BUSINESS CYCLES IN SMALL OPEN ECONOMIES: THE CASE OF COSTA RICI

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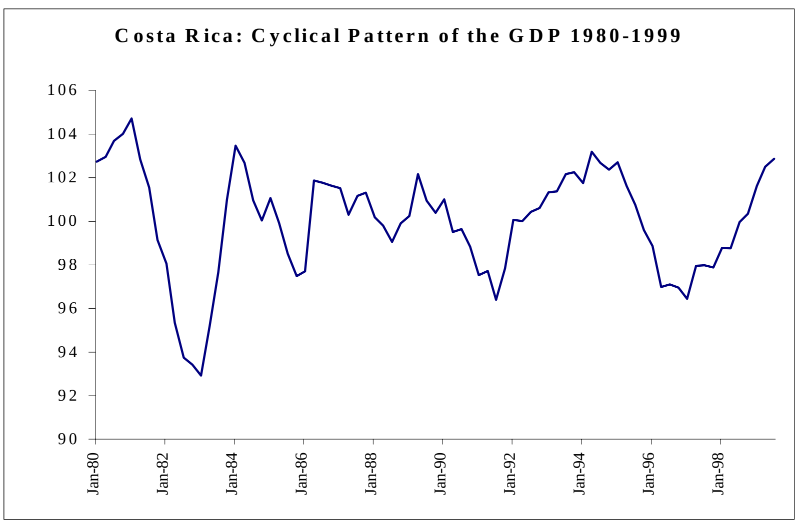
1. INTRODUCTION

Most schools of economic thought recognize that economies do not move linearly but in a persistent cyclical pattern that combines periods of high and low levels of activity. The analysis of the nature, causes and consequences of such expansions and contractions is the main objective of the theory of the **Business Cycles** (BC). Business Cycles can be very helpful for applied economic policy and for private sector decisions. Among other uses, they provide tools *to forecast* the short-run behavior of the economy, *to evaluate* the outcomes of certain policy decisions in different markets or *to assess* the application of policies according to the phase of the cycle. In spite of its policy usefulness, BCs have been poorly investigated in developing countries. It is only until recently that some analysts (Agenor et al, 1999, for instance) have attempted to study the statistical properties of such cycles. However, the economic interpretation of these fluctuations still remains a mystery.

The situation in Costa Rica is not different. Authors like Azofeifa et al (1995) have shown that this small economy experiences cyclical fluctuations in its key macro variables (as in the GDP, see graph below) with statistical properties that resemble those ones described by the BC theory. Many questions, yet, remain still unanswered. Do these macroeconomic movements represent a BC, or are they merely random fluctuations? If they constitute a BC, what is its cause? It is these type of questions that the following research paper attempt to address.



Source: Author's calculation

Specifically, the paper aims to consider if the macroeconomic fluctuations of the Costa Rican economy correspond to a BC and, if they do, what the causes and origins of this BC might be. The paper found that *Costa Rica effectively experiences a BC that is mainly caused by variations in investment. Such changes in investment are highly, but not exclusively, conditioned by the dynamics of the USA economy, that channels its impulses through variations in exports and interest rates.*

The research has both a theoretical and an empirical approach. First, it extends the traditional Keynesian theory of BC to the case of Less Developed Countries (LDCs). Then, it makes use of certain econometric tools (ARIMA models, Cointegration and VAR models) to identify, measure and establish the causes and impulses of BCs in Costa Rica. In this course, the paper follows a 3-step model that describes the process going from impulses to the dynamics of the BC.

The paper is structured as follows. Chapter two deal with the theoretical framework. There, we will discuss the concept and measurement of BC, its causes according to three schools of thought (Keynesian, Monetarists and Real Business Cycle) and the role of the external sector in LDCs fluctuations. Chapter three provides an overview of the structure and dynamics of the Costa Rican economy between 1980 and 1999. Chapter four is devoted to the empirical measurement and identification of the BC as well as its causes. Chapter five evaluates the origin of the impulses, which is mainly centered in the links with the USA economy. Finally, chapter six summarizes the main findings and highlights some policy recommendations.

2. THEORETICAL FRAMEWORK

2.1. Introduction

This chapter comprises the theoretical framework of the paper, and it aims to look at the literature on BC in order to understand the criteria adopted to identify, to measure and to determine the causes of the cycles in developing countries. As mentioned before, few efforts have been made to incorporate the LDCs reality into this world of BCs, although any attempt in that direction does not imply the emergence of a new BC theory. However, their particular conditions (small, open and developing economies) suggest the inclusion of analytical factors not traditionally covered by the different approaches, such as the role of exports, the exchange rate, or the importance of trading partners.

The chapter is structured as follows. Section 2.2 provides the basic tools to understand business cycles. Then, in section 2.3 we discuss the causes and dynamics of BC according to three schools of economic thought, the Keynesian, the Monetarists and the Real Business Cycle. Section 2.4 analyzes BCs in the context of developing countries. Finally, section 2.5 is devoted to conclusions.

2.2. Identifying Business Cycles: Process, Concept and Measurement.

2.2.1. BCs, the Process: a brief approximation.

This section describes the way in which we approach the dynamics of a BC, from the origin of the impulses to their consolidation as a cyclical pattern. Figure 2.1 shows a 3-step sequence to analyze them; in short, the origin of the cycle is found in an initial impulse (1); this generates the response of a variable(s), called cause(s) (2), that finally trigger the cycle (3).

Figure 2.1. BC sequence

Initial Impulse	→	**Variable X (cause/condition)**	→	**Business Cycles**
1		**2**		**3**

An impulse is the originating force, the element that begins the movements of the BCs, and they come from either real, monetary or psychological factors. As established by Hansen, "*impulses mainly operate through variations in the expectations of profits*"[1] (1951: 363).

The initial impulse is propagated throughout the economy via several routes, the so-called **channels of transmission**, the most important being demand and costs changes. The impact of this impulse is heavily conditioned by the magnitude of the impulse and the way the economy responds to such variations. Weak impulses, of course, will not provide much of a stimulus and, thus, will have no effect on the cycle. But, even if the impulse is big, we need an adequate response of certain key variables that have the potential to generate cycles. Provided that impulses basically operate on *expectations of profits*, investment becomes the key variable (the '**cause**') that gives rise to the cycle. This is the background

[1] An impulse is also a 'cause' in the sense that it precedes the evolution of the cycle; however, the literature prefers to distinguish impulses from those variables that finally trigger the BC.

of the paper. In the following three sections we expand on the above. The rest of section 2.2 deals with how to identify a BC (step 3). Then, section 2.3 the chapter moves on to discuss the causes and dynamics of the cycle according to some economic schools (step 2), while segment 2.4 discusses the origin of the impulses in LDCs (step 1).

2.2.2 The Nature and Characteristics of Business Cycles.

Many concepts appear to define BCs, but practically all explain the same idea. Hence, few controversies have risen around this issue. Burns and Mitchell's definition of the BC is usually regarded as the standard concept

> "Business Cycles are a type of fluctuations found in the aggregate economic activity of nations that organize their work mainly in business enterprises: a cycle consists of expansions occurring at about the same time in many economic activities, followed by similarly general recessions, contractions, and revivals which merge into the expansion phase of the next cycle; this sequence of changes is recurrent but not periodic; in duration, business cycles vary from more than one year to ten or twelve years; they are not divisible into shorter cycles of similar character with amplitudes approximating their own". *(1946: 3)*

Lucas (1977) says that BCs are the **recurrent** deviations and **serially correlated** movements in the GDP around its long-term trend. Similarly, Dornbusch et al identify them as "the more or less **regular** pattern of expansion (recovery) and contraction (recession) in economic activity around the path of trend growth" (1998: 12) (bold is ours). Finally, for Haberler, "the business cycles …may be defined as an alternation of periods of prosperity and depression …" (1946: 264).

Burns and Mitchell's definition clearly delineates the main characteristics of BCs. First, BCs are a *type of regular fluctuations in aggregate economic activity*: This feature is key because it implies that **not all the fluctuations observed in an economy are BCs.** A country's economy can also oscillate because of random, isolated circumstances (like a war), that may drive the economy up and down without a consistent pattern of behavior. *The main characteristic of a BC that needs noting here is the presence of a set of factors that **regularly** pushes the economy into cyclical movements.* This is, precisely, what makes BCs so special and useful for policy purposes. Second, BCs are fluctuations in the aggregate economic activity, so it includes not only output but prices, money and employment. Third, they are phenomena exclusively pertaining to *capitalist economies* (Sherman, 1987). Fourth, BCs are movements occurring *at about the same time in many economic activities*.

This characteristic is commonly known as **comovement,** and we will comment on this in 2.2.3. Fifth, c*ycles are recurrent but not periodic*. This means that the pattern expansion-contraction-expansion repeats continually, but the extension and severity of the fluctuations are not always the same. Finally, *business cycles vary in duration from one year to ten or twelve years.* These limits are, however, not accepted by everybody, as we will see in 2.2.2.

In summary, there are four primary features required to identify a BC: a certain duration, regularity in the events, comovement among macroeconomic aggregates, and recurrence of cycles and stages.

2.2.3. Identifying and Measuring Business Cycles.

Most attempts to identify and measure BCs pass through an understanding of the cycle' s phases, being the GDP the traditional reference cycle. It is generally agreed that a typical BC has four phases: the **expansion** or **upswing**, the **peak** or **crest**, the **contraction** or **downswing** and the **trough** or **valley** (Hansen, 1951, Mitchell, 1954). The expansion corresponds to a situation in which the economy experiences relatively high and increasing rates of real GDP growth (segment AB, figure 2.2). Then, at the peak, the economy reaches its highest level of production before it begins a slowdown (point B, figure 2.2). This stage is also referred as the upper turning point of the cycle. The third phase, the contractionary one, is characterized by a continuous de-acceleration in the rate of growth of the economy and thus, by decreasing increments in the levels of output (figure 2.2, segment BC). Finally, the trough is the bottom part of the cycle, the lower turning point (figure 2.2, points A or C). It is commonly known as recession[2].

[2] A recession can be either a situation when output grows at negative rates or when the economy is growing at rates that are lower than the long-run, natural rate.

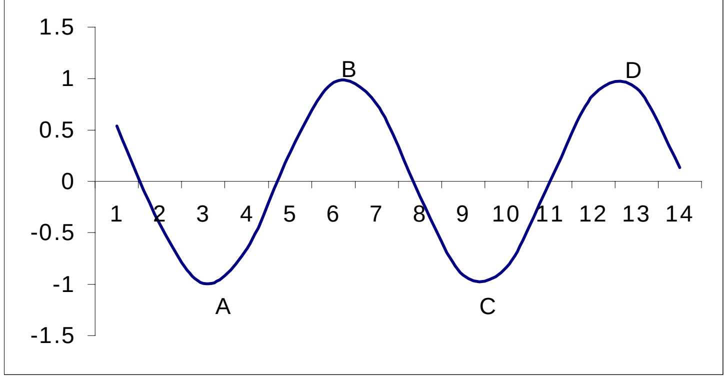


Figure 2.2
A Typical Business Cycle Sequence

In this context, it is generally agreed that, to constitute a cycle, they must display certain extension or duration and persistence. The characteristic of ‘extension’ means that a complete cycle, from trough to trough (AC) or from peak to peak (BD), must be minimally one year in duration (Burns and Mitchell, 1946). Anything that lasts less than that is considered a random fluctuation. Other authors (Hodrick and Prescott, 1980, Pedersen, 1998), however, see the range as lying between 15 months and 6-8 years. On the other hand, the characteristic of persistence means that the expansionary and contractionary phases of the cycle should last for several consecutive quarters (Hall, 1990), minimally two quarters each. Persistence is measured by the **expansionary** (trough to peak) and **contractionary** (peak to trough) **amplitudes** in quarters (Sherman and Kolk, 1996). Indeed, this is the reason why cycles must be at least one year in duration.

In addition to extension and persistence, analysts also identify and measure BCs by using the concepts of comovement and volatility. As mentioned in section 2.2.2, BCs are not events exclusively characterized by movements in output but also in prices, employment, money and many other macroeconomic aggregates (hence, we talk in terms of **BC phenomena**, as pointed by Prescott, 1986). This ‘cyclical massive pattern’ is the basis of the concept of comovement.

Comovement means that the cyclical pattern observed in many productive sectors and macro aggregates is *more or less contemporaneous* to the fluctuations in output (Chrystal, 1983). That is, in a BC, the peaks and troughs of all the relevant variables occur at roughly the same time with respect to one another. Comovement analysis is typically made from two perspectives: *time and direction*. According to *time*, the variables can be

leading, **coincident** or **lagging series**. Leading variables are those whose turning points change before the reference variable. Similarly, coincident variables move at the same time as GDP, and lagging ones shift after the reference cycle (Sherman and Kolk, 1996). In terms of *direction*, they can be **procyclical**, **countercyclical** or **acyclical**. If the variable moves in the same direction as the reference cycle, it is said to be procyclical[3], as is the case of the GDP components (real investment, private consumption, etc). On the other hand, if the movement goes in the opposite direction respect GDP, the variable is countercyclical as, for example, in the case of the nominal interest rate. Finally, acyclical variables move without any specific pattern.

The other characteristic stressed by many authors is **volatility**, a measure of the degree of instability presented in a variable, or, in other words, of "the tendency of a variable to fluctuate" (IADB, 1995: 193). A high level of volatility, compared to the one presented in a reference variable, is seen as an indication of the strength of a series to generate cycles.

These two characteristics are vital not only to identify a BC but also to evaluate causality. A typical "causal" variable shows a leading, procyclical, and highly volatile behavior. However, one must consider some caveats. One is that, individually, none of the indicators can be taken as an enough proof of causality; other elements, like the theoretical support, are required to identify causes. The second issue is that a highly volatile variable cannot be associated immediately with causality unless it also presents a cyclical pattern.

2.3. Business Cycles Theories: Causes and Sequences.

Currently, there are three competing explanations of BC phenomena. These are the Keynesian, the Monetarist and the Real Business Cycle (RBC). In this section we will consider each of them in terms of their explanation of fundamental causes and dynamics of the BC, indicating also what is seen as their major limitations[4].

[3] That is, if it rises during expansions and falls during contractions.

[4] For a detailed review of BC theories see Haberler (1946), Zarnowitz (1985), Hall (1990) or Sherman and Kolk (1996).

2.3.1 Keynesian Theory

In the Keynesian tradition, "**investment** and nothing else is the source of changes in output and employment" (Estey, 1950: 296). Although other GDP components like exports and consumption[5] may also affect the level of output, *only investment is capable of moving the economy into cyclical patterns through changes in all the rest of macro variables*.

It is clear that, to understand BCs, it is necessary to comprehend the nature of investment. According to Kalecki, the decision to invest is determined by profits, or more explicitly, by current and future **expectations** of the level of profits[6]. Expectations can be affected by several factors. Mitchell (1913) mentions selling prices, prices of inputs, volume of sales and availability of currency or credit as the most important. In an attempt to simplify the analysis, one can classify these factors into two groups, **cost** and **demand changes**. In relation to costs, reductions in nominal interest rates, nominal wages or in the price of intermediate inputs influence positively investment, so we expect a countercyclical behavior in these variables with respect to investment and, therefore, output. In respect to the second, a higher demand (either domestic or foreign) increases the volume of sales and thus, profits, hence encouraging investment. Changes in real consumption or real exports can be considered in this case.

At the bottom of the cycle, a decrease in costs, an increase in demand, or both, stimulate investment. This initial response in investment shifts up employment and, consequently, the level of consumption, pushing the economy into the expansionary phase[7]. Movements in investment and consumption increase the demand of all type of goods. According to the Keynesian theory, **capital** and **intermediate** goods move first because investment moves first. After a lag, the demand for **final consumption** goods also rises, being consequent with the lagged behavior of consumption. This sequence is manifest also in the different imports categories.

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[5] Consumption, for instance, depends on the level of income, so it either lags or coincides GDP; this situation does not suggests any causal relation.

[6] This point is in agreement with Marx's idea of why the economy is cyclical; in some sense, Kalecki's contributions group Marxist and Keynesian tools in an unified theory.

[7] This is known as the multiplier effect, that is, the original increment in investment will generate a more-than-proportional effect in output because more investment and consumption are also stimulated.

Within the monetary sector, **real credit i**s the main variable. Near the bottom of the cycle, negative expectations and the accumulation of inventories induce a reduced demand for credit, hence there is an excess of it in the economy. Later, when the economy begins growing, and the level of stocks decreases, credit acts as the lubricant that permits the continuity of the expansionary process.

As expansion continues, prices rise, and this stimulates workers to ask for higher (nominal) wages. Eventually rising costs cause a turn around in expectations, pushing the economy into the downswing. During the contractionary phase, the levels of unemployment increase, while prices, consumption, wages and nominal interest rates go down. Near the bottom, the decline in costs and the appearance of new business opportunities (due, in part, to less competition), create the conditions to initiate a new upswing; a new cycle begins.

The sequence of facts in the downswing is practically the same as in the upswing except for one point: at the peak of the cycle, *investment lags GDP changes*. This important aspect is explained by two factors: the sluggish response of the expectations to changes in the environment and the cycle of capital goods. First, the perception that things are going wrong is not immediate, so the entrepreneurs continue investing even though the economy is effectively slowing[8]. Second, because of their physical properties, capital goods (i.e machines) have longer cycles, so when the economy turns down capital goods demand decreases only with a lag.

The Keynesian theory is not without its critics. Perhaps the most important criticism is in terms of turning points. Specifically, there is a problem in explaining why, in a context of increasing prices and growing output, private expectations change and drive the economy into a downswing. This missing link, for instance, is explained by the Marxists school on the grounds of the decreasing rate of profit capitalist firms experience.

2.3.2 Monetarist Theory

For the Monetarist approach, "changes in the flow of money are the sole and sufficient cause of changes in economic activity" (Hawtrey, quoted by Haberler, 1946: 15).

[8] This is, in essence, the argument of the Accelerator Principle: investment reacts according to the changes in output, lagged one or two period. In other words, changes output precedes changes in investment.

Here, money plays an active role, and thus, BCs are seen as a "purely monetary phenomenon" in which random money shocks cause variations in effective demand and they in the whole economy (Hall, 1990, Chrystal, 1986).

The foundation of the Monetarist analysis is the Quantity Theory of Money. The approach contends that any change in the level of money will increase, in the short run, prices and output. Algebraically, it is illustrate by the equation

$$\mathbf{MV=PQ}$$

Where M is the money stock, V is the velocity of money, P the price level and Q is real output.

The initial impulse of the cycle is given by a change in the money stock, either bank credit or currency (Friedman and Schwartz, 1966, Estey, 1950), due to, for instance, an expansionary monetary policy. The increment of the money stock generates two effects that push the economy into the expansionary phase. First, people experience an excess of liquidity in their hands[9] and decide to get rid of that excess by increasing their demand of both financial assets and final goods. As a result, consumption increases and the interest rates decreases. Second, the decline in the interest rate and the higher demand for final goods create favorable expectations to invest: aggregate demand increases and more labor is demanded.

According to Monetarists, the evolution of the cycle is very similar to the one explained by Keynesians. However, there is a major difference in the way the expansion reaches its peak. In the Monetarist context, such a situation is explained by the real balance mechanism. When people begin spending their nominal balances, prices rise and real money balances fall to equilibrium levels, forcing people to stop spending. This situation decelerates the dynamics of the aggregate demand and therefore, of the economy.

The Monetary theory has been criticized on a number of grounds. Perhaps the most important critique is that, for the Monetarists, the money supply shocks are *randomly generated*. This is a major weakness because it means that the theory does not have an explanation of *recurrent* BCs, that is, of why cycles repeat one after the other in a regular pattern. A second, less important criticism is on the direction of the causality Money-

[9] In the Monetarist tradition, the demand for money is stable.

Prices/Output (Greenwald and Stiglitz, 1988). As mentioned by Haberler (1932), it is equally possible that the impulse may come from money to production/prices through a deliberate expansion of credit, or from production to money, in which an increase in the volume of output draws into circulation a greater amount of means of payment, as in the Keynesian framework.

2.3.3. Real Business Cycle Theory.

The Real Business Cycle theory is the New Classical explanation of why output fluctuates. In this approach, **technological shocks to productivity** are the regular, consistent cause of the business cycle (Prescott, 1986, King and Rebelo,1999).

The RBC explanation is founded on two pillars: preferences in relation to consumption/leisure explaining the dynamics of the labor market, and technological change in the context of the neoclassical growth model. In the case of preferences, the RBC models assume that the population is composed by identical individuals who maximize their utility function

$$\mathbf{U = \Sigma\, \beta t\, u\, (Ct, Lt), \qquad \beta<1.}$$

U stands for utility, C is consumption, L is leisure and β is the discount factor (substitution parameter). Changes in real wages or real interest rates will affect the opportunity cost of labor and/or leisure, forcing individuals to adjust their C/L decisions in a search for a new equilibrium point. In respect of production, the models assume an economy in a steady state condition[10]. Following King et al (1988), this can be modeled as a Cobb Douglas function of the type

$$\mathbf{Q = A * \mathit{f}(NX, K)}$$

where K is the capital stock, N is the labor input and A is the level of technology (Solow residual). Changes in A, the level of technology (and, thus, in productivity), are the only way to make the economy fluctuate given that it is in a steady state condition.

The RBC explanation is relatively simple. As a result of a positive technological shock, productivity of labor goes up and thus, output. More production entails a higher demand for capital goods and labor. Consequently, investment, real wages and consump

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[10] In a steady state condition, labor and capital grows at rate zero.

tion go up. Higher wages make individuals supply more labor (opportunity cost of leisure increases), increasing the levels of employment in the economy. The expansionary phase becomes weaker once the original technological shock is expanded throughout the firms; in any moment, the economy experiences a negative shock that drives the economy to the contractionary stage, repeating the same sequence as in the upswing.

Despite its popularity over the last 20 years, this approach has been the subject of many attacks and there is a considerable skepticism regarding its power to describe BC dynamics[11]. The core of the criticism is on the explanation that technological shocks cause BCs. First, as in the Monetarist approach, the theory has problems in explaining why technological changes are large enough, recurrent and cyclical. As part of this, some other critiques have appeared. Blanchard (2000), for instance, argues that the RBC cannot explain the downswing of the cycle appropriately. If expansions are explained by positive technological shocks, contractions are the result of negative technical shocks, a very improbable situation. In a similar line, Hartley et al mention that "new technologies take decades rather than quarters to spread through the economy" (1997: 45), so the impact of a the technical change is seen only over the long run. Finally, the consideration that all cycles are alike (Lucas, 1977) contradicts the empirical evidence on the extension of BCs and the presence of deviations from the regular pattern.

