Instability Constraints and Development Traps: An Empirical Analysis of Growth Cycles and Economic Volatility

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Abstract

Macroeconomic volatility is an issue that creates major constrains to the process of economic development, affecting long-term decisions and imposing periodic crises (Stiglitz, 2000). This article consists in an empirical exercise focused on understanding economic volatility in developing countries using developed countries as a benchmark. The paper starts by analyzing the evolution and standard deviation of GDP growth during the period 1950 – 2016 for 136 countries. Data comes originally from the Maddison Project Database. In order to look and analyze stable and recurrent patterns of volatility, the same data is filtered into cyclical components. This filtering methodology consists in the use of an Asymmetric Band Pass-Filter (Christiano and Fitzgerald, 2003) to decompose the original time series into band components. Stable economic cycles emerge from market, investment and technological reasons. In order to capture the distinct sources of cycles, we decompose data into four types of cycle and a trend according to their time range: the Kitchin cycle (up to 8 years), the Juglar cycle (8-15 years), the Kuznets Swing (15-30 years), the Kondratiev wave (30-60 years), and a structural residual long-run trend. Attributes related to amplitude, duration and the synchronization between cycles (Harding-Pagan index) are computed for each country and time range. Countries are grouped and compared using Cluster Analysis, resulting in a classification of patterns of volatility.

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

JEL: C21, C32, 047.

Área 6 - Crescimento, Desenvolvimento Econômico e Instituições

Introduction

Historically, sustaining growth has been a central problem for a virtuous development strategy (Foster-McGregor, Kaba, & Szirmai, 2015). Short-term growth and high volatility of macroeconomic prices are constantly observed in developing countries, reducing their average period of stable growth. It results in an endogenous pattern of instability, reproduction of inequality, net outflows of financial capital, and halt in investments. Macroeconomic volatility creates major constrains to the process of economic development, affecting long-term decisions and imposing periodic crises (Stiglitz, 2000). This volatility has impacts on the economic structure, affecting long-run economic growth. This impact is understood as the structural cause of Macroeconomic Instability.

Macroeconomic Instability is not a new issue and is a central problem currently affecting developing countries. Despite its importance, little effort has been made to understand the consequences of the type of instability that emerges from the productive structure, affecting the growth potential of developing countries. It is mostly treated in the literature as related to fluctuations in stock markets and government debt

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(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 (Taylor, 1991), we plan to address the periodical phenomenon of volatility that emerges from the structural fragilities (defined as the weakness of an economy to absorb external economic shocks). In this article, we focus on understanding the aspects concerning GDP growth volatility. We empirically show distinct patterns of volatility that emerges in different countries.

The first step in this research is to show some stylized facts of per capita GDP growth volatility. We apply filtering techniques to decompose the time series of per capita economic growth in distinct cycles and analyze the patterns that emerge from them. The second step is to build a typology using cluster analysis that groups patterns of volatility according to the average amplitude and duration of countries' cycles. This methodology gives us an approach about the type of expansion-cycle processes that exists. Finally, the residual that appears after the filtering techniques can be observed as a structural component that relates macroeconomic volatility with the economic structure of an economy.

In section 1 we discuss the literature review regarding the main theories behind the idea of economic cycles, its empirical evidences and the debates behind cycle synchronization. In section 2, we present the data that is being used in this research. In section 3, we briefly explain the methodologies employed – the Christiano-Fitzgerald's Band Pass Filter, the Harding-Pagan index of cycle synchronization, the K-Means method of cluster analysis, and the MICE imputation method used to input missing data and clean the database. In section 4, we show some evidences from the data before applying the filtering analysis. In section 5, we apply the filters in the data and discuss the results for the different types of cycle and the residual structural component. Finally, in section 6, main results and the conclusion of the paper are discussed.

1. Cycle Theory

The study and development of economic cycle theories has enabled many analysts to understand the behavior of the economic dynamic. Distinct theories explained in this section approached the observance of cycles with its own explanations of the phenomenon. The relevance on the study of these cycles lays in the fact that their occurrence 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.

In the first half of the XX century, relevant economists claimed the identification of cyclical patterns for economic prices and growth. Clement Juglar identified cycles related to business activities that range from 8 to 11 years caused by the maturity processes of investments. This behavior was later developed in the Business Cycle Theory. In terms of long run cycles, Kondratiev (1935) discussed the existence of periods of volatility between 45 to 60 years in the world economy. These long cycles are still sources of long debates in terms of their identification and the causes behind it (Korotayev et al, 2010). Another type of cyclical behavior, with a medium-run period, was discovered by Kuznets (1940), relating it to the behavior of infrastructure investments. This cycle was broadly discussed by Abramovitz (1961, 1968), that analyzed the recurrence for a broad range of countries of deep depressions at similar intervals.

Joseph Schumpeter wrote in 1933 a classical book about business cycle. Schumpeter described the technological aspects related to cyclical behavior and proposed a typology of business cycles according to 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 will use this typology. We will expand, though, the range for each cycle in order to make a perfect coverage of all the cycles that range between 2 and 60 years.

According to Schumpeter (1939), any of these cycles are divided into four phases: (1) expansion and growth; (2) turning point; (3) recession and crisis; and (4) recovery. The most important aspect of these economic cycles is that these fluctuations are not only related to a certain aspect of the economy, but affect and are diffused through the whole economic system, having pervasive effects in the economic system.

The reasons behind the existence of these cycles are also a topic of great debate in the economic theory. Different kinds of explanation try to answer the causes of these cycles. These answers range from the appearance of inventories (Kitchin ,1923; Metzler. 1941), to credit behavior, the maturity of investments (Besomi, 2005; Fukuda, 2009), investments in infrastructure (Kuznets, 1930; Abramovitz, 1968) and technology development (Schumpeter, 1939; Perez, 2009). Also important explanations to mention are the Debt Deflation theory by Fischer (1933) and the Financial Instability Hypothesis by Minsky (1974).

The Post-Keynesian and the Structuralist traditions have theories that aim to explain the behavior of cycles looking for demand-side aspects. These theories have the specificity of observing the existence of cycles aas endogenous to the behavior of the economic system. Distinct 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 (Lucas, 1975), being fluctuations a result of bad policies or market failures.

A relevant aspect of the structuralist tradition, used in this paper, is the fact that this tradition deals with issues that puts developing countries in the center of the analysis and links cycles to the productive structure. Remounting to the seminal works started with Prebisch (1950) and later developed in a whole tradition, this tradition sees the existence of a north-south dynamic in the international division of labor that result in distinct trajectories between advanced and developing economies. The Structuralist and Post-Keynesian theoretical approaches are used in order to evaluate the results of the research.

1.1 Methodologies for cycle analysis and some empirical evidence from economic cycles

Most recently, many empirical works were made to observe the existence of cycles in the world economy. The main methodologies used are the Spectral Analysis (Kuczynsky, 1978; Bossier & Huge (1981); Van Ewijk (1981); Korotayev et al (2010)), the Filter design approach (Metz & Stier, 1992; Kriegel et al, 2009) and Wavelet analysis (Gallegati et al, 2017). These methodologies focus on analyzing the distinct frequencies that emerge from time series. These are methods usually applied to economic variables.

Spectral analysis applies Fourier transformations to the 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 is a restriction that allowed using windowed transformation (use of bands). The wavelet analysis is analogous to the Spectral analysis but it uses a finite domain.

