big countries in the region, Mexico and Colombia have a different pattern than Brazil and Argentina, which are also different than Chile.

It is relevant to discuss the meaning of the Kondratiev-dominance. What does it mean to have a long-run cycle so relatively important in explaining growth volatility compared to the others?

Figure 3. Map of volatility patterns in Latin America by cluster group.



Legend: cluster group categories colors from 1 to 9 (top to bottom)
Source: Author's own and Maddison Project Database

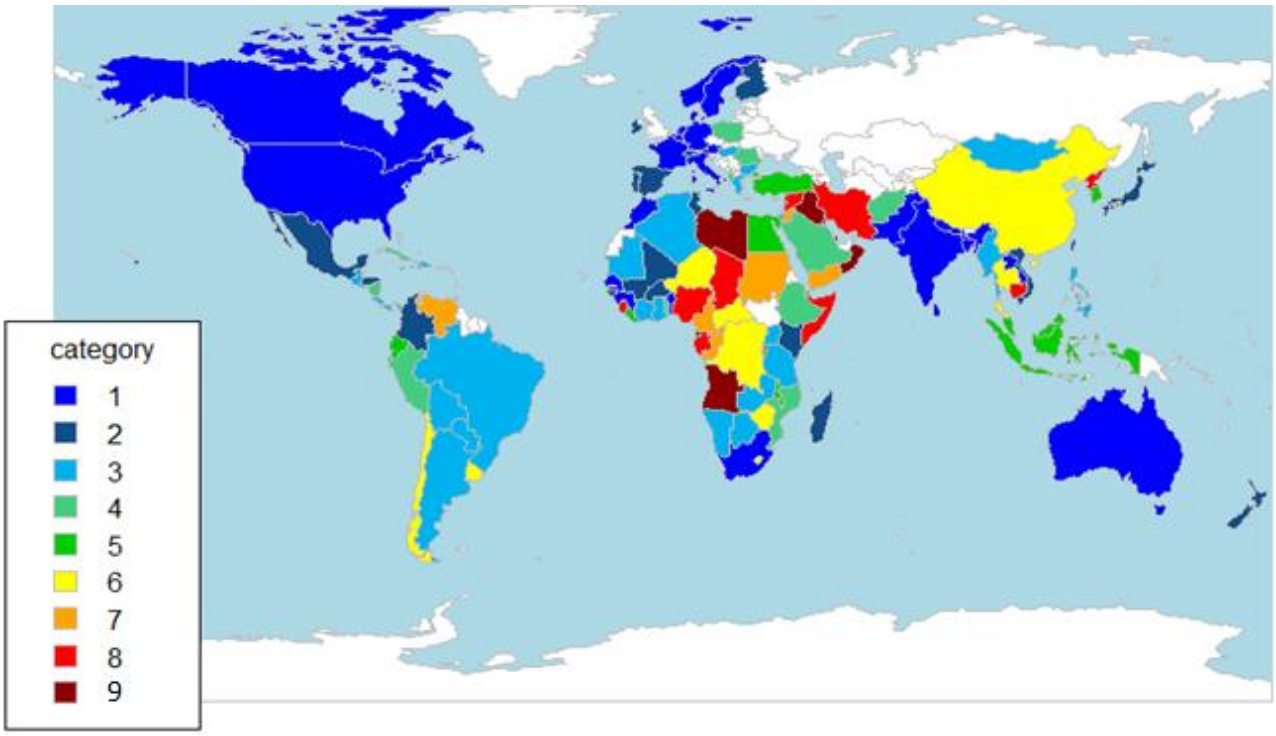
Before investigating the relationship between volatility and development, as it is the intent of the research agenda associated to this paper, it is relevant to observe the aspects that lead to similar patterns in the world level. That occurs for groups of countries with many distinct volatility patterns. From the observance of the cluster analysis we may find the following results:

(1) Developed countries are the less volatile. They find themselves in G1 and G2. Oil rich countries are the more volatile in the world, being in G8 and G9.

(2) In addition to the more developed countries, there are many low- and medium-income countries in G1 and G2. This aspect has to be further investigated, as the sources of their low volatility may not be related to their structural conditions.