2.3.4. Business Cycles Theories: an assessment.

All BCs theories agree that BCs are cumulative processes in which investment plays a key role (or, in other words, the economy experiences a **cycle of investment).** The difference between them arises with its location. For Keynesians, investment is **the cause** of the cycle, while for Monetarists and RBC theories it is an intermediate variable that respond to a previous force (i.e. money or technological shock). Also, all the approaches coincide that **aggregate demand components** (investment, consumption, etc) and costs are procyclical to GDP, although there are some discrepancies in terms of the time-response of the latter. Besides, there is some disagreement between the theories regarding which cost variables are relevant for BCs analysis. Keynesians consider nominal variables

[11] See Blanchard, (2000), Sachs and Larrain, (1993), Mankiw (1989), and Summers (1986) for more positions

(the nominal interest rate for instance), while the RBC stresses the importance of real variables (real interest rate, for example).

For the purposes of this paper, the Keynesian approach is the best to understand BCs, specially in LDCs, as we will discuss later. First, because it is the only theory that provides an explanation of the causes and dynamics of BCs as recurrent phenomena. Second, the empirical and practical experiences confirm the idea that investment is the main cause of cyclical variations in the economy. Finally, given that impulses mainly affect expectations (and thus, investment), the Keynesian theory provides a link to understand how impulses are propagated in the economy.

2.4. Business Cycles and Small, Open Economies.

The final section of the theoretical chapter is devoted to discussing how the literature has incorporated the 'small and open' dimension that characterizes the countries we are dealing with. We are interested in discussing two issues: the 'new' literature of BCs in LDCs, and the role of the external dimension in the dynamics of their cycles.

2.4.1. What is a small, open economy?

In the literature of BCs, the group of 'small, open economies' comprises every country in the world except USA. Given the heterogeneity of its composition, we propose the following categorization. One group corresponds to all those studies in which the main objective is to document the empirical regularities of small economies cycles. The works of Backus and Kehoe (1992), Ahmed (1999) for Latin America, Agenor et al (1999) for a group of Latin, Asian and African countries and Kose and Reizman (1999) for Africa, are some examples. The second group analyzes single cases. This one can be split, at the same time, into two. Firstly, studies that analyze fluctuations in small, open and **industrialized** countries. Under this category we can find the papers of Mendoza (1991) for Canada, de Roos and Russell (1996) for Australia, and Danthine and Girardin (1989) for Switzerland. Secondly, papers dealing with small, open and **semi-industrialized (developing)** economies. This group, the smallest in terms of number of researches, comprises the works of Kamil and Lorenzo (1998) for Uruguay and Bergoeing and Suarez (1998) for Chile, among others. This last group is our focus of attention.

In this paper, a ' small, open economy'[12] is a country with the following characteristics:

- A high dependence on international trade and external capital inflows (money and Foreign Direct Investment).
- Higher vulnerability to external shocks and a more unstable economy (respect closer ones).
- It has a price-dependent condition (**small economy principle**), which means that foreign prices, inflation, interest rates, and demands are exogenously given (Muellbauer, 1997).
- Poor development of the financial system and technological backwardness. The financial system lacks an adequate stock market or a competitive banking system. Also, the poor technological development entails low productivity levels and a high import dependence.
- High participation of the Public Sector in the GDP (Gaba et al, 1993): the role of the government is not only in terms of ' policy maker' but also as consumer and investor, so it is capable to influence output.

2.4.2 Small open economies and the BCs literature.

The literature on cyclical fluctuations in LDCs is relatively new, scarce, and limited to certain topics. In terms of the 3-step sequence of figure 2.1, one notices that most papers has been devoted to studying step 3 (the characteristics of the cycles), leaving steps 2 (causes) and 3 (impulses) as secondary elements. Besides, the statistical dimension has tended to rule over the economic interpretation, such that it is now impossible to integrate the three links and the two dimensions in a single work.

This situation casts doubts on the validity of the general conclusions reached by these studies. In general, the most important conclusions are that LDCs experience BCs similar to those in developed countries (Kydland and Zarazaga, 1997) and that the sources of such fluctuations are either *aggregate demand or aggregate supply shifts* (Hoffmaister

[12] From here onwards, in this paper, small open economies, semi-industrialized and less developed countries are synonyms, otherwise is said.

et al, 1998). This does not mean that the studies are without use; the statistical approach is a key starting point for identifying the existence of cycles. Nevertheless, it tells half of the story. We require more that this, an economic interpretation of such processes, to help us to understand if cycles in LDCs are really different from those in industrialized economies. The following chapters are an attempt to develop such an interpretation.

2.4.3 The International Dimension and BCs in small, open economies.

From section 2.4.1 we know that the external sector plays a key role in shaping the dynamics of small, open economies. In the context of BC analysis, the former implies that the origin of BCs in LDCs can be understood as impulses emanating from developed countries that condition the evolution of the cycle, mainly its turning points. In other words, LDCs cycles cannot be seen as purely endogenous processes.

The international dimension can impact small economies by two means; one is via variations in the relations with important trading and financial partners, and the second is throughout random events like Oil crises. For the analysis of BCs, the first variations are the important ones because they are persistent over time.

Impulses coming from big trading/financial partners are typically propagated in the small country via two **mechanisms of transmission**, the trade and the financial channels (IMF, 1998, Iguíñiz and Aguilar, 1998, Schmitt-Grohe, 1998). The trade channel mainly deals with alterations of the small country' s **exports (demand factor)**, while the financial mechanism is via variations in the **domestic interest rate (cost factor)** as a result of changes in the world interest rate.

In the commercial channel, shifts in the big country' s demand for imports affect the small economy exports, altering the GDP level and the expectations of private agents. The first outcome is straightforward: as a component of the GDP, any shift in exports will move output in the same direction. Expectations are also influenced because exports, as the most dynamic sector in LDC economies, represent the possibility of selling in bigger markets and in a more stable currency. Effectively, the small size of LDCs domestic markets[13] limits the continuous expansion of output. This obliges countries to look outside and trade, making exports the engine of growth for these economies. As such, they significantly influence the behavior of investors, who will react positively when the economy expects higher levels of external sales.

The financial channel basically works in a context of **no capital controls** and comprises movements in the domestic interest rate (NIR) and adjustments in the (expected) rate of devaluation (END) due to changes in the world interest rate (WIR). With no controls, domestic and external financial assets are substitutes, and the NIR corresponds to

NIR= WIR + END[14]

The former means that movements in the international rate alter the returns (in foreign currency, i.e. dollars) on domestic assets, forcing the internal rate to move in the same direction. If the expected devaluation/appreciation is kept unaltered, the NIR must change in a proportional way as the change in WIR; if not, both NIR and NER adjust to maintain the premium at the same level as before.

The trade channel is expected to generate a greater effect in the economy than the financial one because it goes directly to output. However, one can anticipate the financial link to be absorbed faster by the country given that changes in the productive sector takes longer time to be incorporated.

2.5. Final Remarks.

In this chapter we have indicated how BCs are identified. To identify a BC, a cyclical pattern must pass two tests: a **statistical one** (extension, persistence, comovement, and volatility) and an **economic one** (sequence of facts that follow the description of a determined theoretical approach). Then, we discussed on the causes of BCs according to three schools of economic thought. Our major conclusion was that the Keynesian theory has the best characteristics to understand BCs, specially in the context of LDCs. Finally, we extended the analysis to the small open economies in order to understand the origin of its impulses. We concluded that cyclical variations in these economies are highly conditioned by the impulses coming from trading partners. External impulses are channeled via trade and financial flows, which generate variations in the levels of demand and internal costs. These variations modify entrepreneurial expectations and investment decisions that finally give

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[13] Small in terms of their purchasing power, and, in some cases, the number of consumers.
[14] This is called the 'uncovered interest parity'; due to an inherent risk, this equation may not hold exactly.

rise to recurrent cycles.

3. COSTA RICA: STRUCTURE AND DYNAMICS OF A SMALL, OPEN ECONOMY 1980-1999

3.1. Introduction

The objective of this chapter is to study the economic structure and the macroeconomic performance of Costa Rica between 1980 and 1999. In the first case, the chapter will show that the growth of this country is highly dependent on the exports dynamism. Then, the analysis will demonstrate that the most relevant macroeconomic variables grow in cyclical patterns that resemble the characteristics of BCs. The chapter finishes with some remarks.

3.2. The Structure of the Costa Rican Economy: the last 20 years.

Costa Rica is a small country with a population of 3.5 million inhabitants and an income per capita of about $3,000. For the past 20 years, its economic structure has experienced changes in the final destination of output but not in its composition. According to the productive sector (table 3.1), the last two decades show practically no changes in the aggregate production structure of the economy. Although during the first half of the 20th century agriculture contributed more than 40% of GDP, currently its share does not exceed 20%, with a continuous tendency to decline over time. On the other hand, the industrial sector accounts for between 25% and 30% of GDP, while services take the largest portion of output with almost 55% of the total. In this group, the commercial activities generate 30% of GDP, more than half the total participation of Services, while other minor activities are the General Government (10%) and Transport (8%).

Table 3.1
Costa Rica: Participation of the Productive Sectors in the GDP
1980-1999

Sector	1980	1985	1990	1995	1999
Agriculture	18.0	19.2	19.3	18.7	17.1
Industry*	28.2	26.4	25.6	25.5	29.5
Services	53.8	54.4	55.1	55.8	53.4

Source: Ministry of Planning web page.

Important changes are observed in the composition of the aggregate demand. Table 3.2 shows the results. The most striking conclusion one can derive is the amazing change in the participation of exports. While in 1980 they represented 24.7%, by 1999 its share increased to 47.6%, that is, 1.9 times higher. In the same line, private consumption and government expenditure remain as the most affected items in terms of participation. In the first case, by 1999, its share fell by 30%, while in the case of the public sector, the decline was higher (40%). Investment was the less affected component with a 25% loss in total participation.

Table 3.2
Costa Rica: Composition of Aggregate Demand
1980-1999

Sector	1980	1985	1990	1995	1999
Private Consumption	45.8	46.7	41.3	37.4	33.2
Government Expenditure*	9.4	9.2	7.6	6.3	5.6
Investment	20.2	15.6	16.3	15.4	13.6
Exports	24.7	28.6	34.9	40.9	47.6
Total	100	100	100	100	100

* Corresponds to the final consumption of the General Government.
Source: Ministry of Planning web page.

The former results present a polarized situation. On one hand the economy presents a highly dynamic sector (exports) that becomes the engine of Costa Rica's growth. This great evolution of external sales is the result of the Export Promotion strategy applied in the mid-80s. The new trade policy included the provision of several incentives and a more flexible exchange rate regime (mini-devaluation) that is continually adjusted in order to avoid an overvaluation[15]. Besides, the dynamism of exports has created an even more out-wardly oriented economy; while in 1983-86 the openness coefficient[16] was 57%, in 1995-98 the ratio was 97% of GDP (Lizano and Zuniga, 1999). On the other side, there is a weak domestic demand that was in many cases stagnated (i.e. 1996 or 1999). The application of stabilization programs to control government expenditures and real wages is typically seen as responsible for such low dynamics.

[15] In fact, since 1983, the exchange rate has been continually devaluated by the Central Bank, either weekly of daily.
[16] Openness is measured by the equation (Exports+Imports+Tourism)/GDP.

3.3 The Performance of the Costa Rican Economy: Growth and Volatility.

This section analyzes the performance of the main Costa Rican macro variables with the aim to show that their growth rates move cyclically and that they also show properties that resemble the existence of a BC in this economy.

3.3.1 The Aggregate Demand Sector

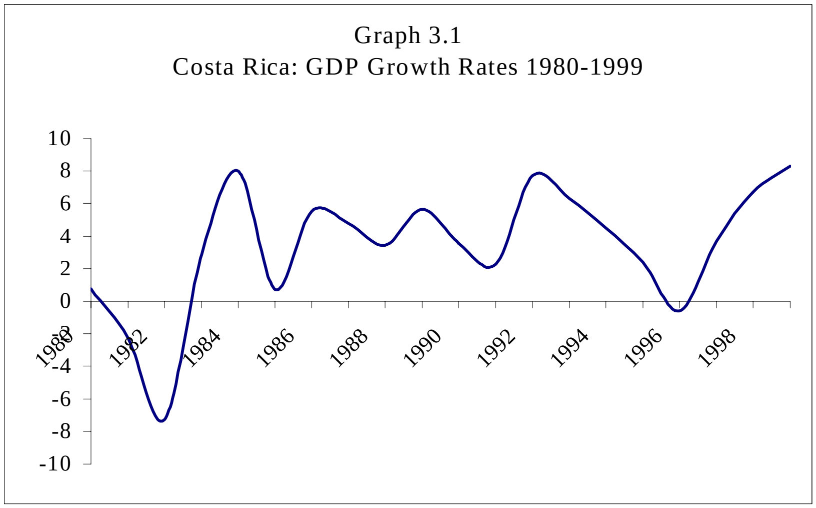
This segment comprises 4 variables, shown in table 3.3. In terms of growth, GDP presents an average rate of 3.3% per year, although this result is strongly influenced by the negative rates of the 1981-82 critical period. If we only consider 1985-1999, the rate is 4.3%, being practically the same for the sub-periods 1985-1992 (4.2%) and 1993-99 (4.5%).

Table 3.3
Real Sector Indicators
1980-1999

	Average Growth Rate	Volatility	Volatility Respect GDP	Correlation Coefficient with GDP
GDP	3.3	3.8	1.0	1.0
Consumption	2.1	4.8	1.2	0.8
Investment	4.1	15.6	4.1	0.8
Exports	7.4	6.9	1.8	0.6

Source: Own calculations based on Vargas and Saenz (1994), MIDEPLAN web page and IMF (1999).

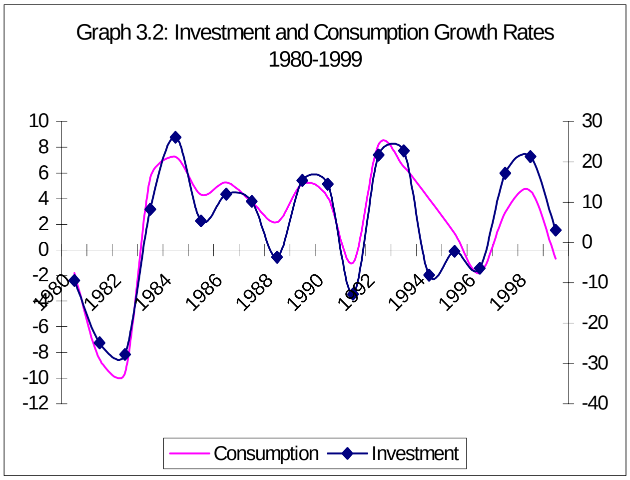
Despite the apparent uniformity in the pattern of growth, graph 3.1 shows that the economy moves in an up-an-down behavior in which it is possible to find relative well-defined peaks that approximate a cyclical pattern. Although the periods between one peak and the other are not periodic (same length), the movement is persistent over time.

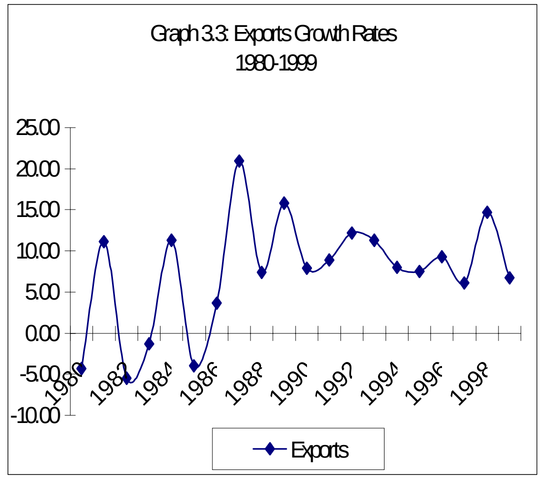


Source: Own elaboration based on Vargas and Saenz (1994), MIDEPLAN web page

GDP volatility is 3.8, slightly superior to the average rate of growth, but if we eliminate 1981-82, it falls to 2.5, an economy less stable by 35%. One can say that Costa Rica is a relatively stable economy compared to Latin America, one of the most unstable regions (IADB, 1995, Hausmann and Gavin, 1996).

Exports were the most dynamic variable of all with an average growth rate that was 3.5 times greater the one of consumption and 1.8 times the one of investment. However, they all share the fact that they move in a cyclical pattern (graphs 3.2 and 3.3) close to the one observed in the GDP, hence their high correlation coefficients. In terms of volatility, investment and consumption behave as it was theoretically expected: a high variability in the first one (4.1) and a moderately low instability (1.2) in the second one.





Source: Author' s elaboration based on Vargas and Saenz (1994) and MIDEPLAN web page.

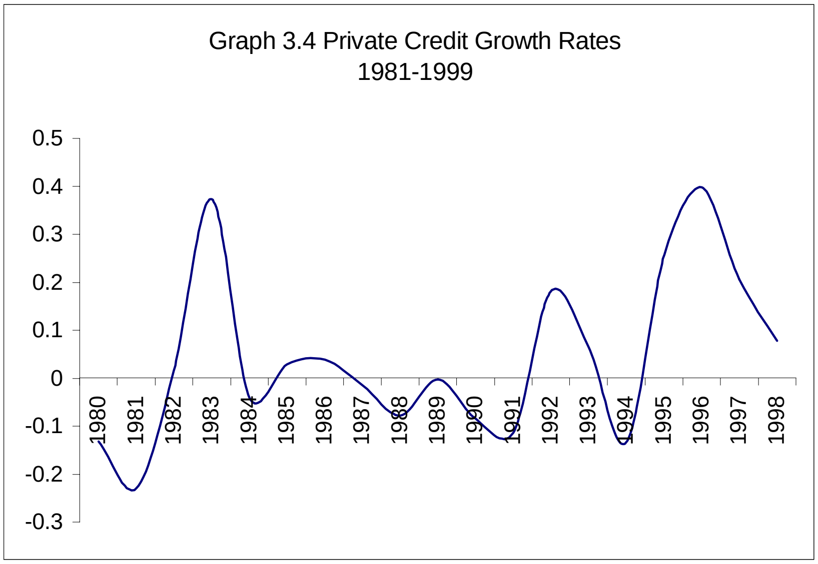
3.3.2. The Monetary Sector: real credit.

Within the monetary sector we will concentrate exclusively in **private real credit**, the most important Keynesian variable in this market. Following table 3.4, real credit experienced both rates of growth (4.3) and volatility coefficients (4.5) similar to the ones in investment, suggesting a close evolution of that variable with respect to investment. In terms of correlation with GDP, credit presents a moderate one, although it also follows a cyclical pattern (graph 3.4). When we correlate it with investment, the coefficient increases to 0.56, reinforcing our previous idea that credit is mainly driven by this variable.

Table 3.4
Credit Indicators
1980-1999

	Average Growth Rate	Volatility	Volatility Respect GDP	Correlation
Real Credit	4.3	16.7	4.4	0.45

Source: Own calculations based on Vargas and Saenz (1994) and FMI, several issues.



Source: Own calculations based on Vargas and Saenz (1994), MIDEPLAN web page

3.3.3. Prices

Finally, we analyze inflation, devaluation and the interest rate as the key prices in our analysis. According to the results of table 3.5, the first two presented a similar situation: rates of growth of about 21% per year and very high relative volatility coefficients of 4.7 and 8.1, respectively. However, again, this instability is due to the 1980-82 crisis period[17]; if we eliminate them, the average rates drop to 15 and 13% per year respectively, with a relative volatility of 1.8 for inflation and 2.7 for devaluation.

The correlation coefficients between GDP and inflation/devaluation present two important characteristics. First, both variables tend to move very similar to GDP (0.8 and 0.7, respectively), a high result given that they are non-productive variables. Secondly, they are *contemporaneously countercyclical* (graphs 3.5 and 3.6), instead of the procyclical behavior claimed by the Keynesians. This result, however, can change if we add some lags, but this will be discussed in chapter four.

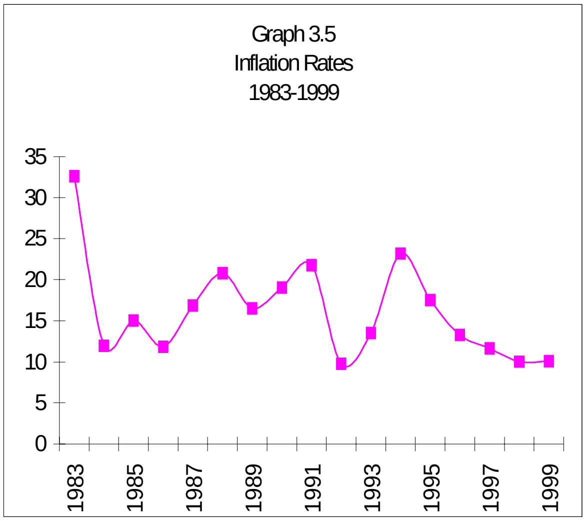
[17] For instance, inflation rates were 37% and 91% in 1981 and 1982.

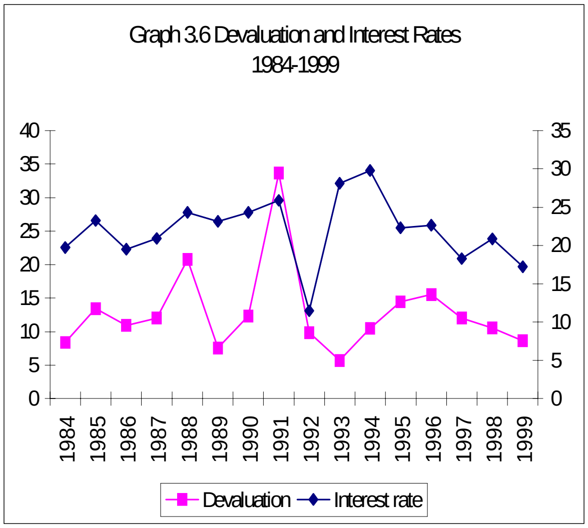
Table 3.5
Prices Indicators
1980-1999

	Average Growth Rate	Volatility	Volatility Respect GDP	Correlation
Inflation	21.0	17.8	4.7	-0.8
Devaluation	21.2	30.8	8.1	-0.7
Int. Rate	6.1	3.8	1.0	-0.5

Source: Own calculations based on Vargas and Saenz (1994) and MIDEPLAN web page.

The performance of the nominal interest rate is evaluated separately. In general, this variable is as volatile as GDP, its movements are moderately close to GDP and it behaves countercyclically. However, the important feature to highlight here is the relation between the interest and the devaluation rates. Following graph 3.6 we can see that, before the 1990s both variables move practically in different ways, but after 1991 their correlation becomes stronger. The explanation behind this is the openness of the Capital Account in 1991. The liberalization of this account created a direct link between the world and the domestic interest rates. Any change in the international rate is followed now by adjustments in the nominal rate and an acceleration of the rate of devaluation with the aim to keep constant the returns on domestic assets.