This research uses a **Filter Design approach**, which is a development of the Spectral Analysis defining a specific band filter. There are distinct filters as described and enumerated by Pollock (2014). One commonly used filter is the low pass filter, the Hodrick-Prescott's filter (Hodrick and Prescott, 1980), heavily criticized by Hamilton (2016). Another important methodology is the Band-Pass 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 filter coefficients to isolate specific frequencies looking for the ideal filter band.

Baxter and King (1999) developed the symmetric band-pass filter inverting the Fourier series and truncating the data building a moving average. This methodology had an issue related to reach the ends of the sample. This issue has been solved by the asymmetric Band-Pass filter of Christiano and Fitzgerald (2003). They proposed a way to extrapolate the end of the data. In this research we use the Asymmetric Band-Pass filter.

It is relevant to observe some empirical evidences of cycles for GDP growth. There are many works that test the existence of cycles for the world level. Korotayev et al (2010), using spectral analysis, claim that there is a very high significance for the existence of Kitchin, Juglar and Kondratiev cycles. Kuznets cycles, in the authors' argument can be understood as a third harmonic of the Kondratiev cycle, detected for the world level for each 17 years. In another relevant work, Diebol & Doliger (2006, 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 are still contrasting and contradictory, depending on the methodology applied. There are still disagreements about the empirical existence of short and long waves (Bosserelle, 2013).

2. Data

In this paper we are using the Maddison Project Database (MPD), updated with data from the World Bank Database (WBD). The MPD continued the works of Maddison (2001) and Maddison (2003). The database was most recently updated by Bolt and Van Zanden (2013). 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 roman times until 2010. We select from the MPD the period from 1950 to 2010 and update for 2010 to 2016 using the growth rates of per capita GDP from the World Bank Database (WBD). The reason why we choose this period is data availability and biases caused by the war period (post-World War II). Before 1950's many countries also did not have available data for GDP per capita. There are some corrections in the database concerning the fact that there are many countries that did not exist before 1991 (Former soviet republics and former Yugoslavia) and because the element of war strongly affected the data. As we want to observe the economic causes of economic cycles, data during periods of war were treated, and seen as an exogenous element.

The database after updating consists of 132 countries using per capita GDP growth data from 1951 to 2016. For each country's time series we applied the Christiano and Fitzgerald (2003)'s Band Pass Filter and decomposed the actual data in distinct cycles, 2-8 years (Kitchin Cycle), 8-15 (Juglar cycle), 15-30 years (Kuznets cycle), and 30-60 years (Kondratiev cycle). We observe in these cycles the average amplitude and the duration of periods of growth and crisis. The results were grouped in clusters using the K-means methodology, dividing the instability patterns in different groups.

3. Methodology

3.1 Band-Pass filter

In this section we follow the approach of Erten and Ocampo (2013) and use the asymmetric Band-Pass (BP) filter of Christiano and Fitzgerald (2003), to identify cycles in our different GDP per capita growth. The BP filter allows for a time-series to be decomposed into different frequency components, which then identify the cycles in the different series. The approach we adopt in this analysis follows closely the approach of Erten and Ocampo (2013), the major addition being that we further search for the possibility of medium-run cycles following Comin and Gertler (2006) and Drehmann et al (2012). The approach we adopt therefore 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-term 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 reported by Erten and Ocampo (2013) in their analysis is 35.7 years, with a minimum of 24 years and just three (of 18) super-cycles being more than 40 years in length. We therefore consider Kuznets cycles with 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 20 years, with the short term cyclical Kitchin cycle trend having a periodicity less than 8 years.

The analysis is undertaken using annual data from the Maddison Project Database and the World Bank Database for the period 1950-2015, thus allowing us to consider the most recent data.

Table 1. Cycles in economic theory and its periods

Cycle Name	Main origin	Period	Main Cause
Kitchin	Market Cycle	0y-8y	Inventories (Consumption)
Juglar	Business Investment Cycle	8y-15y	Medium-run Investments
Kuznets	Structural Investment Cycle	15y-30y	Long-run Investments
Kondratiev	Technological Cycle	30y-60y	Technological paradigm change
Residual	Trend	-	Structural element

3.2 Cycle Synchronization – Harding-Pagan index

We are interested in examining whether the cycles for different countries are synchronized. To the extent that if cycles are not particularly well synchronized then we may expect that cycles could develop differently for different countries and regions.

In our analysis we are interested in examining the synchronization of each cycle between different countries. In order to do that we use the concordance index developed by Harding and Pagan (2006), which defines the interdependence between cycles as the probability that their phases coincide. This is achieved in the following way. For each per capita GDP value, i, a dummy variable, S_{it}, is created that takes the value 1 when the cycle is going through an upward phase and zero otherwise. The concordance index is then defined – for a given pair of cycles in two different countries – as the probability that both cycles are simultaneously going through the same phase (either upward or downward), i.e. $\Pr(S_{it} = S_{jt})$. The concordance index is then calculated as:

$$I_C(p) = \frac{1}{T}\left\{\sum_{t=1}^{T} S_{it}S_{jt} + \sum_{t=1}^{T}(1 - S_{it})(1 - S_{jt})\right\} \quad (2)$$

The index takes values between zero (i.e. always in the opposite phase) and one (i.e. phases always coincide), with a value of 0.5 indicating no synchronization between these cycles during the sample period. In addition to reporting values of the concordance index we further report the correlation coefficient between the two dummy variables (along with information on whether these correlations are significant).

3.3 Cluster Analysis

Cluster Analysis consists on grouping elements in similar groups or clusters. There is no general way of clustering, but many distinct methodologies used to group elements with similar attributes. In this paper countries are divided into distinct groups based on their cycle attributes of amplitude and duration. The methodology used is the K-Means, a method of vector quantization that partitions observations in cluster partitioning the data space into regions.

The K-Means method divides k distinct clusters composed of certain means. The n objects are then grouped according to the nearest mean to the clusters. The best number of clusters is not known and must be exogenously defined. The objective of this methodology is to minimize intra-cluster variance (The squared error function). This is made through defining an objective function j that calculates a distance function that must be 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 giver k variables. Then it selects randomly cluster centers and assign objects to clusters following the distance function ad calculate the mean of each object. This method repeats itself until minimizing the distances. This method will create groups of clusters in which countries will be divided. I have selected exogenously to divide countries into 6 country groups, from the less to the most volatile.

4. Evidence from the Data

From the per capita GDP growth data described in the last section, it is possible to observe its average and standard deviation (volatility). In Figure 1, we see that most countries have an average growth rate between 0% and 3.5%. The exceptions are Japan and the Asian tigers (South Korea, Taiwan, Thailand, Hong-Kong, Singapore), Myanmar and Botswana, that show a high growth with low volatility and Jordan and Angola, countries that showed high growth but also very high volatility. On the other hand, there are Kuwait, Qatar, Congo, and Madagascar, countries that showed a reduction in their per capita GDP between 1950 and 2015. Most of the countries are in the big cloud in the center.