(3) Developing countries with a similar overall volatility have very distinct patterns when examining the sources of this volatility. For some countries the volatility comes from shorter-run cycles, while, for others, it comes from longer-run cycles and the trend.

Figure 4. Map of volatility patterns by cluster group, World Level. Groups 1 to 9.



Legend: cluster group categories from 1 to 9 (top to bottom)
Source: Author's own calculations and Maddison Project Database

5.1.Kondratiev-dominance: the importance of the long-run cycles

The evidence in this research shows that most of the Latin American countries are in a situation in which the Kondratiev long-run cycle is relatively dominant compared to the other groups defined in the previous session. The Kondratiev long-run growth can be, as already mentioned, associated to technological changes in international patterns (Perez, 2010).

Latin America has a high dependency on commodity exports. A possible explanation for the dominance of long-run cycles is that changes in technological paradigm result in long-run volatility in commodity prices. This may be caused by a reduction in the dependency of the inputs of the previous industrial paradigm, with effects on the exchange rate. The emergence of a new paradigm requires new inputs. Because of that, LA economies adjust to the cycle and change the products in which they will specialize if they have the possibility to do so. In Brazil, as an example, there have been historically distinct commodity cycles: the Rubber cycle, the Sugar Cane cycle, the Gold cycle, the Oil cycle. Each cycle was directly related to the industrial paradigm of the period.

The explanation on input volatility has had a strong resonance with the idea of dependence/world-systems (Brady et al., 2011). Schwartzman (1995) and Bollen and Appold (1993) pioneered the debate that trade dependence hurt diversification. This idea can be related to the concept of natural resource curse (Collier, 2007), also mentioned by the New-developmentalist school (Bresser-Pereira, 2008, 2013). As discussed by Brady et al (2011): "In an argument anticipated by Bunker (1985), the dependence on raw material exports fails to produce economic linkages into manufacturing, leads to cycles that hinder diversification, forcing government subsidization of distant outposts of extraction disconnected from urban populations and economic centers" (p.188).

The further specialization pattern fragilizes the structure, as there is a strong dependency, in terms of external sector dynamics, on the price of a few commodities. When, for a certain reason, such as a reduction in world demand caused by changes in production patterns, the demand for those commodities are reduced, then those suffer a strong price reduction, with direct impact on the domestic economy of the exporter country. That is amplified even further by the financial dynamics, that reacts pro-cyclically to the economic crisis (De Paula et al, 2020). This problem on external constraints has had a lot of attention in the short and medium-run dynamics. However, we want to argue that there is long-run dynamics also associated with the beforementioned behavior (Marañon & Kumal, 2019), as waves of industrial and technological development at world level change the input requirements, with a very strong historical effect on developing economies. In that way, we can add another element to explain the long-run dynamics, that is empirically and historically discussed by Bertola and Ocampo (2012).

Most developing countries have a high dependency on the production and exports of commodities, Latin America included. This region, though, seems to be integrated into the world economy in a different way. If we observe cycle synchronization (from the data observed in this research), we see that Latin America runs actually very coherently with the international pattern. This coherence is not that strong in Africa and Asia. The economic space of Latin America seems strongly linked with the developed countries, especially with regard to long-run changes. The short-run volatility is not as big as expected, but there is an element of dependency that generates high volatility in the long run.

A peripheral (strong) integration is the key to answer the specificity of Latin America. There is a low capacity for absorbing and generating technology, and a structure that favors specialization in low-technology intensive sectors. Finally, economic history (Ffrench-Davis & Griffith-Jones, 1995) suggests that the debt crisis in the 1980s, changes in the openness of capital account in the 1990s, and the rise of China in the 2000s (Stiglitz et al. 2016), had a very strong impact on the volatility of growth and export of Latin America. That affects almost immediately the short-run volatility, and the medium-run pattern. For the long-run, it is still necessary a longer data to see the impacts of those changes in the Kondratiev waves. However, we can argue that changes with (1) the new industrial paradigm (industry 4.0 and the green revolution), and the reallocation of production to new areas, we are at a tipping point to the emergence of a new production system, with new requirements in terms of inputs. Erten and Ocampo (2013) indicates those changes by analyzing the long-run cycle of commodity process using a similar empirical strategy as the one developed in this paper. They see that commodity prices were close to the tipping point in terms of their long-run dynamics. And since we have observed since 2014 a decline in some important commodity prices (a movement that started before the COVID pandemic), that may indicate the decline of the last wave, and the beginning of a new one, with strong impacts for Latin America.