Source: Vargas and Saenz (1994) and MIDEPLAN web page.

3.4. Final Remarks

This chapter reviews the structure and performance of the Costa Rican economy between 1980 and 1999. In the first case, it is clear that exports became progressively the most important and dynamic activity in such a way that they practically condition the growth of the entire economy. In relation to its performance, the chapter shows that the Costa Rican macro variables move persistently in cyclical waves, resembling several of the characteristics of BCs. This last situation opens the discussion for the following chapters. One is whether those cyclical patterns correspond to a BC. The other is in relation to what causes those variations. These are the following tasks. In chapter 4 we will deal with the identification of the BC and its causes, while in chapter five we will investigate the origin of its impulses.

4. EMPIRICAL IDENTIFICATION AND MEASUREMENT OF THE BUSINESS CYCLE

4.1 Introduction.

The objective of this chapter is to identify the existence of a BC in Costa Rica as well as its major causes. Although this step corresponds to the last link of our 3-step model (chapter 2), given the situation of the BC analysis in Costa Rica, one cannot discuss the causes and impulses of the cycle without previously identifying its existence. For this reason, we begin with step 3. To identify a BC we impose two restrictions. The first one is the **statistical condition** (section 4.2), in which the main macro variables are tested in terms of extension, persistence, comovement and volatility. The second restriction is the **economic condition** (section 4.3), where we analyze if the sequence showed by the Costa Rican cycle follows the Keynesian explanation of BCs.

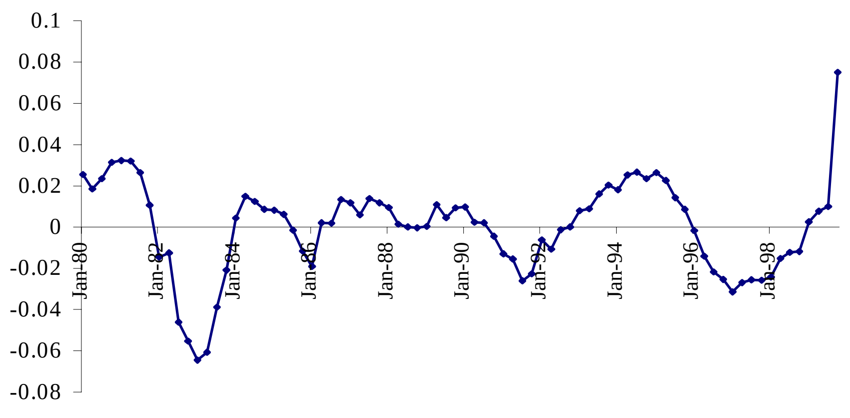
4.2. Statistical Identification of the Cycle.

This section describes the statistical properties of the GDP and some [theoretically] relevant variables in terms of extension, persistence, comovement and volatility. A previous step before measuring these properties was the estimation of the cyclical component of each macroeconomic series by applying the ARIMA Model Based Approach[18]. Once the cycles were isolated, the correspondent coefficients were calculated.

4.2.1 Extension and Persistence

Graph 4.1 presents the cyclical pattern of the real GDP between the first quarter of 1980 (I-1980) and the fourth quarter of 1999 (IV-1999)[19]. As it is expected, cycles are not regular, periodic movements; they differ considerable in terms of shape, extension of their fluctuations and intensity of the peaks and troughs. For instance, two periods, 1980-1984 and 1989-1999, exhibit longer, deeper troughs and well-shaped cycles, that those ones between 1984 and 1989.

Graph 4.1
Costa Rica: GDP Cycle I-80: IV-99



Source: Author' s own elaboration.

To measure the cycles we must identify the turning points in GDP. To get better results, the turning points were estimated by considering both the dates of the GDP and the Monthly Index of Economic Activity (IMAE, in Spanish[20]), specially because the 1999 GDP data was still preliminary. Table 4.1 summarizes these dates. On average, cycles last **14.4 quarters** (around 3.6 years) if the measure is made from peak to peak and **14.2** (3.5 years) if the cycle goes from trough to trough. However, these means are not homogenous, as we mentioned above.

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[18] See annex 1 for a methodological description of the approach and annex 3 for the results of the ARIMA models.
[19] For a test of the robustness of the cycle by using a different detrending method, see annex 2.
[20] The IMAE is a composite, Laspeyres-type index where the most important economic activities are weighted according to their participation in the generation of value-added.

Table 4.1
Estimated Dates of GDP Cycle Turning Points
1980-1999

Peaks	Duration from Peak to Peak*	Troughs	Duration from Trough to Trough*
Apr-81		Jan-83	
	13		11
Jul-84		Jan-86	
	8		10
Oct-86		Oct-88	
	13		11
Jan-90		Jul-91	
	17		21
Apr-94		Jan-97	
	20		-
Apr-99**		-	

* In quarters.
** Turning point according to the Monthly Index of Economic Activity.
Source: Author's calculations.

From peak to peak, the longest cycle has 20 quarters, while the two shortest have only 8 quarters. The cycles of the nineties are longer than those ones in the eighties: 18.5 quarters versus 11.3 quarters. A particularly unstable period was the mid-eighties (1983-1989), when the cycles only lasted 10.5 quarters (2.5 years) each. From trough to trough the results did not change significantly. The longest cycle has an extension of 21 quarters (5.25 years) in the nineties while the shortest only lasted 10, practically the same results of the peak-to-peak measurement. In conclusion, *the Costa Rican GDP cycle has an average extension that is longer than the minimum posted by Burns and Mitchell (1 year, or 4 quarters), and in that way it passes the first requirement to be a BC.*

The second condition is related to persistence, that is, the continuation of each stage to last several quarters (at least 2). Persistence is estimated by using the expansionary (peak to trough) and contractionary (trough to peak) amplitudes, and the results are shown in tables 4.2 and 4.3. Both phases always last more than 2 quarters (the minimum bound), with the expansionary phase tending to be just longer than the contractionary one (7.4 versus 7 quarters). As with extension, this condition is also fulfilled by the Costa Rican cycle.

Table 4.2
Expansionary Amplitudes (in quarters)
I:1980-IV:1999

Peaks	Troughs	Amplitude
Apr-81	Jan-83	7
Jul-84	Jan-86	6
Oct-86	Oct-88	8
Jan-90	Jul-91	5
Apr-94	Jan-97	11

Table 4.3
Contractionary Amplitudes (in quarters)
I:1980-IV:1999

Troughs	Peaks	Amplitude
Jan-83	Jul-84	6
Jan-86	Oct-86	4
Oct-88	Jan-90	5
Jul-91	Apr-94	11
Jan-97	Apr-99	9

Source: Author' s own calculations.

4.2.2 Comovement and Volatility[21].

This section considers the two other statistical aspects to identify BCs, comovement and relative volatility. The section focuses exclusively on those variables that are relevant for BCs analysis, according to the Keynesian school and in the context of small, open economies.

We start by studying the Aggregate Demand (AD) components, whose results are in table 4.4. With respect to **real private consumption**, the same is procyclical and leads GDP by one lag (0.78). However, this leading behavior is not constant, and in half of its turning points, consumption is coincident with GDP shifts, as the theory predicts. Despite its strong correlation and its average leading pattern, consumption rarely can be the cause of the cycle. First, it shows a relatively low volatility (1.47), that is, it does not suggest a strong erratic pattern that may affect the stability of the GDP. The other problem deals with the way consumption is computed. In National Accounting, this variable is calculated as a *residual* after deducting the other AD components[22]; this severely limits our analysis. Finally, consumption mainly depends on income, so a previous shift in the GDP (coming, for instance, from investment) is needed to modify the former.

[21] See annex 4 for a summary of the graphs showing the cyclical movements of the main macro variables.

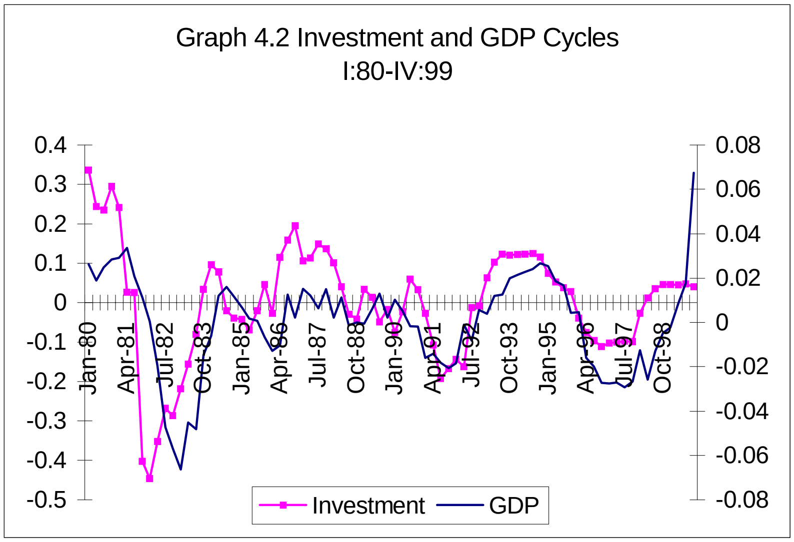
Table 4.4
Costa Rica: Aggregate Demand Components
MAIN INDICATORS

		Correlation Coefficients										
Variable	**Volat.**	-5	-4	-3	-2	-1	**0**	1	2	3	4	5
Consumption	**1.47**	0.29	0.49	0.66	0.76	0.78	**0.69**	0.52	0.31	0.09	-0.11	-0.26
Investment	**5.11**	0.41	0.59	0.72	0.75	0.72	**0.63**	0.42	0.21	0.02	-0.14	-0.23
Public Exp.	**1.16**	0.23	0.34	0.45	0.53	0.60	**0.60**	0.49	0.35	0.21	0.05	-0.09
Exports	**4.90**	0.02	0.28	0.51	0.67	0.70	**0.60**	0.49	0.24	0.01	-0.21	-0.38
Imports	**3.80**	0.44	0.64	0.75	0.75	0.67	**0.51**	0.31	0.07	-0.15	-0.32	-0.42

Critical values at α = 5%: (-0.22, 0.22) and at α = 1%: (-0.29, 0.29).
Source: Author' s calculations.

Real investment, our most important variable, presents a completely different situation. Investment procyclically leads GDP by 2 quarters and has an average correlation coefficient of 0.75 at lag –2. Besides, its relative volatility is 5.1, the highest among the AD components. Both results, its high volatility and its leading behavior, strongly suggest that investment causes Costa Rican cycles[23].

The time-shifting pattern of investment is also not homogeneous. During expansions, investment **leads** output by 2 quarters, while its general tendency is to **lag** GDP during the contractions by one period (see graph 4.2). This behavior follows the Keynesian explanation of how investment moves within the cycle, and becomes part of the evidence to prove the causal link we are analyzing.



Source: Own elaboration

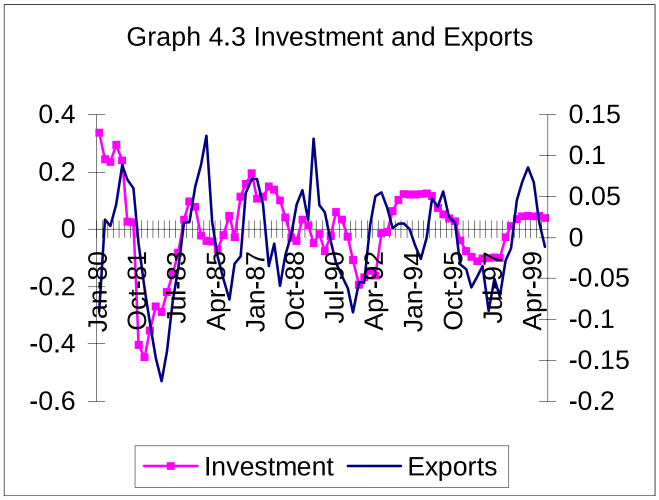
[22] Retail sales can be more useful, but they were not available for Costa Rica.
[23] Similar results can be observed in the works Backus and Kehoe (1992) and Bergoeing and Suarez (1998).

In relation to **real government expenditure**, although it also has a strong link with output (0.6), but tends to coincide GDP and has a low volatility coefficient (1.16), showing not enough properties to be the cause of the cycle. Public expenses, however, seem to be important to explain the upper GDP turning points because they usually lead the reference cycle by 1-2 quarters. The chronic high fiscal deficit (more than 2.5-3% of GDP) limits the use of government expenditures to trigger the economic activity, and, for that reason, we cannot consider them as causing the cycle. Nevertheless, when inflationary pressures arise (near the peak), the expenditures are cut to reduce such problems. A decrease in public expenses cools down the economy by reducing aggregate demand and by affecting the expectations of investors.

The characteristics found in **real exports (in dollars)**[24] also point toward them as a key factor in explaining GDP cycles. Exports present a strong procyclical comovement with output (0.70), leading GDP by 2 quarters at the trough (coincident at the peak) and having the second highest volatility coefficient, 4.9 times more unstable than output. These results and the fact that exports determine the growth rate of the GDP suggest a close link among them and investment. First, as the main determinant of output growth, it is clear that what happens in exports affect the decisions of investors on whether invest or not. Second, statistically, their similar volatility coefficients and their 2-quarter leading shift at the trough are evidence that changes in exports drive movements in investment (graph 4.3).

Despite the former, exports cannot be taken as the main cause of the cycle. Although this variable represents an important source of dynamism of the GDP, it is only through its link with investment that its impulses are channeled in the form of BCs. That is, *if any shift in exports is not followed by a correspondent response in investment, output surely will increase but the rest of macro aggregates would not as the BC theory requires*. In the final instance, investment is responsible of such massive cyclical movements.

[24] We consider exports in dollars because they represent the possibility for the investor to increase its earnings in a stronger currency, creating an extra incentive.



Source: Author' s own elaboration

Real imports are the last productive variable. As the other AD series, they move procyclically (0.5), leading the GDP by 2-3 quarters with a strong 0.75 correlation coefficient and a relative volatility of 3.8, slightly lower than exports but still high. At both phases, they lead the reference cycle, but they cannot be considered causes of the cycle. Imports mainly reflect the overall dynamics of the GDP, in particular movements in investment and consumption.

The importance of imports can be traced in the sequence followed by their different components, say, intermediate inputs and final goods. Table 4.5 shows the correlation coefficients of the different import categories with respect to GDP. As theoretically expected, capital goods and intermediate inputs shift first, around 2-3 quarters before GDP while final goods tend to coincide with output. This sequence, as explained by the Keynesians, is a faithful image of our previous results where investment always shifts first than consumption.

Table 4.5
Imports Cycles
I: 1989-IV: 1999

		Correlation Coefficients										
Variable	Volat.	-5	-4	-3	-2	-1	0	1	2	3	4	5
Intermediate Inputs	1.33	0.25	0.36	0.40	0.40	0.36	**0.28**	0.28	0.18	0.08	-0.03	-0.12
Capital Goods	6.40	0.43	0.40	0.37	0.29	0.18	**0.07**	-0.03	-0.18	-0.33	-0.44	-0.50
Final Goods	7.36	0.13	0.28	0.32	0.37	0.45	**0.56**	0.50	0.48	0.37	0.22	0.10

Source: Author' s calculations.

Within the monetary sector, **real private credit** is the key variable. Credit presents all the characteristics necessary to be among the causes of the cycle: procyclical with a contemporaneous correlation coefficient of 0.72. It leads the GDP by one lag with one of the highest values we calculated: 0.8. In terms of volatility, it is also a highly variable aggregate with a value of 4.9.

The correlation of private credit and investment is even higher (0.83), being credit a lagging variable. This close link is important for two reasons. One is that the high volatility coefficient of credit is easily explained by the proximity of its movements to investment ones. The other is that the credit' s lagging behavior weakens the possibility that monetary aggregates are the cause of the Costa Rican cycle, so investment is still considered as the key variable.

Table 4.6
CREDIT COEFFICIENTS

		Correlation Coefficients										
Variable	**Volat.**	-5	-4	-3	-2	-1	**0**	1	2	3	4	5
Real Credit.	**4.87**	0.25	0.49	0.69	0.79	0.80	**0.72**	0.56	0.35	0.12	-0.10	-0.29

Critical values at α = 5%: (-0.22, 0.22) and at α = 1%: (-0.29, 0.29).
Source: Author' s calculations.

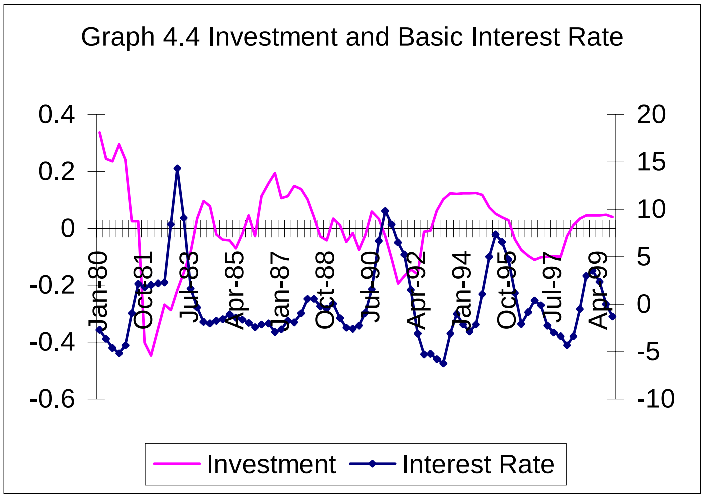
Our third and final block of variables deals with **costs and prices** and includes the nominal interest rate -NIR-, the nominal exchange rate -NER-, nominal and real wages and the consumer price index (table 4.7). These variables are not directly the causes of the cycle, but they hold a significant influence on investment decisions, hence their importance in the analysis.

Table 4.7
COSTS AND PRICES COEFFICIENTS

		Correlation Coefficients										
Variable	**Volat.**	-5	-4	-3	-2	-1	**0**	1	2	3	4	5
Nom. Interest Rate	**1.75**	-0.23	-0.29	-0.37	-0.44	-0.46	**-0.42**	-0.28	-0.11	0.07	0.21	0.31
Nom. Wages	**2.8**	0.36	0.18	-0.05	-0.30	-0.51	**-0.65**	-0.69	-0.68	-0.59	-0.46	-0.29
Real Wages	**1.63**	0.43	0.59	0.68	0.67	0.56	**0.39**	0.19	-0.02	-0.20	-0.33	-0.40
NER	**0.79**	-0.02	-0.21	-0.38	-0.50	-0.59	**-0.62**	-0.53	-0.41	-0.27	-0.12	0.01
Consumer Prices	**3.24**	0.09	-0.14	-0.38	-0.58	-0.70	**-0.75**	-0.69	-0.57	-0.42	-0.24	-0.07
Rate of Inflation	**18.58**	-0.37	-0.53	-0.64	-0.68	-0.62	**-0.45**	-0.21	0.04	0.26	0.43	0.51

Critical values at α = 5%: (-0.22, 0.22) and at α = 1%: (-0.29, 0.29).
Source: Author' s calculations.

The **nominal interest rate** is countercyclical and comoves with GDP and investment at a moderate -0.46 in both cases. At the trough, the NIR tends to lead output by 3 quarters, while at the peak this gap is reduced to 1 or 2 periods. The relation with investment reflects that the NIR is the most important cost in inducing investment changes. At the trough of the cycles, the interest rate is the only one that leads investment' s behavior, normally by 1 quarter. None of the other costs, wages and exchange rate, has this leading pattern.



Source: Author' s own elaboration

Wages are studied in both nominal and real terms[25]. Nominal wages are also countercyclical and lag the GDP by 1-2 quarters (-0.69), with a volatility coefficient of 2.8. Given that nominal wages are adjusted according to past inflation (a variable that also lags GDP), it is quite understandable why they have this lagging behavior. Real wages have a low volatility (1.6) and lags investment by 1-2 periods at the bottom of the cycle. The low volatility is the result of the stable path followed by nominal wages, as described above. In relation to lagging link with investment, real wages appear as an important cost not in conditioning investment turning points but in affecting its dynamics once the revival has appeared.

The **nominal exchange rate** (NER) is, with respect to GDP, a highly countercyclical and coincident (-0.62) variable with a low relative volatility (0.72), being the most stable cost. This variable is very important for investment for three main reasons. One is that it impacts the price of imported inputs, and this is particularly important for a country where they represent 50% of

[25] For Keynesians, nominal wages are the reference variable for workers, but for investors real wages are the key.

the GDP. The other is via movements in the NIR, as we discussed in section 2.4.3. Finally, a currency depreciation stimulates exports, with the consequent effects on investment. Despite this multiple role of the NER, it tends to lag or coincide with investment at the trough of the cycles, suggesting that it cannot be taken as causing investment shifts.

Finally, **consumer prices** are countercyclically correlated (-0.75) with output, something that in appearance contradicts the Keynesian prediction[26] of procyclical prices. However, such a contradiction disappears if we allow for a lagged response. As shown in table 4.7, the inflation rate[27] is **positively** correlated with output 3 quarters after GDP begins expanding. This lagging response of prices is also presented in cost variables, although at different moments.

In summary, the comovement results show that the NIR is the most important cost in inducing shifts in investment because is the only variable that leads its behavior. Certainly the other costs influence investment, but its transition from the downswing to the upswing is mainly due to reductions in the NIR.

The preceding section has completed our statistical identification of the Costa Rican cycle. First, the most relevant macroeconomic variables comove with the GDP and in the same direction predicted by the Keynesian school. Second, the characteristics of investment point to it as the cause of the cycle. Finally, investment's shifts are strongly influenced by movements in exports (demand-factor) and in the NIR (cost factor).

4.3. Economic Characterization of the Cycle.

This section analyzes the second condition imposed to identify a BC, the economic one. The aim is to evaluate if the empirical regularities found in the Costa Rican cycle follow the Keynesian explanation of BCs. The reader must be aware that the following is a general description of the cycle without any intention to be a point by point analysis of the dynamics of the same.

In the Keynesian school, given an initial impulse, investment shifts and triggers the upswing of the cycle. Because of that, employment increases and, consequently, the level of consumption. The joint effect of investment and consumption generates two additional increments,

[26] This results coincide with the conclusions of recent studies (Backus and Kehoe, 1992, Serletis and Krause, 1996, Kydland and Prescott, 1990) where prices move negatively respect output in many countries.
[27] There is some debate on whether one may use the price level or the inflation rate. See Serletis and Krauze (1996).

one in the level of imports and the other in the demand of credit. In relation to imports, Keynesians expect inputs to move firstly, while final consumption goods may respond later. Similarly, credit goes up and permits the continuity of the upswing by providing additional productive resources. The continuous expansion of output, employment and credit increases consumer prices, wages and interest rates, although they react with a lag. However, cost variables like the NIR are expected to be contemporaneously countercyclical because their decreases stimulate investment.