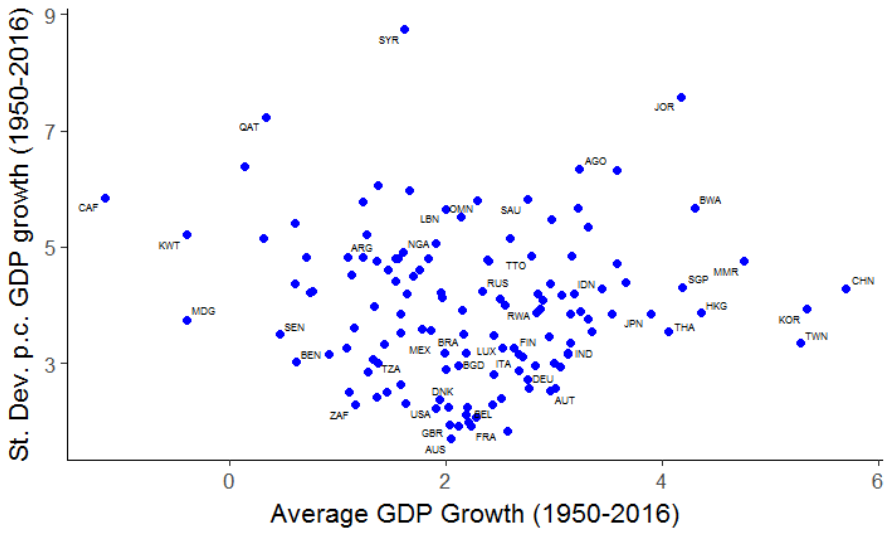


Figure 1. Relationship between Average per capita GDP growth, and Standard deviation of per capita GDP growth.
Source: Author's own and Maddison Project Database

Observing only the big cloud in Figure 1, we see some different patterns. Among countries with low standard deviation, we have most developed countries such as Australia, Norway, France, Netherlands, Belgium, Denmark, Sweden, Norway, USA, Austria, Germany, and Switzerland. These countries showed a stable growth in the observed period. There are cases of developed country that showed high growth right after the second war and then a reduction afterwards, which increases their volatility. These are the cases of Japan and Finland. Countries with very high volatility are usually associated with war. We have the example of former Yugoslavian republics and Sub-Saharian Africa.

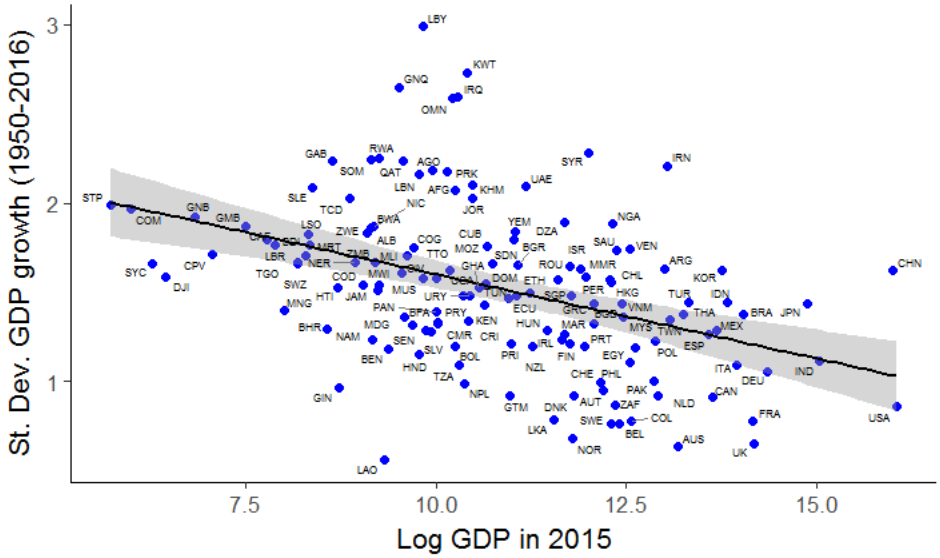


Figure 2. Per Capita GDP level in 2005 versus Standard Deviation of GDP growth.
Source: Author's own and Maddison Project Database

Another interesting observation is that countries that in the end of our analysis showed a higher per capita GDP have on average lower volatility. This can be seen observing Figure 2. Still a high number of countries with low per capita GDP also showed low volatility, so an automatic relationship between being a rich country and having low volatility is visible but not strong. For this reason we should further investigate the different elements behind each economy, in order to build a typology of different volatility groups. In this sense, extracting cycles from original time series will be the first effort to give a picture about the patterns of volatility.

5. Analysis by type of cycle

This research proposes to capture four cyclical components and a long-run trend. These components are associated with the four distinct type of cycle discussed in the economic theory. Starting from a very short-run cycle, The Kitchin cycle is associated with cycles with less than 8 years. The Juglar cycle is associated with fixed investments with periods between 8 and 15 years. The infrastructural investment Kuznets cycle deals with medium cycles that have a periodicity adjusted in this research to between 15 to 30 years. Finally the Kondratiev wave captures long-run trends with periodicity higher than 30 years until 60 years.

In every cycle it is possible to identify four phases: expansion, turning point, stagnation and recession. In each of these phases we observe the amplitude and the duration of each process in order to observe the average type of growth-crisis dynamics that each country shows. The heteroscedasticity will also be analyzed, as there are relevant changes in the growth dynamics of different countries since the post-war 1950's until the globalized post-financial crisis world in 2016. Finally, we group countries into categories that can represent a typology of instability patterns.

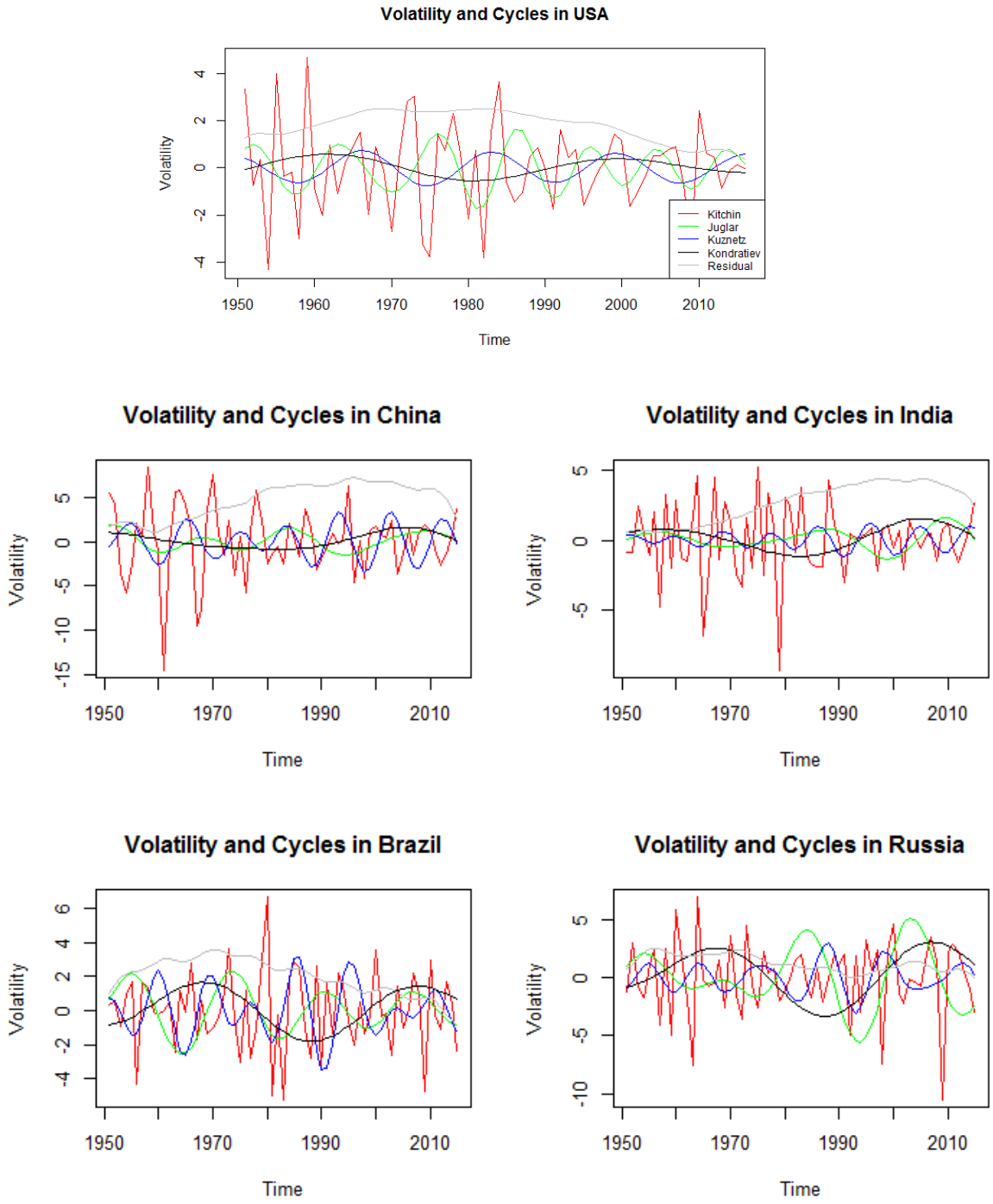
In order to extract the cycles we made the following procedure: initially, from the original time series, we applied the band-pass filter to remove the high frequency filter Kitchin cycle. From the residuals of the Kitchin cycle we adjusted the band and filtered the Juglar cycle. From the residuals of the Juglar cycle we made a new adjustment and filtered the Kuznets cycle. Finally we did the same to extract the Kondratiev