5.2.Juglar-dominance: the importance of the short-run cycles

We argue based on (Korotayev & Tsirel, 2010) that the Juglar cycles are related in the literature to investment cycles. A high volatility in this type of cycle is related to the fact that investments are done in blocks (immobilize a lot of capital). The uncertainty intrinsic in the economic systems is higher in developing countries. This uncertainty results in investments being made in periods in

which there is a positive condition in the economic environment, commonly related to moments that coincide with commodity cycles. These cycles start maturing while the economic conditions of the system change. There is a period in which the investments are reduced, and that coincides with a worsening of the environmental economic conditions, increasing uncertainty and raising the (opportunity) costs to make new investments. This investment reduction results in a decline of the cycle.

This cyclical component is then associated with the commodity cycles in developing countries. The dependence of the productive structure on the imports and exports of a few low-technology intensive commodity goods is a main component of the uncertainty. The Balance of Payments Constrained model (Thirlwall, 2012) states that investment in these economies tend to be endogenous to the foreign sector situation, which is also related to the structural conditions of the economy (Cimoli et al., 2010). The unstable effects of export and import prices as well as the price and income elasticity of imports and exports of traded goods result in the oscillation captured by the Juglar Cycles.

This is the case of countries such as Chile, Mexico and Colombia, in which the dependence of mining activities have been the main economic activity in terms of exports. Investments are responsive to price changes in the mining products these countries export, occurring when prices sustain themselves in high level for a certain period of time (Bertola & Ocampo, 2012).

6. Conclusion

Macroeconomic volatility is a thermometer that measures the resilience that countries suffer from economic, political and institutional shocks. This paper proposed itself to empirically study volatility at the country level. The specificity of this paper resides in the effort to identify different types of regularities on GDP growth time series. The filter analysis extracted the regularities from the original series into different components (cycles). A cluster analysis applied on the cycle components allowed the identification of countries with similar volatility patterns.

The above procedure allowed the constitution of country groups that helped answering the research question initially defined in this research: **Are Latin American economies different in terms of**

their volatility patterns than developed countries and other developing regions? The answer to this question is not simple and should take into account the following consideration:

LAC is at its most characterized by an average GDP growth standard deviation (compared to all 136 countries observed in the analysis). Half of its countries are marked by a high relative importance of the long-run cycles, despite a smaller relevance of the long-run trend (and of the short-run cycle). LAC countries are not homogeneous in terms of their volatility patterns but follow a similar characteristic, being the high relative relevance of the short-run Juglar cycle. These differences create a problem when generalizing results to the whole continent. In this sense, finding a general theory to explain the causes of overall volatility in LAC countries must take into account these specificities and discuss the causes of these differences.

Latin America has a high dependency in commodity exports. Changes in technological paradigm result in long run volatility in commodity prices. This is caused by a reduction in the dependency of the inputs of the previous industrial paradigm, with effects on the exchange rate (Guzman et al., 2017). The emergence of a new paradigm requires new inputs. LA economies adjust to the cycle and change the products in which they will specialize if they have the possibility to do so, generating high long-run Kondratiev cyclical oscillations.

A high volatility in the Juglar short-run type of cycle is related to the fact that investments are done in blocks. The uncertainty intrinsic in economic systems is higher in developing countries. This uncertainty results in investments being made in periods in which there is a positive condition in the economic environment, commonly related to periods that coincide with commodity cycles. These cycles start maturing while economic conditions of the system change. There is a period in which no new investments are made, that coincides with a reduction in the economic conditions, increasing uncertainty and raising the costs of making new investments.