During the downswing, the succession of events is practically the same as the previous stage. When GDP falls, employment and therefore consumption go down, impacting negatively the demand of credit and imports. Prices continue rising for some quarters until the decreasing demand reduces any pressure on them. With respect to the revival, the only difference the Keynesians describe is the lagging behavior of investment, instead of the leading pattern at the trough. The late response of investors' expectations and the greater amplitude of capital goods are the main reasons for this special behavior. The contraction continues until the economy receives a new impulse that pushes investment into the revival.

4.3.1. The Upswing[28].

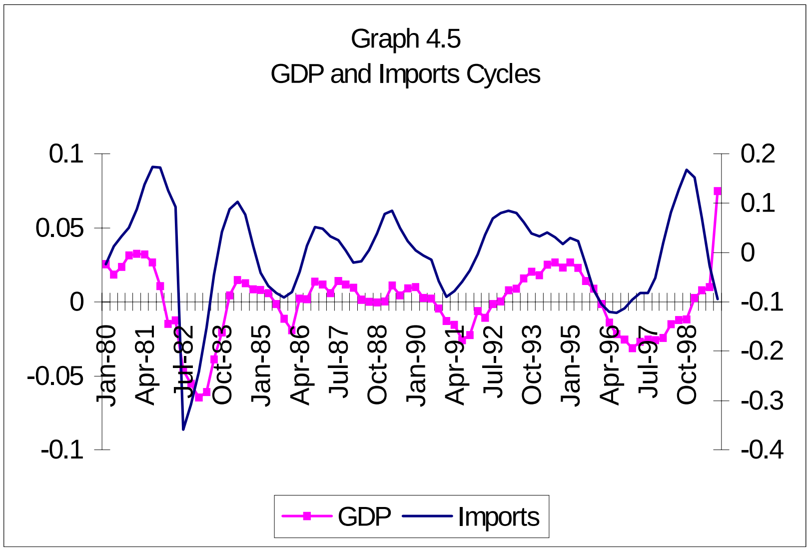
The beginning of the Costa Rican cycle is given by a change in investment. The statistical results showed that it presents all the characteristics depicted in section 2.2.3, say, a cyclical movement, a strong procyclical, leading behavior with respect to GDP (2 quarters) and the highest volatility coefficient. This initial shift, as we observed, is the result of a *cluster of events*, an increase in exports and a decrease in the NIR, both of which stimulate investment.

Changes in investment generate increases in consumption with a lag, generally one or two quarters after. Although we do not have the required data, such an increase may be due, at this stage, to increments in the level of employment, because we know that wages start growing 3 quarters after investment moves.

The combined effects of exports, investment and private consumption stimulate changes in imports and credit, as Keynesians predict. From our analysis of imports, we know that intermediate inputs and capital goods move 2 to 3 quarters before GDP, while final consumption goods coincide with output and lag private consumption by one period. This sequence is in line

[28] The results of the previous section are mainly averages; here, on the contrary, the analysis is made to what happens specifically at the trough/peak, and for that reason some dates (leads/lags) may change.

to what is happening in the economy, that is, the primary shift in investment and the correspondent increase in consumption. This sequence fits the Keynesian explanation, with the special addition that the final response of imports is more than proportional to the one in GDP, as seen in graph 4.5.



Source: Author' s own elaboration

Credit also responds positively to the increments in investment and consumption with a correlation coefficient of 0.86. Interestingly, near the trough, credit lags the shifts in GDP, while at the peak it usually leads. The lagging behavior can be explained by the fact that, at the bottom of the cycle, firms have accumulated stocks, so, when the economy begins expanding, firms reacts by selling their excess of inventories. After a period, when firms reach certain limits, supplementary resources are needed, either as working capital or as money for plant expansion. It is then that the demand for credit rises.

In relation to cost variables, one year after GDP shifts, the NIR begins increasing simultaneously with an acceleration in the devaluation of the local currency. Both elements contribute to increases in consumer prices and, consequently, a rise in nominal wages. The increase in wages is, at the same time, pressured by the continuous demand for labor in a country with relatively low unemployment, just 4-5.5% of the working population- (Barahona et al, 1998). These results fit the Keynesians explanation in two ways. One is that costs, except real wages, are contemporaneously countercyclical (table 4.7), implying that reductions in any of them induces increments in output. The second issue is that all of them become procyclical with a lag, around 2 to 4 quarters after the GDP shifts.

The sequence of facts described in this section has shown that the stylized facts of the upswing fit, broadly speaking, the description made by the Keynesian school. In general, the initial change in investment generates the expected movements in consumption, imports, credit, prices and costs and in both timing and direction. The questions that still remain unanswered are basically on the factors that push the expansion to the end.

4.3.2. The Downswing

At the peak of the cycle, the cluster of events that drives the economy to the contractionary phase is somewhat different as it is at the bottom. Exports and government expenditures generally lead GDP peaks by 2 to 3 quarters. Inflation, restrictive credit and increasing interest rates reduce the competitiveness of firms, so those external sales weaken rapidly and impact negatively on the economy[29]. On the other side, fiscal expenditures decrease as part of the government efforts to stabilize the economy and avoid further increases in inflation rates. Consumption and credit are negatively affected by such outcomes and the economy begins decreasing almost immediately.

At this stage, the problems faced by exports and the increasing costs erode the profitability of firms, causing investment to fall. The reaction of investment, as we expected, is very different. At the top of the cycle, investment **lags** GDP, on average by one quarter, and this fully identifies the Costa Rican cycle with the Keynesian explanation. The fall in investment confirms the fact that the economy is in the downswing. After investment turns, all the variables, including imports and credit, fall.

Imports represent a special case because they only partially fit the Keynesian sequence. At the peak, given the lagging behavior of investment, the sequence goes in the other way, that is, final consumption goods shift first and inputs and capital goods change later. However, our results suggest that, while final goods and inputs behaved as expected, capital goods generally lead GDP changes, breaking the expected sequence.

As for prices, they still grow for several quarters after the contraction takes place, keeping their lagging behavior to GDP changes as it was theoretically expected. Consumer prices, for

[29] Of course, international conditions also affect their dynamics, but we just consider here domestic factors.

instance, go up for 2 or 3 more periods before they finally fall, while the NIR persists growing by 1 or 2 periods.

Some developments at the bottom take us back to the starting point of the upswing. Attempts to bring down the NIR are done at the time other variables of the economy, like exports, begin recovering. This combination provides the basis for a new cycle, given the positive reaction of investment.

4.4. Final Remarks

This chapter was oriented in identifying the existence and nature of the BC in Costa Rica. The identification of the BC had two parts: first, a statistical evaluation of the properties of 17 cycles, and second, an economic interpretation of the results. Statistically, we showed that the GDP cycle and a group of relevant macroeconomic variables fulfill the four theoretical conditions of extension, persistence, comovement and volatility. The results also indicated that investment is the driving force of the BC, with exports and the interest rate as key variables influencing its behavior.

The second part of the analysis showed that the sequence followed by those cycles accords the Keynesian understanding of the cycle. Of particular interest was the fact that investment leads GDP growth in the revival and lags it in the contraction. Similarly, the lagging upward behavior of prices and costs respect GDP constituted a second aspect that faithfully fitted the Keynesian description. Finally, the response of the different import categories to changes in the economy (first, capital goods and inputs, then final goods) reinforced the conclusion that the Costa Rican cycle is theoretically explained by the Keynesian school.

5. THE US ECONOMY, MAIN IMPULSE OF THE COSTA RICAN CYCLE

5.1. Introduction

In the previous chapter, investment appears as the cause of the Costa Rican BC. In addition, we showed that, at the trough, changes in investment are largely linked to movements in exports and the NIR. Besides, from chapter 2, we know that these two variables are externally determined **(the small economy principle)**, meaning that the impulses of the Costa Rican cycle mainly come from external factors.

For the case of Costa Rica, the chapter identifies the US economy as the *origin of such* *impulses.* This follows from two facts. One is that the US is Costa Rica's most important trading partner, so its weight in the small economy's GDP is quite high[30]. Second, it is widely acknowledged that movements in the US interest rates have an important impact of LDCs rates, particularly in those, like Costa Rica, whose currencies are linked to the US dollar.

The present chapter expands this primary idea. First, it describes the structural links between these two economies and the synchronization of their cycles. Then, it proceeds by measuring (using Cointegration and VAR models) the impact of US impulses and the mechanisms of transmission through which such impulses are propagated in the Costa Rican economy. The last section ends with a summary of the major findings.

5.2. Trade and Investment links between Costa Rican and US.

5.2.1 Trade

Trade relations are the strongest link of Costa Rica with the American economy. By 1970, one-third of the total Costa Rican trade was with the US, representing around 15% of Costa Rican GDP. In the last 15 years, commercial linkages have grown because both the share of trade in Costa Rican GDP and the importance of US in total exports have been increasing continuously (see table 5.1 –columns C and F- and graphs 5.1-5.2). Table 5.1 shows how the share of 'Exports to US' in GDP almost doubled between 1985 to 1999, going from 11.2% to 20.1% of GDP.

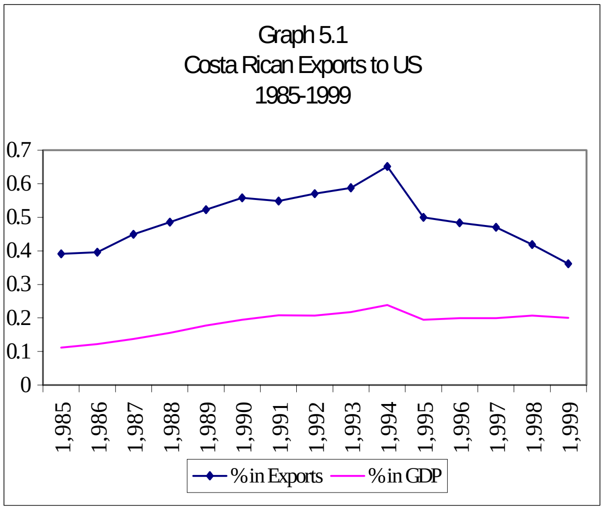
Table 5.1
Costa Rica: Trade with the US 1985-1999 selected years

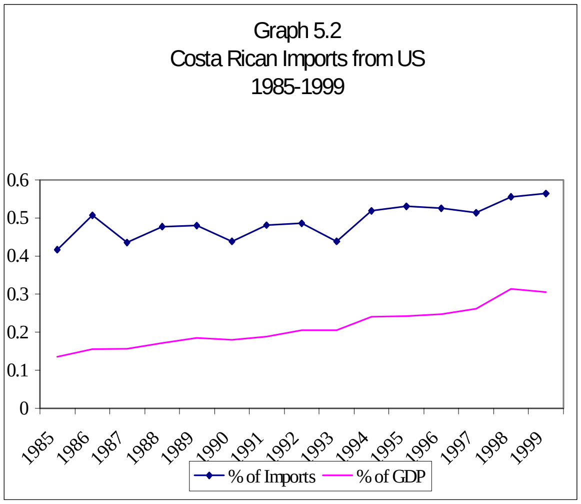
	Exports			Imports		
Year	A	B	C	D	E	F
1985	39.1%	28.6%	11.2%	41.7%	32.5%	13.6%
1988	48.5%	32.0%	15.5%	47.7%	35.8%	17.1%
1991	54.8%	38.0%	20.8%	48.1%	39.1%	18.8%
1994	65.1%	36.6%	23.8%	51.9%	46.4%	24.1%
1997	47.0%	42.3%	19.9%	51.4%	50.8%	26.1%
1999	36.2%	55.5%	20.1%	56.4%	54.0%	30.5%

Columns: A= exports to US; B= total exports in GDP; C= exports to US as % of GDP. For Columns D to F the same criteria apply but in relation to imports.

Source: Author's elaboration based on Vargas and Saenz (1994) and MIDEPLAN and US Census Bureau web pages.

[30] Remember, from chapter three, that exports currently represent more than 40% of Costa Rica's GDP.





Source: Author' s elaboration based on MIDEPLAN and US Census Bureau web pages.

Analytically, one can divide the evolution of exports to US in two periods. The first goes from 1985 to 1994 and is characterized by an increasing participation of US in total exports (from a 39% to 65%). In the second period (1994-1999) the share declined and represented 36% by 1999. During the first period, exports to this country showed an extraordinary dynamism with an average growth rate of 17.9% per year, while the mean rate in total exports was 11%. The share of exports to US in Costa Rica' s GDP went from 11.2% to 23.8%, that is, it more than double its participation.

As explained in chapter three, the good performance in exports is mainly the result of the **Export Promotion Program** applied since 1984. This strategy applied a set of incentives (the **Export Contract, Temporal Admission Regime** and the **Zonas Francas**[31]) to Non Traditional exports with the objective of expanding the export supply and the number of final markets. However, the US continued being the most important destination, as exemplified by the fact that 83% of the exports of the Zonas Francas regime went to that market (Pacheco, 1998).

In the second period (1994-99), exports to US grew at 7.9% per year, decelrating the dynamics of all the export sector (8.7% average rate). The share in GDP passed from 23.8% in 1994 to 20.1%, still a very high proportion. In this case, the sudden decrease can be explained by

[31] The three regimes established packages of incentives (direct subsidies, taxes exemptions, etc) to those firms that fulfill certain requirements, specially to export to Non-Traditional markets (including US).

the market diversification strategy of the mid-90s, the elimination of some incentives, and the barriers raised by US to some Costa Rican exports, specially textiles.

Imports from US also grow steadily, but without any break along the period (graph 5.2). The importance of USA went from 41.7% to 56.4% of total purchases, averaging 49% in these 15 years (column D, table 5.1). With respect to GDP, while in 1985 the American participation was 13.6%, by 1999 it increased to 30.5%, 2.2 times higher (column F). The strong connection with imports not only creates a strong dependency from inputs and capital goods but also establishes a direct link between Costa Rican and US prices. The former means that, between 1985 and 1999, the average participation of US in the Costa Rican GDP was 40%. Exports to US represented 49% of total exports (18.5% of GDP) and imports 49% of total imports (22% of GDP).

5.2.2 Foreign Direct Investment.

The participation of the US in the total Foreign Direct Investment -FDI- is also high. During the Industrialization period (1960-80), one third of foreign firms installed in Costa Rica belonged to American capital (Pacheco, 1998). After 1983, the upward tendency of the US investment continued given the elimination of restrictions to foreign capital and some FDI incentive programs, particularly in the 90s. A recent study of the Ministry of Foreign Trade of Costa Rica shows that in the last 15 years, 65% of the total accumulated FDI came from the US, 7.1 times the investment of all the European Community (COMEX, 2000). Provided that in that period the FDI averaged 3.2% of Costa Rican GDP, the US investment in Costa Rica represents 2% of total output. In terms of employment and total investment, the US FDI represents 74% of all FDI jobs (6% of Costa Rican employment), and 10% of total local investment. Interestingly, 60% of this FDI has been made in the Zonas Francas regime, the most dynamic export program of Costa Rica. Finally, by productive sector, the most important investments have been done in manufacturing activities (65%), while agriculture has received 20% and services 15% of the total. Within the industry, metallurgy, electronics and textiles are the most important branches with 44% of total US FDI.

5.3. The Synchronization of the Costa Rican and US Cycles

On the bases of the previous section, this segment analyzes the synchronization of the Costa Rican and US cycles. The close linkages among the two economies and the structural characteristics of the former nation constitute the framework to understand that the main impulses of the Costa Rican BC come from the US.

5.3.1 The Synchronization of GDPs Cycles.

Table 5.2 and graph 5.3 present the results of comovement among the two economies. Statistically, the results show that, in general, the Costa Rican economy tends to coincide (0.66) or lag (0.63) the US GDP by one quarter. At the trough, the USA economy always leads the Costa Rican GDP, while at the peak they generally coincide. The leading behavior of the US is an indication that the US causes variations in Costa Rica, a result supported by the highly significant result of the Granger Causality Test[32] (table 5.2).

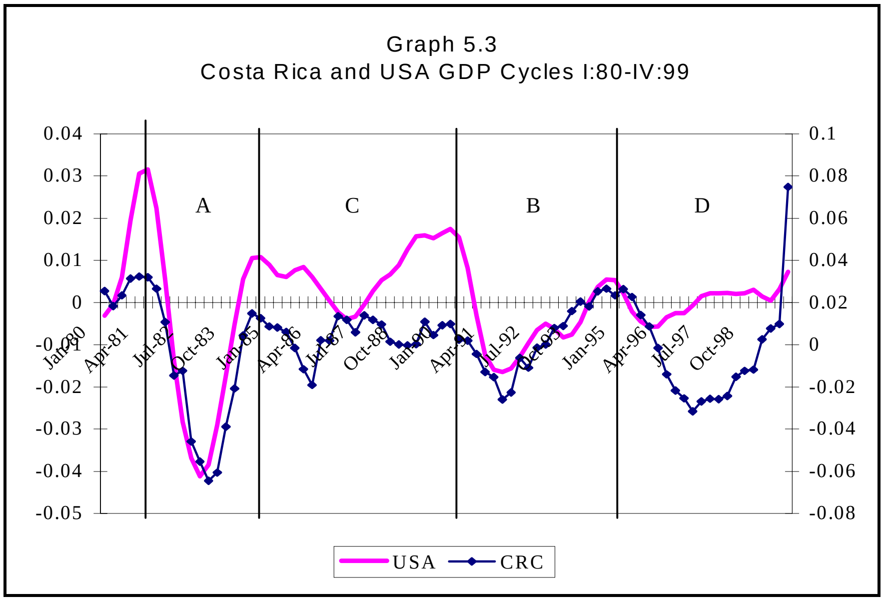
Table 5.2
Correlation Coefficients among USA and Costa Rica GDP I:80-IV:99

			Correlation Coefficients								
Variable	Volat.	GCT	-4	-3	-2	-1	0	1	2	3	4
USA GDP	0.59	6.6 (3.1)*	0.10	0.32	0.51	0.63	**0.66**	0.56	0.41	0.22	0.03

* F-Statistic
Source: Author' s own elaboration

The synchronization of the two cycles is better viewed following graph 5.3. For analytical purposes, we divided it into four segments according to the observed degree of correlation. Sections A and B (*moment 1*) are characterized by a strong comovement between the two economies, while sections C and D (*moment 2*) show a weaker association, being even negative during D.

[32] See annex 5 for a description of the test.



Source: Author's own elaboration

During Moment 1, the comovement is strong (0.9 for A and 0.6 for B) and it occurs exactly in the recession-immediate revival period of the US cycle. Segments A and B clearly show that Costa Rica practically 'copies' the movements of US, coinciding in both the contractionary and expansionary phases. The strong link, however, tends to be diluted as the cycle becomes 'older'. For instance, in C the correlation coefficient is 0.4, while in D it is -0.12. This aspect will be retaken in the following section. Up to here, the important conclusion is that the results show that there is a very strong correlation between the two economies, going the impulses (or the direction of the causality) from the large to the small economy.

5.3.2. The synchronization of Costa Rican GDP and Exports with USA Imports.

Chapters three and four showed that exports are the most dynamic sector in Costa Rica, and this impacts positively on investment because of the implications for future earnings. If we link these results with the data of section 5.2, it is clear that to understand Costa Rican exports dynamics we have to concentrate on US imports. In this section, therefore, we will evaluate the trade channel, one of the two ways through which trading partners generate economic fluctuations in small LDCs economies.

Table 5.3 presents the correlation coefficients and the Granger tests for the links Costa Rican GDP-US imports and Costa Rican exports-US imports. On average, US imports move in a procyclical, leading way respect GDP (0.65) and in a coinciding pattern in relation to exports

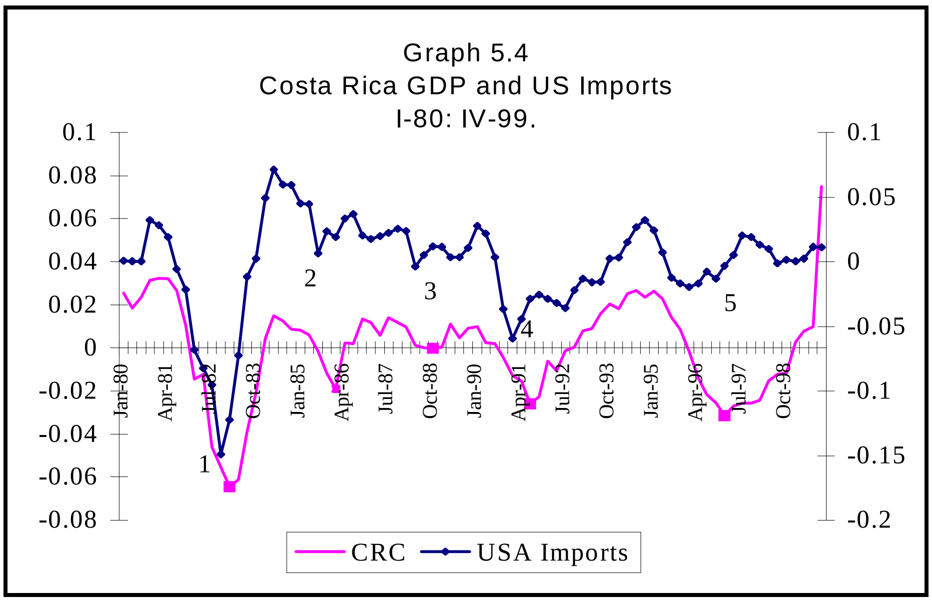
(0.62). At the trough of practically all the cycles, the American imports lead changes in the GDP by approximately one or two quarters.