cycle. The resulting residual after all filtering cycles were finally extracted. This last element will be further discussed, as it results in a fundamental variable to discuss the structure of the economic conditions of countries.

The different patterns of cyclicality observed in different countries can be grouped using cluster analysis. These patterns are compared in terms of the average duration of the cycles and their amplitude. Also, for comparison, we observe the cross-correlation in cycles of different countries, calculated with the Harding-Pagan index which measures the degree of synchronization. The results showed here use the cycle of the USA as a reference, and how cycles in other countries are related to the biggest economy in the world.

In order to illustrate the methodology and the results obtained, we can observe the filter methodology applied on the USA's and the BRIC's data. In Figure 3 we see the four types of cycle filtered from the original per capita GDP time series for selected countries. Each cycle has a detailed aspect and can be used to help identifying some historical turns in countries' economies. This extraction shows the different degrees of stable volatility. An interesting aspect is the residual non-cyclical component finally extracted from the data. This residual show the long-run aspects related to the countries' economic structures. It is a topic discussed in Section 5.2.

Figure 3. Volatility, cycles and residual in the US and the BRIC countries



Source: Author's own and Maddison Project Database

In this example we can see the decomposition of per capita growth time series into cycles and trend for the USA and the BRIC countries. The scales are different in each graph, which represents the big difference in terms of volatility patterns in each country. In red we see the short-run Kitchin cycles with a high frequency and variance. This cycle is marked with higher amplitude and smaller duration. Presence of major economic crisis can be easily seen in this market cycle, as in the case of 1950's to China, 1980's to Brazil and 2010 to USA and Russia. The cycles are then smoother in larger ranges with bigger duration but smaller amplitudes.

These cycles show some stable patterns and can also be used to think about possible predictions in the case of no exogenous major shock. Each cycle can 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 related to technology. We can also observe the presence of the residual component. This 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 the USA, which started with the outsourcing processes present on globalization. We see the results of each cycle below.

5.1 Results by Cycle

The Kitchin Cycle is a short-run market cycle that lasts until 8 years. This cycle is associated with investment in inventories. The cycle can be explained in the case of a positive commercial situation that raises output. Firms increase the employment of their factors of production – capital and labor until the limit of their fixed assets. The market ends up being full of commodities, leading to overproduction. There is then the emergence of stocks in inventories. This leads to a lagged decision to reduce production and decrease the amount of commodities on inventories. This consumption-based cycle then *coeteris paribus* returns to its initial condition.

We extracted the Kitchin cycles for all countries in the database. The results were grouped using cluster analysis (Figure 4) and show that in terms of this type of cycle we can group the countries. The data was calculated in terms of amplitude (Average distance between peaks and valleys) and duration (average time spent to complete a full cycle).

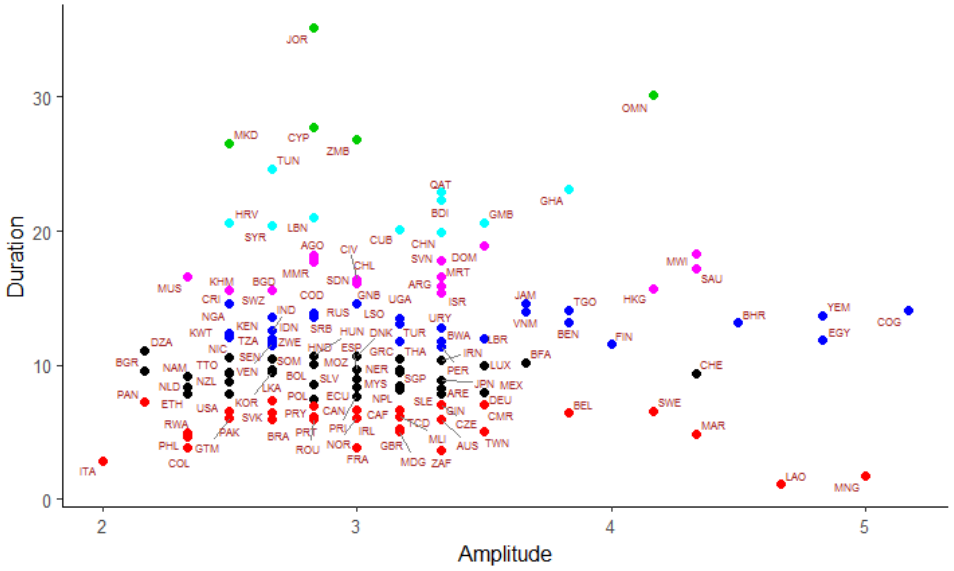


Figure 4. Cluster K-Means Analysis of the Kitchin Cycles (Each color consists of a different group)
Source: Author's own and Maddison Project Database

Countries in Group 1 (Red) show smaller volatility in terms of their market adjustments in inventories. These economies since 1950 until 2015 showed a less volatile combination of amplitude and duration in terms of their Kitchin cycles. With few exceptions developed countries can be found in groups 1 or 2 (Black). In groups 4 (Purple), 5 (Light Blue), and 6 (Green).

The Juglar cycle is related to an identified investment cycle that takes between 8 to 15 years. The existence of this type of cycle is related to the maturity time related to investments in fixed capital. Initially thought by Juglar (1862) as a cycle caused by an increase of commodity prices, the evidence of the cycle was later related to overproduction and overinvestment. Finally, it was understood as a mismatch between fixed capital investment decisions and the maturity of these investments, (Lewis, 1978).