On one hand, LAC in terms of volatility differs clearly from the pattern observed in developed countries. On the other hand, it shows a similar pattern to many other developing regions, especially in central Asia and parts of Sub-Saharian Africa. We see some evidence to suppose that LAC has a distinct behavior compared to developed countries, but there is no evidence to extend this conclusion to differentiate LAC from other developing countries.

In summary, the evidence from the Maddison's data shows that LAC is in average more volatile than developed countries. However, this is not necessarily true when comparing it to other developing countries. This is a common mistake presented in the Structuralist perspective, mainly because it frequently compares LAC with developed countries and not with other developing regions, which leads to these sometimes misleading strong statements. On the other hand, we see that LAC is a continent following a similar cyclical behavior, visible after applying the filtering methodology, which characterizes an idiosyncratic element – at least for the majority of LAC countries.

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Annex 1.

Table 6. Country and code correspondence

Code	Country	Code	Country	Code	Country	Code	Country
AFG	Afghanistan	EGY	Egypt	LSO	Lesotho	SGP	Singapore
AGO	Angola	ESP	Spain	MAR	Morocco	SLE	Sierra Leone
ALB	Albania	ETH	Ethiopia	MDG	Madagascar	SLV	Slovenia
ARG	Argentina	FIN	Finland	MEX	Mexico	SOM	Somalia
AUS	Australia	FRA	France	MLI	Mali	STP	Sao Tome and Principe
AUT	Austria	GAB	Gabon	MMR	Myanmar	SWE	Sweden
BDI	Burundi	GHA	Ghana	MNG	Mongolia	SWZ	Swaziland
BEL	Belgium	GIN	Guinea	MOZ	Mozambique	SYC	Seychelles
BEN	Benin	GMB	Gambia	MRT	Mauritania	SYR	Syria
BFA	Burkina Faso	GNB	Guinea Bissau	MUS	Mauritius	TCD	Chad
BGD	Bangladesh	GNQ	Equatorial Guinea	MWI	Malawi	TGO	Togo
BGR	Bulgaria	GRC	Greece	MYS	Malaysia	THA	Thailand
BHR	Bahrain	GTM	Guatemala	NAM	Namibia	TTO	Trinidad & Tobago
BOL	Bolivia	HKG	Hong Kong	NER	Niger	TUN	Tunisia
BRA	Brazil	HND	Honduras	NGA	Nigeria	TUR	Turkey
BWA	Botswana	HTI	Haiti	NIC	Nicaragua	TWN	Taiwan
CAF	C. African Republic	HUN	Hungary	NLD	Netherlands	TZA	Tanzania
CAN	Canada	IDN	India	NOR	Norway	UAE	United Arab Emirates
CHE	Switzerland	IND	Indonesia	NPL	Nepal	UGA	Uganda
CHL	Chile	IRL	Ireland	NZL	New Zealand	UK	United Kingdom
CHN	China	IRN	Iran	OMN	OMN	URY	Uruguay
CIV	Côte d'Ivoire	IRQ	Iraq	PAK	PAK	USA	United States
CMR	Cameroon	ISR	Israel	PAN	Panama	VEN	Venezuela
COD	DRC Congo	ITA	Italy	PER	Peru	VNM	Vietnam
COG	Republic of Congo	JAM	Jamaica	PHL	Philippines	YEM	Yemen
COL	Colombia	JOR	Jordan	POL	Poland	ZAF	South Africa
COM	Comoros	JPN	Japan	PRI	Puerto Rico	ZMB	Zambia
CPV	Cyprus	KEN	Kenya	PRK	North Korea	ZWE	Zimbabwe
CRI	Costa Rica	KHM	Cambodia	PRT	Portugal		
CUB	Cuba	KOR	South Korea	PRY	Paraguay		
DEU	Germany	KWT	Kuwait	QAT	Qatar		
DJI	Djibouti	LAO	Laos	ROU	Romania		
DNK	Denmark	LBN	Lebanon	RWA	Rwanda		
DOM	Dominican Republic	LBR	Liberia	SAU	Saudi Arabia		
DZA	Algeria	LBY	Libya	SDN	Sudan		
ECU	Ecuador	LKA	Sri Lanka	SEN	Senegal		