Table 5.3
US Imports-Costa Rica GDP and Exports I:80-IV:99

			Correlation Coefficients								
Variable	Volat.	GCT	-4	-3	-2	-1	0	1	2	3	4
GDP-USM	1.65	5.1 (3.1)*	0.3	0.45	0.60	0.65	**0.60**	0.43	0.20	0.0	-0.2
Exports-USM	3.33	3.1 (3.1)*	0.1	0.27	0.46	0.59	**0.62**	0.55	0.40	0.2	-0.1

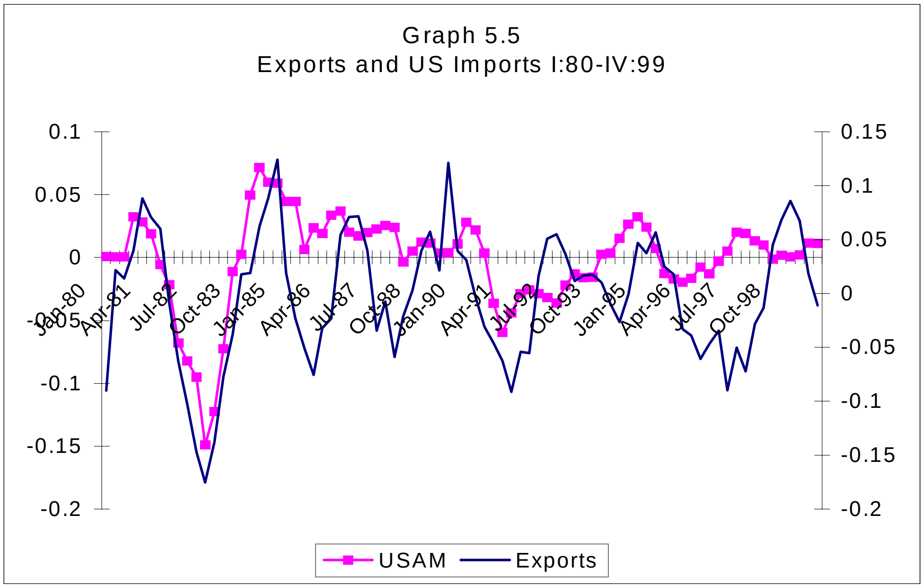
* F-Statistic Source: Author's elaboration.

Graphs 5.4 and 5.5 plot both links. The picture depicted by graph 5.4 is even clearer than the one of graph 5.3. In this figure one can see the strong coincidence of troughs (dots 1 to 5), the leading behavior of imports and the very similar up-and-down pattern of the Costa Rican GDP respect US imports movements. A similar situation is observed in graph 5.5 in the relation exports-US imports, although in this case they have a coincident behavior. In both cases, with respect to GDP and with respect to exports, the Granger test proved statistically that there is a causal relation running from US imports (table 5.3).



Source: Author's own elaboration.

Graph 5.5
Exports and US Imports I:80-IV:99



Source: Author' s own elaboration.

As with GDP, it must be noted that there are periods of important deviations between the US imports and the Costa Rican GDP and exports. The following are some explanations of such deviations:

- Special International Episodes: two examples are the coffee and banana booms in the mid 80s and the financial crises of the mid-late 90s. For instance, the international prices of coffee and banana, at that time, the most important export products, jumped, respectively, from \$1.49 to \$2.31 (an 55% increase), and from \$0.17 to \$0.25 (47% increase) between 1985 and 1989.
- Domestic Issues: domestic factors can also impact the cycles. We will comment on one, the so-called INTEL effect. In its firsts two years of operations (1998-9), the multinational INTEL accounted for 4% of the GDP, 33% of total exports and practically doubled the expected rate of growth of the Costa Rican economy. Such a performance magnifies the expansionary phase of the cycle despite the fact that USA imports decline slightly during this period.

Despite such periods of ' deviation' observed in the former two sections, our idea on the origin of the impulses is still valid. Variations in the link between the two economies do not invalidate the recurrence (regularity) of the dependent relation. Even more, if the high-low correlation is a repeated pattern, it means that a special recurrence is presented; what changes is the strength of the short-run correlation, not the essence of the link.

5.3.3 The Synchronization of the Costa Rican and US Interest Rates.

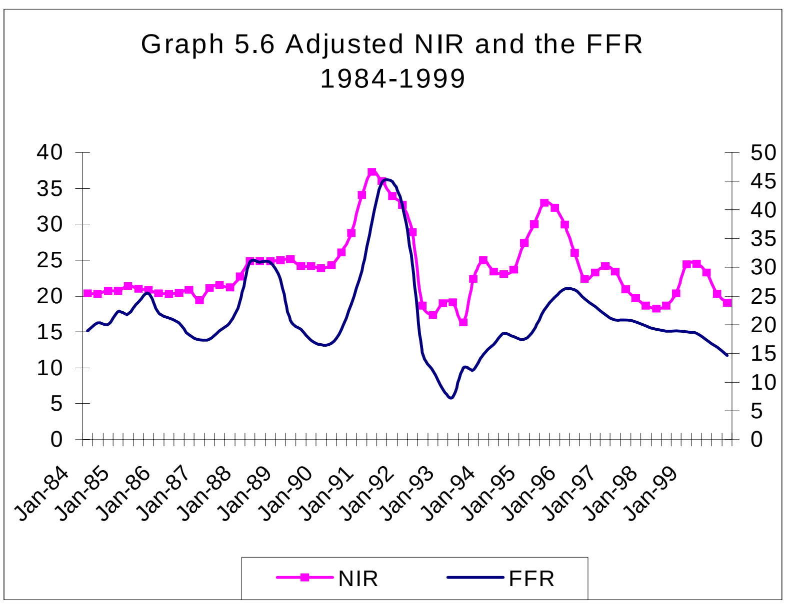
The second mechanism through which the US economy impacts the Costa Rican GDP is the financial one. Specifically, allowing for exchange rate changes, it would appear that the Costa Rican interest rate follows US rates, proxied by the Federal Funds Rate (FFR).

Table 5.4 and graph 5.6 show the close correlation between the adjusted NIR and the FFR, 0.72 at a coincident quarter. This situation reflects the fact that the Costa Rican domestic rate tends to absorb quickly and closely changes in the FFR. The association becomes even stronger after the liberalization of the Capital Account (0.83).

Table 5.4
Costa Rica: Federal Funds Rate, NIR and Devaluation
I:80-IV:99

		Correlation Coefficients								
Variable	Volat.	-4	-3	-2	-1	0	1	2	3	4
FFR-CRI	0.55	-0.21	0.01	0.29	0.55	**0.73**	0.72	0.63	0.44	0.19

Source: Author' s elaboration.



Source: Author' s own calculations.

5.4. Measuring the Impact of US in Costa Rica: Cointegration and VAR models[33].

Having established that there are strong linkages between the US and the Costa Rican economies, we will now consider the impact of movements in the former economy and the way they affect the latter. To achieve this objective we will make use of two econometric tools, Cointegration equations and VAR models. The first ones yield the elasticity coefficient of the Costa Rican GDP to US GDP and the change of the domestic interest rate to a one-percentage point increase in the FFR. The VAR models will generate the sign and magnitude of the reaction as well as the percentage contribution of US to Costa Rican economic fluctuations.

5.4.1 Cointegration Results.

The results of the cointegration analysis (table 5.5) confirm the impressions gathered from the previous sections. The USA economy emits significant impulses that generate BCs in Costa Rica. The first model, the elasticity of the Costa Rican GDP to a 1% change in USAGDP is 1.22, showing that the Costa Rican economy responds more than proportional to changes in US. This reaction helps us understand why the ups and downs in Costa Rica are more violent (volatile) than in USA. The second cointegration equation shows that a 1 percentage point increase in the Federal Funds Rate increases the Costa Rican domestic rate by 2.6 percentage points, or more than double the shift in US. Given the cost-importance of the NIR in the behavior of the Costa Rican investment, one can conclude from this that changes in investment (and thus in the origin of the cycle) are partially conditioned by the cycles of the FFR.

Table 5.5
Cointegration Results 1980-1999

	CRGDP-USGDP	**NIR-FFR**
Coefficient	**1.22 (33.3)**	**2.66 (32.7)**
Constant	-2.68 (-8.3)	----
R^2	0.93	0.94
Durbin Watson	0.69	0.21
D. Fuller on Residuals	-4.38	-6.36

t-values in parenthesis. All coefficients are significant at 5%.
Source: Author’s own elaboration

33 Annex 5 provides a mathematical description of Cointegration and VAR models. Annex 6 summarizes the results of the VARs.

5.4.2. VAR Models.

This analysis comprises two parts, one for the Variance Decomposition and the other for the Impulse-Response results. The first one will measure the contribution of the US GDP to the fluctuations in Costa Rican GDP, exports and NIR. The second outcome depicts the characteristics of the response of the Costa Rican economy to changes in US.

5.4.2.1 Variance Decomposition.

The Variance Decomposition (VD) analysis measures the percentage contribution of the US economy to the variability of the Costa Rican GDP. In other words, it tells how much responsible is the US economy in accounting for fluctuations in Costa Rica. To know that, we first ran bivariate VAR models and then a multivariate model, this one for robustness purposes.

The results of the bivariate models are shown in tables 5.6 for the Costa Rican GDP and 5.7 for Exports and the NIR. The outcomes on GDP establish that a shock in the US GDP will account for 30% of the Costa Rican GDP fluctuations 2 years after the shock and for 37% of the total variability 5 years after. Similarly, if the same situation occurs in US imports, the same coefficients will be 8.8% and 9% respectively, while a shock in the FFR will be responsible of 19% and 22%. In the three cases two remarkable issues are, on one side, the high contribution the US has in the economic fluctuations of the Costa Rican GDP, and in the other, the persistence of such contributions over time.

Table 5.6
Costa Rican GDP Variance Decompositions
-bivariate models-

	% due to		**% due to**		**% due to**	
	CRGDP	USAGDP	CRGDP	USAM	CRGDP	FFR
1 Quarter Ahead	100.0	0.0	100	0.0	100.0	0.0
4 Quarters Ahead	82.1	17.9	93.9	6.0	91.1	8.9
8 Quarters Ahead	70.0	30.0	91.2	8.8	80.8	19.2
20 Quarters Ahead	63.0	37.0	90.4	9.5	77.4	22.6
25 Quarters Ahead	62.8	37.2	90.4	9.5	77.3	22.7

Source: Author's own calculations.

In relation to the two channels of transmission, table 5.4 shows that shocks in US imports are responsible of 10% of the exports variance (first two years) and 19% in the long run. Similarly, the FFR contributes with a constant 12% to the domestic interest rate's variance. In both cases, it is clear that the movements of both Costa Rican exports and the NIR are highly conditioned by the variations in the US correspondent variables.

TABLE 5.7
Variance Decomposition for Exports and NIR
-bivariate models-

	% due to		**% due to**	
	CR Exports	USAM	NIR	FFR
1 Quarter Ahead	100	0.0	100	0.0
4 Quarters Ahead	89.8	10.2	87.7	12.3
8 Quarters Ahead	84.2	15.8	87.4	12.6
20 Quarters Ahead	81.3	18.7	87.4	12.6
25 Quarters Ahead	81.2	18.8	87.4	12.6

USAM: US Imports   Source: Author' s elaboration

In order to test the robustness of the former results, we calculated a 4-variate VAR that included the Costa Rican GDP, US GDP, USA consumer prices and the FFR (table 5.8). Despite the new specification, the **total share** of all USA variables continues being large, representing around 36% of the Costa Rican variance. The individual contributions are lower than before (as expected), but still highly significant. For instance, the US GDP is responsible of 18% of the total variance, while the shocks to the FFR represented 9%. In summary, the US is the single most significant source of Costa Rican GDP fluctuations. This influence is high even for Latin American standards. Carrera et al (1998), in a similar research for Argentina, concluded that USA accounts for no more than 15% of that country' s variations.

Table 5.8
Costa Rican GDP Variance Decomposition
Alternative model

	CRGDP	**USAGDP**	**USA Prices**	**Fed. Funds Rate**	**Total USA**
1 Quarter Ahead	100.0	0.0	0.0	0.0	**0.0**
4 Quarters Ahead	71.7	15.2	6.9	6.1	**28.2**
8 Quarters Ahead	65.3	19.1	6.8	8.9	**34.8**
20 Quarters Ahead	62.7	20.4	6.1	10.8	**37.3**
25 Quarters Ahead	62.3	20.6	6.0	11.1	**37.7**

Source: Author' s own calculations.

5.4.2.3 Impulse-Response Functions (IRF).

The IRF illustrates the reaction of variable X (Costa Rica) to shocks in Y (US). This tool is useful to measure the magnitude (percentage change), the orientation (increase or decrease) and the length (for how long the shock directly affects the variable) of such response. Also, it evaluates the speed at which the two mechanisms of transmission operate. The earlier the variable achieves its peak, the faster is that channel in absorbing the impact.

Figures 5.8 to 5.10 display the impulse response functions of the GDP, exports and NIR to innovation shocks in USA variables[34]. According to graph 5.9, the dynamic effects of a 1 standard deviation shock to US GDP increases the Costa Rican GDP by roughly **10 quarters** (2.5 years) before becoming non-significant[35]. The highest increase is experienced **4 quarters** after the shock (**0.31%)[36],** and one year after it the total effect is an 1.12% increment, or 25% of the average growth rate experienced by this country!

The response of the trade channel (graph 5.10) shows that a shock in USA imports is also highly significant for Costa Rican exports. In total, a shock in this US variable pushes exports by **6 quarters**, although is **3 quarters** after the impact that the highest effect is experienced (1.6%). One year after, exports have increased by 5.3%, almost 50% of their normal growth rate.

Finally, a shock to the FFR rises the NIR by **4 quarters**, but its peak, a **0.6** percentage point increase, occurs just **2 quarters** after the impact. The total effect on the domestic rate is an increase of 1.4 percentage points. Compared to the trade one, the financial channel is absorbed faster but its effect lasts six months less. The faster absorption of this channel evidences that financial factors are the first manifestation of the US impulses in the Costa Rican economy. This conclusion is supported by the fact that the NIR is the variable that leads the GDP by the longest period, 3 quarters.

Our IRF robustness test comprised two new VARs (a 3-variate model and a 4-variate one[37]) to see whether new specifications change significantly the **sign**, **duration** and **magnitude** of the Costa Rican GDP to US GDP shocks. The results showed no changes in the *sign* of the response of the Costa Rican GDP to shocks in to the US GDP. In terms of *magnitude*, at the peak, the change in the total output was similar as in the bivariate model (0.29%). The only as-

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[34] Each figure shows the point estimate and one standard error band obtained with Monte Carlo simulations.
[35] At a 10% level of significance.
[36] The VAR models were calculated by using the first-differences of the variables, not their levels.

pect that experienced an important modification was the *period of incidence*, which fell to 7 quarters instead of the 10 quarters in the original specification. For the purposes of this research, however, this does not alter the essence of the analysis.

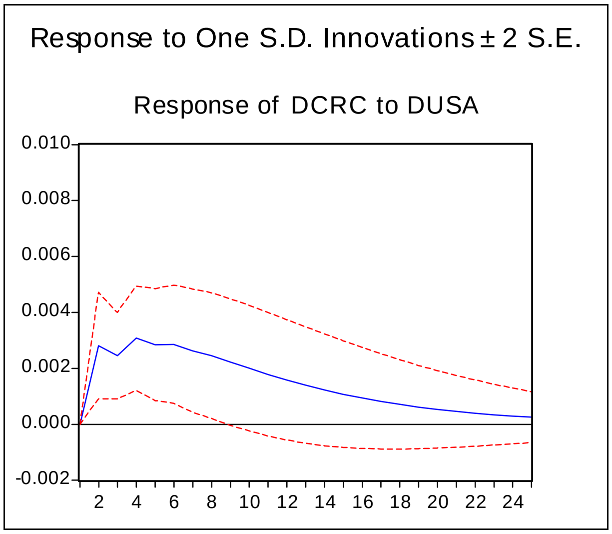
In summary, the responses of the Costa Rican economy and the two channels of transmission were as theoretically expected. In the three cases we studied, the Costa Rican variables react positively to the impulses coming from the US. The positive reaction of the NIR implies, indirectly, that shocks to the FFR impact negatively the Costa Rican GDP, given the countercyclical behavior of the domestic rate. However, given that at the trough of the cycle the FFR is decreasing and the US imports are increasing, both channels, far from opposing, reinforce the total impulse coming from this economy to Costa Rica.

5.5. Final Remarks.

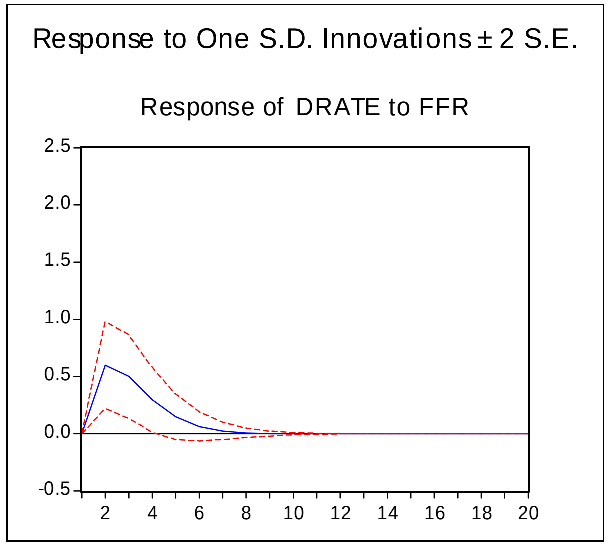
This final chapter shows conclusively that the US is the most important source of impulses to the Costa Rican economy. The evidence also showed that those impulses are channeled via exports and interest rates variations, precisely the two variables that mostly influence investment decisions in Costa Rica. These results confirm our idea that the Costa Rican BC is highly conditioned by movements in the US economy.

37 Annex 6 includes a complete specification of the models.

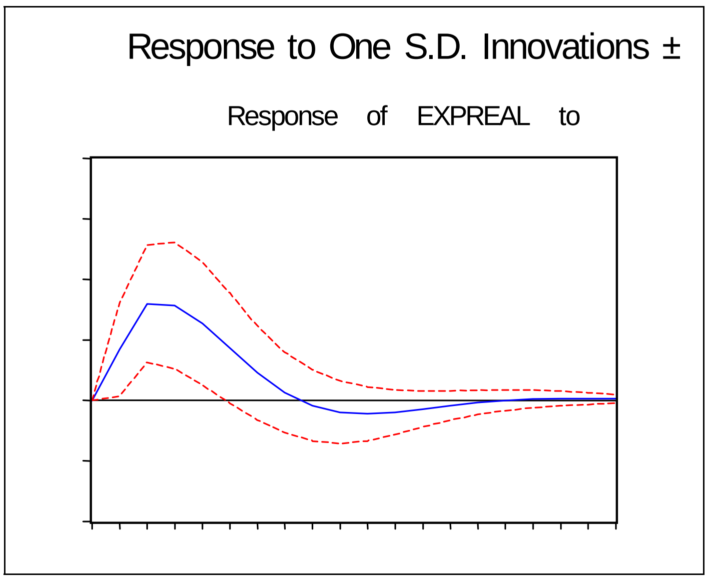
Impulse Response Graphs



Graph 5.8: Response of GDP to US GDP



Graph 5.9: Response of NIR to FFR



Graph 5.10: Response of Costa Rican Exports to US Imports

6. CONCLUSIONS AND POLICY ANALYSIS

6.1. Summary and Conclusions

In chapter one we outlined our working hypothesis that Costa Rica experiences a BC that is caused by investment shifts. Besides, we established that the dynamism of investment is greatly influenced by the behavior of exports and interest rates, two variables determined by the situation of the USA economy. To substantiate the working hypothesis we designed a 3-step sequence on how a BC works. This sequence was explained by using the Keynesian theory of the BC in the context of LDCs (chapter 2). On the empirical grounds, to identify and measure the cycle in Costa Rica we used ARIMA models and a set of particular coefficients (chapter 4). To evaluate the impulses coming from the US, we applied Cointegration and VAR models (chapter 5).

The paper found the Costa Rican economy to be cyclical in a BC sense. Statistically, the results shows that the GDP cycle lasts, on average, 3.5 years, while its two phases (the upswing and the downswing) each persist for about 7 quarters. We also proved the existence of comovement between GDP and the most relevant macro variables (see annex 4). In other words, the main aggregates are also cyclical and their peaks and troughs occurred at more or less the same quarters as the GDP. Finally, the high volatility coefficients of investment and exports were an important evidence that both variables have an active role in generating cycles.

A second major finding was, precisely, that the Costa Rican BC is caused by shifts in investment. The empirical evidence showed that this variable comprises all the characteristics of a typical 'cause'. Investment had the highest volatility coefficient (4.1), it led the GDP movements by 2 quarters and it displayed a high pattern of comovement with output, 0.75. We also found that investment shifts are greatly influenced by the dynamics of exports and the nominal interest rate. Statistically, both variables either coincide or lead investment at the trough. Given that, we interpreted the bottom of the cycle as a situation in which changes in those variables have a *demand and cost effect* that modify business expectations and explain the corresponding shifts in investment.

The Costa Rican cycle also passed the economic test. Our economic analysis of the cycle showed that the sequence and behavior of the relevant macroeconomic variables are consistent with the Keynesian explanation of the BCs. Three findings were relevant for this conclusion. Firstly, it was showed that investment leads GDP at the expansion but lags at the contraction. Second, the different import categories shift according to what the theory predicts, that is, an initial change in capital goods and intermediate inputs followed by an increase in final consumption goods. Finally, the lagged procyclical behavior of prices matched the Keynesian idea that they do not react immediately to changes in output. For instance, consumer prices, originally with a countercyclical pattern, become procyclical three quarters after the expansion begins. All this proved that the succession of events of the Costa Rican cycle have economic sense.

Our last conclusion establishes that the impulses generating Costa Rican cycles mainly come from the US economy. These impulses are propagated via exports (trade channel) and interest rates (financial channel) variations. On one hand, we showed that the structure of the Costa Rican trade is highly dependent on the US imports cycle. On the other, with the liberalization of the Capital Account in the 1990s, the financial links with US became so strong, that the Costa Rican interest rate closely follows the movements of the American rates (allowing for exchange rate shifts). The absorption of US interest rate shifts in the Costa Rican economy appear to be quicker than the effect of an export demand expansion. However, the total impact of the latter appears to be more long lasting.

In summary, the paper succeed in showing that the Costa Rican BC is caused by investment and conditioned, not by an endogenous process, but by the impulses from US that are propagated to investment via exports and interest rate variations.

6.2. Policy Analysis.

BC analysis is useful for both policy makers and private agents. The following are three suggestive uses of how it can be applied.

1. **Forecasting.** The BCs analysis can be very useful in forecasting the evolution of the economy because it provides a guide of the current performance of the economy. The BC stylized facts depicted in chapter four, for instance, can help us to construct *leading indices* (to predict turning points) or to evaluate the future trend of the economy. For example, in the last 2 quarters of 1999, credit and imports expenditures, two important proxy variables of investment performance, reached a peak and began falling (see graphs 4, 6 and 7 in annex 4). These results suggested that, by the year 2000, the economy would be entering in a contractionary phase. Does the conclusions fit the current situation of the country? Yes. After growing by 8% in 1999, this year the economy is expanding at 4% (Periodico La Nacion, 2000), and this confirms the deceleration we expected by following the behavior of two leading variables.

   We can also approach the evolution of the year 2001. The bad performance of some macro variables suggests that, for the first months of next year, the economy will continue in the contractionary phase. During the first three quarters of the 2000, imports grew by just 1%, exports fell by 7%, and private credit only showed some lending recovery in the real estate sector. Besides, the US economy appears to be decelerating. All these facts reinforce our forecast for the Costa Rican economy in the 2001.