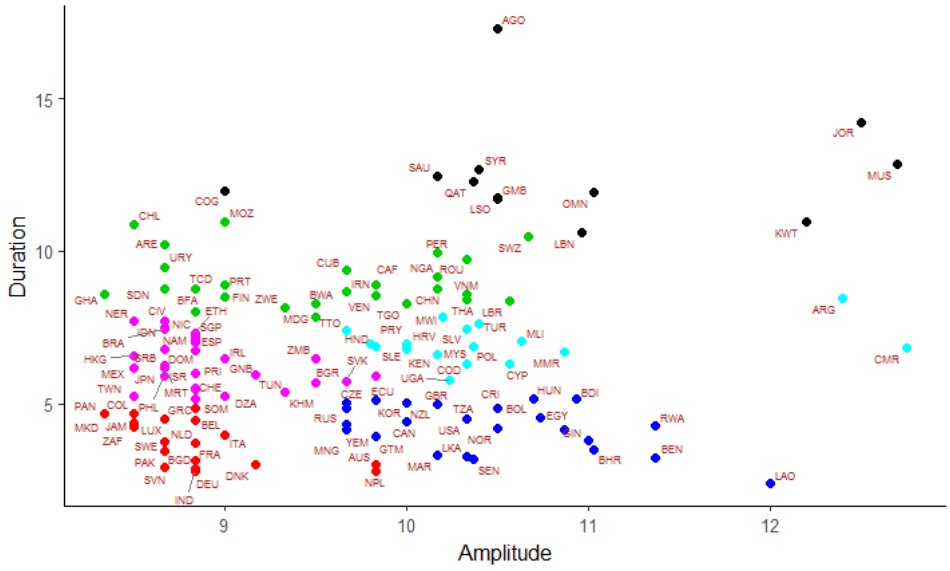


Figure 5. Cluster K-Means Analysis of the Juglar Cycles (Each color consists of a different group)
Source: Author's own and Maddison Project Database

The groups of countries that emerge from the Juglar cycle differ from the one resulted from the Kitchin cycles. In group 1 (Red) we can see the countries that are able to show a lower variability in their investment mismatches. The results are interesting when analyzing individual cases. Japan for instance, despite being a very developed country, is defined as group 3 (Purple). Observing the data behind this fact we see that Japan show a high heteroscedasticity with a likely structural break between the periods that range from 1950 to 1980 and the one from 1980 to 2016. The countries with higher volatility though suffered from war and so their results are biased by exogenous aspects that will be controlled.

A medium-run cycle observed in the literature was initially discussed by Kuznets (1930). Initially linked to demographic processes, this cycle is currently linked to infrastructural investments. Despite the main reasons behind the cycle, the presence of this cycle is a very important element as it gives a good picture of the economic recent history of most countries. The duration of the cycle is related to the speed that infrastructural investments operate in the economy while the amplitude is related to the weight that a crisis impact in investment cycles. This discussion is directly related to the Keynesian topic about uncertainty, which affects the long-run investment decision. This relates as well with the smaller time range cycles – the most uncertainty caused by instability, the harder is to the investors to make a decision to immobilize capital with major investments. These investments are central to change the characteristics of the economic structure, moving toward new and modern sectors with a virtuous structural change.

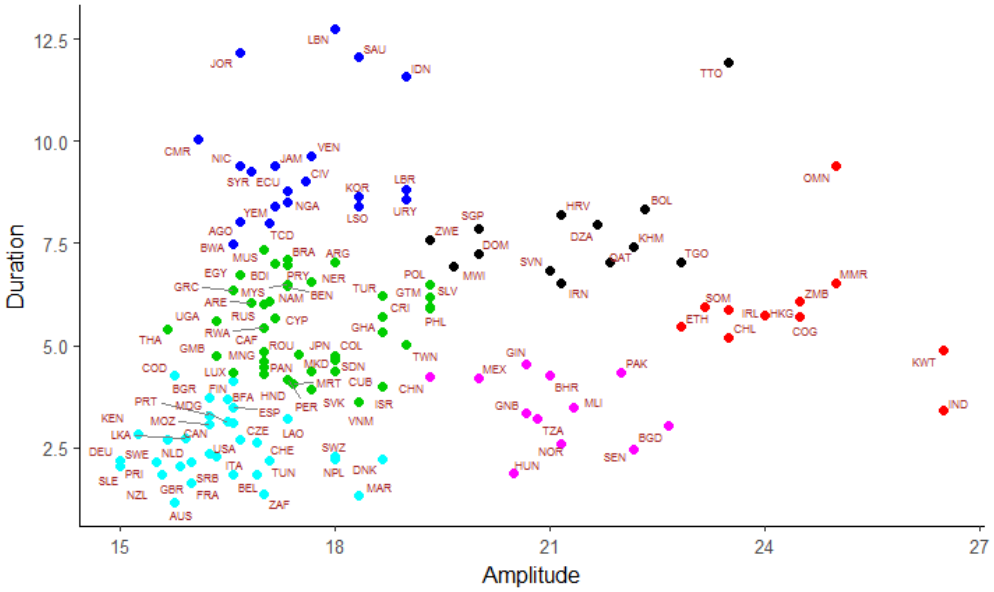


Figure 6. Cluster K-Means Analysis of the Kuznets Cycles
Source: Author's own and Maddison Project Database

Concerning the cluster analysis that selected countries in different group cases, we see that most developing countries find themselves in groups 3 (Red), 4 (Green) and 5 (Black). In group 6 (Blue) we observe countries marked by a known high political and economic instability and oil producers – Saudi Arabia and Venezuela. Group 4 (green) is composed by many Latin American and Caribbean. A group of African countries and some south European countries are also in this group. Group 2(purple) and 3(red) are a heterogeneous group composed of many African and Asian countries. In group 1 (light blue) there are many developed countries such as Australia, Austria, Belgium, Canada, Finland, France, Netherlands, New Zealand, Sweden, Switzerland and the UK.

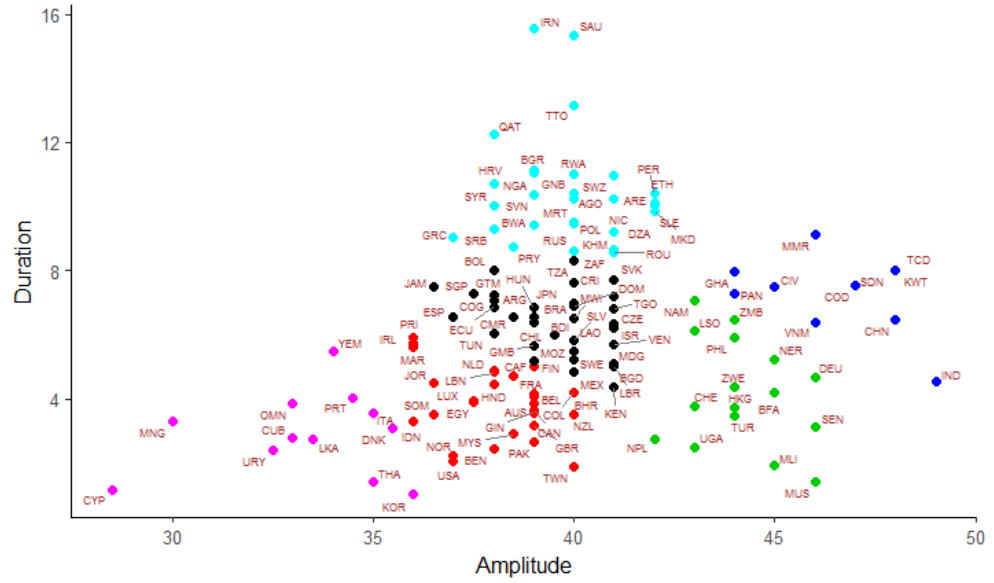


Figure 7. Cluster K-Means Analysis of the Kondratiev Cycles
Source: Author's own and Maddison Project Database

Kondratiev cycles are long-run economic cycles that last between 30 and 60 years. These cycles were discovered by Kondratiev (1935) and have been subject of big discussion since its identification. Recently it has been linked by authors such as Perez (2009) to waves of technological changes. By applying a band-pass filter for a period between 30 and 60 years and applying the cluster analysis, there is the following result in Figure 7.