2. **Countercyclical policies**. Countercyclical policies have been traditionally used to either cool-down inflationary pressures during the upswing or to stimulate the economy during the contractionary phase. The preceding BC analysis suggests that the government should be in the process of applying expansionary policies given the contractionary moment of the Costa Rican economy. This, of course, still leaves open the question of which one is the most viable policy.

   An expansionary fiscal policy has no room in this moment given the chronic budget deficit the country experiences (more than 2.5% of GDP). There may be, however, some margin for variations in the composition of the budget. In other words, the government should spend more in 'productive' expenses (i.e. infrastructure) with the aim to generate positive signals in the private sector.

   On the other side, the liberalization of the Capital Account also limits the scope for an expansionary monetary policy. In this case, we consider that the monetary authorities could apply some *temporary* measures like reductions in the interest rate or the alleviation of any money liquidity constrains. Any policy, however, has to be carefully analyzed in order to minimize the negative impact on reserves.

3. **Other policy uses.** Finally**,** BCs analysis can also be used for other structural-type policies. One is, for example, in relation to the high trade dependence on the US economy. A market diversification strategy can help the country not to eliminate the cyclical fluctuations in GDP but to mitigate the 'violence' of the contractions when the US experiences a recession.

   A second non-traditional example of BCs analysis is in the political grounds. The political strategy of the government can be highly influenced by the current and future performance of the economy. For instance, during a contractionary situation like the present, one can expect the government to approve important laws or to apply specific programs that may influence expectations and incentive firms to invest.

ANNEXES

Annex 1:Derivation of the Cyclical Component: ARIMA Models and the HP Filter.

This annex describes the most relevant methodological aspects of the derivation of the cyclical components for each of the series used in Chapter 4. The first part deals with the description of the ARIMA Model Based Approach to calculate the trend-cycle component of a time series. Then, we incorporate the Hodrick Prescott filter to eliminate the trend. In a second section, we depict the battery of indicators that accompanied the statistical analysis of the cycle.

On the Concept and Characteristics of Time Series.

A time series is "a set of observations on a variable, say Y, recorded for consecutive time intervals" (Planas,1997: 13). They can be seen as the multiplicative result of four main forces:

- Trend (T): the long run component
- Seasonal Fluctuations (S): correspond to these regular patterns observed in a series within a year.
- Cycle (C): the more or less regular pattern of behavior with a duration of more than one year.
- Irregular component (I): the non-systematic movement of the series.

Algebraically, it is represented by the equation

$$Y_t = T \times S \times C \times I$$

By applying logs at both sides we get an additive equation of the form,

$$y_t = t + s + c + I$$

To calculate the cyclical component one can follow two basic methods:

1. The definition of trigonometric-based models of the form

$$y_t = \alpha \cos \omega t + \beta \sin \omega t$$

   where ω represents a particular frequency, as followed by the Spectral Analysis. However, because economic cycles are not periodic, the approach may present several problems.

2. The second method takes the cyclical component as the 'residual' once the trend, seasonal and irregular components are subtracted from the original series. This is the line

followed by the ARIMA Model Based (AMB) approach and the one this paper considers.

ARIMA Models and the AMB Approach

An Autoregressive-Integrated-Moving Average model –ARIMA- (p, d, q,) is an econometric equation in which a series depends on its own *p* past values and its *q* errors, the later being treated as a moving average process; *d* is the order of integration required to be stationary.

After the required stationary transformation, we modeled the macroeconomic series of chapter four by following the general form of the ARIMA models

$$y_t = \mu + \phi_1 y_{t-1} + \phi_2 y_{t-2} + \cdots + \phi_p y_{t-p} + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2} + \cdots + \theta_q \varepsilon_{t-q} + \varepsilon_t$$

$$y_t - \phi_1 y_{t-1} + \phi_2 y_{t-2} + \cdots + \phi_p y_{t-p} = \mu + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2} + \cdots + \theta_q \varepsilon_{t-q} + \varepsilon_t$$

by applying the lag operator ($L^n y_t = y_{t-n}$) at both sides, we get the reduced-form equation

$$\phi(L^p)\Delta^d y_t = \mu + \theta(L^q)\varepsilon_t$$

or

$$y_t = \mu + \frac{\theta(L^q)}{\phi(L^p)}\varepsilon_t$$

where $\phi(L^p)$ and $\theta(L^q)$ are polynomials that satisfy the conditions of stationarity and invertibility of the model.

To obtain the ARIMA models we followed the 3-step method developed by Box and Jenkins (see, for instance, Box and Jenkins, 1970, Gujarati, 1998, Cuthbertson et al, 1992). The procedure defines the following phases:

1. **Identification of the Model**: in this first stage we check for the existence of stationarity and for the possible combination of p and q lags.

   Stationarity is tested by applying the Dickey-Fuller (DF) test with a constant, with a constant and a trend and on series of order 1. Given that unit roots can only appear in autoregressive processes, the DF test runs regressions of the form

$$y_t = \alpha + \rho\, y_{t-1} + \varepsilon_t \text{ for the "only constant" case}$$

$$y_t = \alpha + \rho\, y_{t-1} + \delta\, t + \varepsilon_t \text{ for the "constant plus trend case" and}$$

$$\Delta_1 y_t = \rho \ y_{t-1} + \alpha_1 \Delta_1 y_{t-1} + \cdots + \alpha_{p-1} \ \Delta_1 y_{t-(p-1)} + \varepsilon_t \text{ for the Augmented DF}$$

Under the null hypothesis that ρ=1, the t-test is (ρ-1)/s.e.(ρ). The acceptance of the null hypothesis implies the existence of a unit root, so the series must be differentiated.

To identify the possible number of p and q lags we obtain the Autocorrelation (ACF) and Partial Autocorrelation (PACF) functions. The first one is defined as

$$\rho(\tau) = \frac{\gamma_\tau}{\gamma_0} = \frac{auto\,\mathrm{cov}\,(y_\tau, y_{t-\tau})}{\mathrm{var}\,(y_t)}$$

where

$$\gamma_t = T^{-1} \sum_{t=k+1}^{T} (y_t - \bar{y})\,(y_{t-k} - \bar{y})$$

On the other side, the PACF is set by the formula

$$y_t = \phi_1 \ y_{t-1} + \phi_2 \ y_{t-2} + \cdots + \phi_p \ y_{t-p} + \varepsilon_t$$

where T is the size of the sample, τ is the n-lag and the ϕ' s correspond to the values of the PACF.

The ACF is used to determined the possible number of moving average lags, while the PACF does the same thing for the autoregressive part. For a pure p-autoregressive model, the PACF is significantly different from zero until lag p, while the ACF decreases just after lag 1. Similarly, if the values of the first q lags are different from zero in the ACF at the time the PACF decreases heavily, there is a pure of moving average process. Any combination of this implies an ARMA process in which the number of lags of each component depends on the number of ' peaks' observed in the former functions.

2. **Estimation of the model**: once we complete the first step, the second one consists in the estimation of the model. This phase is made by applying Maximum-Likelihood methods, something directly applied by the statistical packages available.
3. **Diagnostic checking**: finally, the results of step two must be analyzed for the existence of significant coefficients and autocorrelation and normality in the residuals. In this paper we used the coefficients calculated by DEMETRA[38], the statistical package that

[38] DEMETRA is a computing package of EUROSTAT, the Statistical Office of the European Community, that decomposes a time series into seasonal, trend-cycle and irregular components based in an ARIMA model. The calculated model is tested by applying those coefficients.

decomposes the series:

- The **Ljung-Box** test on the significance of autocorrelation in the first m-lags: this coefficient is defined as

$$LBT = n\,(n+2)\sum_{k=1}^{m}(n-k)^{-1}\ r_k^2\ (\hat{\varepsilon})$$

following a χ^2 distribution with T-p-q degrees of freedom.

- The **Box-Pierce** (or Q-test) statistic for randomness in residuals: the Q test is

$$Q = T\sum_{\tau=1}^{P} r_\tau^2$$

where P is the number of lags we want to evaluate and r is the τth sample autocorrelation in the residuals (Harvey, 1990). Q follows a χ^2 distribution with P-p-q degrees of freedom. The acceptance of the null hypothesis implies that the residuals are randomly generated.

- The **Durbin Watson** test for autocorrelation: this test is defined as

$$d = \frac{\sum_{t=2}^{T}(e_t - e_{t-1})^2}{\sum_{t=1}^{T} e_t^2}$$

where the e' s correspond to the residuals of the model.

- **Skewness and Kurtosis**: they correspond to the third and fourth moments of a distribution, and they are mainly used to test normality. Skewness tests the existence of any bias in the distribution (outliers), while kurtosis is a measure of ' heavy tails' . Both coefficients are defined as follows

$$SK = \frac{1}{n\,s^3}\sum(y-\bar{y})^3$$

$$KT = \frac{1}{n\,s^4}\sum(y-\bar{y})^4$$

- The **Bera-Jarque** test checks the join hypothesis the skewness and kurtosis coefficients are 0 and 3, respectively (the values that rule in a perfect normal distribution). Thus, it is defined as

$$JB = \frac{\alpha_3 \sqrt{n}}{\sqrt{6}} + \frac{(\alpha_4 - 3)\sqrt{n}}{\sqrt{24}}$$

where α_3 and α_4 are the skewness and kurtosis coefficients; the critical value is established at 5.99, the χ^2 value with two degrees of freedom and at 5% level of significance.

Once the model passes all the tests, we apply the AMB approach to extract the trend-cycle component. Although the statistical package calculates the three parts of the time series, we are interested only in that one. The AMB assumes that (Planas, 1996)

- The unobserved components are uncorrelated.
- The structures can be modeled by using ARIMA equations.
- The AR polynomial do not share any common roots.

The extraction of the trend-cycle component follows the 2-step algorithm proposed by Kaiser and Maravall (1999). This approach comprises

1. Step 1: the series is decomposed in three parts, say, the seasonal (s_t), trend-cycle (p_t) and irregular components (u_t). This is done by modeling each one with ARIMA equations[39].
2. Step 2: the p_t component is split into two parts, m_t (trend) and c_t (cycle), so we have

$$p_t = m_t + c_t$$

m_t can be seen as the fitted value of the equation and c_t as the residual, white-noise process. The traditional way to model the trend-cycle is by assuming a IMA (2,2) process of the form

$$\Delta^2 \; p_t = \theta_p \; (B) * a_{pt}$$

where θ_p (B) is the polynomial (1- αB) (1+B) and a_{pt} is the residual component.

The Hodrick-Prescott Filter (HP Filter)

Once the trend-cycle is extracted, the final step consists in filtering it with a specific detrending method so the cycle remains as the unique component. The literature on filtering is large, but we decided on the HP filter because it has been the most popular

[39] The decomposition of the series was made by applying the statistical package DEMETRA, from EUROSTAT, the European Office of Statistics.

method used in the last years and gives us the possibility to make comparisons. Besides, the method was available in the statistical packages STATA and E-Views, while other methods, like the Baxter-King filter was not there[40].

The HP filter is a two-sided linear filter that calculates the smooth series **s** of y_t by minimizing the function

$$\sum_{t=1}^{T}(y_t - s_t)^2 + \lambda \sum_{t=2}^{T-1}((s_{t+1} - s_t) - (s_t - s_{t-1}))^2$$

in which λ is the penalty parameter that controls the smoothness; the larger its value, the more linear the calculated trend. The convention is to apply a value of 1600 to this parameter when one works with quarterly data. The application of the HP filter eliminates the trend and leaves the cycle as the only component of the original time series.

Extension, Persistence, Comovement and Volatility.

The extraction of the cyclical component is just the first step in the statistical analysis of the BC. The second stage is the measurement of the four basic features of BC variables: extension, persistence, comovement and volatility. Extension is merely the length of the cycle measured in quarters from peak to peak or from trough to trough. According to Burns and Mitchell, this period must be greater than one year; however, not everybody agrees with this bound and prefers longer periods to separate any seasonal factor from the 'pure cyclical component'. For instance, Pedersen (1998) takes 15 months as the minimum period, while Baxter and King (1996) consider that a BC must last between 1.5 and 8 years.

The second feature is persistence. As we explained in chapter 2, persistence means that the "deviations from the average or trend level of activity are maintain for considerable lengths of time …" (Diebold and Rudebusch, 1999: 14). To test it we will adopt the expansionary/contractionary amplitudes, that is the number of quarters each phase individually lasts.

To measure comovement and the phase-shift of the series (timing and direction),

[40] In order to test the robustness of our cyclical component, we regress the SA series on time by using polynomial of different degrees; the residuals correspond to the cycle. See annex for a visual description of the results.

we will use the **coefficient of cross correlation** between the GDP and the different series. Algebraically, the cross correlation coefficient is defined as

$$\rho_{xy} = \frac{c_{xy}(\ell)}{\sqrt{c_{xx}(0)\, c_{yy}(0)}}$$

where ℓ = 0, ±1, ±2, ..±n lags and where

$$c_{xy}(\ell) \begin{cases} = \sum (x_t - \bar{x})(y_t + \ell)/T \text{ for } \ell = 0, 1, 2 \cdots \\ = \sum (y_t - \bar{y})(x_t - \ell)/T \text{ for } \ell = 0, -1, -2 \cdots \end{cases}$$

The significance of the cross correlation coefficients at lag ℓ is evaluated under the null hypothesis that $\rho_{xy}= 0$; the critical values at a 5% level of significance are defined as $\pm 1.96/\sqrt{T}$, corresponding to ±0.22 in our case[41].

The following rules have to be considered:

1. A variable y is strongly correlated (or, it strongly comoves) with output if $|r_{xy}(0)| \geq 0.29$; it is weakly correlated if $0.22 \leq |r_{xy}(0)| < 0.29$ and is no correlated if $|r_{xy}(0)| < 0.22$[42].
2. A positive sign of the correlation coefficient implies that the series is procyclical respect the GDP, while a negative one establishes a countercyclical relation. If the coefficient is not significant (not significantly different from zero), the series is acyclical.
3. Finally, in the cross correlation results, if the X series reaches it highest value before ℓ=0, it is said that the variable leads the GDP; if this value is reached after ℓ= 0 the series lags the reference cycle and if the coefficient has its maximum at ℓ = 0 the series is coincident.

In terms of comovement, a variable highly comove with GDP if its result is higher than $Z/\sqrt{n}$ where Z is the Z-distribution evaluated at 1%. Similarly, two variables weakly comove if the result is between the values of $Z/\sqrt{n}$ at 1% and 5%; finally, the variables do

[41] Note that the cross correlation coefficient at lag 0 is equal to the coefficient of simple correlation.

[42] The cutoff points correspond to the critical value of considering the null hypothesis that the ρ=0 at a 5% (0.22) and 1% (0.29) levels of significance, with a sample of 80 observations.

not comove if the coefficient is lower than $Z/\sqrt{n}$ at 5%.

This coefficient is very useful in guiding us toward causal relations. If a variable is a leading and procyclical series, this suggests, but not confirms, causality respect the GDP; the only way to corroborate a causal link among two variables is through theoretical arguments.

The relative volatility coefficient measures how unstable is variable x respect GDP, so it corresponds to the ratio between the standard deviation of the x cycle and the standard deviation of the GDP cycle. For the analysis of volatility there are no universally defined benchmarks. Empirically, however, some authors (i.e. Kamil and Lorenzo, 1998) use the following parameters: if the relative volatility is higher than 2, the variable is ' highly volatile' ; between 1 and 1.99 is ' moderate' and below 1 is ' low' . Low volatile variables hardly give the required impulses to shape the GDP cycle, while high ones, on the contrary, can be more associated in causing the fluctuations in output.

Sources of Data

Most of the data came from the Central Bank of Costa Rica: from there we got Real GDP, private consumption, private investment, private credit, imports, exports, consumer prices, nominal interest rates, nominal wages and nominal exchange rate; when necessary, this information was complemented with the International Financial Statistics of the IMF. Government expenditure comes from the Ministry of Treasury. The American variables were gotten from the web page of the US Census Bureau; trade between Costa Rica and USA can be found in the same web, Foreign Trade Division. Finally, chapter three is based on the web page of the Ministry of Planning of Costa Rica.

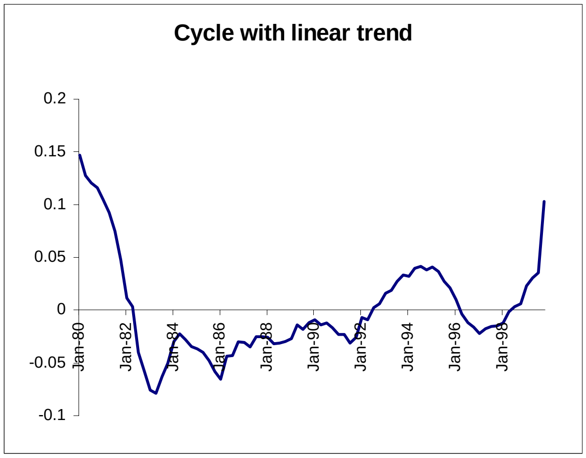
Annex 2:Robustness of the HP filter

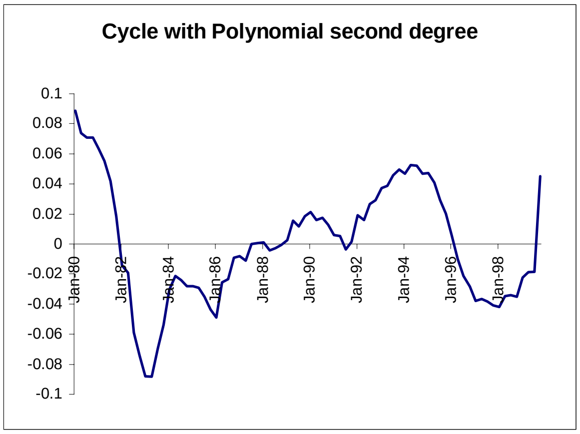
We test the robustness of the HP filter to extract the cycle of the Costa Rican GDP by applying alternative detrending methods. These methods mainly consist in regressing the seasonally adjusted GDP on a time variable, using polynomials of several degrees; the typical equation for this purpose is of the form

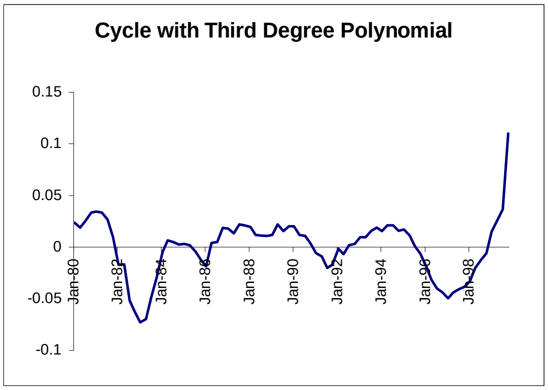
$$saGDP_t = \mu + \sum_{p=1}^{n} \beta_t t^p + \varepsilon_t$$

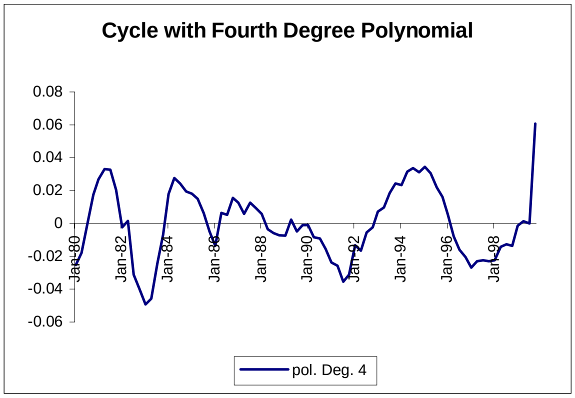
where p is the degree of the polynomial. The residuals of each regression correspond to the cyclical component.

The main conclusion, as we can observe in the five graphs below, is that no significant change can be observed by applying these polynomial instead of the HP filter. With the exception of the linear trend, practically all the other cycles follow the same pattern of behavior.