Among the groups selected by the cluster analysis, we see that in group 1 (less volatile) is composed by most developed countries. Some African countries are also in this list, such as Burkina Faso, Guinea Bissau, Madagascar, Mali, Mauritania, Morocco, São Tomé e Principe, South Africa, Tunisia and Zambia. Some Asian countries are also in this less volatile group, such as Bangladesh, Laos, Mongolia, Nepal, Sri Lanka, Thailand and Vietnam.

Group 2 is composed mainly by developing countries with the expection of Norway and New Zealand. China and India as well as Mexico enter in this classification. Group 3 have a big group of countries from Latin America (Argentina, Brazil, Costa Rica, Dominican Republic, Ecuador, Guatemala, Panama, Paraguay, Uruguay, Venezuela, Jamaica, and El Salvador) and a big group of countries in Asia. There are some African countries and also exceptions such as South Korea, Greece, and Turkey. Group 5 is mainly composed by former URSS countries Middle Eastern economies and some African countries. Finally Group 6 has African countries such as Nigeria, Saudi Arabia and Sudan; some Middle Eastern economies such as Oman, Qatar and Saudi Arabia; Russia and Ukraine.

5.2 Structural Residual

Finally we can see the residual that appears after the extraction of all different cyclical component. This structural residual is a non-cyclical component associated with a trend and with long-run economic growth. Following a separation between cycles and trends we can have a short run behavior of the economic captured by the cyclical aspects and the long run behavior captured by the trend residual. This long-run aspect of the economy can be linked to the structural conditions of the economic system, especially the productive structure. There is a large tradition that links the economic performance with the structural conditions of the economy (Cimoli et al, 2010; Cimoli and Porcile, 2011).

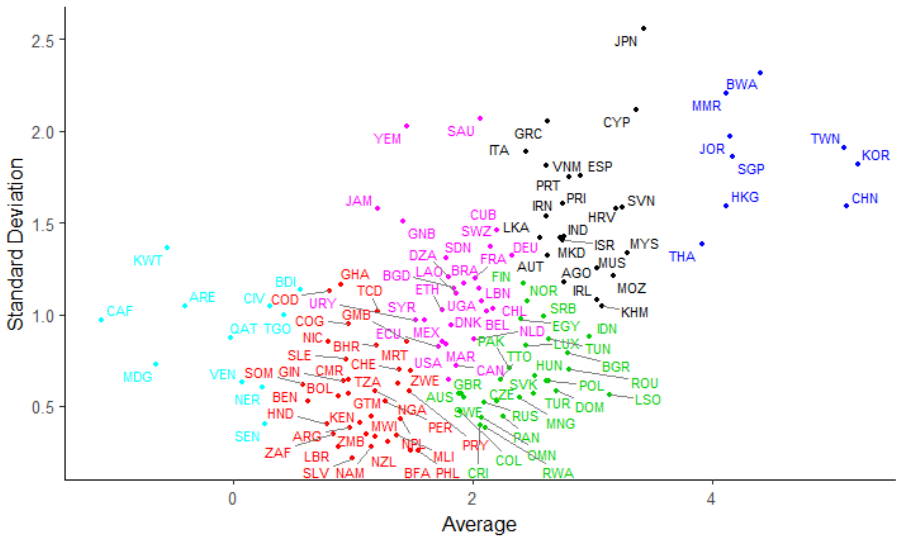


Figure 8. Cluster K-Means Analysis of the Residual (Each color consists of a different group)
Source: Author's own and Maddison Project Database

The structural residual was analyzed in basis of its average and standard deviation. The average indicates which countries managed to keep a higher non-cyclical growth. Countries with high average and high standard deviation were the ones that managed to achieve a higher catch-up. In blue we see that many East Asian countries are in this catch-up group, as well as Japan, country with higher standard deviation in its structural component. Countries that were reconstructed after World War II and became developed ones are also in this higher Black (Italy, and Spain and Portugal after) and some in the eastern part of the purple group such as Germany, France and The Netherlands. In light blue we see the countries with worst performance in terms of their structural non-cyclical components. These ones, as well as countries in the red group, did not manage to advance in the elements that change their structural component – which is related to structural change. The light blue and red groups, as well as some in purple groups can be seen stuck in development traps. Either in poverty traps or middle income traps. In green we see countries that managed to keep a higher structural component without a strong break in their growth pattern.

African and Latin American countries are mainly in this western region of Figure 8 associated with development traps. The fragility of their structural component is directly associated with the weaknesses of their productive structure. Countries that did not manage to catch up and make a big structural change are then seen in these groups.

6. Cycle concordance

As we can observe in the Annex, in Figure 9 we observe which countries show higher synchrony of their Kitchin cycles with the USA. Canada shows higher synchrony, followed by Germany, Thailand, France and the UK. The hypothesis here is that countries with bigger economic interaction with the USA are the ones with higher synchrony of their short-run market cycles. This result may look a tautology, but this is not true for the other cyclical components as it will be further discussed.

Observing the concordance between the Juglar cycles of distinct countries related to the USA we see interesting results. Considering that 0.5 means no relation between the selected country and USA, most of the countries, as expected show a positive correlation with the investment cycles in the USA. The demand generated by the USA end up being an important aspect to stimulate investments in other parts of the world. The countries with higher correlation with the USA involve some Latin American countries such as Bolivia, Costa Rica, El Salvador and Honduras. Also Canada, Australia, UK and Norway, economies directly linked to the US economy show high synchronization. Some surprises involve countries such as Turkey, Tanzania, Romania, Hungary and Iraq, with a high positive synchronization. The countries with negative concordance are Bahrain, Zimbabwe, Iran, Liberia and Congo.

The concordance of the Kuznets cycles with US economy brings interesting elements. Firstly, most countries have not their cycles synchronized with the USA. The countries with highest positive synchronization are Australia, UK and Canada, followed by some African countries such as Mauritania and Burkina Faso, and Denmark and Finland. On the other hand, the countries with negative synchronization of their Kuznets cycles with the USA includes most Latin American countries, such as Argentina, Brazil, Colombia, Ecuador, Honduras, Paraguay, Uruguay and Venezuela. Some African countries are also included with negative synchronization with the USA such as Jordan, Serbia, Gambia, Lesotho, Mauritius, Somalia and Tunisia.

The main characteristics of the Kondratiev cycle is related to the fact that is much smoother than other cycles and it is related to international patterns of technological change. Most countries show a positive synchronization of their Kondratiev cycles with the USA. There are still some countries with negative synchrony with the USA, especially in the middle east and Sub-Saharian Africa, as well as Ukraine and

Uruguay. These countries can be seen as the ones with bigger lag in the adaption of new international technological standards. Their growth in the technological cycle may indicate a slow adoption of new technologies.