Cycle with Third Degree Polynomial
0.15
0.1
0.05
0
-0.05
-0.1
Jan-80
Jan-82
Jan-84
Jan-86
Jan-88
Jan-90
Jan-92
Jan-94
Jan-96
Jan-98


Cycle with Fourth Degree Polynomial
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
Jan-80
Jan-82
Jan-84
Jan-86
Jan-88
Jan-90
Jan-92
Jan-94
Jan-96
Jan-98
pol. Deg. 4

Annex 3: ARIMA Results

GDP				
ARIMA	**0,1,1**			
D.gdpcosta	**Coef.**	**Std. Err.**	**z**	
Cons	0.0084351	0.00236	3.574	
ma				
L1	-0.5642761	0.1105694	-5.103	
Analysis of Residuals	Calculated Test	Range		
Ljung-Box Test	7.76	(0, 25)		
Box-Pierce Test	0.71	(0, 5.99)		
Durbin Watson	2.11	(0, 4)		
Mean	0			
Std Dev	0.02			
Normality	2.10	(0.5, 5.99)		
Skewness	0.41	(-0.56, 0.56)		
Kurtosis	2.85	(1.88, 4.12)		
Outliers	1.25	(0, 5)		
DFuller Test				
	Test Statistic	0.01	0.05	0.1
Constant	-0.017	-3.539	-2.907	-2.588
Constant, Trend	-4.939	-4.086	-3.471	-3.163
D1	-8.984	-3.541	-2.908	-2.589

IMAE				
ARIMA	**0,1,1**			
	Coef.	**Std. Err.**	**z**	
ma				
L1	-0.50841	0.099433	-5.113	
Analysis of Residuals	Calculated Test	Range		
Ljung-Box Test	11.2	(0, 25)		
Box-Pierce Test	3.16	(0, 5.99)		
Durbin Watson	2.27	(0, 4)		
Mean	0.27			
Std Dev	1.86			
Normality	0.50	(0.5, 5.99)		
Skewness	0.19	(-0.56, 0.56)		
Kurtosis	2.81	(1.88, 4.12)		
Outliers	0.025	(0, 5)		
DFuller Test				
	Test Statistic	0.01	0.05	0.1
Constant	-1.552	-3.539	-2.907	-2.588
Constant, Trend	-1.529	-4.086	-3.471	-3.163
D1	-3.294	-3.541	-2.908	-2.589

Consumption				
ARIMA	**0,1,1**			
	Coef.	**Std. Err.**	**z**	
Cons	0.0061682	0.0030179	2.044	
Ma				
L1	-0.6506076	0.0986048	-6.598	
/sigma	0.0675241	0.0060116	11.232	
Analysis of Residuals	Calculated Test	Range		
Ljung-Box Test	16.89	(0, 25)		
Box-Pierce Test	2.58	(0, 5.99)		
Durbin Watson	2.14	(0, 4)		
Mean	0			
Std Dev	0.03			
Normality	0.31	(0.5, 5.99)		
Skewness	0.15	(-0.56, 0.56)		
Kurtosis	3.06	(1.88, 4.12)		
Outliers	0	(0, 5)		
Dfuller Test				
	Test Statistic	0.01	0.05	0.1
Constant	-1.435	-3.539	-2.907	-2.588
Constant, Trend	-5.658	-4.086	-3.471	-3.163
D1	-10.754	-3.541	-2.908	-2.589

Investment				
ARIMA	**0,1,1**			
Ma				
L1	-0.572557	0.1244527	-4.601	
/sigma	0.2583002	0.0115036	22.454	
Analysis of Residuals	Calculated Test	Range		
Ljung-Box Test	4.78	(0, 29.7)		
Box-Pierce Test		(0, 5.99)		
Durbin Watson	2.02	(0, 4)		
Mean	0			
Std Dev	0.11			
Normality	0.08	(0.5, 5.99)		
Skewness	0	(-0.56, 0.56)		
Kurtosis	2.83	(1.88, 4.12)		
Outliers	**0.05**	(0, 5)		
Dfuller Test				
	Test Statistic	0.01	0.05	0.1
Constant	-0.017	-3.539	-2.907	-2.588
Constant, Trend	-4.939	-4.086	-3.471	-3.163
D1	-8.984	-3.541	-2.908	-2.589

Government Expend.				
ARIMA	**3,1,0**			
	Coef.	**Std. Err.**	**z**	
_cons	0.0580633	0.008439	6.88	
Ma				
L1	-0.6815945	0.0947654	-7.192	
L2	-0.5286333	0.1158761	-4.562	
L3	-0.4343670	0.1068429	-4.065	
/sigma	0.1372038	0.0087146	15.744	
Analysis of Residuals	Calculated Test	Range		
Ljung-Box Test	21.02	(0, 22.4)		
Box-Pierce Test	2.30	(0, 5.99)		
Durbin Watson	1.95	(0, 4)		
Mean	-0.01			
Std Dev	0.09			
Normality	0.80	(0.5, 5.99)		
Skewness	0.15	(-0.56, 0.56)		
Kurtosis	2.59	(1.88, 4.12)		
Outliers	0.05	(0, 5)		
DFuller Test	Test Statistic	0.01	0.05	0.1
Constant	-1.045	-3.539	-2.907	-2.588
Constant, Trend	-5.236	-4.086	-3.471	-3.163
D1	-13.86	-3.541	-2.908	-2.589

Exports				
ARIMA	**0,1,1**			
	Coef.	**Std. Err.**	**z**	
ma				
L1	-0.2694299	0.1072402	-2.512	
/sigma	0.0896303	0.0072037	12.442	
Analysis of Residuals	Calculated Test	Range		
Ljung-Box Test	21.08	(0, 23.7)		
Box-Pierce Test	0.84	(0, 5.99)		
Durbin Watson	2.09	(0, 4)		
Mean	0.01			
Std Dev	0.06			
Normality	2.32	(0.5, 5.99)		
Skewness	-0.42	(-0.56, 0.56)		
Kurtosis	0.93	(1.80, 4.20)		
Outliers	0.025	(0, 5)		
DFuller Test				
	Test Statistic	0.01	0.05	0.1
Constant	-3.247	-3.539	-2.907	-2.588
Constant, trend	-3.022	-4.086	-3.471	-3.163
D1.	-6.606	-3.541	-2.908	-2.589

Imports				
ARIMA	**1,1,0**			
Ar				
L1	0.53	0.09584087	5.53	
Analysis of Residuals	Calculated Test	Range		
Ljung-Box Test	23.17	(0, 23.7)		
Box-Pierce Test	4.44	(0, 5.99)		
Durbin Watson	1.84	(0, 4)		
Mean	0			
Std Dev	0.10			
Normality	1.81	(0.5, 5.99)		
Skewness	-0.21	(-0.56, 0.56)		
Kurtosis	2.37	(1.80, 4.20)		
Outliers	0.0375	(0, 5)		
DFuller Test				
	Test Statistic	0.01	0.05	0.1
Constant	-3.005	-3.539	-2.907	-2.588
Constant, trend	-2.979	-4.086	-3.471	-3.163
D1.	-6.578	-3.541	-2.908	-2.589

Private Credit				
ARIMA	**1,1,0**			
D.realcredit	**Coef.**	**Std. Err.**	**z**	
AR				
L1	-0.70577	0.079	-8.9338	
Analysis of Residuals	Calculated Test	Range		
Ljung-Box Test	20.81	(0, 25)		
Box-Pierce Test	0.86	(0, 5.99)		
Durbin Watson	1.90	(0, 4)		
Mean	0.01			
Std Dev	0.04			
Normality	2.57	(0.5, 5.99)		
Skewness	0.06	(-0.56, 0.56)		
Kurtosis	3.94	(1.82, 4.18)		
Outliers	0.05	(0, 5)		
DFuller Test				
	Test Statistic	0.01	0.05	0.1
Constant	0.887	-3.539	-2.907	-2.588
Constant, trend	-1.635	-4.086	-3.471	-3.163
D1.	-5.565	-3.541	-2.908	-2.589

Nominal Interest Rate				
ARIMA	**0,1,1**			
	Coef.	**Std. Err.**	**z**	
L1	0.3011132	0.0884469	3.404	
/sigma	2.967016	0.1009276	29.397	
Analysis of Residuals	Calculated Test	Range		
Ljung-Box Test	18.24	(0, 23.7)		
Box-Pierce Test	0.19	(0, 5.99)		
Durbin Watson	2.28	(0, 4)		
Mean	-0.23			
Std Dev	2.04			
Normality	0.30	(0.5, 5.99)		
Skewness	-0.17	(-0.56, 0.56)		
Kurtosis	3.02	(1.80, 4.20)		
Outliers	0.0375	(0, 5)		
DFuller Test				
	Test Statistic	0.01	0.05	0.1
Constant	-3.247	-3.539	-2.907	-2.588
Constant, trend	-3.022	-4.086	-3.471	-3.163
D1.	-6.606	-3.541	-2.908	-2.589

Nominal Wages				
ARIMA	**0,1,2**			
	Coef.	**Std. Err.**	**z**	
ma				
L1	-0.2476	0.1	-2.47	
L2	0.5851	0.1	5.53	
Analysis of Residuals	Calculated Test	Range		
Ljung-Box Test	13.12	(0, 23.7)		
Box-Pierce Test	0.71	(0, 5.99)		
Durbin Watson	1.89	(0, 4)		
Mean	0.25			
Std Dev	5.50			
Normality	2.93	(0.5, 5.99)		
Skewness	0.40	(-0.56, 0.56)		
Kurtosis	3.73	(1.80, 4.20)		
Outliers	0.0375	(0, 5)		
DFuller Test				
	Test Statistic	0.01	0.05	0.1
Constant	4.756	-3.548	-2.912	-2.591
Constant, trend	0.741	-4.099	-3.477	-3.166
D1.	-11.351	-3.549	-2.912	-2.591

Nominal Exchange Rate				
ARIMA	**2,1,0**			
	Coef.	**Std. Err.**	**z**	
ar				
L1	0.5238832	0.064278	8.15	
L2	0.3184174	0.0716112	4.446	
Analysis of Residuals	Calculated Test	Range		
Q-Test	145			
Durbin Watson	2.11	(0, 4)		
Mean	2.85			
Std Dev	2.33			
Normality	4.79	(0.5, 5.99)		
Skewness	0.49	(-0.56, 0.56)		
Kurtosis	2.32	(1.80, 4.20)		
Outliers	0.05	(0, 5)		
DFuller Test				
	Test Statistic	0.01	0.05	0.1
Constant	4.484	-3.539	-2.907	-2.588
Constant, trend	0.222	-4.086	-3.471	-3.163
D1.	-5.125	-3.541	-2.908	-2.589

Inflation Rates				
ARIMA	**0,1,2**			
	Coef.	**Std. Err.**	**z**	
Ma				
L1	-0.3448596	0.0952587	-3.62	
L2	0.4182856	0.1257007	3.328	
Analysis of Residuals	Calculated Test	Range		
Ljung-Box Test	21.3	(0, 32.9)		
Box-Pierce Test	3.77			
Durbin Watson	2.16	(0, 4)		
Mean	0			
Std Dev	0.02			
Normality	1.58	(0.5, 5.99)		
Skewness	-0.16	(-0.56, 0.56)		
Kurtosis	3.63	(1.80, 4.20)		
Outliers	0.0375	(0, 5)		
DFuller Test				
	Test Statistic	0.01	0.05	0.1
Constant	-3.254	-3.539	-2.907	-2.588
Constant, trend	-3.722	-4.086	-3.471	-3.163
D1.	-11.056	-3.541	-2.908	-2.589

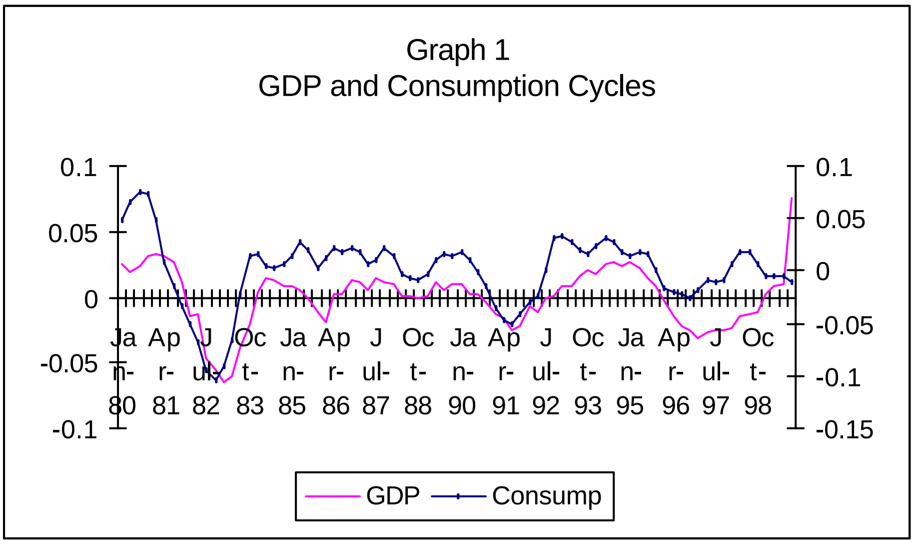
CPI				
ARIMA	**0,1,1**			
	Coef.	**Std. Err.**	**z**	
constant	5.5432	0.8143	6.80731917	
Ma				
L1	0.8703	0.0808	10.7710396	
Analysis of Residuals	Calculated Test	Range		
Ljung-Box Test	17.75	(0, 32.9)		
Box-Pierce Test				
Durbin Watson	1.42	(0, 4)		
Mean	0			
Std Dev	24.1			
Normality	14.6	(0.5, 5.99)		
Skewness	0.7	(-0.56, 0.56)		
Kurtosis	4.3	(1.80, 4.20)		
Outliers	0	(0, 5)		
DFuller Test				
	Test Statistic	0.01	0.05	0.1
Constant	10.302	-3.539	-2.907	-2.588
Constant, trend	1.045	-4.086	-3.471	-3.163
D1.	-3.21	-3.541	-2.908	-2.589

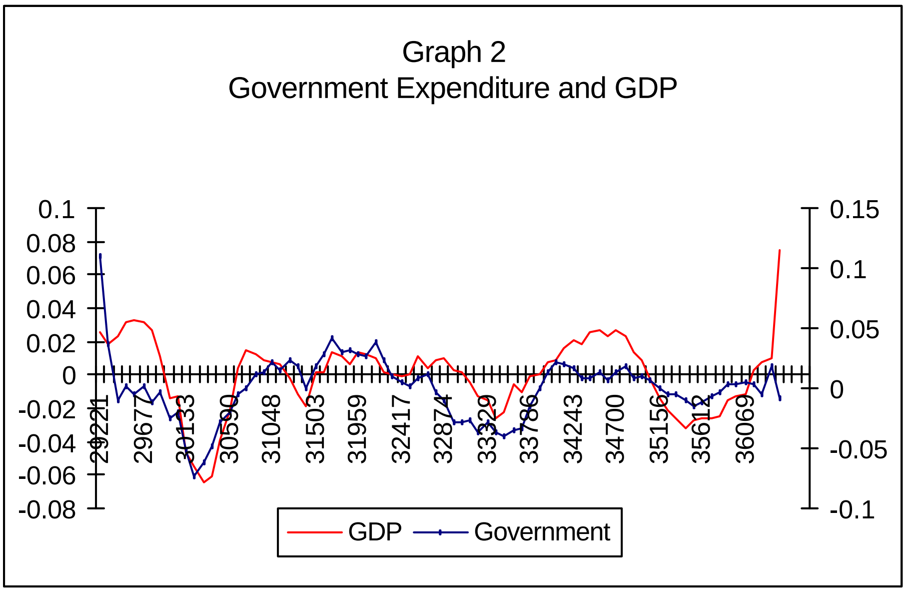
Federal Funds Rate				
ARIMA	**0,1,1**			
	Coef.	**Std. Err.**	**z**	
ma				
L1	-0.6963	0.08793	-7.91879904	
Analysis of Residuals	Calculated Test	Range		
Ljung-Box Test	11.87	(0, 25)		
Box-Pierce Test				
Durbin Watson	1.98	(0, 4)		
Mean	0			
Std Dev	0.06			
Normality	3.1	(0.5, 5.99)		
Skewness	-0.46	(-0.56, 0.56)		
Kurtosis	3.25	(1.82, 4.18)		
Outliers	0.0375	(0, 5)		
DFuller Test				
	Test Statistic	0.01	0.05	0.1
Constant	-2.237	-3.539	-2.907	-2.588
Constant, trend	-2.473	-4.086	-3.471	-3.163
D1.	-8.383	-3.541	-2.908	-2.589

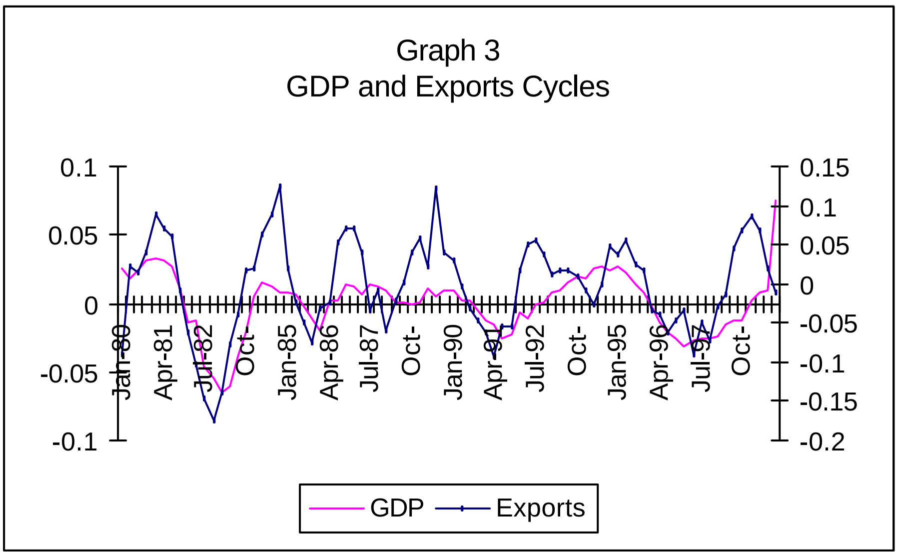
USA GDP				
ARIMA	0,1,1			
D.gdpusa	Coef.	Std. Err.	z	
_cons	0.0075286	0.0012946	5.815	
ma				
L1	0.3208861	0.0764384	4.198	
/sigma	0.0074246	0.0005215	14.237	
Analysis of Residuals	Calculated Test	Range		
Ljung-Box Test	11.06	(0, 25)		
Box-Pierce Test	3.01	(0, 5.99)		
Durbin Watson	2.16	(0, 4)		
Mean	0			
Std Dev	0.01			
Normality	2.72	(0.5, 5.99)		
Skewness	0.26	(-0.56, 0.56)		
Kurtosis	3.79	(1.88, 4.12)		
Outliers	0.0375	(0, 5)		
DFuller Test				
	Test Statistic	0.01	0.05	0.1
Constant	1.398	-3.539	-2.907	-2.588
Constant, Trend	-1.761	-4.086	-3.471	-3.163
D1	-6.657	-3.541	-2.908	-2.589

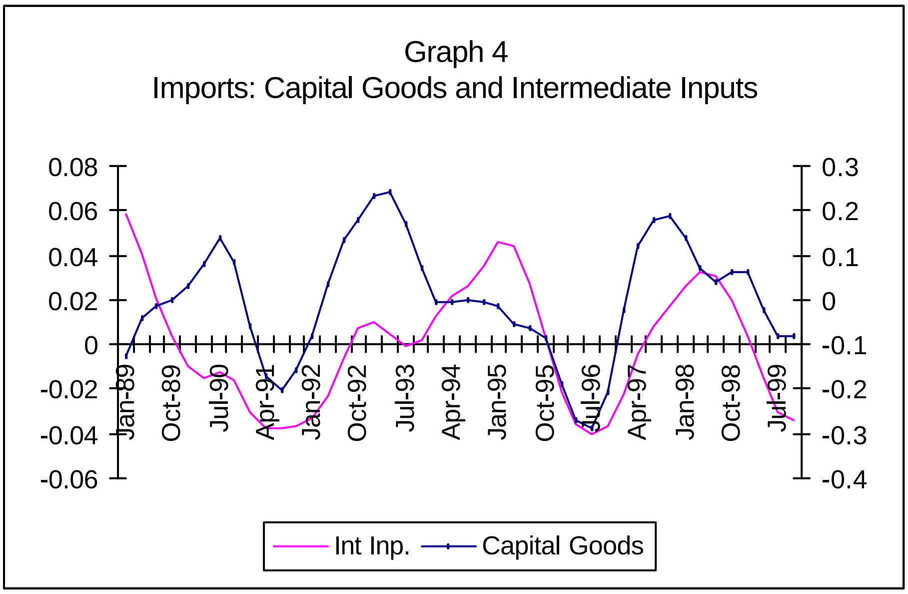
USA Imports				
ARIMA	**1,1,0**			
logimpor				
_cons	0.0172631	0.0044503	3.879	
ar				
L1	0.2706059	0.0721816	3.749	
/sigma	0.0263187	0.001774	14.836	
Analysis of Residuals	Calculated Test	Range		
Ljung-Box Test	19.73	(0, 23.7)		
Box-Pierce Test	3.13	(0, 5.99)		
Durbin Watson	1.54	(0, 4)		
Mean	0.01			
Std Dev	0.02			
Normality	0.74	(0.5, 5.99)		
Skewness	-0.11	(-0.56, 0.56)		
Kurtosis	3.44	(1.80, 4.20)		
Outliers	**0.05**	(0, 5)		
DFuller Test				
	Test Statistic	0.01	0.05	0.1
Constant	1.502	-3.539	-2.907	-2.588
Constant, trend	-1.732	-4.086	-3.471	-3.163
D1.	-7.505	-3.541	-2.908	-2.589

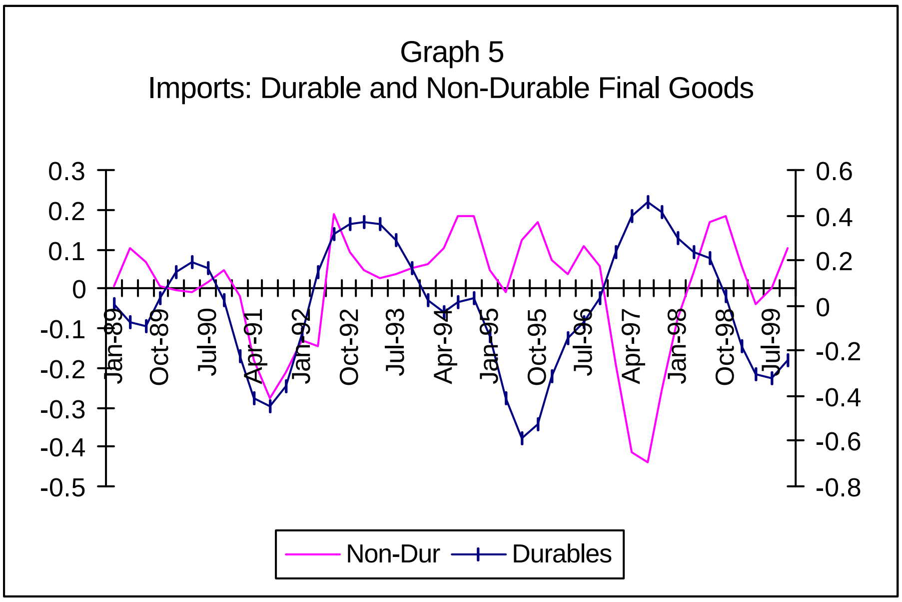
Annex 4
Main Macroeconomic Cycles

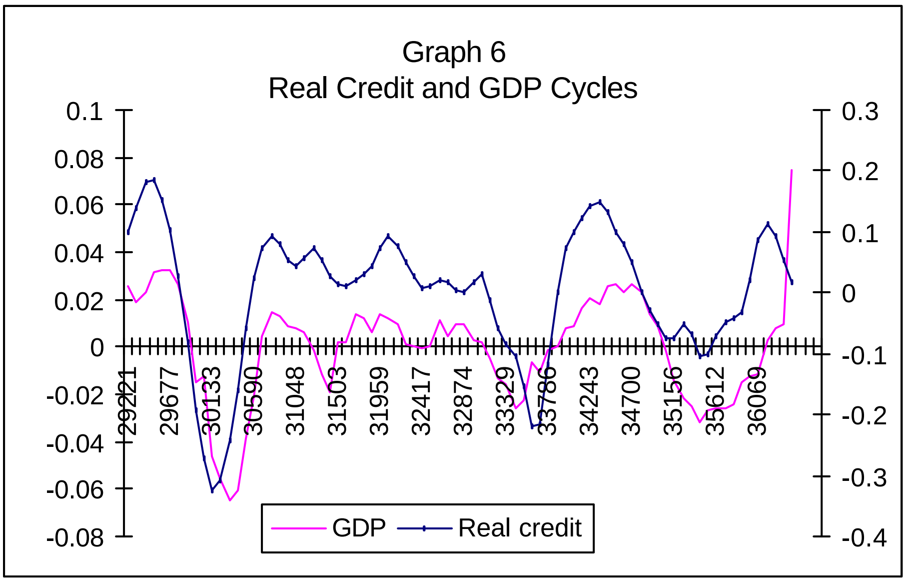


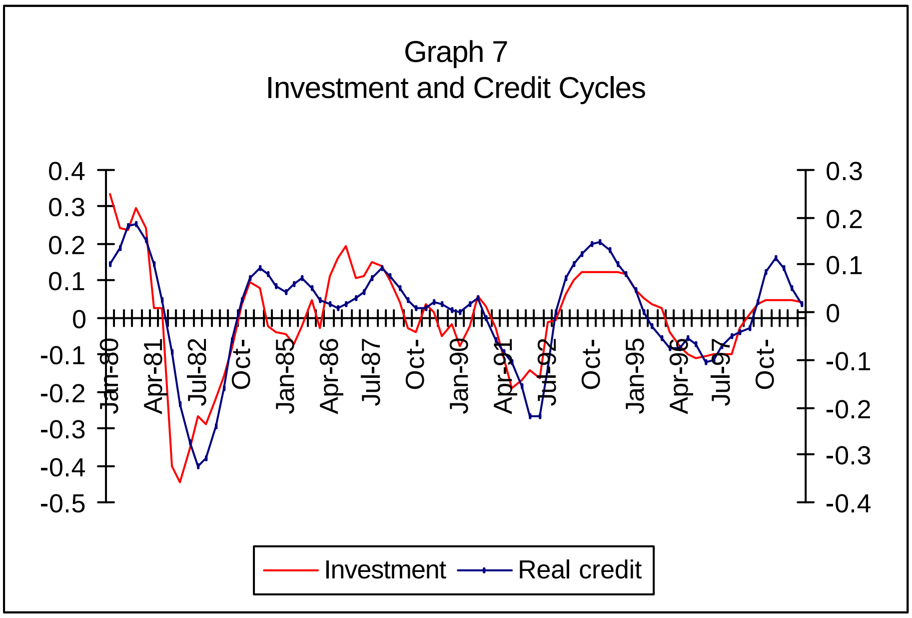


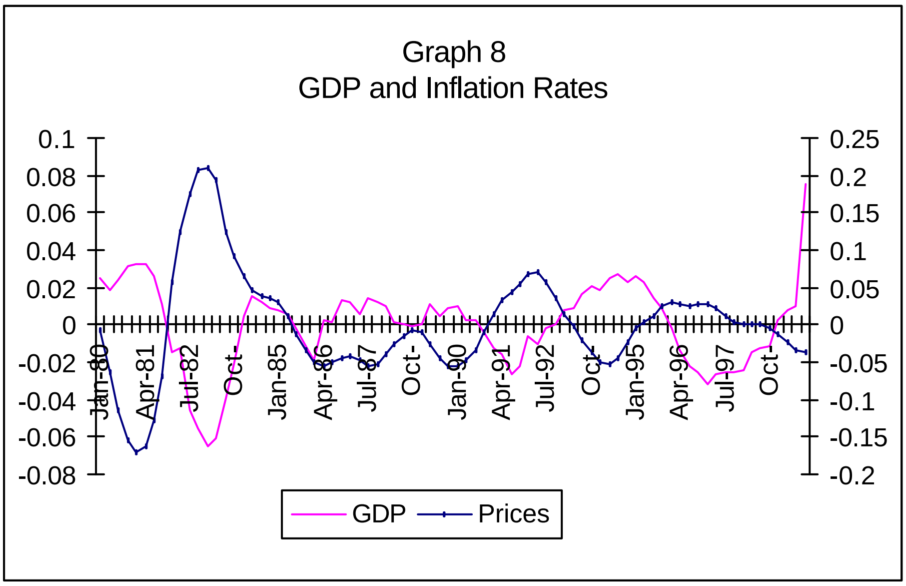



Graph 4
Imports: Capital Goods and Intermediate Inputs
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
Jan-89
Oct-89
Jul-90
Apr-91
Jan-92
Oct-92
Jul-93
Apr-94
Jan-95
Oct-95
Jul-96
Apr-97
Jan-98
Oct-98
Jul-99
Int Inp.
Capital Goods


Graph 5
Imports: Durable and Non-Durable Final Goods
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
Jan-89
Oct-89
Jul-90
Apr-91
Jan-92
Oct-92
Jul-93
Apr-94
Jan-95
Oct-95
Jul-96
Apr-97
Jan-98
Oct-98
Jul-99
Non-Dur
Durables


Graph 6
Real Credit and GDP Cycles
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
29221
29677
30133
30590
31048
31503
31959
32417
32874
33329
33786
34243
34700
35156
35612
36069
GDP
Real credit


Graph 7
Investment and Credit Cycles
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
Jan-80
Apr-81
Jul-82
Oct-
Jan-85
Apr-86
Jul-87
Oct-
Jan-90
Apr-91
Jul-92
Oct-
Jan-95
Apr-96
Jul-97
Oct-
Investment
Real credit


Graph 8
GDP and Inflation Rates
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
Jan-80
Apr-81
Jul-82
Oct-
Jan-85
Apr-86
Jul-87
Oct-
Jan-90
Apr-91
Jul-92
Oct-
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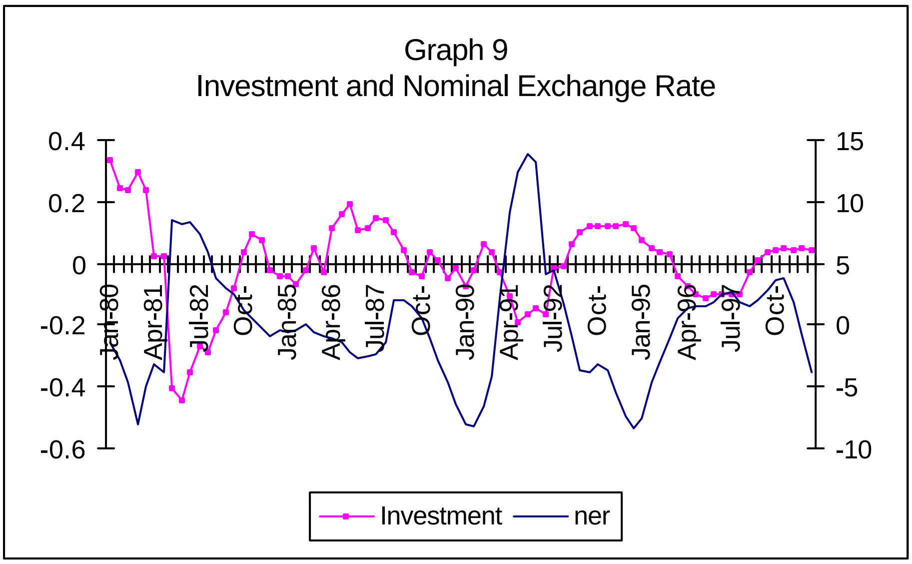
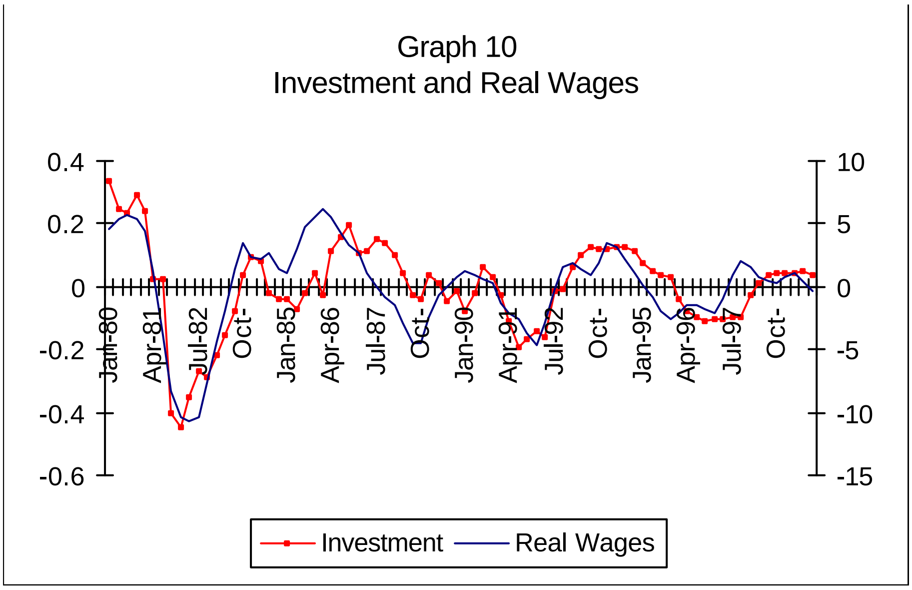
Apr-96
Jul-97
Oct-
GDP
Prices


Graph 9
Investment and Nominal Exchange Rate
0.4
0.2
0
-0.2
-0.4
-0.6
15
10
5
0
-5
-10
Jan-80
Apr-81
Jul-82
Oct-
Jan-85
Apr-86
Jul-87
Oct-
Jan-90
Apr-91
Jul-92
Oct-
Jan-95
Apr-96
Jul-97
Oct-
Investment
ner


Graph 10
Investment and Real Wages
0.4
0.2
0
-0.2
-0.4
-0.6
10
5
0
-5
-10
-15
Jan-80
Apr-81
Jul-82
Oct-
Jan-85
Apr-86
Jul-87
Oct-
Jan-90
Apr-91
Jul-92
Oct-
Jan-95
Apr-96
Jul-97
Oct-
Investment
Real Wages

Annex 5:Cointegration and VAR Models

This annex develops the methodological aspects used in chapter five, say, the Cointegration and the VAR models. Respect the latter, we are interested in analyzing the methodological aspects behind the Granger Causality Test, the Impulse Response Function and the Variance Decomposition Analysis.

Cointegration Analysis

An (n X 1) vector of time series is said to be cointegrated if each of the series is integrated of order 1 -I (1)- while some linear combination of them is stationary, that is I (0). This approach will allow us to regress variables that share a common trend without incurring in the problems associated with spurious regressions.

Thus, a bivariate equation (run at the levels of the variables) of the form

$$Y_t = \mu + \alpha_t \ X_t + \varepsilon_t$$

is cointegrated only if 1- Y and X are integrated of order 1 and 2- their linear combination Y- αX-μ results in a stationary process; in other words, the second condition to be cointegrated is that the residuals must be stationary.

For our purposes, we ran regressions of the form

$$\ln CRC_t^* = \mu + \alpha \ln USA_t^* + \varepsilon_t$$

where CRC* and USA* are the Costa Rican and United States macroeconomic variables under analysis and α is the **elasticity coefficient,** except for the case of the interest rates**.**

VAR Models

A VAR is a system of equations in which each variable is regress on n of its own lags as well as on n lags of each of the other variables (Hamilton, 1994). VAR models have became very popular since the pioneer work of Sims (1980), specially to measure the impact of economic policy variables in production, inflation and others. In our case, we are interested to evaluate three aspects:

- Causality, through the Granger test.
- The speed of transmission and magnitude of the impact of a 1 s.d. shock to the USA in Costa Rica, measured by the Impulse-response functions.

- Finally, the contribution of USA variables in the variability of the Costa Rican GDP by using the Variance Decomposition analysis.

A VAR(n) model can be represented mathematically by the equation

$$\mathbf{y}_{p,t} = \mathbf{C} + \sum_{m=1}^{n} \boldsymbol{\alpha}_{p,m}\, y_{p,t-m} + \boldsymbol{\varepsilon}_{\mathbf{t}}$$

In which n is the number of lags, $y_{p,t}$ is the vector of p endogenous variables, **C** is the constant term, $\boldsymbol{\alpha}_{\mathbf{p,m}}$ is the matrix of coefficients to be estimated and ε is the vector of residuals (innovations). The basic VAR models we want to construct follow the pattern

$$CRC_t^* = C_1 + \sum_{m=1}^{n} \alpha_t\ CRC_{t-m} + \sum_{m=1}^{n} \beta_t\ USA_{t-m} + \varepsilon_{1,t}$$

$$USA_t^* = C_2 + \sum_{m=1}^{n} \phi_t\ CRC_{t-m} + \sum_{m=1}^{n} \gamma_t\ USA_{t-m} + \varepsilon_{2,t}$$

where α, β, ϕ, and γ are the coefficients of the regressions. The optimum number of lags is defined by the application of the Akaike Information Criteria (AIC), the Schwarz Information Criteria (SIC) and the Likelihood Ratio Tests. If these tests do not drive us to a unanimous decision, we refer to the significance of the coefficients to decide the final model.

The Akaike Information Criteria is defined as (Franses, 1998)

$$AIC = \log\left|\Sigma_p\right| + 2m^2 p / n$$

where $|\Sigma_p|$ is the determinant of the residual covariance matrix for the VAR model, n is the number of effective observations, m the number of time series involved in the model and p the number of lags.

Similarly, the Schwarz Information Criteria corresponds to

$$SIC = \log\left|\Sigma_p\right| + (\log n)\, m^2\, p / n$$

For each of the models specified in chapter five we run up to three VARs, going from lags 1 to 3, each one with the three tests. To determine the correct number of lags we compared the AICs and selected that model with the lowest value. The same situation applies for the SIC. Given that not always both criteria agree (that is, the SIC may point to a 2-lag model while the AIC may select a 3-lag one), we apply Log Likelihood Tests -LLT- to those difficult cases. The LLT is calculated as

$$2(L_1^* - L_0^*) = T\left\{ \log|\Omega_0| - \log|\Omega_1| \right\}$$

where the L' s represent the log likelihood value of the VAR model and Ω is the variance covariance matrix; T is the sample size, with the special consideration that it must be kept constant for all the calculations. The test follows a χ^2 distribution with n^2 (p_1-p_0) degrees of freedom (n= number of variables, p_1 the number of lags in the higher order VAR and p_0 the number of the lower order one). An acceptance of the null hypothesis implies that lower order model captures better the dynamics than the higher one.

Finally, all the models are tested for the presence of unit roots (Dickey-Fuller test on seasonally adjusted series), coefficients' significance (T-tests) and white noise residuals (Durbin Watson and Portmanteau tests for serial correlation).

From the former VARs, we calculate three additional products: Granger Causality Test -GCT-, Impulse Response Function and Variance Decomposition. Respect the first one, Harvey (1990: 304) says that "the essence of Granger' s concept of causality is that x causes y if taking account of past values of x leads to improve predictions of y." The GCT is not a test of economic causality, but its results will help us to draw inferences on the dynamic impact of y on x and vice-versa (Franses, 1998) . To implement the test we run a special autoregressive p-lag regression[43]

$$x_t = c + \alpha_1 x_{t-1} + \alpha_2 x_{t-2} + ... + \alpha_p x_{t-p} + \beta_1 y_{t-1} + \beta_2 y_{t-2} + ... + \beta_p y_{t-p} + \mu_t$$

Then, we conduct an F-test under the null hypothesis that X does not cause Y, that is

$$H_0 : \beta_1 = \beta_2 = \beta_3 = \beta_p = 0$$

with (m, n-k_u) degrees of freedom, being m the number of restrictions imposed in the former equation (β' s parameters), n is the sample size and k_u the number of estimated coefficients in the unrestricted model (without the y' s) (Mukherjee et al, 1998).

The Impulse-Response function (IRF) describes the answer of variable y at time *t+h* to a one-time shock in variable x at time *t*. The IRF measures the speed of the response, the duration of the effect and the maximum impact of that shock in variable y.

Following Hamilton (1994), the IRF can be presented as a moving average set of matrixes of the type

$$\mathbf{y}_t = \boldsymbol{\mu} + \boldsymbol{\varepsilon}_t + \boldsymbol{\Psi}_1 \boldsymbol{\varepsilon}_{t-1} + \boldsymbol{\Psi}_2 \boldsymbol{\varepsilon}_{t-2} \ldots + \boldsymbol{\Psi}_s \boldsymbol{\varepsilon}_{t-s}$$

in which

$$\frac{\partial y_{t+s}}{\partial \varepsilon_t^{'}} = \boldsymbol{\Psi}_s$$

An element of the row i, column j in the matrix $\boldsymbol{\psi}_s$, measures the change in y in date t+s due to a unit change in the innovation ε at date t, holding the rest of innovations constant. However, if we want to measure the combined effect of several innovations changing at the same time, we will have an equation of the type

$$\boldsymbol{\Delta}\mathbf{y}_{\mathbf{t+s}} = \frac{\partial y_{t+s}}{\partial \varepsilon_{1t}}\delta_1 + \frac{\partial y_{t+s}}{\partial \varepsilon_{2t}}\delta_2 + \cdots + \frac{\partial y_{t+s}}{\partial \varepsilon_{nt}}\delta_n = \boldsymbol{\Psi}_s \boldsymbol{\delta}$$

that is, precisely, our impulse IRF.

The final tool derived from VARs is the Variance Decomposition. This application shows the percentage of the forecast error variance that is caused by a particular variable. Given again, the 2-equation VAR system described above, the forecast error variance of variable x corresponds to the expression

$$\text{FEV}_1 = \sigma_1^2 \left(1 + \sigma_{11}^2\right) + \sigma_{12}^2 \, \sigma_2^2$$

in which the first part of the equation corresponds to the own variable error variance, while the second member is due to the other variable. For n variables in the system, the equation is generalized to

$$\text{FEV}_1 = \sigma_1^2 \left(1 + \sigma_{11}^2\right) + \sigma_{12}^2 \, \sigma_2^2 \cdots + \sigma_{1n}^2 \, \sigma_n^2$$

[43] The number of lags corresponds to the same of the VAR model.

Annex 6: VAR Results

Model1: VAR (2) CRC-USAGDP			
Dcrc	Coef.	Std. Err.	t
Dcrc			
L1	0.301	0.142	2.120
L2	0.377	0.134	2.800
Dusa			
L1	0.950	0.285	3.330
L2	-0.538	0.300	-1.790
Tests			
Number of obs	77		
R-squared	0.57		
Durbin Watson	1.80		
Q Test	20.75		
Jarque Bera	0.16		
Mean	0.0003		
SD	0.01		
Model Selection	Lag 1	lag 2	lag 3
Determinant Residual Covariance	1.51E-09	1.23E-09	1.72E-09
Log Likelihood	556.17	563.80	551.19
Akaike Information Criteria	-14.53	-14.63	-14.19
Schwarz Criteria	-14.41	-14.38	-13.82
log determinant residual	-20.31	-20.52	-20.18
Likelihood Ratio Test		15.25	
Critical Chi-Sq.		9.49	
* Non significant coefficient at 10%.			

Model 2: VAR (1) Interest Rate-FFR			
	Coef.	Std. Err.	t
Drate			
L1	0.418	0.096	4.348
Ffr			
L1	1.267	0.388	3.266
Tests			
Number of obs	67		
R-squared	0.32		
Durbin Watson	1.25		
Q Test	36.06		
Jarque Bera	2.38		
Mean	-0.07		
SD	1.80		
Model Selection	lag 1	lag 2	lag 3
Determinant Residual Covariance	0.733	0.572	0.562
Log Likelihood	-174.367	-166.287	-165.705
Akaike Information Criteria	5.488	5.363	5.468
Schwarz Criteria	5.622	5.630	5.869
log determinant residual	-0.311	-0.559	-0.577
Likelihood Ratio Test		16.159	
Critical Chi-Sq.		5.99	
The AIC and the SIC pointed toward			
models 2 and 1 respectively.			
In this case, model 1 was selected			
because some VAR (2) coefficients			
were not significant			
*Non significant coefficient at 10%.			

Model 3 VAR (2) Exports-USAM			
Dcrc	Coef.	Std. Err.	t
Dexports			
L1	0.848	-0.117	-7.265
L2	-0.120	-0.116	1.036*
Dusam			
L1	0.508	-0.235	-2.160
L2	0.391	-0.237	-1.650
Tests			
Number of obs	77		
R-squared	0.69		
Durbin Watson	1.80		
Q Test	45.40		
Jarque Bera	2.64		
Mean	0.006		
SD	0.08		
Model Selection	lag 1	lag 2	lag 3
Determinant Residual Covariance	3.47E-07	3.09E-07	2.12E-07
Log Likelihood	344.96	349.31	363.36
Akaike Information Criteria	-9.09	-9.10	-9.37
Schwarz Criteria	-8.97	-8.85	-9.00
log determinant residual	-14.87	-14.99	-15.37
Likelihood Ratio Test		8.69	28.10
Critical Chi-Sq.		9.49	
Model 3 was pointed by the AIC and			
the SIC as the best one; however, it was			
discarded because non of the USAM			
coefficients was significant at 5% and only 1			
at 10%. Considering that, model 2 was chosen			
* Non significant coefficient at 10%.			

Model 4: VAR (3) CRGDP-USAGDP-USAPric			
Dcrc	Coef.	Std. Err.	t
Dcrc			
L1	0.350	-0.107	-3.256
L2	0.339	-0.114	-2.965
Dusagdp			
L1	0.057	-0.039	-1.489
L2	0.063	-0.034	-1.834
Dprice			
L1	-0.003	-0.002	1.730
L2	0.003	-0.002	-1.818
Tests			
Number of obs	76		
R-squared	0.41		
Durbin Watson	1.64		
Q Test	25.50		
Jarque Bera	0.43		
Mean	0.002		
SD	0.03		
Model Selection	lag 1	lag 2	lag 3
Determinant Residual Covariance	2.40E-08	1.13E-08	1.25E-08
Log Likelihood	343.23	371.70	368.07
Akaike Information Criteria	-8.80	-9.31	-8.98
Schwarz Criteria	-8.52	-8.76	-8.15
log determinant residual	-17.55	-18.30	-18.20
Likelihood Ratio Test		56.95	-7.27
Critical Chi-Sq.		9.49	
* Non significant coefficient at 10%.			

Model 5: VAR (4) CRGDP-USAGDP-Prices-FFR			
Dcrc	Coef.	Std. Err.	t
Dcrc			
L1	0.237	-0.112	-2.124
L2	0.403	-0.109	-3.679
Dusagdp			
L1	0.680	-0.255	-2.661
L2	-0.122	-0.285	0.427
Dprice			
L1	-0.004	-0.002	2.324
L2	0.003	-0.002	-1.729
FFR			
L1	-0.002	-0.001	2.217
L2	0.000	-0.001	0.102
Tests			
Number of obs	76		
R-squared	0.51		
Durbin Watson	2.30		
Q Test	41.30		
Jarque Bera	0.95		
Mean	0.001		
SD	0.03		
Model Selection	lag 1	lag 2	lag 3
Determinant Residual Covariance	3.66E-10	1.57E-10	1.03E-10
Log Likelihood	389.14	420.95	436.67
Akaike Information Criteria	-9.95	-10.37	-10.36
Schwarz Criteria	-9.46	-9.38	-8.88
Likelihood Ratio Test		63.60	
Critical Chi-Sq.			
* Non significant coefficient at 10%			

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