7. Conclusion

Discovering the regularities in economic behavior is a relevant topic to understand some elements that trap economies in underdevelopment. In this paper we made an empirical effort to observe volatile regularities by looking at the cyclical behavior related to per capita GDP, an important measure of economic development. We initially showed some stylized facts about the relationship between volatility and per capita GDP growth. This analysis gives us an idea about economic instability, especially in developing countries. Though, it does not allow us to observe the regularities in volatility that can be associated with the economic structures of an economy. For this reason, we applied filtering analysis in order to discuss the distinct regularity patterns of economic behavior. As database we used the Maddison Project Database and adjusted data using methods to identify structural breaks and outliers (that may be associated to the presence of wars, a non-economic component). After removing this data we re-estimated the results using a MICE (Multivariate Imputation by Chained Equations) framework.

The Asymmetric Band-Pass Filter was applied on data extracting four types of cycle (Kitchin, Juglar, Kuznets and Kondratiev), and a residual non-cyclical trend. The results were grouped using Cluster Analysis (K-means algorithm) into 6 distinct groups based on two main measures – amplitude and duration of the cycles. The cycles were compared for different countries using the Harding-Pagan index of cycle synchronization.

The results confirmed some expected outcomes. Cycles in developed countries are less volatile than developing countries, despite some exceptions. There are some developed countries, though, that do not appear in the less volatile group for some cycles, such as Japan. In terms of short run cycles (Kitchin) the country groups with most volatility are also the ones with smaller synchronization with the cycle of the USA – but this is not true for medium run cycles. Latin American countries, which in the short run follow a similar behavior as the USA, in the medium-run Cycle results show themselves having a completely opposite behavior. This is interesting not only because it shows that distinct cycles result in distinct behaviors, but because the investment cycles in Latin America follows a different pace than in the USA, which raises elements to think if the low resilience to external shocks long known in Latin America is only a matter of short-run reactions. The development of the economic structure (structural investments and the structural residual) follows a different pace.

Among the most volatile regions we can cite the Middle East, West Africa and Former Soviet countries followed them by Latin American economies. The most stable regions are North America, Western Europe and Oceania. Eastern Asia, a region with a big amount of countries that managed to catch-up recently showed a medium volatility, but this should be tested with heteroscedasticity, as we can suppose the existence of two time dynamics – before after starting the industrialization strategy. Wars had a big impact on volatility – so they were identified and treated in the data. This paper aims to give inputs to the observance of the economic reasons behind instability.

The explanation behind the cycles let us understand the main economic mechanisms that generate this unstable behavior in the economic system. The very short run cycles are linked to demand answers of the economy to inventory changes and to price modification (case of exchange-rate devaluation). This very short cyclicality also affects investment decisions, having a lagged impact on the short run Juglar cycle, which is

related to investments. High short-run instability will create an environment with high uncertainty that impacts on the investment decisions, affecting the Juglar cycle and also the structural component. This latter is seen as the element that is directly linked with the quality of the productive structure of the economy. The next step is to capture the relationship between the structural component, structural change, increases in technological capabilities and modernization.

The medium-run Kuznets cycle, which is related to structural investments have a very important aspect in this discussion. Infra-structural investments affect directly the productive structure, a central element related to the long-run economic growth. In this sense the Kuznets cycle links more directly the short-run volatility to the long-run growth. Finally, Kondratiev cycles are linked to technological changes. The speed in which countries absorb and adapt their structure to the technological frontier can be seen through Kondratiev's cycle synchronization.

In further research, the results found in this empirical analysis will be used as inputs to the development of the Chronic Macroeconomic Instability model. This model links volatility, productive structure and the fragility pattern of countries. Theoretically built on the Sructuralist theory (Taylor, 1991), the model aims to explain how some countries are trapped in development issues that do not let them catch-up in their economic development strategies.

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Annex. Cycle Concordance with the USA

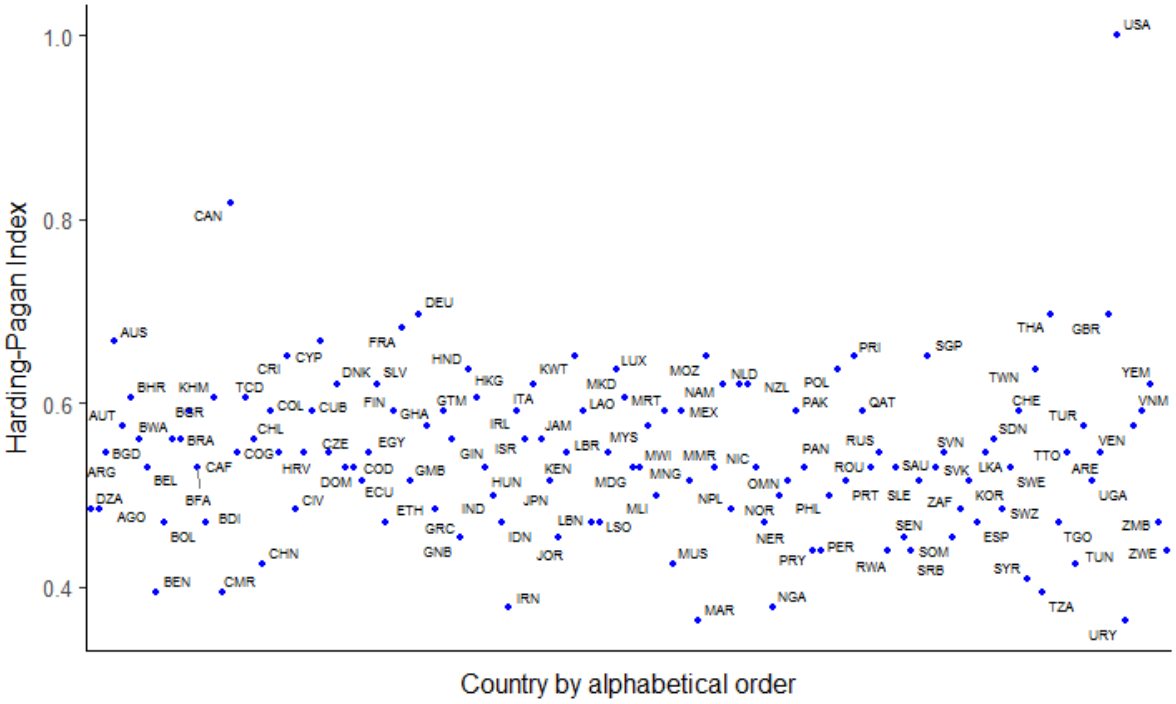

Figure 9. Country's concordance of the Kitchin Cycles related to the USA
Source: Author's own and Maddison Project Database

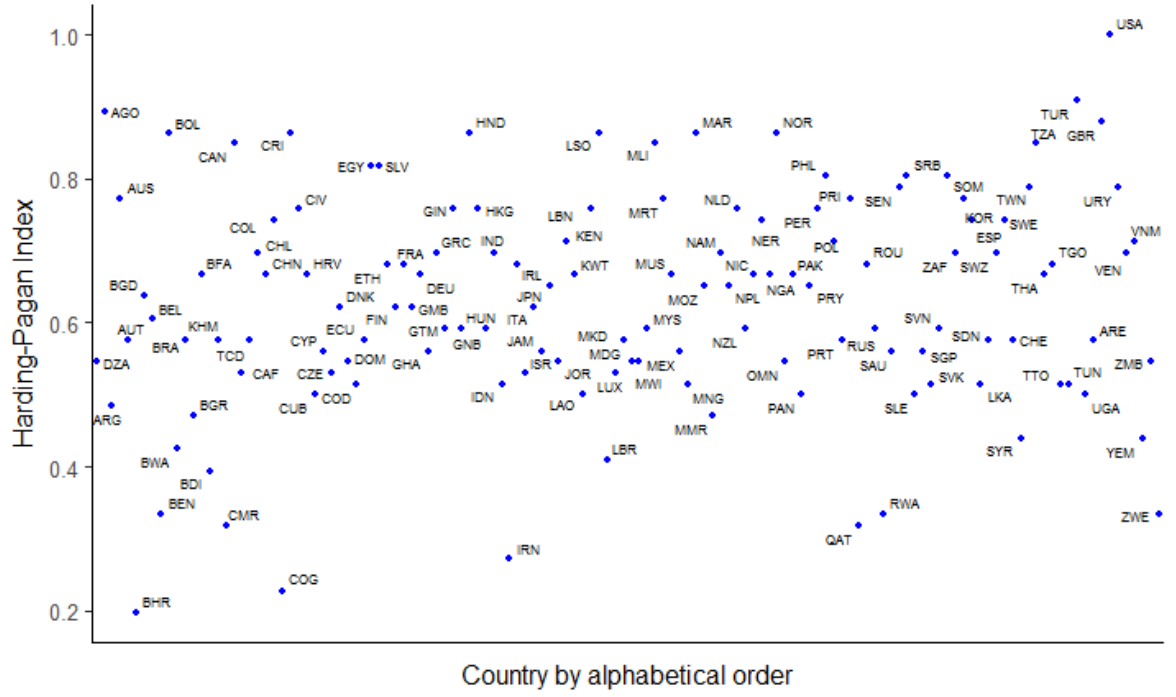

Figure 10. Country's concordance of the Juglar Cycles related to the USA.
Source: Author's own and Maddison Project Database

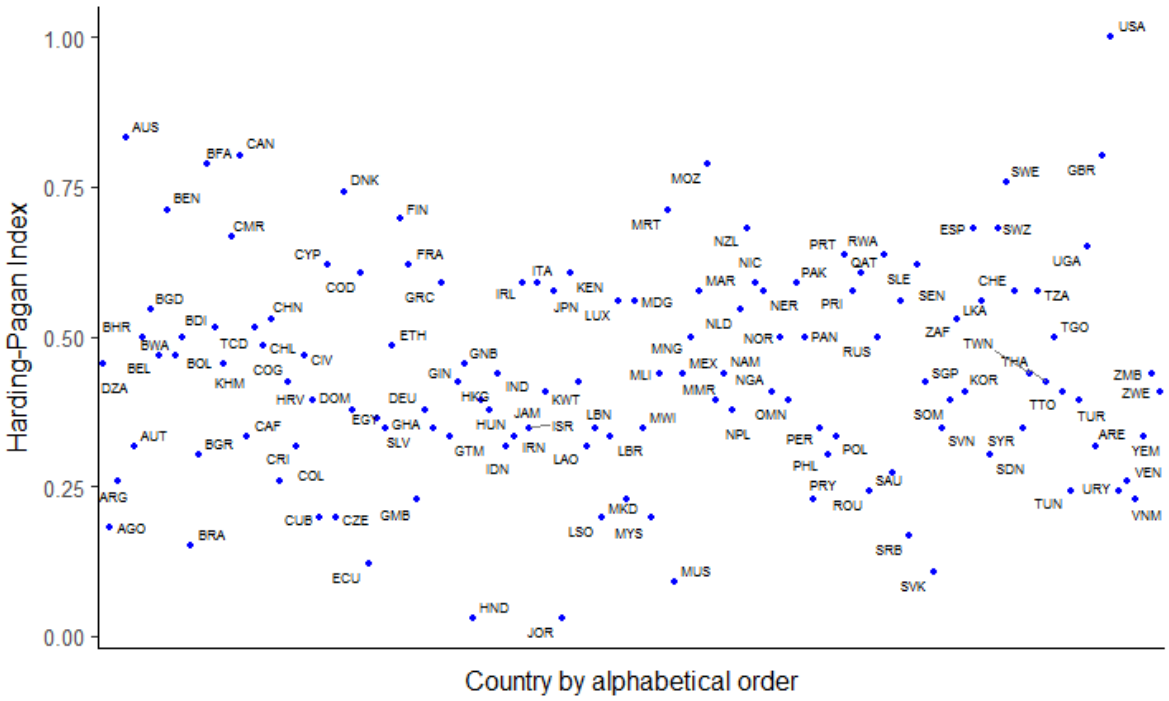

Figure 11. Country's concordance of the Kuznets Cycle related to the USA
Source: Author's own and Maddison Project Database

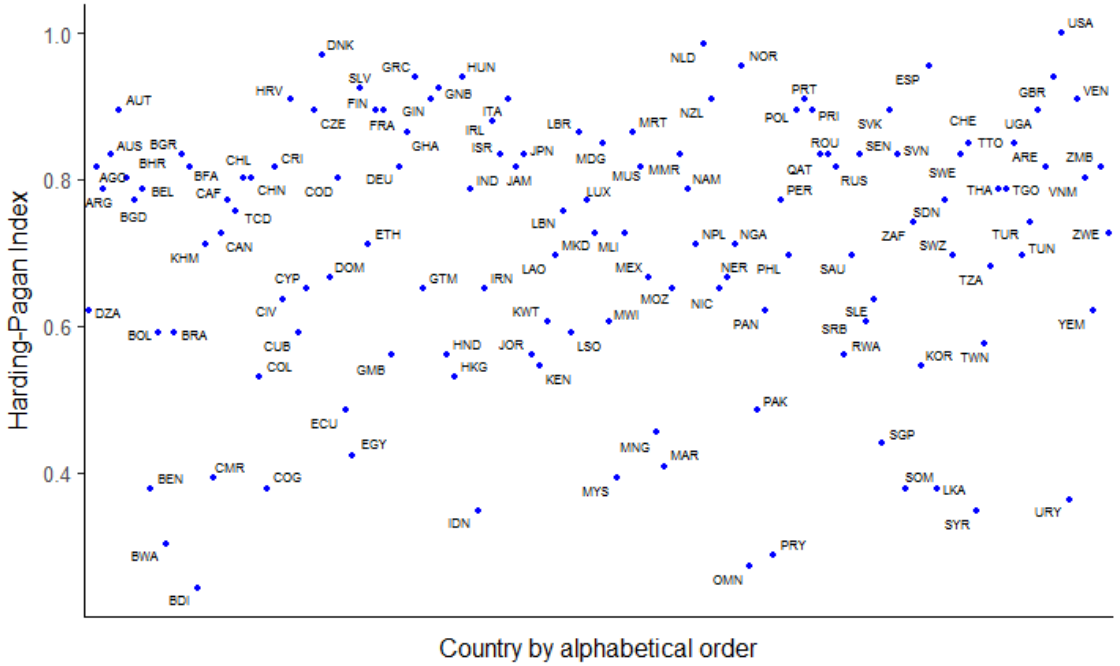

Figure 12. Country's concordance of the Kondratiev Cycles related to the USA
Source: Author's own and Maddison Project Database